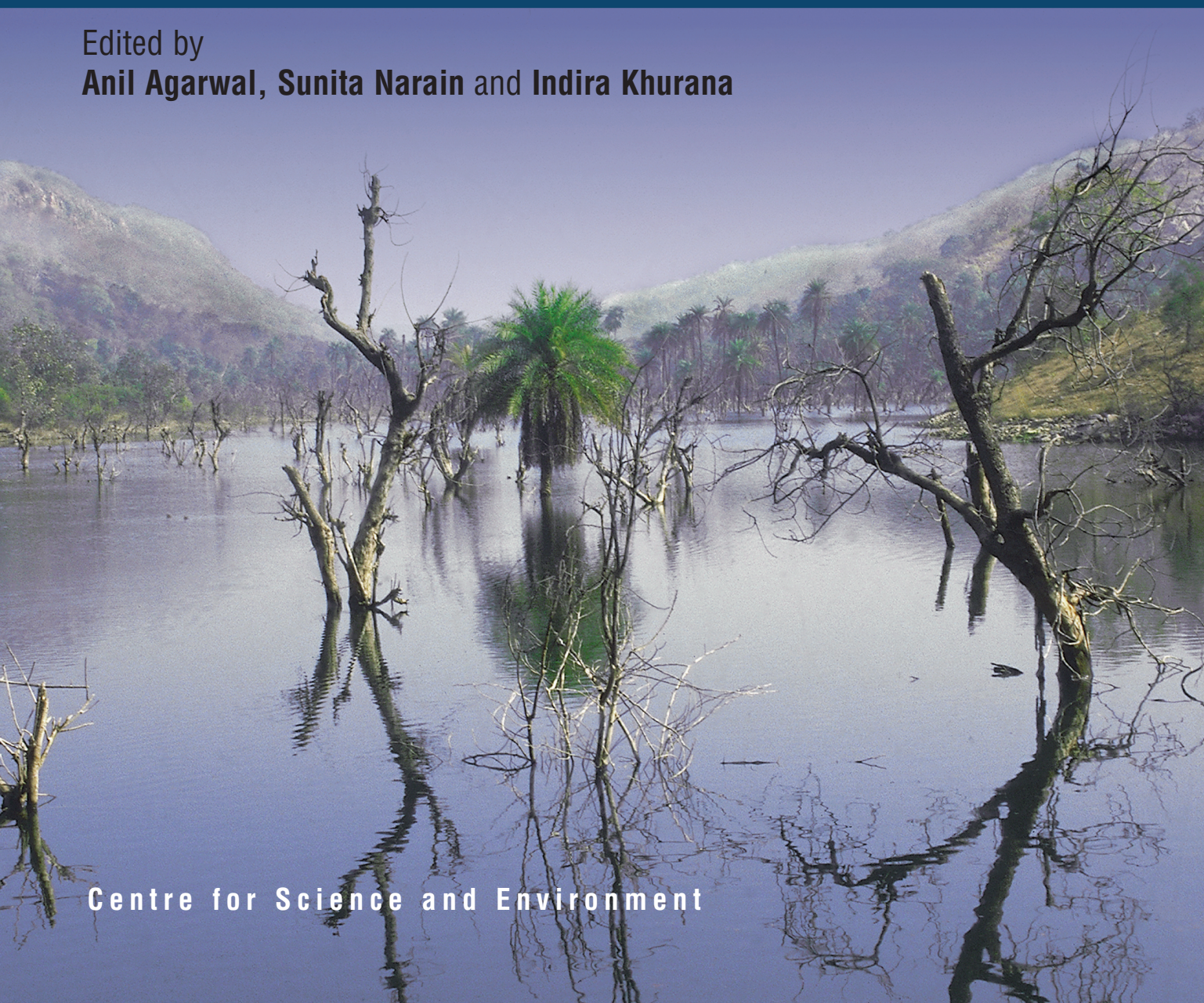
MAKING WATER EVERYBODY'S BUSINESS

PRACTICE AND POLICY OF WATER HARVESTING

Edited by
Anil Agarwal, Sunita Narain and **Indira Khurana**



Centre for Science and Environment

To those who are trying to make Mahatma Gandhi's dream of *gram swaraj* come true

LEAVES OF IMPORTANT SURVIVAL TREES IN INDIA — MAHUA, KHEJDI, ALDER, PALMYRA AND OAK

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Material from this publication can be used but only with proper acknowledgement.

This report supplements the information provided in the citizens' fourth report on the State of India's Environment –1997 entitled *Dying Wisdom: Rise, fall and potential of India's traditional water harvesting systems,* but is not a substitute for it.

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MAKING WATER EVERYBODY'S BUSINESS

PRACTICE AND POLICY OF WATER HARVESTING

Underneath the verandah in front of the room in which the Mahatma was born, in the space enclosed by the three wings of the house, is an underground reservoir, 20 feet long, 20 feet wide and 15 feet deep, with a capacity of 20 thousand gallons, for storing rainwater for domestic use. The well water in Porbandar, owing to its vicinity to the sea, is brackish, hard and unfit for cooking. Rainwater was, therefore, collected and stored in the underground reservoir for use the year round. The terrace on the top floor, carefully washed before the first monsoon showers, served as catchment for the water, running down a pipe straight into the tank. A heap of lime at the mouth of the pipe served to filter and purify the water.

In this house five generations of Gandhis lived and prospered.

—Mahatma Gandhi Vol 1 (The Early Phase) by Shri Pyarelal

"We have spent enough on extravagant temples of stone. Let us call a temporary stop to it and spend it on jal mandirs *(water temples like check dams). How will these temples of stone survive without water?*

—Swami Madhavpriyadas, Swaminarayan sect

CSE Centre for Science and Environment

Editors: **Anil Agarwal, Sunita Narain** and **Indira Khurana**

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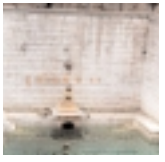

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Introduction

It was on October 3, 1998 that Shri K R Narayanan, president of India, inaugurated our three-day Conference on the *Potential of Water Harvesting: Technologies, Policies and Social Mobilisation*.

This conference was organised by the Centre for Science and Environment to follow-up the release of its fourth citizens' report on the State of India's Environment entitled *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems.* CSE had tried to build in an advocacy programme with the release of this book as **it felt that the community-based water harvesting paradigm still had great relevance in this modern day and age.** Firstly, it allowed everybody to get involved with water collection, storage and management, taking an enormous pressure off the state agencies. In addition, it allowed people access to a much larger quantity of water, howsoever diffuse, than the concentrated water sources available to us in the form of rivers and underground aquifers.

Some 11 releases of the book were organised with the help of non-governmental organisations across the country *(see Table 1: Getting people talking about water harvesting)* which helped to focus public attention on the message contained in the book. The media also gave us full support and within a span of three to four months, there were more than 50 reports in 32 newspapers and magazines in six languages published on the book *(see Box: Useful contribution).* **Several senior political leaders, including Mrs Sonia Gandhi, now leader of the Congress Party, lent support to this effort, which greatly added to the public discussion on the book.** Mrs Gandhi

T C MALHOTRA

Appreciating the Centre for Science and Environment's request to undertake water harvesting in the Rashtrapati Bhavan, the president, Shri K R Narayanan, said, "I am happy to accept the suggestion and invite CSE to develop a plan for us." OPPOSITE PAGE: ***Villagers toiling to build one of the earliest water harvesting structures in Ralegan Siddhi. The village has carved a name for itself in history. A destitute village, with extremely degraded natural resources, stands transformed. It is now perhaps the richest village in India.*** (PIX: ANIL AGARWAL)

Table 1: Getting people talking about water harvesting

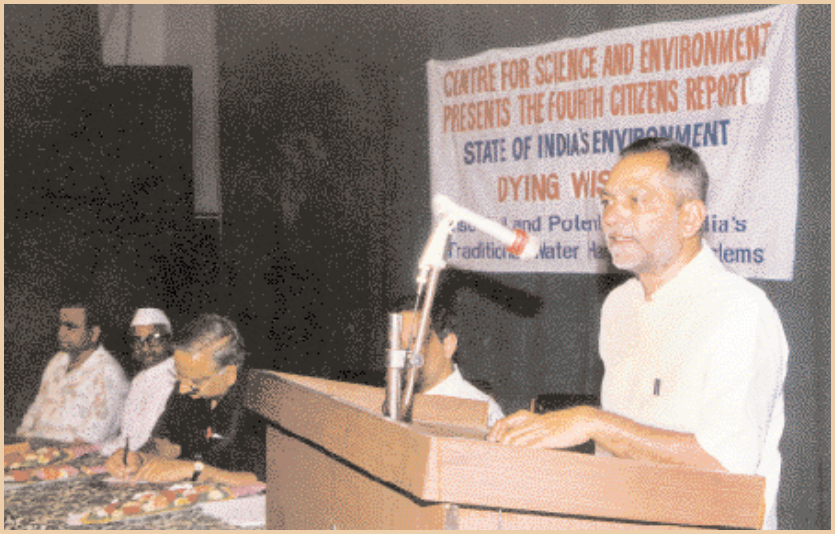
Place and Date	Chief guest	Supporting NGO	Water harvesters honoured at the release function
HYDERABAD (March 10, 1997)	**Prabha Shankar Mishra** *Chief Justice of Andhra Pradesh High Court*	Society for Preservation of Environment and Quality of Life	• K L Vyas, leader of the 'Save the Lakes Campaign' in Hyderabad • T Hanumantha Rao, engineer-in-chief in Hyderabad irrigation department, who has authored a number of reports on water harvesting systems • Anuradha P Reddy, secretary of SPEQL, who has been active in saving the lakes of Hyderabad • M S Kodarkar, an aquatic biologist, for his enthusiastic participation in the 'Save the Lakes Campaign'
NEW DELHI (March 11, 1997)	**Sonia Gandhi** Rajiv Gandhi Foundation		
LEH (March 12, 1997)	**Thupstan Chewang** *Chairperson and chief executive councillor of the Ladakh Autonomous Hill Council*	Ladakh Ecological Development Group	• Chewang Norphel, engineer in the rural engineering department for having constructed/repaired many canals and tanks using traditional methods • Tsetan Gurmet, a farmer with experience in the construction of traditional irrigation canals
PUNE (March 22, 1997)	**Anna Hazare** *Social activist and leader of Ralegan Siddhi village*	OIKOS: Centre for Natural Resource Management	• Ashok Tanurkar, who manages the activities in Ralegan Siddhi village • Laxman Khedkar, a villager who has learnt to conceive, plan and execute lift irrigation schemes • Vijay and Saroja Parulkar, writers, who first documented Hazare's Ralegan Siddhi and Vilas Salunke's Pani Panchayat experiments
KOCHI (March 25, 1997)	**K K Usha** *Judge in the Kerala High Court*	Kerala Sastra Sahitya Parishad and the Centre for Water Resources Development and Management, Calicut	• T J Mathew of Thumbasseri, Punalur, who has developed simple techniques for increasing water retentivity of soils and for groundwater recharge • T N N Bhatathripad, a former engineer with the Kerala Water Authority, who has been advocating indigenous methods of water conservation
AHMEDABAD (March 29, 1997)	**S K Shelat** *Chief Secretary of Gujarat*	Pravah	• Shyamjibhai Antala of Saurashtra Lok Manch Trust, for spearheading a movement in Saurashtra for well recharging • Lata Sachade of Kutch Mahila Vikas Sangathan, for creating awareness of environmental issues • Devuben Pandya of Mahiti-Dholera, for creating awareness of environmental issues • Nafisa Barot of Utthan-Ahmedabad, for creating awareness of environmental issues • Reema Nanavaty of SEWA-Banaskantha, for encouraging local water harvesting in different parts of Gujarat, particularly with women's participation • Ashok Rathi of Manviya Technology Forum, Baroda, who has launched a movement against pollution of Narmada river and people's control over local groundwater resources • Mayur Shah of Prarthana Constructions, Ahmedabad, for encouraging rainwater harvesting in Ahmedabad
INDORE (March 30,1997)	**B R Yadav** *Minister for agriculture and cooperation in the Madhya Pradesh government*	*Nai Duniya*, a leading newspaper of Madhya Pradesh and Abhyaas Mandal Water Works Society	• Rakesh Trivedi for creating awareness of environmental and water conservation issues • Taiyab Sihorivala for creating awareness of environment and water conservation issues • T G K Menon for his contribution towards creating awareness on environment and water conservation issues
MUMBAI (May 6,1997)	**Prakash Javdekar** *Executive president of Maharashtra State Planning Board*	Samarthan, Mumbai	
CHENNAI (May 6,1997)	**V C Kulandaiswamy** *Chairperson, High Level Committee for Wastelands Development, Government of Tamil Nadu*	M S Swaminathan Research Foundation	
PATNA (May 17, 1997)	**B P Singh** *Judge in the Bihar High Court*	East and West Educational Society	• R K Sinha, reader in zoology in the Science College, for his work on Gangetic biodiversity • Dinesh Kumar Mishra, a writer on flood problems, who has highlighted the negative impacts of current water resource development policies • Taru Mitra, an organisation of school and college students, for its efforts in raising environmental consciousness
JHABUA (August 12, 1997)	**Harbans Singh** *Minister for panchayat and rural development, government of Madhya Pradesh*	Madhya Pradesh government	

AMIT SHANKER / CSE

The release of Dying Wisdom *in New Delhi in 1997 by Sonia Gandhi helped generate interest in the media and amongst parliamentarians*

M P Vasimalai of DHAN Foundation being felicitated by M S Swaminathan at the release of Dying Wisdom *in Chennai. The release was organised by M S Swaminathan Research Foundation*

M S SWAMINATHAN RESEARCH FOUNDATION



Vilasrao Salunke at the release of Dying Wisdom *in Pune. The book was released by social activist Anna Hazare*

USEFUL CONTRIBUTION

The report* Dying Wisdom *received an enthusiastic response. We present some of the comments it received

Let me congratulate you on this very useful effort, which is a contribution to the welfare of society at large. Immediately after receiving *Dying Wisdom*, I studied some important section that impressed me. Your coverage of Karnataka is very good.

G Thimmaiah
Member, Planning Commission

We are glad to notice you are releasing the Fourth Citizens' Report, which focuses on traditional water harvesting systems. We can also offer to be part of CSE's campaign, using our organisational facilities to support and sustain your efforts.

Jurgen Putz
Centre for Ecological Landuse and Rural Development
Auroville

The report is really worthy. It should be published in Telugu. I can help in doing it. The lakes here continue to be destroyed. Saheb Nagar Lake and Kapra Lake (Secunderabad), among others, are subjected to heavy encroachment.

K L Vyas of the Save Lakes Committee
Hyderabad

This book will force everyone to think about how traditional systems can be applied in the present context.

Anna Hazare
Social Activist

The book is a passionate plea for going back to the roots of Indian traditional skills to overcome the current water crisis…. India's planners must make it compulsory reading.

Anand Parthasarathy
in ***The Hindu***

If taken seriously and used by policymakers, NGOs and water management agencies, it could be the perfect backgrounder for a sound water management policy for the country.

Business Line

We want to convey to you our appreciation for CSE's new publication *Dying Wisdom* which I think can only be classified as a classic work. I think the work ranks in range, scope and importance with CSE's *First Citizen's Report on the State of India's Environment*. Our congratulations to you and CSE team for bringing out such a fine work.

Shripad Dharmadhikary
Narmada Bachao Andolan, Vadodara

This book (*Dying Wisdom*) is another milestone for the entire nation who have for long ignored such critical themes like water conservation. Your dedicated team deserves sincere applause for this great and noble task.

Mahendra P Lama,
Associate Professor, School of International Studies,
Jawaharlal Nehru University, New Delhi

We got the copy of *Dying Wisdom* in time for our consultation on "water harvesting for mountain households" in Chengdu, China. It reinforced our own ideas that the new technologies as promoted by the Chinese should not overlook indigenous knowledge and age-old practices.

Egbert Pelinck, *director-general,*
International Centre for Integrated Mountain Development,
Kathmandu, Nepal

I must compliment you on the publication of *Dying Wisdom*, which is indeed of a very high standard. I am sure we shall find it useful for our radio programmes.

O P Kejariwal, *director-general,*
All India Radio, New Delhi

The book (*Dying Wisdom*), as aptly titled, is really a treasure of our traditional wisdom. I sincerely appreciate the effort made by CSE in making such an extensive survey and congratulate it for its laudable achievement.

K Vijayakumaran,
Central Marine Fisheries Research Institute, Visakhapatnam

In the course of the last five decades, we have had the Central Water Commission, the Ministry of Water Resources and many water authorities in the states. But, none of them has produced a document as detailed as *Dying Wisdom.*

L C Jain
in ***The Indian Express***

was not involved in politics at that time and was refusing to release books. But because of the importance that her husband, former prime minister, Rajiv Gandhi, had given to the earlier citizens' reports on the state of India's environment, and the importance of the subject, she agreed to release this report. Her presence helped the book to get considerable media coverage and questions in the Parliament.

But it was not enough to talk about the long history and tradition of water harvesting in India. At a conference in Hyderabad, a visiting water expert even said that we should not have titled our book *Dying Wisdom* but should have called it *Emerging Wisdom.* It was, therefore, necessary to inform the public that outstanding changes in village ecology and economy have taken place where village communities have undertaken water harvesting. Apart from the well-known efforts of villagers in Ralegan Siddhi in the drought-prone Ahmednagar district of Maharashtra, and Sukhomajri in the degraded Shivalik hills in Haryana, there were numerous other efforts taking place in India and abroad to revive the water harvesting paradigm. We wanted to bring these to the notice of the people of India.

Therefore, we approached the president to inaugurate the conference which would add eminence to our effort and announce that he would also undertake water

AMIT SHANKER / CSE

Sukhomajri village, situated in the foothills of the Himalaya, was one of the first villages in India to revive the concept of community-based rainwater harvesting. It built its first earthen dam in 1979

harvesting in the Rashtrapati Bhavan. He graciously agreed to lend us his support. The conference was able to bring together a cross-section of some 104 water harvesting activists, builders, policymakers and academics from India and abroad. The conference was chaired by A Vaidyanathan, former member of the Planning Commission and a leading irrigation economist, and was attended by several leading politicians, including Digvijay Singh, chief minister of Madhya Pradesh. The deliberations clearly showed that water harvesting is necessary even today and the conference participants recommended the creation of a National Water Harvesters Network to strengthen the hands of all those involved in this effort.

The concept of water harvesting has, thus, come a long way since CSE organised its first conference on water harvesting traditions of India in October 1990. The information gathered at the conference finally resulted, seven years later, in the publication of *Dying Wisdom.* **All through, this effort has been an intensely cooperative exercise in which historians, social scientists, economists, journalists, NGOs and various other sections of the civil society, policymakers and politicians have given us their full support to push revival of this ancient technique of water management.**

Why are we promoting this new paradigm of water management?

Its value was widely recognised across the country in the summer of 2000 when several western states witnessed a severe drought. The result was acute drinking water shortages in Gujarat, Rajasthan, western Madhya Pradesh, Orissa and Andhra Pradesh. According to newspaper reports, several towns in Saurashtra were getting an extremely irregular supply of water *(see Table 2: Water crisis).* Most of the dams and reservoirs in the region have dried up. The government was trying to deal with the problem by providing water through tankers and by deepening existing borewells. The Central government promised to run

Table 2: Water crisis

Drinking water availability in Gujarat towns in April 2000

Place	Availability of drinking water
Rajkot[1]	30 minutes every alternate day
Jamnagar, Jasdan and Amreli[1]	20 minutes once in three days
Jodiya town Jamnagar district[2]	20 minutes in 12 days
Dhrol town Jamnagar district[2]	Half the population gets water once in eight days

Source: 1. Janyala Sreenivas 2000, Forget the Sensex for a second, look what else is going down, *Indian Express,* New Delhi, April 19, p.1

2. Janyala Sreenivas 2000, Once a fortnight they get a few drops and that too for 20 minutes, *Indian Express,* New Delhi, April 21, p.1

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The failure of the 1999 monsoon saw women in Gujarat digging for a few drops of water in dry riverbeds. A woman in Rentia village tries her luck in the Sukhi riverbed

water trains. **But is all this inevitable? That we have to do this every time the rainfall is less than normal?**

We didn't think so and we tried to brief the media on what can be done to solve this problem almost permanently unless, of course, there is a series of consecutive droughts for several years. We knew that the change we were advocating would come, we are afraid to say, only if our political leaders are prepared to promote a new approach to water management in this country.

During one of the meetings of the World Water Commission, which submitted its report in The Hague in April 2000 to a bevy of water ministers, a member had strongly emphasised the need for educating politicians about the importance of water. But this argument is incorrect because we have rarely met a politician, especially in India, who does not emphasise the importance of water. But what we have indeed found is that hardly any of them know how to solve the water problem.

Not surprisingly, few government initiatives have been able to deliver the goods as the current unprecedented drought has shown in such starkness. The portents of this so-called once-in-a-century drought had become clear as far back as September 1999 when national elections were being held and Shri L K Advani, Union Home Minister, had to face slogans like *'Pehle Paani Phir Advani'* in Saurashtra. As far back as December, many villagers in north Gujarat had begun to leave home because of water shortage. Once the monsoon season was over, the government could not have done anything to solve the water problem except to provide some succour in terms of drought relief works, emergency water supply through tankers, and digging deeper borewells for some residual water in the bowels of the earth.

But this is not enough. Many will term what is happening in Gujarat and Rajasthan a 'natural disaster'. This is really far from the truth. It is truly a 'human-made' or rather a 'government-made' disaster. Over the last one hundred years or so, the world and India, too, have seen two major shifts in water management. One is that individuals and communities have steadily given over their role almost completely to the state even though more than 150 years ago no government anywhere in the world provided water. The second is that the simple technology of using rainwater has declined and in its place exploitation of rivers and groundwater through dams and tubewells has become the key source of water. As water in rivers and aquifers is only a small portion of the total rainwater, there is an inevitable and growing, and, in many cases, unbearable stress on water from rivers and groundwater.

Dependence on the state has also meant that costs of water supply are high; with cost recovery being poor the financial sustainability of water schemes has run aground; and, repairs and maintenance is abysmal. People have no interest in using water carefully and so the sustainability of water resources has itself become a question mark. Despite all the government efforts, the number of 'problem villages' does not seem to go down. As N C Saxena, former rural development secretary has put it, "In our mathematics, 200,000 problem villages minus 200,000 problem villages is still 200,000 problem villages" *(see Graph 1: Unending exercise: in the opening address by Anil Agarwal in the Inaugural Session).* **Given the fact that India is one of the most well-endowed nations in the world in terms of average annual rainfall, there is no reason why it should suffer from drought. This year or any other year. The most important lesson that our decision-makers should learn from the current crisis is how to drought-proof the nation in the years to come — a task that can easily be accomplished in less than a decade if the country puts its mind to it.**

The government has indeed invested heavily on water resources development. But these programmes have focussed mainly on:

- Large-scale irrigation development for increasing Green Revolution-style agricultural production; and,
- drinking water supply programmes.

Yet a large part of the country remains drought-prone. This is because no specific effort has been made to drought-proof rainfed areas which suffer from high rainfall variability from year to year and season to season. Moreover, the government has encouraged a massive intervention into the country's hydrological cycle but it has precious little to sustain the integrity of the hydrological system. A fine example of the disintegration of the country's hydrological system is what we are doing to our groundwater. The country has been constantly encouraging exploitation of groundwater but has done little to recharge it. As a result, groundwater tables are falling all over the country. Considering the fact that over 90 per cent of rural Indians depend on groundwater to get their drinking water, the decline poses a serious problem which becomes an emergency in a year when the rains are low as in 2000. The poor, of course, who depend on dug wells, which dry off first, as compared to tubewells or borewells, are the first to suffer.

COMMUNITIES AND RAIN

Community-based rainwater harvesting — the paradigm of the past — has in it as much strength today as it ever did before. A survey conducted by the Centre for Science and Environment (CSE) of several villages facing drought in Gujarat and western Madhya Pradesh last December — Ghelhar Choti in Jhabua district, Thunthi-Kankasiya in Dahod district, Raj-Samadhiyala and Mandlikpur in Rajkot district, and Gandhigram in Kachch district — found that all those villages which had undertaken rainwater harvesting and/or watershed development in earlier years had no drinking water problem whatsoever and even had some water to irrigate their crops. On the other hand, neighbouring villages were desperate for water and planning to migrate when the real summer hit them. This survey revealed that rainwater harvesting can meet even the acid test of a bad drought.

In late March 2000, we got further confirmation of our conviction. Going with president K R Narayanan in a helicopter to the Arvari watershed who was scheduled to give the *Down to Earth*-Joseph C John Award to village Bhaonta-Kolyala in late March, we could see nothing but barren fields all the way from Delhi to Alwar. This area was suffering from a second consecutive drought-year. But suddenly we came across green and golden fields and realised that we had reached the oasis of the Arvari watershed where several villages have over the last 5-10 years built hundreds of rainwater harvesting structures. Nobody needed to emphasise the importance of rainwater harvesting any more. The president saw a more or less dead Arvari river, unable to withstand the burden of two years' drought, but wells were still full of water and, therefore, fields were rich and productive and villagers reasonably happy.

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Dressed in their colourful best, village women came in hordes to see President K R Narayanan present the villagers of Bhaonta-Kolyala with the* Down To Earth*-Joseph C John award for the best environment community

AMIT SHANKER / CSE

Water management is about social mobilisation and community action. **Pani yatras** ***spread the message from village to village***

GETTING PRIORITIES RIGHT: POTENTIAL OF RAINWATER HARVESTING

What makes rainwater harvesting such a powerful technology? Just the simple richness of rainwater availability that few of us realise because of the speed with which water, the world's most fluid substance, disappears. Imagine you had a hectare of land in Barmer, one of India's driest places, and you received 100 mm of water in the year, common even for this area. That means that you received as much as one million litres of water — enough to meet drinking and cooking water needs of 182 people at a liberal 15 litres per day. Even if you are not able to capture all that water — this would depend on the nature of rainfall events and type of runoff surface, among other factors — you could still, even with rudimentary technology, capture at least half a million litres a year.

It is, in fact, only with this rudimentary technology that people came to inhabit the Thar desert and have made it the most densely populated desert in the world. And assuming you could capture the 2,000 mm annual rainfall that is common in eastern India, you would need only 500 square metre of land (a 25 metre by 20 metre plot) to capture one million litres. It is also interesting to note that rural population density follows intensity of annual rainfall. Barmer, for instance, has less rainfall but few people and a lot of land available per person whereas 24-Parganas in West Bengal has much more rain but more people and less land available per person.

Even in the villages suffering from drought in 2000, it is not as if there was no rain. In many areas like Andhra Pradesh, Orissa and western Madhya Pradesh the rainfall levels, though lower than normal, were still more than 500 mm, which is an enormous amount of rainfall. The average annual rainfall in Saurashtra and Kachch, the worst affected, is 578 mm. In 2000, according to newspaper reports, it was very depressed but still around a couple of hundred millimetres (mm). But the people of Saurashtra and Kachch let the water go. **It does not matter how much rain you get, if you don't capture it you can still be short of water. It is unbelievable but it is true that Cherrapunji which gets 11,000 mm annual rainfall, still suffers from serious drinking water shortages**.

In fact, we have consistently argued that there is no village in India that cannot meet its basic drinking and cooking needs through rainwater harvesting. Figures speak for themselves *(see Table 3: Where is the water shortage?).* India's average annual rainfall is 1,170 mm. It varies from 100 mm in the deserts of western India to 15,000 mm in the high rainfall hills of the Northeast. Nearly 12 per cent of the country receives an average rainfall of less than 610 mm per annum while 8 per cent

Table 3: Where is the water shortage

Every village in India can meet its own water needs: Land area needed per village in different states of India to capture enough rainwater to meet drinking and cooking water needs

State	Meteorological divisions	Average annual rainfall (millimetres)	Estimated no. of villagers per village, 2001	Land area needed per village to meet drinking and cooking water needs assuming half of normal rainfall is captured (hectares)	Land area needed per village to meet drinking and cooking water needs assuming severe drought conditions, that is, 50 per cent decline in normal rainfall (hectares)
INDIA	–	1,170	1220	1.14	2.28
Andaman and Nicobar Islands	Andaman and Nicobar Islands	2,967	408	0.16	0.32
Arunachal Pradesh	Arunachal Pradesh	2782	236	0.10	0.20
Assam	Assam and Meghalaya	2818	807*	0.32	0.64
Meghalaya	Assam and Meghalaya	2818	311	0.12	0.24
Nagaland	Nagaland, Manipur, Mizoram and Tripura	1881	1153	0.68	1.36
Manipur	Nagaland, Manipur, Mizoram and Tripura	1881	726	0.42	0.84
Mizoram	Nagaland, Manipur, Mizoram and Tripura	1881	549	0.32	0.64
Tripura	Nagaland, Manipur, Mizoram and Tripura	1881	3496	2.04	4.08
West Bengal	1. Sub-Himalayan West Bengal and Sikkim 2. Gangetic West Bengal	2739 1439	1602	1.1.0-1.22*	2.20-2.44*
Sikkim	1. Sub-Himalayan West Bengal and Sikkim	2739	1132	0.46	0.92
Orissa	Orissa	1489	683	1.10	2.20
Bihar	1. Bihar Plateau 2. Bihar Plains	1326 1186	1367	1.12-1.26*	2.24-2.52*
Uttar Pradesh / Uttaranchal	1. East Uttar Pradesh 2. Plain of West Uttar Pradesh 3. Hills of West Uttar Pradesh	1025 896 1667	1026	0.68-1.26*	1.36-2.52*
Haryana	Haryana, Chandigarh and Delhi	617	2,258	4.00	8.00
Delhi	Haryana, Chandigarh and Delhi	617	4769*	8.46	16.92
Chandigarh	Haryana, Chandigarh and Delhi	617	2647*	4.70	9.40
Punjab	Punjab	649	1345	2.26	4.52
Himachal Pradesh	Himachal Pradesh	1251	328	0.28	0.56
Jammu and Kashmir	Jammu and Kashmir	1011	1140	1.24	2.48

Continued

Table 3: continued...

State	Meteorological divisions	Average annual rainfall (millimetres)	Estimated no. of villagers per village, 2001	Land area needed per village to meet drinking and cooking water needs assuming half of normal rainfall is captured (hectares)	Land area needed per village to meet drinking and cooking water needs assuming severe drought conditions, that is, 50 per cent decline in normal rainfall (hectares)
Rajasthan	1. West Rajasthan 2. East Rajasthan	313 675	1039	1.68-3.64*	3.36-7.28*
Madhya Pradesh	1. West Madhya Pradesh 2. East Madhya Pradesh	1017 1338	867	0.70-0.94*	1.40-1.88*
Gujarat	1. Gujarat region 2. Saurashtra and Kachchh	1107 578	1741	1.72-3.30*	3.44-6.60*
Goa	Konkan and Goa	3005	1816*	0.66	1.32
Maharashtra	1. Konkan and Goa 2. Madhya Maharashtra 3. Marathwada 4. Vidarbha	3005 901 882 1034	1389	0.50-1.72*	1.00-3.44*
Andhra Pradesh	1. Coastal Andhra Pradesh 2. Telengana 3. Rayalaseema	1094 961 680	2231	2.34-3.60*	4.68-7.20*
Tamil Nadu	Tamil Nadu and Pondicherry	998	2627	2.88	5.76
Pondicherry	Tamil Nadu and Pondicherry	998	1106*	1.32	2.64
Karnataka	1. Coastal Karnataka 2. North Interior Karnataka 3. South Interior Karnataka	3456 731 1126	1343	0.42-2.02*	0.84-4.04*
Kerala	Kerala	3055	14,083	5.04	10.08
Lakshadweep	Lakshadweep	1515	3,228	2.34	4.68

Notes: *Calculation based on the assumption that average village population in different meteorological sub-divisions is the same as that of the state.
Source: India Meteorological Department for normal rainfall data and projections of average population in 2000 based on Census of India data for 1981 and 1991.

receives more than 2,500 mm. But more than 50 per cent of this rain falls in about 15 days and less than 100 hours out of a total of 8,760 hours in a year. The total number of rainy days can range from a low of five days in a year in the desert regions of Gujarat and Rajasthan — though on some of these days there can be high-intensity rainstorms — to 150 days in the Northeast. Therefore, it is very important to capture this rainwater which just comes and goes in a few hours.

Recognising this fact that almost all the rain comes down in a few years, our ancestors had learnt to harvest water in a variety of ways:

- They harvested the raindrop directly. From rooftops, they collected water and stored it in *tankas* built in their courtyards. From open community lands, they collected the rain and stored it in artificial wells called *kundis*.
- They harvested monsoon runoff by capturing water from swollen streams during the monsoon season and stored it in *zings* in Ladakh, *ahars* in Bihar, *johads* in Rajasthan and *eris* in Tamil Nadu, to name a few.
- They harvested water from flooded rivers in places like north Bihar and West Bengal.

In 1991, India had 587,226 inhabited villages with a total population of 629 million giving us an average population of 1,071 persons per village, up from 942 persons in 1981. Let us, therefore, assume that the average population of an Indian village today is about 1,200. India's average annual rainfall is about 1,170 mm. If even only half this water can be captured, though with technology inputs this can be greatly increased, an average Indian village needs 1.12 hectares (ha) of land to capture 6.57 million litres of water it will use in a year for cooking and drinking. If there is a drought and rainfall levels dip to half the normal, the land required would rise to a mere 2.24 ha. The amount of land needed to meet the drinking water needs of an average village will vary from 0.10 ha in Arunachal Pradesh (average population 236) where villages are small and rainfall high to 8.46 ha in Delhi where villages are big (average population 4,769) and rainfall is low. In Rajasthan, the land required will vary from 1.68-3.64 ha. In different meteorological regions and, in Gujarat, it will vary from 1.72-3.30 ha. And, of course, any more water the villagers catch can go for irrigation.

Does this sound like an impossible task? Is there any

village that does not have this land availability? India's total land area is over 300 million hectares (mha). Let us assume that India's 587,000 villages can harvest the runoff from 200 mha of land, excluding inaccessible forest areas, high mountains and other uninhabited terrains, that still gives every village on average access to 340 ha or a rainfall endowment of 3.75 billion litres of water. **These calculations show the potential of rainwater harvesting is enormous and undeniable. There is just no reason whatsoever for thirst in India.**

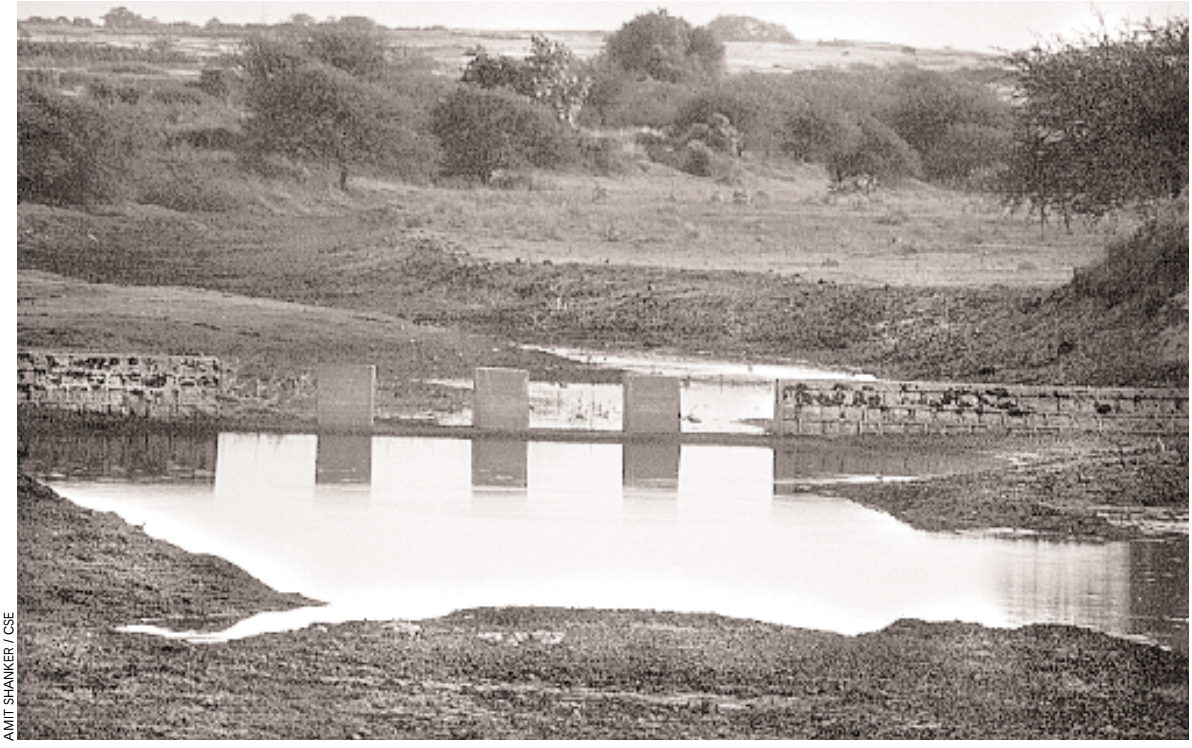
Therefore, it is possible to drought-proof the entire country. Not just drinking water, most of India's agricultural fields should also be able to get some irrigation water to grow less water-intensive crops every year through rainwater harvesting. **The strategy for drought proofing would be to ensure that every village captures all the runoff resulting from the rain falling over the entire land and the associated government revenue and forest lands, especially during years when the rain was normal, and store it in *tankas* or ponds or use it to recharge the depleting groundwater. It would then have enough water in its tanks or in its wells to cultivate substantial lands with water-saving crops like millets and maize.**

Even with a national water grid or all the proposed dams like those on the Narmada being built, there just isn't going to be enough river water to provide irrigation to every single village of India. A substantial part of India's agricultural lands will remain rainfed. This is confirmed by official statistics. The National Commission for Integrated Water Resources Development Plan has estimated that the ultimate irrigation potential is as much as 140 mha.[1] Some 75.9 mha will be irrigated by surface water schemes — of which 58.47 mha will be irrigated by major and medium projects and 17.38 mha will have to be irrigated by minor irrigation schemes like tanks[2] — while 64.1 mha will be irrigated by groundwater.[3] But all this is still a dream. As of 1992-93, 119.3 mha were rainfed, of which 78.43 mha were under foodgrains.[4]

But there is enough rain which with a good combination of rainwater harvesting and groundwater recharge, can increase the productivity of this rainfed land. These lands today support some of the poorest people in the country. And if we don't do this, people living in rainfed areas will not prosper.

DROUGHT-PROOFING VS LARGE-SCALE IRRIGATION

But for this to happen, our planners and politicians will have to stop confusing irrigation for drought-proofing with large-scale irrigation for Green Revolution-style



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The* sarpanch *of Raj-Samadhiyala in Gujarat decided to beat the impact of monsoon failures by constructing check dams in the village. Wells no longer run dry and agricultural productivity has increased. A 'dark zone' village has been converted to one where there is water

agricultural development. Otherwise, the country will get its priorities wrong and tens of millions of poor people will continue to suffer the horrors of drought. Depending on the availability of money and resolution of problems like rehabilitation, both can be attempted but the priority must go to drought-proofing measures which require little money in comparison and will bring results within 5-10 years.

Drought-proofing and large-scale irrigation development are not a substitute of each other. What one can do, the other cannot. Firstly, because even after all the proposed dams are built to promote large-scale irrigation development and interlinking of rivers takes place, every piece of the country's cultivated land will still not see the benefit of canal irrigation. These lands will have to depend either on groundwater or local water harvesting. These two will also have to go together because heavy use of groundwater can only be sustained if there are local efforts to keep recharging the groundwater. Therefore, large-scale irrigation development is no substitute for drought-proofing based on local water harvesting systems and sustainable use of groundwater

The second argument against large-scale irrigation development follows from the first. Big dams can only help to create pockets of Green Revolution-style agricultural production (with water-intensive crops) but they cannot drought-proof the whole country. As a result, they can at best create 'national' food security as they have done uptill now — which means that few districts of the country generate a huge agricultural surplus which is then used to feed the ones which are doing agriculturally poorly, especially during drought years.

But they cannot create 'local' food security — which means that all areas of the country have water management strategies to ensure that local food production is as productive as possible and stable even during water-short years. Local food security is as important as national food security. Which Bhil or Oraon adivasi, for instance, wants to depend only on grains from Punjab? All of them would like to grow enough grain at least to feed themselves. Water harvesting and groundwater together can definitely drought-proof the country and create local food security which big dams cannot. Then India's poor people and poor lands will not have to suffer the ignominy of the kind they had to in 2000. But the government has to realise that Indians cannot survive on a single-track water management policy.

In addition, it is important to realise that India's future food security even from its so-called Green Revolution areas will depend heavily on a nationwide groundwater recharge programme which can only be taken by individual communities through rainwater harvesting. If this is not done, agriculture will suffer even in current irrigated areas because of the increasing overexploitation of groundwater and lowering of groundwater tables across the country. With more than 17 million tubewells and borewells energised by diesel and electricity, groundwater is now used to irrigate more than half of the country's irrigated area. And as areas irrigated by groundwater show higher productivity than those irrigated by canals, the contribution of groundwater to India's total agricultural output from irrigated areas is much more than that of canals. During drought years, when rivers dry up, groundwater becomes the main source of water both for drinking and irrigation.[5] **Indian agriculture and rural life is today heavily dependent on groundwater. Further lowering of groundwater tables can seriously threaten India's hard-earned food security at a time when India will need to produce more food to feed its growing population**.

SMALL MEANS EVEN MORE WATER

Let us look at the relevance of village-based rainwater harvesting from yet another point of view. The key component of water management is 'storage' especially in a country like India where the monsoon gives us on average about one hundred hours of rain and then nothing for the remaining 8,660 hours in a year.

This water can be captured in:

- Large reservoirs with large catchments by building large dams;
- in small tanks and ponds with small catchments; or,
- by storing it in a way that it percolates down into the ground and gets stored as groundwater.

In fact, there is strong scientific evidence to show that village-scale rainwater harvesting will yield much more water than big or medium dams, making the latter an extremely cost-ineffective and unscientific way of providing key water needs especially in dry areas. Some very instructive lessons can be learnt from the work of Israeli scientist Michael Evenari who has produced the best corpus of knowledge on this subject from the bone-dry Negev desert where the average annual rainfall is a mere 105 mm.

Evenari was intrigued by the fact that the ancient Israeli civilisation had built towns right in the middle of the Negev desert with their own agriculture and water supply systems — much like the towns of Jodhpur and Jaisalmer that the enterprising Marwaris developed in the Thar desert. Both the Israelis and the Marwaris used the rain they received with great ingenuity to meet their food and water needs. In his effort to reconstruct the ancient farms of the Negev, Evenari came up with a very surprising finding: Water harvested from small watersheds per hectare of watershed area was much more in quantity than that collected over large watersheds. On hindsight this makes eminent sense because water collected over larger watersheds will have to run over a larger area before it is collected and a large part will get lost in small puddles and depressions, as soil

Table 4: The surprising effect of size

The effect of the size of catchments on the quantity of water harvested as found in the Negev desert (in case of catchments with a 10 per cent slope and a 105 mm rainfall year)

A number of factors determine how much rain falling over a watershed will turn into runoff which can be collected by villagers for their drinking and irrigation needs. This table shows that all other factors like slope remaining the same, the larger the size of the catchment, the less runoff (water) can be collected from it. This is because in large catchments water has to run over larger distances before it gets collected and during that period, a lot of the water is lost in puddles and small depressions, in evaporation or through infiltration into the soil. Therefore, small catchments give the maximum water. And the difference can be quite high. As the table shows, 3000 microcatchments of 0.1 hectare each will give five times more water together than one catchment of 300 hectares even though the total land area from which the rain is harvested remains the same. In simpler words, in drought-prone areas, 10 dams with a one hectare catchment each will give substantially more water than one large dam with a 10 hectare catchment.

S.No.	Size of catchment (hectares)	Quantity of water harvested (cubic metres / hectare)	Percentage of annual rainfall collected
1	Microcatchment (a)	160 cubic metres/hectare	15.21%
2	20 hectares	100 cubic metres/hectare	9.52%
3	300 hectares	50 cubic metres/hectare	3.33%

Notes: (a) A microcatchment is a very small catchment of size upto 1000 square metres or 0.1 hectare.
Source: Michael Evenari *et al* 1971, *The Negev: The Challenge of a Desert*, Oxford University Press, UK.

moisture and through evaporation.

This loss of water can be stunningly high. While a 1 ha watershed in the Negev yielded as much as 95 cubic metres of water per hectare per year, a 345 ha watershed yielded only 24 cum/ha/year. In other words, as much as 75 per cent of the water that could be collected was lost. The loss was even higher during a drought year. After years of research, Evenari summed up his findings as follows: "…**during drought years** with less than 50 mm of rainfall (normal rainfall in the Negev desert is about 105 mm) **watersheds larger than 50 ha will not produce any appreciable water yield** while small natural watersheds will yield 20-40 cubic metres per hectare and microcatchments (smaller than 0.1 hectare) as much as 80-100 cubic metres per hectare" *(see Table 4: The surprising effect of size and Table 5: Even greater effect during drought)***.** These were critical findings because the amount of rainwater one can collect depends on the amount of land from which the runoff can be harvested. But Evenari was finding that even if you have the same amount of land you will collect more water if you break up the land into many small catchments than if you collect water from it as one catchment. Several studies conducted in India by the Central Soil and Water Conservation Research and Training Institute in Dehra Dun also show a clear relationship between size of catchment and amount of runoff that can be captured. One study shows that just increasing the size of the catchment from 1 ha to about 2 ha reduces the water yield per hectare by as much as 20 per cent *(see Graph 1: Bigger watershed, less water).* Several other studies conducted by the Central Soil and Water Conservation Research Institute in Agra, Bellary and Kota and another study conducted in the high rainfall region of Shillong, have all found that smaller watersheds give higher amounts of water per hectare of catchment area.[6] **In simple words, all this means that in a drought-prone area where water is scarce, 10 tiny dams with a catchment of 1 ha each will collect much more water than one larger dam with a catchment of 10 ha** *(see Fig 1: Smaller catchments give much more water).*

An intensive study carried out by the US department of agriculture in a semi-arid area of Arizona (355 mm annual rainfall) carried out over two decades found that for every ten-fold increase in the catchment area, the average annual runoff went down by about 36 per cent *(see Table 6: Small size, high yields and Graph 2: Declining yields)*. The authors of the study point out that "because of the sparseness of hydrological data in the arid and semi-arid area of the world, there is value in the results of

Table 5: Even greater effect during drought

The effect of the size of catchments on the quantity of water harvested as found in the Negev desert during drought years with less than 50 millimetres rainfall

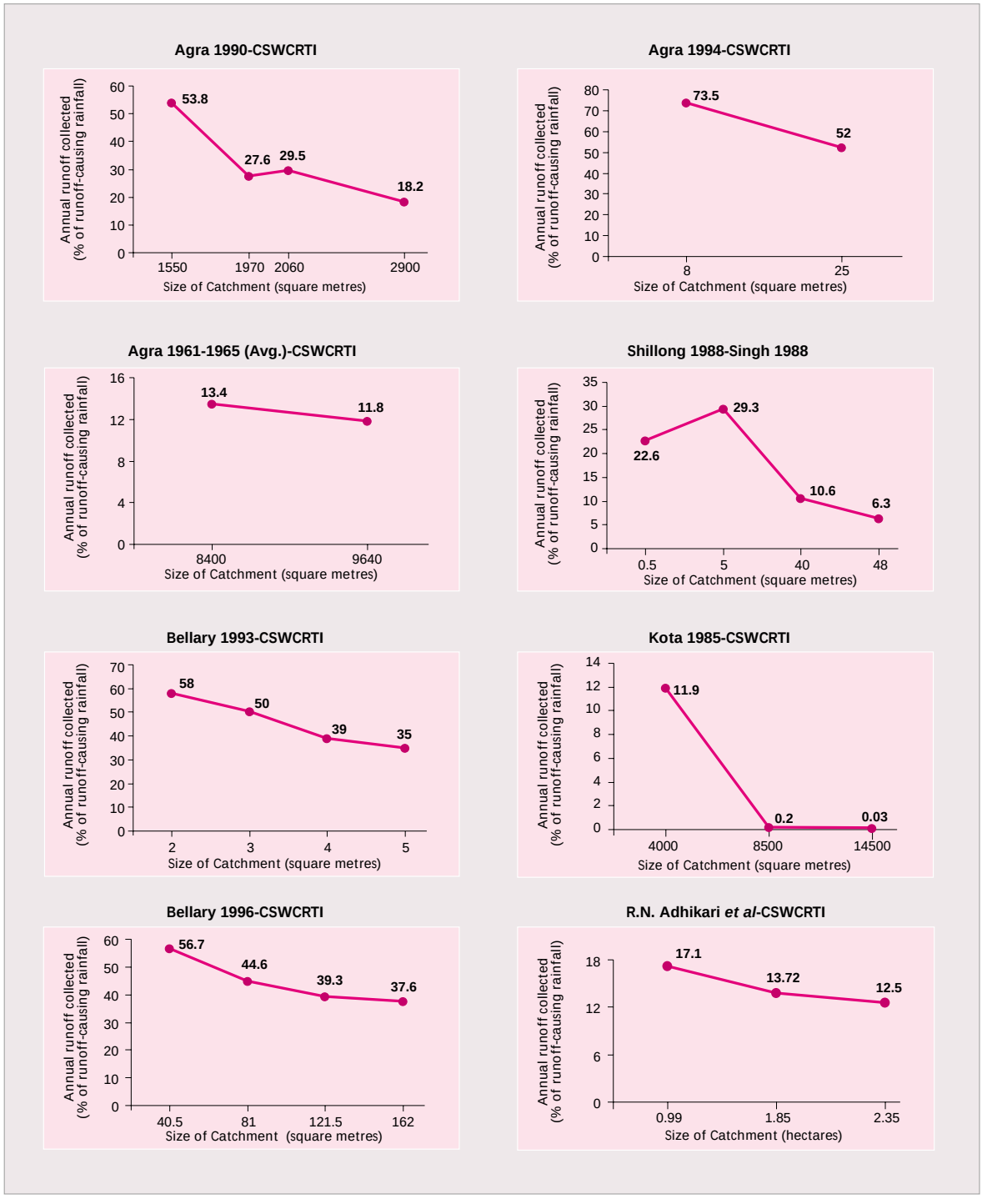
The table below shows clearly that in a desert very little water can be collected from large catchments in a drought year.

Size of catchment (hectares)	Quantity of water harvested (cubic metres/hectare)	Percentage of annual rainfall collected
Microcatchment (a)	80-100 cubic metres/hectare	16-20%
Small natural watersheds	20-40 cubic metres/hectare	4-8%
Larger than 50 hectares	No appreciable water yield	0%

Notes: (a) A microcatchment is a very small catchment of size upto 1000 square metres or 0.1 hectare.
Source: Michael Evenari et al 1971, *The Negev: The Challenge of a Desert*, Oxford University Press, UK.

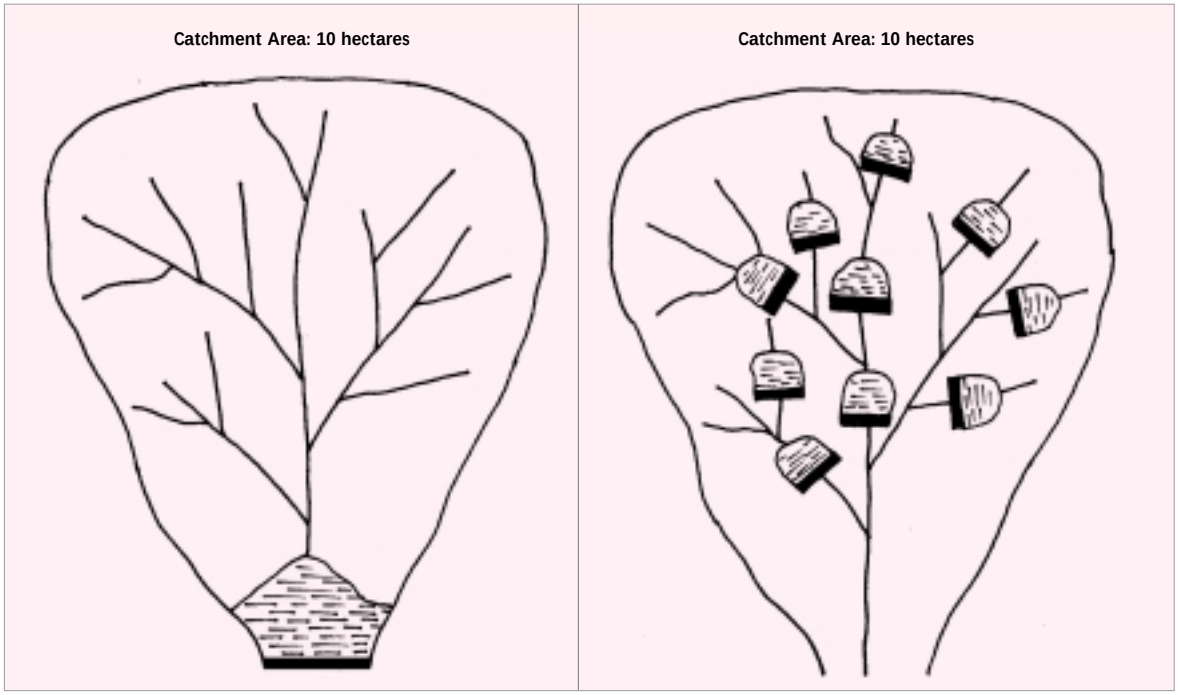
Graph 1: Bigger watershed, less water

Several studies carried out is India show the same results that were found in the Negev desert: Larger catchments resulted in a smaller percentage of the annual rainfall falling on the catchment turning into runoff



Source: J S Samra, director, Central Soil and Water Conservation Research Training Institute (CSWCRTI), Dehradun, *personal communication*

Fig 1: Smaller catchments give much more water
One dam with a catchment of 10 hectares will collect much less water than 10 dams with one hectare catchment each



Source: J S Samra, director, Central Soil and Water Conservation Research Training Institute (CSWCRTI), Dehradun, *personal communication*

any hydrological investigations undertaken in arid areas. (This) research is particularly valuable because of the intensity and quality of data collection that has continued for more than ten years. The results obtained in the study show how transmission loss can affect the probability of obtaining various amounts of annual runoff."

Especially in areas which receive most of their rainfall in the form of thunderstorms which is true for most arid areas, there can be high transmission losses in the stream channels and variability of rainfall over small distances can have significant impacts on runoff from catchments. The Arizona study found that there was a 99 per cent probability of getting an annual average runoff of 3.6 mm from a 1.3 ha catchment whereas the runoff with the same probability from a 14,900 ha catchment was only 0.2 mm. Similarly, a 1.3 ha catchment had a 1 per cent probability of giving an annual runoff of 76.2 mm whereas a 14,900 ha catchment would give only 16.8 mm *(see Table 7: Smaller catchments, higher certainty and Graph 3: Increased size, lower probability).* In other words, small catchments usually tend to give a higher runoff. Therefore, while designing dams in dry areas, the effect of catchment size must be taken into account. But, as the authors point out, few of the published procedures take this factor into account.[7]

It should not be surprising that the large number of medium-size dams that have been constructed in Saurashtra have stored very little water in the drought year of 2000 and started going dry by December 1999. But then the answer to drought-proofing of the area lies not in mega-water harvesting projects like medium and large dams. It lies in small water harvesting structures which are constructed at the farm and village-level.

To demonstrate his findings, Evenari even developed an orchard in the middle of the bone-dry Negev desert by creating a separate microcatchment — a plot of land ranging from 15.6 sq m to 1000 sq m — for each tree to maximise quantity of harvested water. **Therefore, look at it any way, community-based, small-scale rainwater harvesting is not just capable of providing more than drinking water needs even in the worst of drought situations but is also the most efficient way to collect water**.

MINISTERS ARE NOW TALKING OF RAINWATER HARVESTING

After the media storm on drought hit our politicians, several of them, including the prime minister and the ministers for rural development, urban development and water resources, made statements regarding the importance of a community-based rainwater harvesting

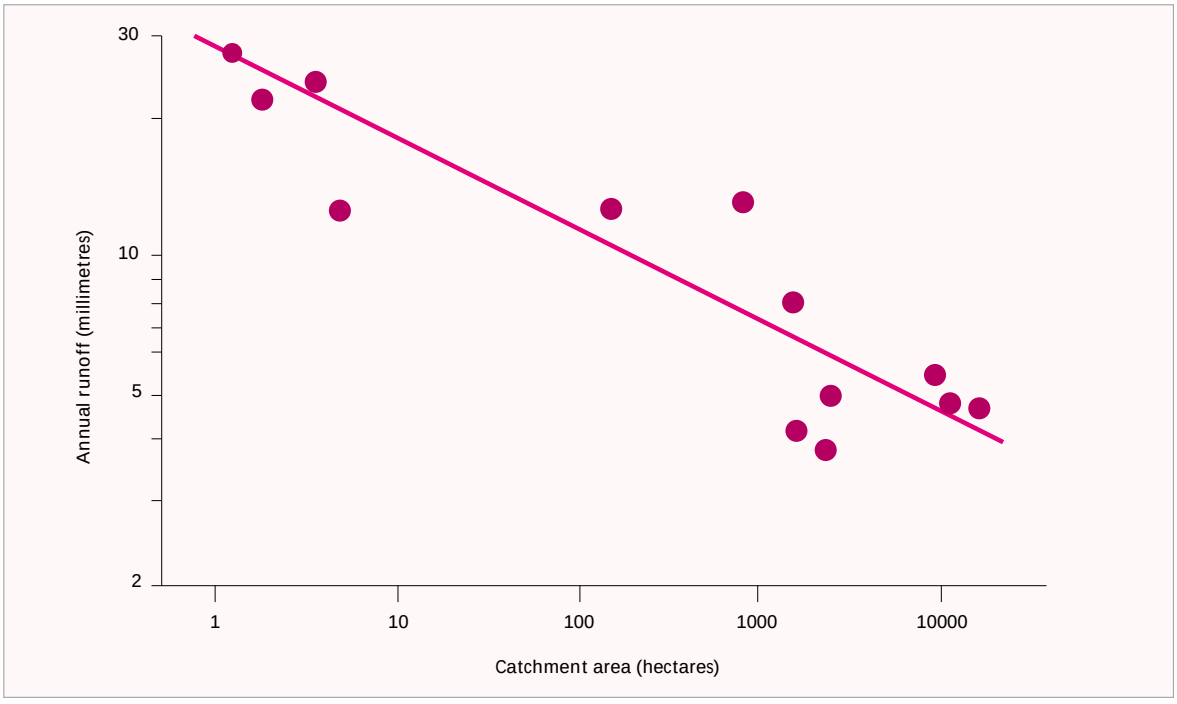
Table 6: Small size, high yields

Mean annual runoff from twelve catchments in the Walnut Gulch experimental area, USA

Area (hectares)	Numbers of years for which the record was maintained	Mean annual runoff (mm/year)
1.30	13	27.6
151	15	12.7
1,550	12	8.2
9,510	13	5.7
14,900	18	4.7

Graph 2: Declining yields

Effect of catchment size on annual runoff: Every10-fold increase in catchment area reduces average annual runoff by about 36 per cent



Source: W C Boughton and J J Stone 1985, Variation of runoff with watershed area in a semi-arid location, in *Journal of Arid Environment*, Vol.9, Academic Press, London, p.13-25

strategy to drought-proof the country.

The first statement came from the rural development minister, Sunderlal Patwa, that the government hopes to gradually replace a government-oriented programme by a people-oriented, decentralised and demand-driven rural water supply programme, the budget for the programme is being increased by 8 per cent, from Rs 1800 crore last year to Rs 1960 crore in 2000-01, and a fifth of this budget will be given to state governments which undertake community-based programmes so that villagers have a decisive role. A part of the total capital cost and operation and maintenance cost will be borne by the users. Some 58 districts have been identified to try out this scheme.[8] Meanwhile, a steering committee was also set up to study the recharge of drinking water sources.[9]

The second statement came from the prime minister who told the parliament that only six per cent of the country's rain is being conserved and that greater emphasis will henceforth be placed on water harvesting.[10]

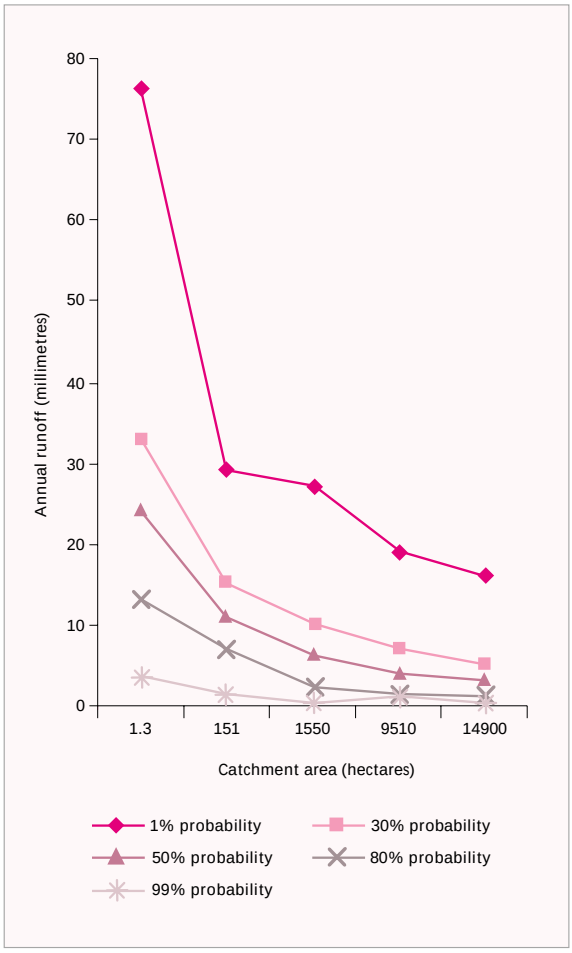
The third statement came from Jagmohan, minister for urban development, who has suggested that water harvesting should be made compulsory under the urban building bye-laws of the country.[11]

The fourth statement came from the minister of water

Table 7: Smaller catchments, higher certainity
Fitted frequency distributions of annual runoff

Area of catchment (hectares)	Annual runoff in millimetres for specified probability of exceedance				
	0.01	0.30	0.50	0.80	0.99
1.30	76.2	33.5	24.6	13.7	3.6
151	29.5	15.7	11.9	7.1	1.5
1,550	27.9	10.4	6.6	2.3	0.2
9,510	19.1	7.4	4.6	1.5	0.1
14,900	16.8	5.8	3.8	1.8	0.2

Graph 3: Increased size, lower probability
Catchment area-runoff relationships for different probabilities of exceedence: A catchment area of 1.3 ha has a 99 per cent probability of getting a runoff of 3.6 mm, while a catchment of 14,900 ha has a 99 per cent probability of getting a runoff of a mere 0.2 mm



Source: W C Boughton and J J Stone 1985, Variation of runoff with watershed area in a semi-arid location, in *Journal of Arid Environment*, Vol.9, Academic Press, London, p.13-25

resources, C P Thakur, who in an interview in late April had merely talked about water harvesting in a few buildings in Delhi like the Shram Shakti Bhavan and the Indira Gandhi National Open University and some nine buildings in Jaipur as his key initiatives in this area, but by early April he was announcing a whopping Rs 550 crore plan to recharge groundwater by constructing about 10,000 water harvesting structures in water-scarcity regions with these funds going directly to village beneficiary groups and water users associations.[12,13]

There have been developments in the states, too. Andhra Pradesh's chief minister, N Chandrababu Naidu, announced and held the first meeting of a Water Conservation Mission to revamp its existing watershed development programme.[14,15] The chief minister told the *Indian Express* in an interview, "Till now, we have dumped crores of rupees into the watershed programme. But the results are very disappointing. Unless farmers are involved, the situation cannot be reversed".[16] The Andhra Pradesh government plans to spend Rs. 400 crore through the new mission and bring 10 mha of land under good watershed management. In the areas chosen, villagers will be given Rs 20 lakh to develop a 500-hectare watershed.[17]

In the urban context, the Delhi government expressed interest in water harvesting. Given the fact that groundwater levels have declined by about 4-10 metres in several parts of the capital over the last decade, the Delhi government began contemplating a law to make it mandatory for all new group housing societies to harvest the rain falling within their complexes.[18,19] Meanwhile, the New Delhi Municipal Corporation sanctioned a special water harvesting project which consists of water ponds being constructed in four major parks: Talkatora Garden, Nehru Park, Lodhi Garden and Kushak Nullah.[20]

In Gujarat, irrigation minister Nitin Patel said in late April that the government is planning to construct 10,000 check dams across the state under its Sardar Patel Sahbhagi Jal Sanchay Yojaya. Villagers will have to provide 40 per cent of the cost of the check dam. The government has received over 16,000 applications of which 8,563

have been approved and, to begin the exercise, the government has sanctioned Rs. 100 crore for the construction of 2,000 check dams.[21] This is a remarkable change as compared to the past. Between 1991 and 1999-2000, various departments of the Gujarat government only built a total of 1,341 check dams.[22]

In Madhya Pradesh, a workshop held in Neemuch district in late April emphasised the importance of water conservation through water harvesting and the district collector promised to promote rooftop water harvesting in the town and draw up a plan for restoring and developing ponds in each *gram panchayat*.[23]

If all the commitments made by the Central Minister and the state governments of Gujarat and Andhra Pradesh were to come true, a sum of Rs 1,500-2,000 crore was committed for rainwater harvesting. This was indeed heartening. Equally heartening were reports of people promoting rainwater harvesting. Under the inspiration of the local Ananda Baba Ashram, a Lakhota Jal Sanchay Abhiyan Samiti was set up to collect money from the residents of Jamnagar town to desilt the huge Lakhota Lake that had been constructed by the former royal family. The people of the town gave their full support to this exercise.[24] Under the leadership of the Swaminarayan gurukul in Rajkot, foundation stones were laid for check dams in more than 15 villages in just five days around the middle of April.[25] In Ahmedabad city itself, the Khadia Itihas Samiti headed by the state's health minister, completed a survey of the underground water tanks (*tanka*) that were traditionally built in each house to harvest roof-top rainwater and is planning a campaign to revive them.[26] Care Today, an organisation set up the magazine *India Today*, announced that it has identified two projects, one each in Rajasthan and Gujarat, to help villagers desilt their traditional water harvesting structures.[27] The Supreme Court, hearing a case on water shortage in Delhi, ordered the Delhi Development Authority (DDA) to harvest rain water starting off with the water-thirsty DDA colonies of Vasant Kunj in New Delhi.[28]

These developments show that community-based rainwater harvesting may well become a widely adopted paradigm in the years to come both in the urban and rural areas. But the question is: Will this all lead to effective results, especially in the rural context? This is a concern that we continue to have.

STRUCTURES WITH A SOCIAL PROCESS

Building water harvesting structures is a very easy task — any contractor endowed with a bit of money can do so. But building an effective structure which starts off a process of self-management in village communities is a much more difficult task. This is possible only if each structure is the result of a cooperative social process — the ability of a community to work in cooperation. Water is a strange natural resource: It can unite a community as easily as it can divide it. Therefore, it is essential that a strong social process precede each structure to build what economists call the 'social capital'. This is an area where the track-record of government agencies is literally non-existent and inflexible government rules militate against the very principle of social mobilisation.

In other words, the above statements by state and Central officials are as much a cause of worry as of applause. Fixed annual targets will prove to be a total disaster: money literally going down the drain. At least the first two years of any water harvesting programme will have to be spent on social mobilisation. This will mean, firstly, creating awareness and confidence in the people that water harvesting works. Once this is achieved, it means sitting with the people to create village institutions which will decide where, when and how the water harvesting structures will be built, who will build the structures, how much the villagers will provide to share the cost of the structure, and once the structure is built, how will its benefits, that is, water, will be shared amongst the villagers, especially in the early years when water is scarce, and how will its use be regulated. Every part of the community will have to involved by making each section — from the landed to the landless and women's groups — appreciate the benefits it will derive from the exercise. And by making efforts to ensure that benefits do indeed flow to each section of the community.

It is for this reason that water harvesting works best when combined with watershed development. It is in the nature of structures to benefit mainly those who have land leaving the landless without any benefits and therefore alienated from the exercise. But development of watersheds to conserve both water and soil not only increases soil and water conservation and leaf and grass production on what are usually common lands, which can greatly benefit landless households, but also increases the life and effectiveness of the structures that benefit the landed by reducing siltation. Contractors must be totally kept out and all wage benefits should go to the landless.

Nothing works better than when villagers see all this in actual practice. For this purpose, it is important to have funds to take interested villagers to see villages where such principles are being observed and how water harvesting has changed their lives. Under the Madhya Pradesh Rajiv Gandhi Watershed Development Mission (RGWDM), busloads of tribals from Jhabua were taken to see Ralegan Siddhi. Tarun Bharat Sangh (TBS) also regularly organises *Paani Yatras* in neighbouring areas so that villagers who have done it can talk face to face with those who have not.

All this means that progress in the first few years will be slow. This was the case both with RGWDM and TBS. But the experience of both also shows that replication comes

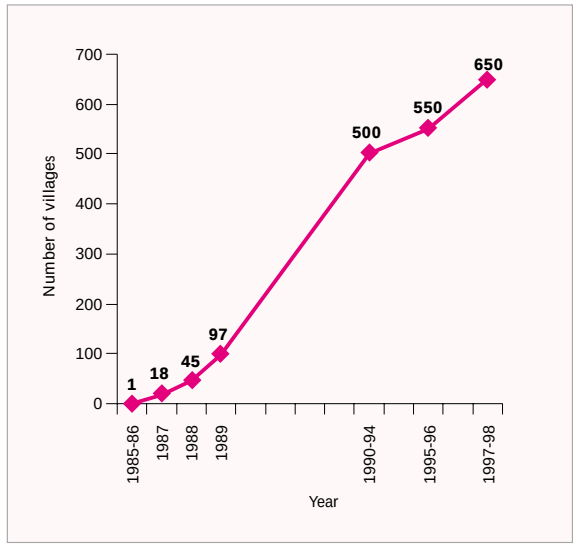
very rapidly once 'the idea' catches on. As R Gopalakrishnan, who oversees RGWDM in Madhya Pradesh, puts it, "In the first two years of the programme, the results were so slow that we kept wondering whether we are getting it right." In other words, governments must be prepared to accept that their first year's effort will bring nothing, second and third year maybe something, and fourth and fifth years hopefully a lot. It is a gradual exercise. The number of villages participating in the water harvesting programme of TBS also grew slowly at first and then very rapidly in the later years as the villagers became more and more confident of the value of what they were doing *(see Graph 4: Promoting environmental self-reliance).*

Social mobilisation is essential for the success of water harvesting for several other reasons. Firstly, the community must be closely involved in the construction of the water harvesting structures to ensure that they are built with technical competence; that is, the site is chosen properly, the technical parameters are correct, etc. Badly built structures will not deliver water and can get easily washed away. Secondly, even in properly built structures which deliver water, once the water starts getting available either as increasing levels of groundwater or as surface water in a tank, the community will have to start managing the available water which in the earlier years may not be enough to irrigate lands of all the farmers. In those years, the farmers will have to share the water and use it on crops that don't use too much water. This will happen if there is already a community process associated with the water harvesting structure. Otherwise a few people will grab the water leading the rest of the community alienated.

The government will also have to review and revise old British-time laws like the Indian Easement Act which prevent public participation in water management. Management experts point out, 'God is in the details'. **Chandrababu Naidu and others like them will have to make sure the culture of rigid and inflexible government rules is changed to fit the task of social mobilisation**. And as government officials are not social workers, all this will happen only if they hand over work to NGOs with a track record, howsoever few they might be, and wait patiently for results to come. But if they want a government programme, it can still be done, but then they themselves will have to oversee the implementation of the programme to keep their warring and errant officials in place. Inter-departmental coordination — between the departments of revenue, soil conservation, irrigation, forests and agriculture — is essential for water harvesting-watershed development programmes to succeed. The direct supervision of the Madhya Pradesh chief minister of the RGWDM was a key element of the programme's success. It is not surprising that despite the drought in 2000, newspaper reports from western Madhya Pradesh

Graph 4: Promoting environmental self-reliance

In the first three years, few villages got involved in the water harvesting programme of Tarun Bharat Sangh. With passage of time, the numbers, however, grew rapidly as villagers gained confidence in the programme and were able to see a positive outcome of their efforts



Source: Tarun Bharat Sangh, Alwar.

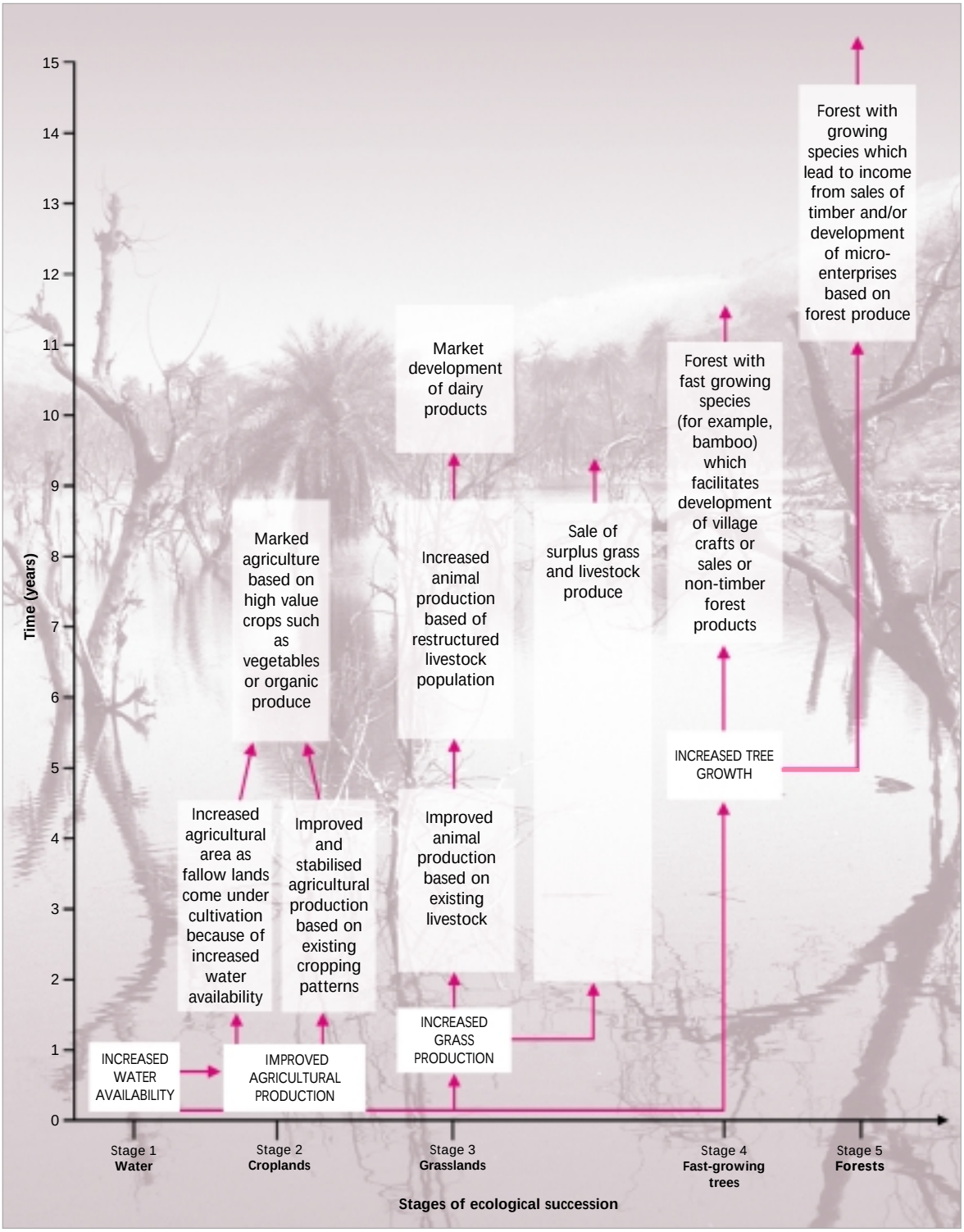
were few. Otherwise the result will be a lot of wasted mud, bricks and mortar and alienated people, with water harvesting getting a bad name. Already, newspaper reports are showing that there has been considerable corruption in the check dams sponsored by the government of Gujarat.[29] **We must make sure that water harvesting does not become money harvesting.**

REVIVING SYSTEMS WHICH HAVE GONE INTO DISUSE

It is not enough to build new water harvesting structures. Efforts must be made also to revive the vast treasure that already exists but has gone into disuse. According to official estimates, there were 1.513 million tanks in India in 1986-87 — 95 per cent of which were in eight states, Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh and West Bengal. But because of silting and poor maintenance, the gross area irrigated by them had come down from 4.78 mha in 1962-63 to 3.07 mha in 1985-86 though many new tanks were constructed in this period. This represents a capital loss of Rs 5,000 crore.[30] It is obvious that efforts must be made to restore these structures to their full potential. Water is a key input in ecological regeneration which can lead to rural poverty alleviation in a biomass-based economy such as ours *(see Fig 2: Water and ecological regeneration).*

Fig 2: Rainwater harvesting and ecological regeneration

Water is a key input in ecological regeneration. This regeneration occurs in successive stages, each with its own associated economic impact on a biomass-based economy



RAINWATER HARVESTING CAN ERADICATE RURAL POVERTY

If water harvesting-watershed development programmes are handled well, villages like Sukhomajri, Ralegan Siddhi and several villages in Alwar district have clearly shown that rainwater harvesting is not just the starting point for meeting drinking water needs but the starting point of an effort to eradicate rural poverty itself, generate massive rural employment and reduce distress migration from rural areas to urban areas. Increased and assured water availability means increased and stable agricultural production and improved animal husbandry — both of which together form the fulcrum of the rural economy. Ralegan Siddhi has been transformed itself from one of the most destitute villages of the country in the 1970s to one of the richest villages today. In all villages which have regenerated their local economy with the help of good management of their natural resources, distress rural-urban migration has been greatly reduced or has been totally eliminated.

Another interesting dimension of community-based rainwater harvesting is that it helps the generate a community spirit within the village — something that is getting lost across the country — and build up what economists call the 'social capital'. In fact, we can argue that if we want *Panchayati Raj* to work, then the first thing that *panchayats* should be asked to take up is water harvesting — *har gaon ka apna talaab* (a tank in every village).

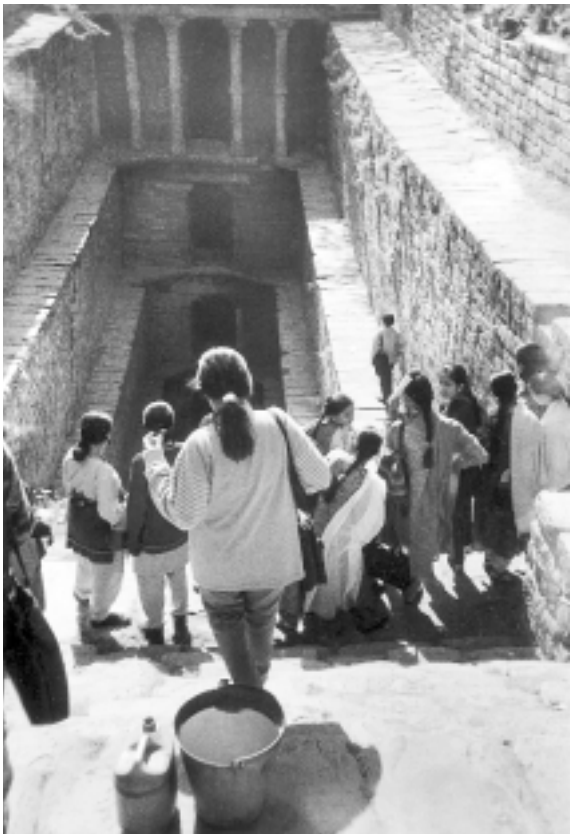
If it all makes so much sense then why is this paradigm not accepted by the government and spread across the country? President K R Narayanan even called for a national movement for water harvesting in his last Republic Day address to the nation. **The problem is really mind-sets. Rainwater harvesting demands a new approach to governance itself — a participatory form of governance rather than a top-down bureaucratic one**. Unfortunately, our political leaders have created a culture of dependence on the government and love to make promises, howsoever hollow they may be, that they will provide everything to the people through government largesse. Given this political mind-set, the water bureaucracy, too, has developed a culture of providing services, howsoever poor they may be, rather than one of empowering people to develop their own water supplies. And it is still locked into the big dam, pumps, pipes and borewell paradigm. Former water resources minister, C P Thakur, did not hesitate in accepting the importance of rainwater harvesting but when push comes to a shove, as it did, for example, at the recent World Water Forum in the Hague, he and the entire Indian delegation could do nothing but talk about big dams. We are not here going into the merits of the small versus large dam debate — in certain situations large dams could be needed — but there can be no doubt that the small has an extremely important role to play and this is being totally neglected. A balance between the big and the small is essential.

But, nonetheless, there has been a remarkable change in the public discourse on the relevance of the country's rainwater harvesting traditions in the last few years, especially since the Centre for Science and Environment (CSE) published *Dying Wisdom: The rise, fall and potential of India's traditional water harvesting systems* in 1997, a compelling account of how these traditions still work in many parts of the country even in the face of all odds. The recent statements by the Central and state ministers are encouraging but the government needs to go beyond them. It should heed the President's advice and prepare a concrete plan of action to develop a mass movement for water harvesting.

....AND THEREAFTER

In other words, a lot of rainwater has flowed down the bridge since the release of *Dying Wisdom* and the release of this latest book. CSE itself has taken up or promoted a number of activities in the intervening period as part of its Campaign to Make Water Everybody's Business.

- In June 1997, CSE prepared a thousand sets of 21 posters each on India's traditional water harvesting systems. The posters were prepared to provide schools, NGOs and other interested groups and institutions with exhibition material that could be easily set up and dismantled. The exhibition has since been displayed in several parts of India and abroad. The first display of these posters took place at the UN headquarters in New York at the time of the UN General Assembly Special Session (June 23-27) to assess the progress made since the 1992 Rio Conference on Environment and Development. CSE was invited by the United Nations Development Programme (UNDP) to set up the exhibition. UN secretary-general, Kofi Annan, was one of the eminent people to visit the display.
- In August 1998, CSE organised a workshop on water harvesting at the Stockholm Water Symposium, which had participants from China (Zhu Qiang), Japan (Makato Murase), Kenya (John Mbugua) and India (Anna Hazare, Anil Agarwal, Dunglena and Sunita Narain). The workshop, chaired by Swedish member of European parliament, Anders Wijkman, was organised to acquaint the world water community about the importance of water harvesting. The workshop was rated one of the best in the entire symposium.
- In October 1998, Digvijay Singh, chief minister of Madhya Pradesh, released the Hindi edition of *Dying Wisdom* entitled *Boondon ki Sanskriti* (A Culture of Raindrops), edited and translated by senior journalist, Arvind Mohan. The entire exercise was coordinated by Sanjay of Deshkaal, an NGO, and reviewed by



LEENA BOSE

CSE Eco-Tour: School children take a look at a Gandhak Baoli at Mehrauli in New Delhi

Anupam Mishra. The Madhya Pradesh government distributed 5,000 copies of this book to *gram panchayats* (village councils) across the state and Rajendra Singh of Tarun Bharat Sangh another 500 copies to villagers involved with water harvesting in Alwar district.

- In October 1998, CSE invited five rural water engineers from all over the country — Chewang Norphel of Leh who has invented a technique to make artificial glaciers; Magga Ram Sutar, a carpenter, from Jaisalmer who specialises in making *kuis*; Ram Singh of Churu district, who specialises in making *kundis*; Kunhikannan Nair of Kasaragod, who specialises in making *surangams*; and, Ganesan, a *neerkatti*, who manages the water distribution from tanks in a Madurai village. The president of India, Shri K R Narayanan, called them 'heroes' when he met them and greatly appreciated the CSE film, *Waterworks India: Four Engineers and a Manager,* on their work.
- In late 1998 and early 1999, CSE organised several meetings of water harvesting experts which included R N Athavale, R Jeyakumar, Rajendra Singh, Gopal Singh — a rural engineer from Alwar with expertise in making *johads* — and others to prepare a plan for harvesting water in the President's Estate in time to capture the 1999 rains.
- In December 1998, CSE encouraged the villagers of the Arvari river basin to form an inter-village 'river parliament' — the first of its kind in the country — to manage the river they had created through their water harvesting activities instead of leaving the task to the government.
- In January 1999, CSE released *Water Links*, a directory of water harvesters in India and abroad, to help people interested in this work to learn about each other.
- In early 1999, CSE started organising field trips for schoolchildren in Delhi to see the ancient water harvesting structures of the city in order to educate children about the importance of water harvesting.
- In January 1999, Anil Agarwal and Sunita Narain wrote a paper entitled *Community and Household Water Management: The Key to Environmental Regeneration and Poverty Alleviation* for the European Union -United Nations Development Programme's joint Poverty and Environment Initiative. Though both poverty alleviation and environmental conservation have been repeatedly emphasized as key national and global objectives, few people understand the links between the two. Agarwal and Narain wrote the paper to emphasise the importance of community-based water harvesting as an important technique for involving local people who live in degraded lands to start regenerating their degraded agricultural lands and associated watersheds. More than half a billion of the world's absolute poor live in degraded lands of Asia, Africa and South America. The paper draws upon some of the most outstanding efforts made in India in village ecosystem regeneration over the last two decades. Agarwal presented the paper at a joint EU-UNDP conference in Brussels.
- In February 1999, CSE started publishing a bi-monthly newsletter *Catch Water* to keep the water harvesting community informed about the latest activities of its members.
- In March 1999, CSE prepared a paper on *Policies, Programmes and Institutions on Water Harvesting in the Himalayan Region of India* for the International Centre for Integrated Mountain Development based in Kathmandu, Nepal.
- In April 1999, UNDP invited CSE's director, Anil Agarwal, to present the paper *Community and Household Water Management: The Key to Environmental Regeneration and Poverty Alleviation* at a luncheon meeting organised by UNDP's administrator, Gus Speth, for the 20-odd environment ministers attending the meeting of the Commission on Sustainable Development. The Chinese environment minister suggested that UNDP take up water harvesting and village ecosystem regeneration projects described in CSE's paper in his own country, China.

- On April 30, 1999, the National Water Harvesters Network was launched with its first state unit starting in Chennai under the leadership of A Vaidyanathan. The network is guided by a national steering committee while state units have their own steering committees.
- In April 1999, CSE started harvesting all the water that falls on its Tughlakabad campus with the help of Chennai builder, R Jeyakumar. No water is allowed to leave the campus: all of it is used to recharge the groundwater.
- In April 1999, Indira Khurana, coordinator of CSE's campaign to Make Water Everybody's Business, gave a presentation at a workshop organised by the World Bank during the Commission on Sustainable Development meeting in New York on the role of community water management as a key input in food security and poverty alleviation.
- In June 1999, the Tamil Nadu unit of NWHN organised a meeting of Chennai's builders, which resulted in a project to provide drinking water to the residents of three blocks of a slum called Kuil Thottam. The lead has been taken by R Jeyakumar, a local builder, who is on the steering committee of the state unit of the NWHN. He received financial support for the project from the Rotary Club of Madras Central. This is the first attempt to harvest rainwater in a slum in India.
- In June 1999, Indira Khurana participated in a conference in Kobe, Japan, organised by the International Environment Technology Centre of the UNEP to emphasise the relevance of water harvesting as an innovative approach for meeting urban water needs.
- In late 1999, CSE started a Water Harvesting Advisory Service to provide designs at a nominal fee, to individual households and institutions like schools, colleges, residential colonies and industrial firms on how to take up water harvesting. This service has been started to help those people who become interested in water harvesting but do not have the expertise to do it.
- In November 1999, R N Athavale, the national coordinator of the NWHN, visited a few arsenic-affected villages in West Bengal with the help of the Institute for Motivating Self-Employment (ISME), an NGO, to see how water harvesting could help the villagers get arsenic-free drinking water. The project will be taken up before the monsoon season of 2001.
- In December 1999, several members of the Tamil Nadu unit of the NWHN attended a meeting on water harvesting organised by the Aringar Anna Government Arts College in Cheyyar (101 km away from Chennai) where the local MLA showed interest in setting up a sub-unit of the NWHN for Cheyyar or at least a rainwater club.
- In December 1999, CSE sent out a reporter to see how villages which had undertaken water harvesting were facing the drought in Gujarat and Madhya Pradesh. As the reporter found that these villagers were meeting most of their water requirements even though neighbouring villagers were fleeing the area, CSE organised a public meeting on January 6, 2000 in New Delhi to emphasise the importance of water harvesting in drought-proofing the country. Hardevsinh Jadeja, *sarpanch* of Raj-Samadhiyala village, and Harnath Jagawat, director of N M Sadguru Water and Development Foundation, shared their experiences.
- In December 1999, Paul Appasamy of the Madras Institute of Development Studies completed a survey of buildings in Chennai which had undertaken water harvesting to assess the impact and effectiveness of the city's law which mandates all new buildings to capture rainwater.
- In March 2000, a CSE team visited Sonia Gandhi's constituency, Amethi, in eastern Uttar Pradesh, to assess the drinking and irrigation water situation there and help her develop a community-based water harvesting programme for the area.
- From March 16-22, 2000, a CSE team led by its deputy director participated in the Second World Water Forum where it organised an exhibition on water harvesting and a day-long workshop on community-based water management which was inaugurated by Digvijay Singh, chief minister of Madhya Pradesh. A CSE film, *Arvari: A 20th century folk tale,* on water harvesting by the people of the Arvari watershed in Rajasthan's Alwar district was screened and a booklet called *Rememory of Water* was released. The World Water Commission, of which CSE's director was a member, also released its report outlining a global strategy for solving the emerging water crisis, which emphasised the importance of water harvesting and community-based water management among other things.
- On March 28, 2000, CSE invited president K R Narayanan, to visit Hamirpura village in Rajasthan's Alwar district and give the first *Down To Earth*-Joseph C John Award for the most outstanding environmental community to the village of Bhaonta-Kolyala. The governor and the chief minister of Rajasthan attended the ceremony together with about 10,000 villagers.
- In March/April 2000, CSE staffers wrote numerous articles for newspapers and appeared in over a dozen TV programmes to emphasise the importance of rainwater harvesting at a time when the media was seized of the drought affecting the country.

  Between April and July 2000, CSE staffers gave at least 20 presentations on the need and the potential of community-based water harvesting at several fora. These included seminars organised by chambers of commerce and industry, Delhi Jal Board, the urban development ministry, Rotary Clubs, HUDCO, Rajasthan state government and schools, amongst others.

- From May 13-18, 2000, CSE organised a *Paani Yatra* for journalists to acquaint them with the success that water harvesting communities were having in meeting the ravages of the drought in Gujarat. The *yatra* visited villages helped by the N M Sadguru Water and Development Foundation in Dahod district, Raj-Samadhiyala village in Rajkot district, Savarkundla village in Amreli district where the Kundla Taluka Gram Sewa Mandal has been working, and Polapan village in Rajasthan's Banswara district. The participating journalists wrote numerous articles about the success of these villagers.
- On May 24, 2000, CSE organised a public meeting in Delhi on 'Water Harvesting for a Drought-free Future' to emphasise the importance of social mobilisation in proposed government water harvesting programmes.
- On June 12, 2000, CSE organised a meeting of Delhi's architects, builders and engineers to acquaint them with water harvesting technologies relevant for urban areas and released a manual on urban water harvesting which contains designs provided to individual households and institutions in Delhi by CSE's Water Harvesting Advisory Service.
- In June 2000, CSE sent out a briefing paper entitled *Drought? Try Capturing the Rain* to all members of parliament and Gujarat, Rajasthan, Andhra Pradesh and Madhya Pradesh legislatures in English and Hindi to help legislators appreciate the importance of water harvesting. The paper brought in numerous requests from legislators for advice on how to undertake water harvesting in their constituencies.
- On July 12, 2000, CSE's director addressed a meeting of state governors, which was also attended by the prime minister and other senior members of the Union cabinet, at the request of the president of India to acquaint them with the importance of water harvesting.
- In July 2000, CSE wrote to chief executive officers of about 1,000 major Indian companies asking them to undertake water harvesting in their factory premises and provide financial support to neighbouring villages to do the same. The response has been quite good.
- In August 2000, two CSE researchers spent a month each in Gujarat and Andhra Pradesh, states whose governments had undertaken crash programmes to build and revitalise water harvesting systems during the May-July drought period. The researchers prepared reports on the effectiveness of these schemes based on visits to villages and interviews with senior officials, politicians, NGOs and village community leaders.
- In September 2000, CSE organised an exhibition during Water Asia 2000 that was held in Pragati Maidan New Delhi. CSE was the only NGO and the only exhibitor that spoke about the need of capturing the rain amidst stalls that displayed technology, pipes, pumps, filters and wastewater treatment systems.

RASTRAPATI BHAVAN

The President, Prime Minister, members of the Union Cabinet and Governors take a few tips on decentralised water management from Anil Agarwal at the Rashtrapati Bhavan

CSE

Begging to differ: CSE's stall on water harvesting in the hi-tech Water Asia 2000 exhibition in New Delhi

All this is just the beginning. We still have a long way to go before water harvesting becomes a mass movement. Linking people to their water is the only way to diffuse the water crisis that is building up.

It is our duty and pleasure to thank all those who have helped us to put this book together. In particular, we are grateful to the participants of the October 1998 conference who not only contributed papers about their work but also sat up a long night to help us prepare the conference statement. A Vaidyanathan's excitement in helping us in this exercise has to be noted, because it gave us the confidence that we are on the right path. Hannah Buttner, a young student, made a special effort to prepare a paper on water harvesting activities in Germany, which went a long way in giving us the confidence that water harvesting is a paradigm that is not just relevant for poor countries but also for rich countries. The International Rainwater Catchment Systems Association has been kind enough to let us publish a few papers from their annual conferences on the possible health effects of the use of rainwater and the measures that need to be undertaken to use the highly polluted urban runoff for a city's drinking water supply. The Intermediate Technology Development Group of Sri Lanka readily provided us the information on water harvesting and revival efforts in Pakistan and Sri Lanka.

We remain deeply grateful to the Ford Foundation which has supported CSE's work on water harvesting and to the Swedish International Development Authority (SIDA) and Evangelische Zentralstelle fur Entwicklungshilfe (EZE) for their support to the institution and its various programmes. The various activities carried out under our Campaign to Make Water Everybody's Business have also benefitted from the support of several other organisations like Action Aid, Aga Khan Foundation, Canadian International Development Agency (CIDA), Caritas-India, Catholic Relief Services, DANIDA, DFID, Foundation for progress de l'homme, Heinrich Boll Foundation, Indo-German Social Service Society, Madhya Pradesh government, Royal Netherlands Embassy, Oxfam, UNICEF, United Nations Development Programme (SEED, New York), United Nations Inter-Agency Working Group on Water Supply and Sanitation (UN-IAWG-WES) and Winrock Foundation. The October 1998 conference itself received support from Action Aid, DANIDA, DFID and the UN-IAWG-WES. We are extremely grateful to all these agencies for their unstinted support and faith in our campaign.

We hope this new book will go a long way in helping people to understand why and how water harvesting can be undertaken. And contribute in its own little way to solving the looming water crisis.

Anil Agarwal
Sunita Narain
Indira Khurana

CHAPTER 1

Inaugural Session

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Inaugural Session

- India is experiencing a water crisis. Rivers and aquifers are being hopelessly overexploited. The Yamuna has no flow in it except for sewage as it passes through Delhi. The country's waters are becoming increasingly polluted. There is hardly any river near an urban area that escapes from the dirt generated by human beings.

- The idea of water scarcity is absurd — there is scarcity amongst plenty. That is why water tankers supply water to towns even when their streets are flooded with rainwater.

- India has a millenial tradition of rainwater harvesting. These traditions have developed over centuries in an ecologically-sound manner. These were decentralised systems, where the urban and rural communities played an active role in water management. Rain was considered as the main source of water, most of which falls in a mere 100 hours in a year. Once captured, this rainfall met the demands for the rest of the year.

- Traditional water harvesting systems declined when the British took control of India. The governments took over the role of the main provider of water and replaced traditional decentralised systems with centralised ones. After the British left, the Indian bureaucracy took over the self-appointed role of supplying water. This marked the end of a glorious tradition. Moreover, there was growth of a heavy and unsustainable dependence on surface and groundwater sources and a gross neglect of the primary source of water — rain.

- Water must once again become everybody's business. A people's movement can help to deal with a lot of the water problems that face the country today.

- Said Babagouda Patil, minister for rural areas and employment, "There is an urgent need to recharge the groundwater so that India does not continue to face an acute water crisis."

- Said president K R Narayanan, "India today needs a people's movement to meet its water needs and to protect its water sources… Encouraging a people's movement means a redefinition of everybody's role…It means that the civil society has to play a critical role in encouraging equity and sustainability in the use of water."

Opening Address

Water Harvesting in a New Age

When the state has reached its limits, community participation becomes essential

Anil Agarwal
Centre for Science and Environment, New Delhi

India is today facing a huge water crisis. There is a an enormous unmet demand for water. Even as clean water sources are being viciously attacked by pollution and overexploitation, hardly any river or a groundwater aquifer near a city today escapes the perils of pollution. While agricultural lands go thirsty, many thousands of villages find it difficult to get clean drinking water.

The world has seen two major discontinuities emerge in the management of water since the 19th century. One, the state has emerged as a major provider of water, replacing communities and households as the primary agents for its provision and management. Two, there has been growing reliance on the use of surface and groundwater, while the earlier reliance on rainwater and flood water has declined, even though rainwater and flood water are available in much greater abundance than river water or groundwater.

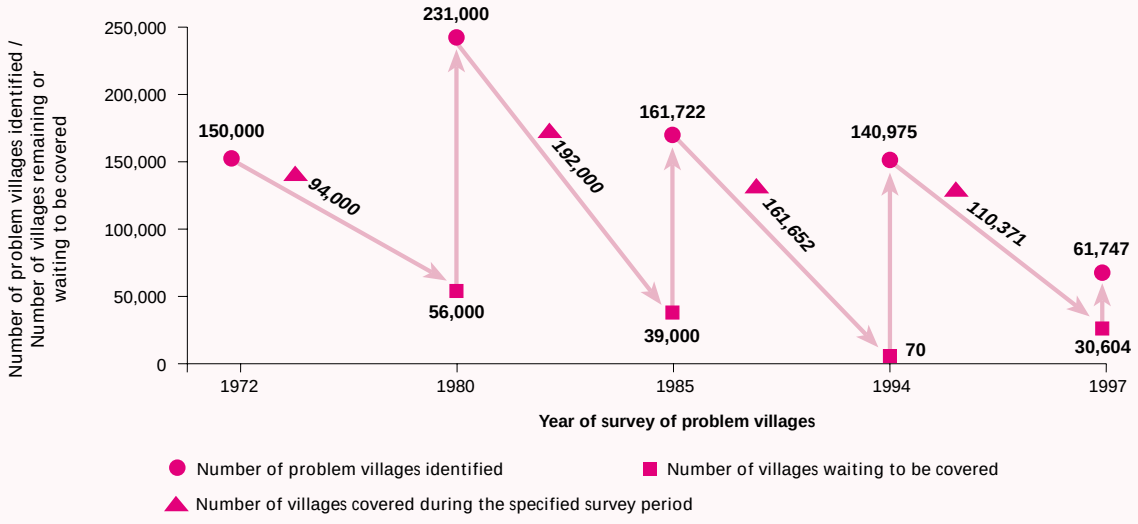
Here is a table and a graph produced by the ministry of rural employment, responsible for rural drinking water supply *(see Graph 1/Table 1: Unending problem)*. It tells a tale of its own. The ministry has been conducting periodic surveys to assess the shortage of drinking water in rural areas. The graph shows that even though a large number of villages are covered between two surveys, the number of problem villages keeps growing.

GANESH PANGARE / CSE

A naada ***(stone check dam across a stream) in Chittor district, Rajasthan: a traditional water source that meets human and livelihood needs***

Graph 1 / Table 1: Unending problem

The graph shows that even though a large number of villages are covered between two surveys the number of problem villages keeps growing. For instance, in 1980, there should not have been more than 56,000 problem villages, but there were 231,000. Obviously, the money pumped in and the methods used were unsustainable



Year of survey	Number of problem villages identified	Number of villages covered till the next survey	Number of villages not covered before the next survey
1972	150,000	94,000	56,000
1980	231,000	192,000	39,000
1985	161,722	161,652	70
1994	140,975	110,371	30,604
1997	61,747		

Source: N C Saxena, ministry of rural development, government of India

For instance, in 1980, there should not have been more than 56,000 problem villages, but there were 231,000.

Just why do we find so many problem villages at the start of each new survey? Obviously, the money pumped in and the methods used were unsustainable. Corruption, lack of people's interest in maintaining government schemes, land degradation leading to heavy runoff, heavy groundwater exploitation leading to lowering of groundwater tables, neglect of traditional water harvesting systems and growing pollution, are all adding to the problem.

WATER BALANCE IN INDIA

According to one water balance study of India, the country receives 400 million hectare metres (mham) of rain and snowfall. Another 20 mham flow in as surface water from outside the country.

These 420 mham provide the country with river flows of 180 mham, of which as much as 75 per cent takes place during the rainy season. Another 67 mham is available as groundwater. Thus, total river flows and groundwater add up to 247 mham, of which a substantial amount, 150 mham, must flow out to neighbouring countries and to the sea.

India has an enormous amount of water — theoretically as much as 173 mham, which is lost as evaporation or becomes soil moisture — which can be captured directly as rainwater or as runoff from small catchments in and near villages or towns. Capturing the flood waters of major rivers can further increase water availability.

If even 20-30 mham can be captured through rain-

water harvesting, tremendous pressure can be taken off the country's groundwater and surface water resources, greatly extending the availability of clean water.

Theoretically, the potential of water harvesting in meeting household needs is enormous. In reality, *there is no village in India which cannot meet its drinking water needs through rainwater harvesting.* Why is Cherrapunji today short of drinking water when it gets more than 11 metres of rainfall every year? Simply because it does not capture the rain that falls over it.

Theoretically, if rain was captured on the area of the union territory of Delhi, there would be enough clean water to meet the drinking and cooking needs of every individual in India.

PROBLEMS WITH THE CURRENT STRATEGY

There are two problems with the current strategy – one, heavy reliance on surface and groundwater alone, and two, dependence on the state.

India's projected use of water is 105 mham in 2025 AD, up from 38 mham in 1974. While the demand for irrigation water is expected to increase from 35 mham to 77 mham, the demand for domestic and industrial uses, which results in highly polluted water, is expected to shoot up from 3 mham in 1974 to 28 mham in 2025.

Of the 105 mham use projected for 2025, some 70 mham is expected to come from surface water and about 35 mham from groundwater.

This exclusive reliance on river waters and groundwater is already leading to a number of problems:

Heavy extraction of water from rivers

There are numerous rivers that are so heavily exploited that they have no river flow left during the summer season. The ministry of environment and forests is talking of the need to legislate minimum river flows, but none of the agencies involved with water resource development are listening.

Construction of large dams and the neglect of small water harvesting structures

This strategy has led to serious problems of forced human displacement and forest submergence. With population growing rapidly in India, the numbers of displaced populations will steadily increase if only large dams are to be constructed in the future, whereas the availability of land for resettlement will go down continuously.

Heavy extraction of groundwater

The groundwater table is falling rapidly in many parts of the country.

RUSTAM VANIA / CSE

A* kundi *helps to satisfy the thirst of both humans and livestock in the Thar desert

AMIT SHANKER / CSE

Water pollution further reduces the availability of freshwater

Dependence on the state

There are financial and human problems with state-sponsored water supply. The state subsidises water. People squander it. The state soon runs out of money for new projects to meet the bloated and burgeoning demand and for maintaining the projects already built. The state becomes responsible for water supply. The people just sit and watch and demand. They do not lift a finger.

In this present scenario, aggravating factors will become even more aggravating in the future. Demand will grow in the future with population growth and increased urbanisation, industrialisation and agricultural modernisation, the three key elements of modern economic development.

An acute crisis can already be seen in smaller river basins like those of the Yamuna, Sabarmati, Noyyal and Bhavani. Water pollution is further reducing the availability of clean water which means greater stress on the remaining sources of ground and surface waters.

THE NEED FOR A REVIVAL OF TRADITIONAL WATER HARVESTING SYSTEMS

What has water harvesting traditionally meant? It has essentially meant valuing the raindrop. It has meant capturing the rain where it falls or capturing the runoff in your village or in your own town.

Additionally, it has meant taking measures to keep that water clean, which, in turn, has meant not allowing dirty activities to take place in the catchment.

The most beautiful thing about water harvesting is that there is a human-rain-land synergy *(see Table 2: The hidden link)*. What this table shows clearly is that rainwater harvesting is possible in all human-land-rain scenarios.

Rainwater harvesting was an old tradition in many parts of the world, particularly in India. India receives most of its rain in just 100 hours a year. For the remaining hours there is nothing. Indians knew that if they did

Table 2: The hidden link

Synergies exist between rainfall, human population density and land availability

Region	Annual level of rainfall	Rain yield potential from one hectare of land(*)	Human population density	Land availability for water harvesting	Surface quality for water collection efficiency	Number of people whose water needs can be met at 100 litres per person per day from one hectare of land
Rural-arid	100 mm	1 million litres	Low	High	–	27
Rural-humid	2,000 mm	20 million litres	High	Low	–	553
Urban	–	–	Very high	Very low	More roof tops and built-up surfaces available with high runoff	

Note: *(*)Assuming rainwater collection efficiency of 100 per cent.*

SONAM DAWA

The snowmelt in the evening and the night is collected in* zings *in Ladakh, to be used the next day

not catch the water when it fell, they would have nothing later on. So they developed a civilisation built on raindrops. There are numerous examples from all over the country.

Take the *kundi*, an artificial water harvesting system. Anywhere in the desert, slope the land towards the centre, put cement or limestone on the artificial catchment to increase the runoff, and make a well in the centre. Cover the well with a dome and put a lock on the precious water. Even with 100 mm of rainfall, as in Jaisalmer district, you can get one million litres of precious water in a year.

The famous fort of Chittor, situated high on a hill, had no groundwater or streams. But why bother? The fort's builders built enough tanks to capture the rain. And 50,000 soldiers could live there for years without any problem. In 1987, the modern Chittor town ran out of water. But not the fort.

In Ladakh, where there is water, there is greenery and life. It is drier than Rajasthan. Glaciers feed streams. There is no water in the morning. But they are full in the evening. The people learnt to capture the evening and night runoff in a tank to use it for irrigation next morning.

In Ramanathpuram district of Tamil Nadu, centuries-old tanks are in a highly dilapidated state. Yet satellites can still see them.

The water harvesting tradition was so well developed in India in the medieval period that British administrator Thomas Munro (who came to India in 1803, later knighted and made governor of Madras in May, 1820) had the following to say about the irrigation system of Vijayanagar kings who ruled southern India from 1336 AD to 1614 AD: "*To attempt the construction of new tanks is perhaps a more hopeless experiment than the repair of those which have been filled up (through siltation). For there is scarcely any place where a tank can be made to advantage that has not been applied to this purpose by the inhabitants.*"

HOW DID ALL OF THIS HAPPEN?

When the British landed in India, it was a land of abundant riches and a high level of urbanisation compared to the rest of the world, especially Europe. The wealth was a result of successful natural resource mobilisation. Surpluses generated at the village level supported the towns and cities. These surpluses resulted from an

intelligent and sustainable use of land–water-vegetation resources.

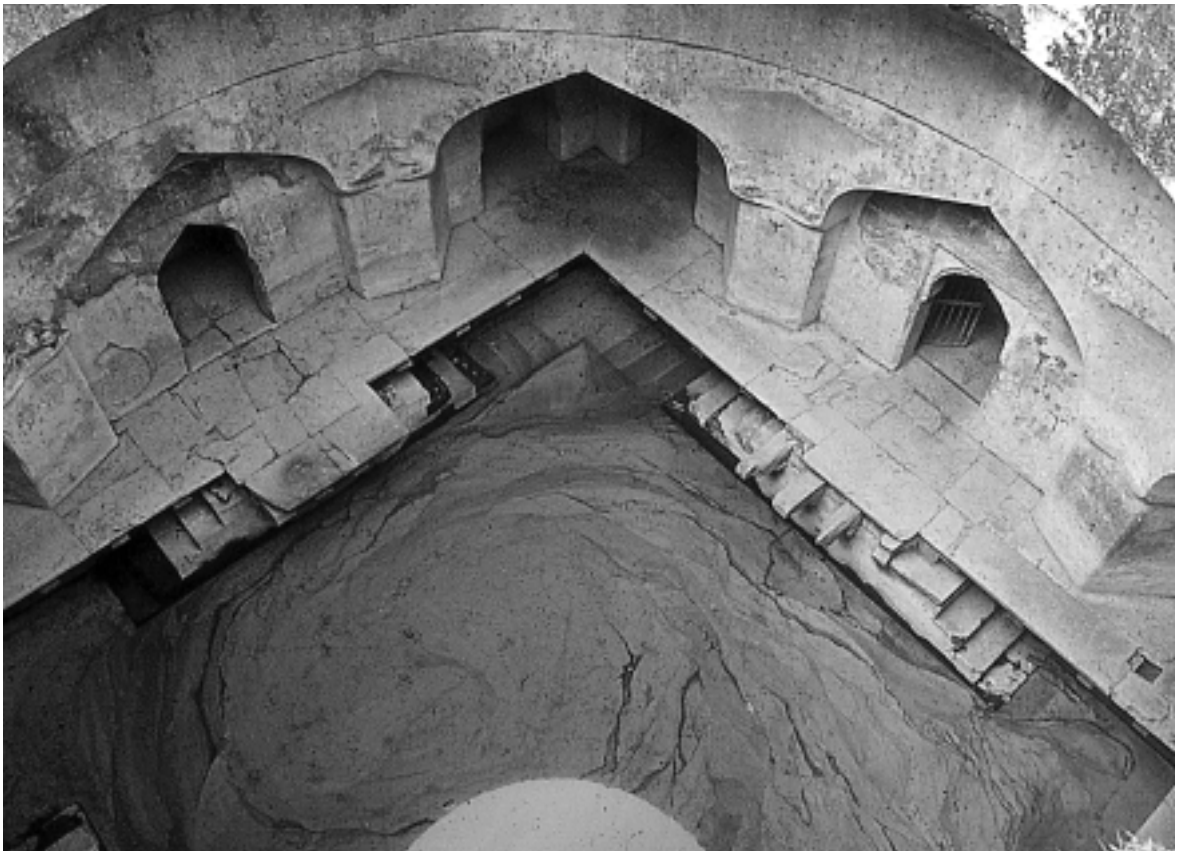
A large part of this prosperity came from the water harvesting systems that ensured an assured supply of water for irrigation. The kings and rulers down the ages had developed a system to encourage people to develop water harvesting systems. Their water policy consisted of three elements:

a) *The kings rarely ever built tanks themselves. If they did, it was largely to meet their own water needs. Therefore, they did not have any water bureaucracies.*

b) *The rulers would encourage people to build water harvesting structures by providing them with fiscal incentives.* The tradition in India was to take land taxes in kind which was equivalent to one-sixth or one-fifth of the farm produce. Therefore, if agricultural production fell in a drought year, the king too would be poorer that year, and therefore had a vested interest in promoting irrigation systems to ensure stable and high agricultural production. The king would, therefore, offer anybody interested in making a tank a grant for an unlimited or specific period in time during which no taxes would be collected from the land irrigated by the tank. Thus, the person making the tank and other people in his or her village would benefit not just from increased agricultural production because of the new irrigation facilities but also because the king did not collect a part of the produce as land tax.

The fiscal incentives had various names such as *dasabandhini inam* or *dasavanda* or *katu kodage*. The Vijayanagar kings in the South used these grants to encourage the building of tanks. The Gond kings in central India also introduced incentives along with sound policies for the management of water structures.

c) *The third thing that was done by the kings was to make their decisions and their agreements transparent.* In southern part of India, the kings would often have their agreement inscribed on the temple walls so that all people in the locality would come to know who has received such a grant and for the benefit of which village or villages. This ensured social pressure on the person who received the grant to



CSE

An elaborate rainwater storage tank in the Jehaz Mahal at Mandu fort in Dhar district of Madhya Pradesh. The kings were well aware about the need to secure water

S RAJAM

Information on water harvesting was inscribed on temple walls of south India. These inscriptions provided records about tanks — their renovation and management systems

stick to his or her promise, or else the people could complain to the king. In many ways, these policies are the same as those advocated today as modern principles of good environmental management.

MAKE WATER EVERYBODY'S BUSINESS

What does water harvesting as a strategy for meeting human needs mean in management terms?

a) It means making water everybody's business. Every household and community has to become involved both in the provision of water and in the protection of water resources.
b) It means making water the subject of a people's movement.
c) It means re-establishing the relationship between people and their environment. Turning water into a sacred element of nature.
d) It means the empowerment of our communities to manage their own affairs with the state playing a supportive role and civil society playing a critical role in encouraging equity and sustainability in the use of water.

WHAT DO WE HOPE TO LEARN FROM THIS CONFERENCE?

Water harvesting is needed in both urban and rural areas, by the rich and the poor, and by industrialised and developing countries. Frankfurt, Cophenhagen, Tokyo, Chennai and Aizawl are all becoming votaries of water harvesting. Water-rich Kerala villages and water-poor Saurashtra villages — all find it useful. That good watershed management with the help of people can make wells full to the brim — in areas like Jhabua in Madhya Pradesh and Alwar in Rajasthan which were once chronically drought-prone.

This is a conference which brings a message of hope and action and a conference which will also ask for a redefinition of the role of the state, of households and of communities. If we get our act together, there is no reason why anyone should go thirsty or any land be parched.

Honourable Mr President, we are truly delighted that you have blessed our efforts with your gracious presence. We need your help to turn our ancient rainwater harvesting tradition from Dying Wisdom, as we have called it in the past, to Emerging Wisdom. ■

Portrait of Rural Water Engineers

Waterworks India

The labour of five rural engineers maintains the rich traditional water harvesting systems

Sopan Joshi
Centre for Science and Environment, New Delhi

India's genius in catching rainwater lies in thousands of its invisible rural engineers who are today being elbowed out by the modern onslaught. In order to understand their pride and their plight, researchers of the Centre for Science and Environment (CSE) sought out five of the most outstanding in Leh in Ladakh, Churu and Jaisalmer in Rajasthan, Kasaragod in Kerala and Madurai in Tamil Nadu. CSE has also made a film featuring them called 'Waterworks India — Four Engineers and a Manager.' Their profiles:

CHEWANG NORPHEL

An innocent face bereft of expression. Inscrutable eyes. Stocky build. His appearance can be deceptive. So is the simplicity of his thought. Chewang Norphel, 62 years, is a retired civil engineer from Leh. He makes *zings* (tanks) and artificial glaciers.

There is hardly anything about him that seems unusual. It takes some time to adjust to Norphel's common sense approach to life. Yet it is this uncommon gift which gives him away. It explains how this man could generate water and greenery in the barren landscape that is Ladakh.

Falling in the rain-shadow area of the Himalaya, Ladakh is a cold, mountainous desert. During winter, temperature drops below the –30°C mark. Annual average rainfall is 50 mm. Dearth of water is *the* most important problem. The only source is glacier water from the mountains. Glaciers melt in summer, releasing the little water that the people of Ladakh get. This water is however managed by the people with the utmost care. It is stored for use throughout the year. Small wonder Norphel realised the importance of water.

Coming from a middle class family of Leh, Norphel went to Amar Singh College in Srinagar as a student of science. He completed a diploma course in civil engineering from Lucknow in 1960. In June 1960, he joined the rural development department of Jammu and Kashmir in Ladakh as a civil engineer.

"There is hardly a village in Ladakh where I have not made a road, a culvert, a bridge, a building or an irrigation system," says Norphel, who is quite fluent in both Hindi and English. Travelling far and wide in Ladakh, he does not remember when he developed his interest in water. His job was also making *zings* (small tanks fed by runoff from melting glaciers).

"I realised that all the problems in the region were related to water. In most areas, it was scarce. In others, it was being wasted," he says. "The best way to deal with this is the construction of clean, efficient channels." The channels he makes bring water from distant areas with minimal losses.

It was while working on the *zings* and channels that he evolved the idea of making an artificial glacier. His method involves channelling glacier water to the shadow area of a mountain, covered from the sunlight.

PRADIP SAHA / CSE

Chewang Norphel of Leh, surveying inhospitable, dry territory. He is able to provide water at crucial times for agriculture

He puts in half-inch-wide iron pipes perpendicular to the edge of the depression where the water collects.

After seeping into the pipe the water freezes. As more water seeps in, it pushes out the frozen block. This also freezes, continuing the cycle. On the other side emerges a neat, artificial glacier.

How does he manage to freeze water in the pipes? Another simple observation. "I noticed in Leh that water did not freeze in the channels but did so in the thin iron pipes. As the pipes are made of metal and are very thin, they lose heat quite rapidly," he narrates, just as if he was telling you how he brushes his teeth. He has already made four such glaciers.

The advantages are clear. Natural glaciers are way up in the mountains, and they melt slowly in summer. Water reaches the villages quite late. Norphel has brought glaciers closer to the villages. Water comes in early as a bonus for the farmers.

In 1996, one year after he had retired, Norphel joined the Leh Nutrition Project, a non-governmental organisation, as project manager for watershed development. "Watershed development is the only solution for Ladakh's rural economy. Otherwise, you will have rural folk flocking the city in search of jobs. And there are not many to go around," he indicates.

Norphel proposes artificial glaciers as a substitute for dams, which to him are environmental and social problems, besides being a financial burden.

Having spent so many years in governmental rural development, he has an interesting view of why they fail invariably. "Financial leakage," he says, using a metaphor of water. Simple, isn't it?

MAGGA RAM SUTHAR

Pokhran zero miles. We stand at a national security milestone. Here lies the holiest shrine of Indian technological (mis)ability. Here, High Science priests A P J Abdul Kalam and R Chidambaram recently did *puja* to nuclear competence.

But we are least interested in either the shrine or this kind of competence. We are looking for Magga Ram Suthar, who makes *beri*s or *kui*s. Who with hammer and ancient acumen makes water available, and so tackles a matter of greater security and importance.

Magga Ram is making a cot in village Pithla in Jaisalmer, the famed district in the heart of the Indian Thar desert. He takes us to the fields of Padam Singh, where some 15 years ago he had made four *beri*s — narrow wells 4.5 metre deep but only one metre wide. Extraordinary structures. How does he make them?

Magga Ram's 67-year-old eyes turn to the horizon. A man from a nearby village appears from behind a dune with a camel in tow, easy to spot in the sparse greenery. The man is lame, the camel one-eyed. The

PRADIP SAHA / CSE

***Magga Ram Suthar of Jaisalmer district, one of the few surviving persons who know the art of making a* beri**

sand is glowing bright in the desiccating heat, challenging his resilience. At the peak of summer, it will be around a scorching 50°C. The only shade is that of the odd *khejari* tree. But there is hope ahead. There is Magga Ram's *beri*.

After reaching the *beri*, the man lowers a soft bag cut out of the tube of a truck's tyre. He draws the sweet, nectar-like water, as rare to the Thar as it is to the taps of Delhi these days. However, when there was not enough water, the villagers did not agitate against the government. They sought Magga Ram. Still earlier, they sought his ancestors.

Magga Ram comes from Pithla's only *suthar* family. *Suthars* are carpenters, situated way down the caste ladder. But there is no lack of respect for Magga Ram. He knows how to catch the meagre rainfall that nature assigns to the area during the monsoon (annual average rainfall is around 160 millimetre).

In Pithla, groundwater can be struck only at a depth of 90-107 metres. Then too, it is mostly saline. Although nature is parsimonious in giving rainwater, there are other gifts. In many areas, a rocky belt of gypsum runs under the surface. Although its depth varies, it is generally wide. This is the key to Magga Ram's art.

The belt can be identified by the moisture retention in the soil. It keeps rainwater from percolating into the salty groundwater, while the sand covers it from the dehydrating sunlight. Villages took root only in areas with such belts. This is why the Thar is the most densely populated desert in the world, both with humans and cattle. But such a gift cannot be used without a detailed understanding of the region. Magga Ram recalls learning his art at the knees of his father Uma Ram and his uncle Kala Ram.

After the gypsum belt, known as *bittoo*, had been marked out by experienced eyes, digging would start under the supervision of engineers such as Magga Ram. The pit was only so wide as to permit the artisan to stand. A difficult, dangerous proposition by all means.

*Beri*s were only dug in the winters to avoid the summer heat. After reaching *bittoo*, which in the case of Padam Singh's fields was 4.5 metre deep, the *beri* was lined with stones. Magga Ram, an excellent sculptor with his works decorating many a house in the village, gave the required shape to the stones.

An interesting feature is the shape of *beri*s in areas where the *bittoo* runs shallow. Magga Ram makes a vase in the air with a measured movement of his slender hands to explain that the mouth is very narrow to prevent losses due to evaporation. It gets wider as you go down, giving greater surface area for water to seep in. All the details were worked out. No paperwork. No project proposals.

Will this art live after Magga Ram? He made his last *beri* 15 years ago. There is no demand for new *beri*s. In 1991 a government tubewell struck sweet water some seven km away. It reaches water to Pithla through a pipeline. But even today, when it fails, villagers walk up to Magga Ram's *beri*s. There is always water.

RAN SINGH

We are at the gateway of the Indian Thar desert. Domes dot the sandy fields of the village of Lahsedi in district Churu, Rajasthan. At the edge of each dome are little holes, surrounded by a clean circular area. They look like upturned cups in saucers staring at the sky. So does Ran Singh, who has made many of these. Habitually, he looks or points towards the sky. Awaiting rain.

PRADIP SAHA / CSE

Ran Singh, a* kundi*-maker from Churu district, has more than 450 such structures to his credit

The structures are *kundi*s. Small, covered tanks to store rainwater captured by the neat surrounding 'saucers'. Under the dome is a well which holds the water. They are the main source of water for the villagers. The saline groundwater is no good.

Official statistics put the average annual rainfall in Churu at 325 mm. There is a government pipeline some two km off Lahsedi. It supplies water once a week. For two hours. Or as and when the administration remembers that Lahsedi needs water. But villages here do not depend on the vagaries of the administration. They rely on Ran Singh and his *kundi*s.

The tall, well-built *jat* is sure-footed, even though 62 years have taken their toll on his physique. He knows what he is all about. And of the five protagonists featured in this section, he is the most articulate. He likes to speak. He has opinions. On everything.

"Pipeline is unpredictable. The government water-works are like waterless eyes that cannot see. What is their use?" he demands. He does not remember how he learned to make *kundi*s. His early childhood memories describe a Muslim craftsman who came to the village from Ramgarh to make a *kundi*. Ran Singh was impressed by the structure.

He saw. He learnt. And he made *kundi*s. About 400, he recounts. Or 450. He made his first *kundi* at the age of 13. Who did he learn from? "God is my *guru*. I just improvise from what I see. God is responsible for rain, without which we cannot exist," he says. This is characteristic of the man. He is philosophical about everything, exhaling smoke from his *hookah*.

Singh's philosophy is rooted in his observation. He is a man who has seen. Watched closely. He understands rain. The behaviour of water, how it travels and how it should be stored. "In the three months of the monsoon, we are okay if it rains thrice. If it is less, then we are in trouble. If it rains four times, then its time to sow *chana* (gram)," he says between pauses.

But what marks him out as a *kundi*-maker are his engineering skills. As he stands near one of his *kundi*s, the farmer on whose land it was built explains: "There are others who make *kundi*s. But the water is either bad in quality or inadequate. Ran Singh's *kundi*s are more reliable. He understands the depth and width very well." Ran Singh says the villages prefer him because he finishes his work in no time.

Making a *kundi* is no easy task. It takes about 25 days. After selecting an appropriate area, the first consideration is the incline towards the holes. The incline should catch as much rainwater as possible.

At the same time, it should not be too steep as it would send too much sand with water. The depth of the well is varied, depending on catchment and requirements. Generally, it is about 5 metres deep and

2.5 metres in diameter.

However, the most important consideration is leakage. Any flaw in the plastering and the water will seep out into the greedy sand. Ran Singh uses cement. After the walls have been plastered, the convex lid is placed on top. This is made with cement.

*Kundi*s have brought Ran Singh the respect of his village. Visitors are a regular feature at his house throughout the day. As he moves about, people salute him. They joke with him. Despite his age, a good joke is never lost on him. He catches it like water.

KUNHIKANNAN NAIR

Kunhikannan Nair's gait is languid, verging on sloth. There is an unmistakable economy of movement. But his hands are different. Varicose veins wrap around supple muscles. Symbols of endless toil and latent power. He looks very young for his 55 years. Just like the man who will carve out a *surangam*, a 300-metre-long tunnel in rock, which collects rainwater from the *ghats*.

Nair's fields in village Kodom Vellur of Kasaragod district, Kerala, are a thick green, characteristic of God's own country, as the state is called. There is coconut, areca nut, rubber, pepper and a little paddy. Although plantations have mushroomed in this northern part of Kerala, there is not a lot of money to make in the fields.

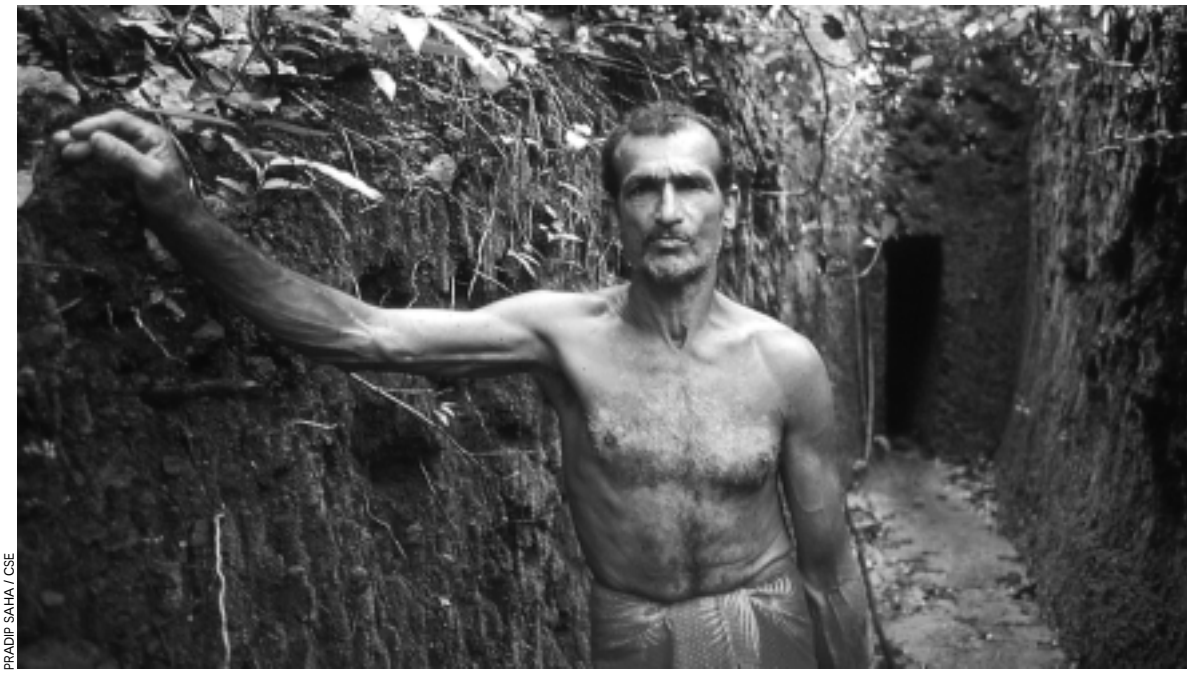
Nair recalls the sleepless nights he used to spend thinking about water for his fields. Kerala is one of the wettest states in India. But the slope of the Western Ghats makes it difficult to store the water from the heavy rains during the monsoon.

The region's answer to the problem is the *surangam*, a tunnel less than one metre wide, which is about as high as an average person. It collects rainwater from the hilly catchment above. A study by the Centre for Water Resources Development and Management (CWRDM), Kozhikode, found some 570 *surangam*s in Kasaragod district. "I always wanted to make one. But it requires money. I did not have it earlier. Besides, I had too many other things on my hands," says Nair, dressed in a red *lungi* rolled up to his knees.

At age 53, he arranged for a loan of Rs 5,000 from a cooperative bank to make his first *surangam*. Making a *surangam* means as much hard work as money. It is less than one metre wide and high enough for a person to stand in it. For 45 days, Nair hammered and chiselled at the hard weathered laterite of the ghats to carve out his *surangam*. He had to hire labourers as well. He will get it extended to catch more rainwater when he has the money.

The *surangam* means no more sleepless nights for Nair. He has assured water supply for paddy. He now saves the money spent on hiring a pumpset. The yield of coconut has risen. There is enough water for daily needs in the house. Enough to spare. Throughout the year. This is the striking aspect of Nair's *surangam*: it has water throughout the year. As *surangam*s go, this is not very common.

The *surangam* is a curious structure, as much in terms



PRADIP SAHA / CSE

A man who can carve tunnels or* surangams *in hard rock. That is what Kunhikannan Nair of Kasaragod district is capable of doing

of engineering as history. It is quite similar to the *qanats* of western Asia, which were popular in Syria, Iraq, Iran and Palestine in 700 BC. Researchers have not been able to establish any link between the *surangam* and the *qanat*. But it is widely believed that Kerala's structure came from western Asia.

The technology of making a *surangam* is quite intricate. Nair, a man of few words, struggles to explain it. His knowledge of the terrain and behaviour of water has not come from a formal school. It is a result of toiling in the fields. But Nair knows that there is water where there are *pala* trees (trees with white milky sap). He also knows that water is limited where there are rubber trees.

After deciding on the catchment, the hammering begins. By instinct, Nair knows the gradient for digging. The CWRDM has studied the digging of a *surangam*. There researchers will tell you that it is most appropriate right above the layer of granite, which does not allow water to seep in. The weathered laterite rock overhead, gives passage to water. Nair knows all this without ever attending school. Like so many other farmers in the region, his calculations are solid. The failure rate of *surangam*s is only 10 per cent in northern Malabar.

Sitting in the neat and simple brick structure that is his house, Nair says the government should provide more loans for making *surangam*s. He does not want much more.

He is capable of doing the rest himself.

GANESAN

If you met Ganesan on the street, you will never know that his work requires the skills of a top-of-the-drawer business executive. He manages the water supply of Madaivini Patti, a hamlet on the outskirts of village Vairavan Patti in district Madurai, Tamil Nadu. He is a *neerkatti* (the irrigator, in Tamil).

The chief ministers of Tamil Nadu and Karnataka will do well to use his water management skills to settle the Cauvery river water dispute. There has never been a major dispute among the farmers of his village regarding water.

Madaivini Patti consists of some 35 families. Poverty, though not abject, is clearly visible. There is only one child who has completed higher secondary schooling. In the off-season, the entire village works as casual labour in neighbouring areas.

Agriculture is limited to subsistence. There is hardly any surplus. Paddy is the main crop and water is essential. The only source is the runoff from the monsoon. This travels down the barely visible slope of the Eastern Ghats, and collects in the age-old *kanmoy*, as tanks are known here. Effective water management is crucial to social harmony. Ganesan provides it.

He comes from the *pallar* caste, which is listed as a scheduled caste in the state. But there are no special benefits from the government for Ganesan. He lives on what he earns. Which includes the respect of the entire

PRADIP SAHA / CSE

Ganesan of Madurai district is a* neerkatti, *an irrigator who decides who gets how much water and when

T C MALHOTRA

Four engineers and a manager: The President with some of India's 'rural engineers' at the CSE water harvesting conference

village. His caste status never clouds the recognition and appreciation of his skills. *Pallar*s have traditionally managed the water supply in this area.

At all community functions, the village priests have to accompany Ganesan to the market to make purchases, a symbol of his special status. He is the authoritative mediator, the honest broker, the village elder. In not just the water disputes but even the social disagreements within the village.

Says S Subramaniam, executive committee member of the village's Tank Farmer's Association: "The *neerkatti* tradition is of great benefit. Faith in the *neerkatti* is crucial to the smooth functioning of agriculture. Otherwise, everyone will fight."

Ganesan knows the topography of the village like the back of his hand. He knows exactly where the water comes from and where it should go. He knows the water need of each and every farmer, each and every crop. His work starts before the monsoon. He walks through the channels, digging and clearing in rhythmical motion. Singing a song or two.

Then there is the maintenance of the embankments of the *kanmoy*. But the most crucial part is the operation of the wooden sluice valves that release water in the channels. This is where the fate of all the farmers rests. While operating the valves, Ganesan is dealing with the life-blood of the village economy. One mistake in the calculation of waterflow and timing of the valves can ruin a poor farmer's crop. Yet it never happens.

Ganesan's social status apart, his economic condition is no better than the rest of the village. For maintaining the channels and the *kanmoy*, he receives rice from each farmer in proportion to the size of the fields (4.5 kg of rice per 60 cents of crop area). In addition, he gets 4 kg of rice from each farmer for operating the sluice valves. If he requires an additional hand or two in his endeavours, it is his own headache.

However, work in the village is restricted to the monsoon. That, too, once in three years. He has two brothers who are also *neerkatti*s. They take up water management in turns.

In the off-season, Ganesan has to go looking for daily wage work to either the neighbouring fields as agricultural labour or to the nearby towns as a loader. Some days are good. He manages to earn Rs 50. Others are bad.

Ganesan's two sons and four daughters are not interested in carrying on the *neerkatti* tradition. But as long as there are paddy fields, the limited water will need to be managed with care. There will have to be a *neerkatti*. A tradition. ■

Guest Speech

Babagouda Patil

Minister for Rural Areas and Employment
Government of India

His Excellency Shri Narayananji, Anil Agarwal, A Vaidyanathan and Adhityan Appan, distinguished delegates, ladies and gentlemen.

I deem it an honour to be present amidst you this morning for this very important National Conference on Potential of Water Harvesting: Technologies, Policies and Social Mobilisation. As you are all aware, our government is committed to providing safe drinking water to all the villages in the next five years. My ministry in coordination with the state governments is to cover all the not-covered habitations in the next one year and all the partially-covered habitations in 2-3 years time so that the promise made in the national agenda for governance is fulfilled.

Water is the most essential item for humankind's day-to-day living. The time has come when society should know how to manage its water resources and how to share it equitably. With more than 85 per cent of the rural water supply being through groundwater, it is important that attention be focussed to manage water so that competing demands on groundwater can be met adequately. Sustainability of the source has become a prime issue in rural water supply especially in the 279 overexploited, 179 dark and 585 grey blocks in the country. *There is, thus, an urgent need to recharge the groundwater so that India does not continue to face an acute water crisis.* In this context, I have already sought coordination of all those concerned for identifying and formulating viable schemes for recharging the groundwater. Against this grim backdrop, the National Conference on Potential of Water Harvesting assumes great importance.

I hope the deliberations during the conference will be a milestone in our concerted efforts to bring sustainable development to the centrestage of the national debate and collective action. Jai Hind. ■

T C MALHOTRA

"There is an urgent need to recharge the groundwater": Babagouda Patil echoes CSE's call for harvesting rain

Inaugural Speech

K R Narayanan

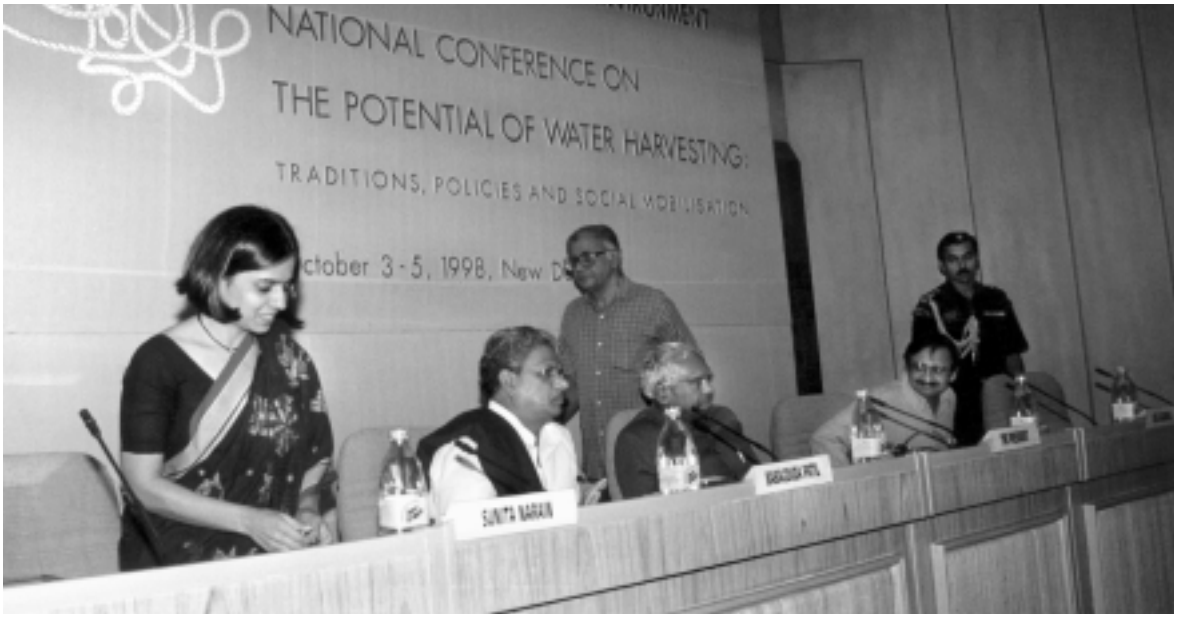
Honourable President of India

This has been a very heart-warming function indeed. I must congratulate the Centre for Science and Environment for the very creative and original way in which you have organised and conducted this function. There can be no subject more important for humankind than water. A well-managed society is one that knows how to treat its water with care, with prudence and with respect. Above all, with a sense of its being a universal asset.

But this universal asset is being fast depleted. Leading experts on water resources have been warning that the world is heading towards a water shock which may dwarf the oil crisis. Some 80 countries and 40 per cent of the world's population are already experiencing water stress. Environmental degradation and population explosion are making the problem even more acute, with pollution poisoning the water that is available.

Today, India faces an acute water crisis. The shortage of water and the growing pollution of water has acquired the proportion of a crisis for our people, and most of all, for the poorest of our poor. Some estimates show that almost the whole of India's economic growth gets wiped out by the health costs of water pollution, which do not get factored into our economic calculations. Until a few years ago, nobody had heard of bottled water but today it is a booming industry, as the rich try to protect themselves from the ravages of the environment. Today, a large proportion of urban India drinks bottled water. It is sad that water is fast becoming as expensive as milk. We must ask ourselves if this is the kind of economic growth we want.

Historically, Indians have been the world's greatest water harvesters. Over centuries they had developed a range of techniques to harvest every possible form of



T C MALHOTRA

An attentive President K R Narayanan at the inaugural session of CSE's conference

RUSTAM VANIA / CSE

A cartoon presented by CSE to President K R Narayanan, exhorting him to harvest rainwater in Rashtrapati Bhavan. Water is now being harvested in the president's estate

water from rainwater to groundwater, stream to river water and flood water. In 1920, when British authorities invited Sir William Willcocks, an irrigation expert, to advise them on why India was suffering from repeated famines, he categorically told them that the British would do best to learn from the natives themselves.

India today needs a people's movement to meet its water needs and to protect its water sources. Over the years, the state has replaced the traditional role of communities and households in meeting their water needs. We must make every household and every community get involved both in the provision of water and in the protection of water sources.

This will also lead to re-establishing a strong relationship between the people and their environment. Water and land go together. If the land is degraded, the water will run off fast and the soil carried away into the village tank and fill it up very fast, thus, reducing the availability of water. If the land is dirty, it will bring polluted water.

But encouraging a people's movement means a redefinition of everybody's role. The state and its various agencies must change from the role of a provider to that of an enabler and supporter. It means empowerment of rural and urban communities and households to manage their own affairs. And it means that the civil society has to play a critical role in encouraging equity and sustainability in the use of water.

There is today talk about subsidies encouraging wasteful use of water. There is equally talk today about privatisation of water supply. There is no doubt that there is today extremely wasteful use of water, and our rivers and groundwaters are becoming dirtier. At the same time, the government does not have as much funds as is required to deal with the massive problems we face in water supply and in keeping our waters clean even as we face the spectre of squandered financial resources because of half-finished projects and projects lying unused because of lack of repairs.

A people's movement for water can help to deal with a lot of the ills that we face today. Privatisation need not only mean private companies. Rural and urban communities and households are also major non-state actors which can contribute their might. They can make major investments. Even the poorest of the poor can contribute labour. This will not only add to the availability of state funds but also greatly reduce the need for perpetual subsidies. And involvement of the people will mean greater ownership of the projects by the people.

For all this we will need a people's technology, a technology that the people can develop, use and manage themselves. This is where our traditional technologies of water harvesting can play a critical role. Water harvesting means capturing rain where it falls, capturing it in your own town and village, and taking measures to keep that water clean. But the use of traditional

technologies does not mean that we do not need modern science and technology. Innovation and upgradation should be an essential part of our efforts to revive our traditions in water harvesting. A people's movement does not necessarily mean leaving people to their own resources. It, of course, means bringing out their initiative, their self-reliance and their enthusiasm. But it also means that the educated and enlightened sections of society should get involved in their development and help and guide them. The state, the NGOs and the scientists have important roles to play. New and simple scientific techniques and methods developed must be disseminated among the people like treatment for preventing evaporation from traditional water tanks.

To promote a people's movement, we will also need laws that encourage the people to take action in their own hands. Urban development rules should encourage all houses to have their own water harvesting system. It is encouraging that Chennai has taken a lead in this and several builders and architects are beginning to recognise the need to do so. This kind of water harvesting can greatly help to recharge groundwater, keep the freshwater table up, and in a coastal city like Chennai, keep the seawater out. The town of Aizawl, similarly, has shown how many of our towns can meet their drinking water needs through rainwater harvesting, something in which the government hardly invested anything. All villages must, in fact, be encouraged to construct and maintain their own water harvesting systems. India's rural development schemes should incorporate water harvesting into their programmes. *I have been asked by Anil Agarwal if Rashtrapati Bhavan would employ these techniques of water harvesting. I am happy to accept the CSE offer and invite it to develop a plan for us.*

For a people's movement for good water management we will need a massive programme to promote water literacy. Our honourable minister has referred to this, but having seen the wonderful film today I feel the best teachers for propagating this water literacy are the heroes of various parts of India, we have seen on the film. I will particularly congratulate them for the remarkable, original and creative work they have done in different parts of India and I am sure they are the greatest teachers of how to undertake water harvesting in our country, even sophisticated scientists have a lot to learn from them. Water must become a part of the school curriculum. Water harvesting must become a subject of technical curricula — in civil engineering, in architecture, in urban planning, in development studies, in economic studies and in health and medical sciences. Meanwhile, the media, especially the electronic media, must play a very important role in creating this water literacy. Surely, we cannot allow millions of our children to continue to die of diarrhoea and dysentery even in the 21st century.

Reading through *Dying Wisdom*, the report produced by the Centre for Science and Environment, and other reports of the centre, I am delighted to note the excellent work that is being done by numerous rural communities and non-governmental organisations in creating a new relationship between people and water. The work of the villagers of Ralegan Siddhi under the leadership of Krishna Bhaurao Hazare in Ahmednagar district, the villagers of Sukhomajri under the leadership of P R Mishra, and the numerous villages in Alwar district under the leadership of Rajendra Singh of Tarun Bharat Sangh is telling us loud and clear that a new relationship can be created. The inspiration provided by Ralegan Siddhi has already resulted in a government-sponsored but people-managed watershed development programme in Madhya Pradesh with excellent results in the extremely-poor and drought-prone, tribal district of Jhabua. Today, the government of Andhra Pradesh is also trying to develop a similar watershed development programme. These are all efforts that should be widely known and widely emulated both in policy and in practice.

Gandhiji's message of people-centred development remains even truer for the 21st century. He had thought deeply on the question of conserving our water resources for the benefit of our people. I should like to quote what he had specifically to say about this problem. In February, 1946 he said at his prayer meeting:

> "In this land of ours, fabulously rich in natural resources, there is the lofty Himalaya with its everlasting snows where, they say, dwells the Lord of the Universe. It has mighty rivers like the Ganges. But owing to our neglect and folly, the year's rains are allowed to run down into the Bay of Bengal and the Arabian Sea. If all this water was trapped and harnessed into irrigational purposes by the construction of dams and tanks, there should be no famine or food shortage in India."

Referring to our groundwater resources, Gandhiji added:

> "…we need not pathetically resign ourselves to fate, fixing our gaze at the skies for the rains to come. There is an inexhaustible reservoir of water in the bowels of the earth. It should be tapped, even though we may have to dig two thousand feet deep for it, and used for growing food. We may not blame fate before we have exhausted all available means for combating a threatening calamity."

May I congratulate the Centre for Science and Environment for organising this Conference as the beginning of a movement in social mobilisation for water harvesting. I am glad that village engineers and grassroots technologists who are involved in using traditional rain water harvesting systems are also present in this conference. I wish the conference all success. Jai Hind. ■

CHAPTER

Rural Traditions

CHAPTER 2

Rural Traditions

- In 1997, the Centre for Science and Environment published *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems,* with the primary objective of documenting traditional water harvesting systems that existed in each of the ecological regions in the country. This book describes a few more water harvesting traditions of South Asia.

- The Mewar region of Rajasthan is home to a rich legacy of traditional water harvesting systems. Systems were in place to share the water available and cultivate accordingly.

- The Bundelkhand region of Madhya Pradesh, with its Chandela and Bundela tanks made Tikamgarh district one of the highest irrigated districts of the state. These tanks played a significant role in irrigation, both directly and indirectly, as groundwater recharge. The main threats to these tanks today is tank bed cultivation and breaching of embankments.

- In Vidisha division of Madhya Pradesh, traditions to clean up the *pakhi*, a two kilometre long well, was undertaken with much fanfare. In nearby Sironj, a historic centre for cloth weaving and printing till the early 20th century, a tank provided water. Wells were built near the tank to take advantage of groundwater recharge.

- In Bhandara district of Maharashtra, the Kohlis built tanks in all sizes, using their inherent wisdom. Often cascades of tanks were constructed so that the spillover from one tank was captured in another. The 16 anna *malguzari* system ensured equitable water distribution and maintenance of these tanks. When the state government took control over these tanks, it alienated the community and ensured the demise of these tanks.

- Rayalaseema region of Andhra Pradesh is home to a host of traditional water harvesting systems, conveyance networks and institutional mechanisms devised to suit local conditions. With the promotion of centralised and energised systems of water supply, these systems have been reduced to sources for the poor alone.

- In the terraced paddy fields of Ganjam and Koraput districts of Orissa, spring water was channelised into fields. In Kendrapada district, the village community pond was ubiquitous.

- In arid regions of Pakistan, rainwater captured in natural or artificial depressions were often the only source of water. Elsewhere, hill torrents were diverted to fields via a network of channels.

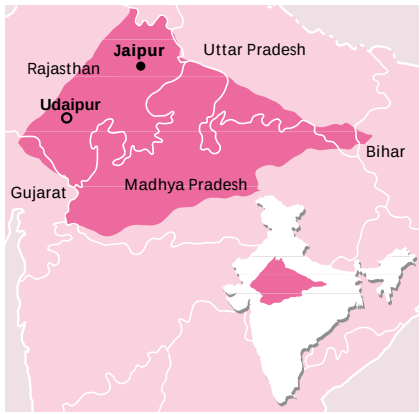
- In Sri Lanka, rainwater was captured using available resources like leaves, tree trunks and rock cavities. Often, the rain was captured for its superior quality.

Traditions to the Rescue

Traditional water harvesting systems are re-emerging as crucial sources to meet the growing water scarcity in Udaipur district

Ajay Desai and Shaswati Ghose
CARE and Vidya Bhawan Krishi Vigyan Kendra, Udaipur, Rajasthan

Udaipur district in Rajasthan continues to suffer from acute water shortages, while a rich legacy of traditional water harvesting systems (TWHS) is allowed to go waste. Time-tested water harvesting techniques, which are usually much more economical than modern alternatives, can still help to solve the soil and water conservation problems of the area.



Today, the entire system of indigenous traditional knowledge is eroding in Udaipur district of the erstwhile Mewar region. With the decline of farming as an income generating activity, most TWHS related to farming are getting neglected.

Reckless deforestation over the last 50 years has reduced water and manure availability, leading to a progressive decline in agricultural productivity. Reduced food security forces families to look for non-agricultural employment and temporary migration. Thus, a vicious cycle begins. Low attention to farmlands leads to lower agricultural production which further lowers attention to farmlands leading to further degradation.

TRADITIONAL WATER HARVESTING

The Mewar region inherits a varied legacy of traditional water harvesting structures and an equally rich tradition of diverse water-lifting devices.

Medbandi

Medbandi is a stone embankment built on a hill slope to help create a level field for cultivation — a structure that encourages controlled erosion, while conserving moisture. The site for *medbandi* construction is selected on a hillock and the dimensions of the structure that needs to be constructed are estimated by a *karigar* (a person having certain skills). The area is then cleared of vegetation before the monsoon. Stones are collected and the structure built under the guidance of the *karigar*. During the monsoon, the field is ploughed from the lower end to the upper end of the slope to facilitate erosion. Crops promoting soil erosion are sown. Soil from the upper reaches is washed down to the lower end of the field and accumulates near the *medbandi*, resulting in a levelled field.

Population pressure and gradual reduction in the size of landholdings are making *medbandis* again popular, since these help reclaim hill slopes for cultivation. Many non-government organisations are promoting *medbandis* around Udaipur, either as drought relief work or as a part of watershed development projects.

Naada/bandha

Naada/bandha is a stone check dam across a stream or gully constructed to capture runoff on a stretch of fertile land submerged in water during the rainy season. The land not only becomes more fertile after trapping silt, it also retains substantial quantities of water in the soil. The *naada* land is very fertile and often does not need any manure or fertiliser. It is suitable for *heerma* or cultivation on residual moisture. Generally, a series of *naadas* are prepared over a period of time on a gully or stream, beginning from the lower side. These structures also minimise damage in downstream areas by reducing the speed of water flow.

A shallow gully usually needs a longer check dam while a deep stream needs a taller check dam. However, in both cases, a rather gentle slope is preferred, leading up to the *naada*, because gentler the slope, longer will be

the *naada* area. The thumb rule is that a *naada* should be constructed at a place where its final length will be at least five times the height of the check dam. Spillways are also provided for drainage of excess water. Such a dam is constructed in phases over years, slowly measuring up to the right height of the check dam and the size of the *naada*.

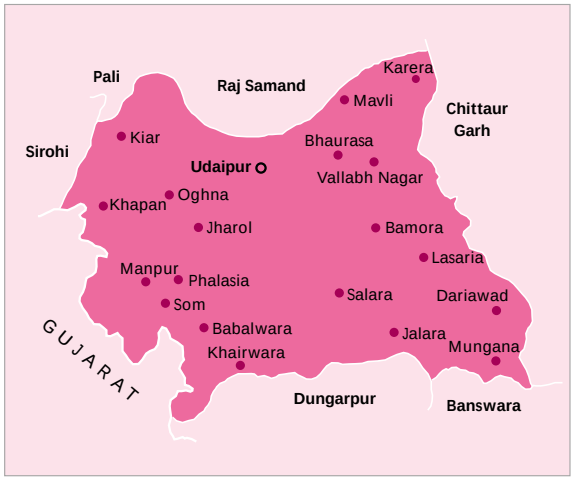
The construction and maintenance of a *naada* is very labour-intensive and, therefore, requires group action. Big *naadas* are collectively constructed by a community under the *halma* system, under which an adult person from each household participates. In case of privately-owned, smaller *naadas*, other families help in the construction with the understanding that the owner will reciprocate. This system of labour-swapping, locally called *arji-parji*, is meticulously followed by every family even when the time lag between construction of the first and the last *naada* is several years.

Though many old *naadas* are still under cultivation, new *naada* construction has gone down considerably. Due to the heavy labour requirement and long gestation period, farmers are reluctant to construct *naadas* on their own and, presently, neither government agencies nor NGOs are supporting this activity.

Hembar

Hembar is a small, temporary dam constructed with stones, twigs and mud over a seasonal stream when water flow in it is reduced to a point that it cannot be taken directly to the fields for irrigation. Owing to the material used for its construction, a *hembar* cannot be more than 1 metre (m) in height, which limits the quantity of water collected in it. It is a common practice to construct a series of *hembars* which act as temporary storages of water for a few hours, which is then taken to the fields through *naalis* or *kuccha* (earthen) channels.

Udaipur district, Rajasthan



TWHS AND AGRICULTURE

Traditional water harvesting systems (TWHS) are still the most critical component of agriculture in the Mewar Aravalli hills, often deciding what should be sown and when

Some interesting examples of such linkages are:

Risk management in *naada*: When water accumulation in the *naada* is assured, it is used for paddy or sugarcane cultivation. At other times, farmers use various risk minimisation strategies like mixed cropping of maize and paddy.

Cropping pattern in *hembar* groups: In a *hembar* group, selection of crops, area allowed for irrigation, and frequency of irrigation is uniform for all members, irrespective of the size of their landholding.

***Heerma/seerma*:** *Heerma* refers to the practice of growing crops in the *rabi* (winter) season on residual moisture conserved *in situ* during the rainy season without resorting to external sources of irrigation.

NGOs in Udaipur are keenly involved in *medbandi* construction, *chak* development, soil and water conservation, well deepening, *anicut* construction and lift irrigation. The farmers themselves are quite keen to undertake *medbandi* on their fields, provided they receive some financial assistance. *Chak* development is also quite popular with them.

When water is required in upland fields, traditional water-lifting devices are used.

Construction of *hembar* is again a group activity performed under either *halma* or *arji-parji* system. Generally the membership of a *hembar* group is restricted to one or more extended families living in a hamlet. The *mautbir* (the informal leader of a hamlet) heads the group and is assisted by a group of experienced, elderly farmers. *Hembar* groups need to be highly cohesive, as they have to manage cropping patterns of members, besides creating and maintaining physical infrastructure.

Traditionally, *hembar* groups follow a 'head-to-tail' irrigation pattern wherein the plot nearest to a *hembar* is irrigated first, and others are irrigated sequentially. This system minimises the seepage loss of water which is otherwise quite high due to the sandy nature of soil in the area. Although, in principle, every member is entitled to an equal amount of water, the drawback of the system is that in case of low water availability, the tail-end farmers always suffer. One way of tackling this problem is to encourage tail-end farmers to enter into crop-sharing arrangements with head-end farmers.

Crop-sharing arrangements called *heejara* or *adhabatta* amongst the *hembar* members is actively encouraged but non-members are not allowed to have such arrangements with members. In *hembar* groups,

AKHILESH / CSE

A* saza kuva *in Mewar region. Almost all of the* saza kuvas *in the region are owned by 'partners'

two types of crop-sharing arrangements are generally followed. In one kind of arrangement, a farmer provides water for irrigation to another farmer's plot. But other inputs like seed, labour and harvest are equally shared. In another arrangement, a farmer provides only irrigation and the landowner provides rest of the inputs. According to this system, the farmer supplying water for irrigation gets only one-third of the produce after some deductions, while the landowner takes the rest of it.

Chak

Chak is a big plot of land, usually a *charnot* or village pasture land, enclosed by a stone boundary wall called *kot*. Activities like tree plantation, seeding of improved fodder grass, contour *bunds*, trenches and loose stone check dams are carried out in this *chak*. Strong collective action is necessary for its development and maintenance, especially to protect it from stray cattle and encroachments. A well-managed *chak* not only meets the fodder and fuelwood needs of the local people but also reduces soil erosion and enhances groundwater recharge.

Talab

The Mewar region is famous for human-made reservoirs (*talabs*) and the city of Udaipur, with a large number of such *talabs*, is known as the lake city. There are reservoirs of various sizes — a small lake with the reservoir area of less than five *bighas* is called *talai;* a medium-sized lake is called *bandh* or *talab;* and, a bigger one is called *sagar* or *samand*. Water from these reservoirs is used both for drinking and irrigation purposes. Elaborate institutions like *hembar* groups exist around the traditional *talabs* for their maintenance and use.

Saza Kuva

Saza kuva is an open dugwell with multiple owners (in local *Mewari* language, *saza* means partner). It is the most important source of irrigation in the Mewar Aravalli hills. About 70,000 wells in Udaipur district alone provide water for 80 per cent of the area under irrigation and almost all of these have multiple owners.

Well construction, being a labour-intensive operation, is generally undertaken by a group of farmers having adjacent landholdings with the help of a *harva* or a person having special skills in groundwater detection.

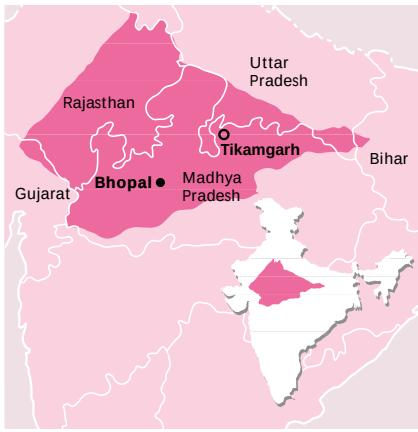
While digging a well, the soil removed is usually used to construct either a huge circular foundation or elevated platform sloping away from the well. *Rehat*, the most common traditional water-lifting device, requires a circular platform whereas another device called *chadas* requires a sloping pathway for the movement of bullocks. ■

Bounty of Bundelkhand

Tikamgarh district has a rich legacy of tanks which 'unofficially' remain crucial for water supply in the region

Krishna Gandhi and Sunanda Kirtane
Lokodyam Sanstha, Jhansi, Uttar Pradesh

There is a mystery that surrounds irrigation in Tikamgarh district of Bundelkhand region of Madhya Pradesh. In the absence of any major irrigation initiative, canal irrigation in Tikamgarh district has grown exponentially and unexplained in the last three decades while the share of irrigation through traditional tanks has shown a steady decline.



Till 1965-66, official figures clearly showed that wells provided the bulk of water for irrigation, followed closely by tanks, while irrigation through canals was a distant third *(see Table 1: The bare facts)*. The 1996-97 figures, however, indicate that the area under irrigation from canals was 19,870 hectares (ha) and from tanks was only 10,820 ha. The question arises as to how the canal system has grown without the commissioning of any new major irrigation project? The answer lies in the tanks, which though in a state of disarray are still supplying water for irrigation. Since Tikamgarh does not possess any large-scale irrigation project, water in canals must come from the 109 medium and small irrigation works maintained by the irrigation department. Out of these 109 works, 80 are traditional Chandela tanks. These are tanks that were built by the Chandela kings who were rulers of the Gond region between the 9th century and 11th century AD. These include some of the reconstructed old tanks, such as Nandanwara, which have been extended and improved with canal systems added to them after independence. The remaining 29 new schemes, constructed during the various five year plans include large tank schemes, lift irrigation schemes and check dams. Even some of the new tank schemes

Table 1: The bare facts
Source-wise breakup of the net irrigated area (in hectares)

Year	Canals	Wells	Tanks	Other sources
1950-51	–	24,570	6,959	4,034
1955-56	3,115	31,293	7,621	–
1960-61	4,080	31,648	7,010	91
1965-66	5,179	35,447	2,998	141
1975-76	13,854	57,690	5,887	2,349
1985-86	16,100	99,900	7,200	4,100
1986-87	139,00	858,00	7,100	3,600
1987-88	13,400	95,300	5,300	3,100
1988-89	13,400	89,900	4,900	3,400
1989-90	3,800	75,600	5,000	3,700
1990-91	16,300	95,100	5,700	6,200
1991-92	15,800	97,900	8,000	6,800
1992-93	17,000	107,300	7,900	7,700
1996-97	19,870	123,680	10,820	8,390

Source: *Gazetteer of Tikamgarh* 1995

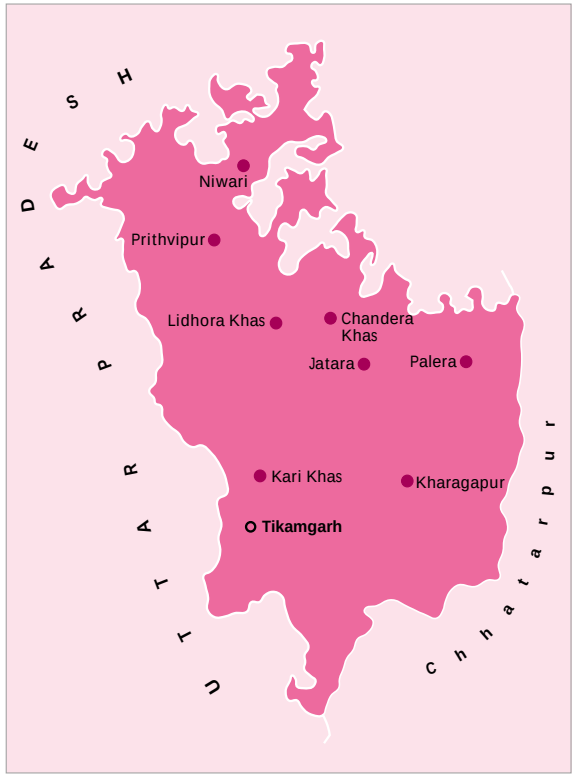
are nothing but the extended and improved versions of smaller traditional tanks like *teharka.*

It is, therefore, evident that the area under irrigation from tanks has really increased, but the credit has been given to the newly evolved canal system. To get the actual figure of the area irrigated by tanks, the figures for tank-irrigated area and canal-irrigated area should be added and then the area irrigated by new irrigation schemes should be subtracted from the total.

Tikamgarh is one of the highest irrigated districts of Madhya Pradesh. Located in the semi-arid tropical region of Bundelkhand which comprises seven districts of Uttar Pradesh and six districts of Madhya Pradesh, Tikamgarh inherits a rich legacy of water harvesting structures. The high level of irrigation in the district is not the result of any major modern irrigation project. In fact, there are no major irrigation projects, despite the district sharing its borders with such major rivers as Dhasan, Jamini and Betwa.

Traditionally, groundwater resources in Bundelkhand are meagre due to the presence of hard rocks like gneiss and granite. However, quartz reefs traversing the undulating terrain and mountain ranges play an important role in forming groundwater reservoirs. Many tanks are found bunded along these reefs. The most important factor for the satisfactory levels of groundwater in the region is the presence of a large number of traditional water tanks built mostly during the Chandela rule a thousand years ago. The seasonal

Tikamgarh district, Madhya Pradesh



ANUPAM MISHRA

A Chandela tank in Bundelkhand, built in the 11th century

A CHERISHED INHERITANCE

Historical water harvesting structures are the most potent reminders of Bundelkhand's glorious past

Bundelkhand region, comprising seven districts of Lalitpur, Jhansi, Jalaun, Hamirpur, Mahoba, Banda, Shahujinagar in Uttar Pradesh and six districts of Datiya, Tikamgarh, Chhatarpur, Panna, Sagar and Damoh in Madhya Pradesh, presents a bleak picture today. It is plagued by poverty, illiteracy, unproductive agriculture and an acute lack of infrastructure. Environmental degradation is increasing with soil erosion and disappearing forest cover. Social inequities continue to thrive on remnants of a feudalistic power structure. But the region had a glorious past. Historical water harvesting systems are one of the most cherished inheritances of the region.

The history of water harvesting goes back to the 9th century in Bundelkhand. The Chandela dynasty started ruling the land with Nannuka as its first king in 831 AD. From 851 to 1545, when the dynasty ended with the death of Kirti Singh in a battle with the king of Delhi, Sher Shah Suri, almost every Chandela king built tanks of various sizes.

Rahila (885-905 AD), the fourth king of the dynasty, built a large tank near Mahoba called Rahilya Sagar. Khajuraho inscriptions of 1059 credit Yasho Varman (925-950 AD) with the excavation of big tanks which may be identified with the tanks situated in and around the village of Khajuraho. Kirti Varman (1060-1100 AD) constructed Kirtisagar in Mahoba, Kirtisagar in Chanderi and Budhyia Tal in Kalanyara. Madan Varman (1128-1165) built many tanks. These included Madansagar with a periphery of 4 km and two equally large tanks of the same name in Jatara and Aghara in Narayanpura, Tikamgarh. Madan Varman's prime minister Gadadhara also constructed an impressive tank with many broad stories built out of masonry in the boundary of Deddu village. Parmardideva (1165-1203) built Parmala tank at Ajaygarh. Vira Varman's (1245-1285) wife, Kalyanidevi, also constructed a well and a tank at Ajaygarh. The Ajaygarh epigraph describes it as resembling an ocean. In the Kalinjar stone inscription, Vira Varman (1245-1285) is credited with the construction of many tanks and ponds. Alha's (Parmardideva's warrior, who fought against the legendary king of Delhi, Prithviraj Chauhan) father Dasharaj built Shandilya Tal. There are hundreds of tanks scattered throughout Bundelkhand whose history remains largely unknown. In fact, almost each village in Bundelkhand has a tank whose structure indicates a Chandela origin.

Bundela ascendancy began after the death of the Chandela king Parmardideva in 1202. The capital of Bundela dynasty was at Kudar (Tikamgarh district) till 1531 when it was shifted to Orchha (also in Tikamgarh district). Bundela kings built and reconstructed many tanks during their period, although their number is not as large as that of Chandela tanks. Sindursagar and Virsagar were built by Vir Singh Deo I. It is said that Vir Singh built 52 edifices in addition to many tanks. Sujansagar near Adjar was built by Sujan Singh in 1661 AD.

Maratha dominance began in this region from 1729, when Chhatrasal took help from the Peshwa. Till 1857, the Marathas remained the dominant force in this region but did little to manage water resources. This led to their decline.

streams that pass through narrow gaps in the mountains offer good opportunities to harvest rainwater by constructing check dams and other embankments.

TREASURES OF TIKAMGARH

Tikamgarh has inherited numerous tanks built by the Bundela and Chandela kings of Bundelkhand *(see Box: A cherished inheritance)*. Although tanks built during the Chandela period were not intended to provide direct irrigation, they helped in maintaining a high groundwater level by creating natural percolation and groundwater recharge. Later in the Bundela period, many of these tanks were enlarged and renovated with the conscious aim of providing water for irrigation. These tanks traditionally constituted one of the most important sources of water not only in Tikamgarh district but the entire Bundelkhand region.

In view of the overwhelming evidence about the role played by traditional tanks in Tikamgarh district, a detailed study was undertaken to ascertain the extent and quality of contribution made by traditional tanks and other water harvesting structures such as wells, *baories* or *bers*, *bandhies*, tubewells, handpumps, reservoirs, canals, *pokhariyans* and *talabs*.

The first project was an intensive survey of Niwari block in Tikamgarh district and Bangra block of Jhansi district undertaken between January-December, 1997. The second project was undertaken to document some 12 selected traditional tanks each in Tikamgarh and Mahoba districts *(see Box: Instruments of irrigation)*.

The results were fascinating. The spread of tanks was profuse, in the form of a small and sprawling network. These numerous tanks of Bundelkhand were the key to water availability in the region. Although not much is known about the numerous small tanks, they formed a vital link in a sprawling network of tank systems. According to settlement records, there were 962 tanks constructed during the Chandela period, most of which were small in size with low bunds. Out of these, 125 tanks were being used for tank-bed cultivation. The number of these tanks has now come down to 421. In 1961, the number of large tanks irrigating more than 40.5 hectares (ha) of land was only 65. Some of the larger tanks renovated recently are Nandanwara, Dharamsagar, Madansagar, Padmasagar and Gwalsagar, besides other smaller tanks. But even the official figure of 421 tanks mentioned above is quite old, and in all likelihood the number may only be 351.

Chandela tanks

Usually Chandela tanks were constructed by stopping the flow of water in *nullahs* (rivulets) flowing between hills by erecting massive earthen embankments, having widths of 60 m or more. These hills, with long stretches of quartz reefs running underneath them, acted as natural groundwater barriers, helping to trap water between ridges. The earthen embankments were supported on both sides with walls of coarse stones of approximately 0.17-0.22 cubic metres in size, forming a series of stone steps. Stones and soil for raising these embankments were locally produced. Lime and mortar were used only in construction of waste weirs which were strong enough to have survived a thousand years. The only problem facing these tanks today is siltation of tank beds. The width-to-height ratio of the earthen embankment was very high. For example in the cases of Nandwara, Virsagar, Kailashsagar, Sindursagar and Bagan Ki Talaiyan (in Orchha), this ratio is 7:1 or higher.

Chandela tanks usually had a convex curvature somewhere in the middle of their embankment at which point the breadth of the embankment increases and where a small temple or *chabootra* (platform) was usually constructed. Many older or smaller tanks were located near human settlements on or near the slopes of a cluster of hills. Some of these Chandela tanks near Teharka and Jugiayi formed a chain of 2-3 tanks.

Irrespective of the size of tanks, they were meant to be used by everybody. There was no restriction on access of water even when individuals constructed them. Chandela tanks called *nistars* were not used for direct irrigation. Smaller *nistar* tanks were generally situated close to the villages while the large tanks were

INSTRUMENTS OF IRRIGATION

Besides traditional tanks, Tikamgarh has a large collection of other sources of irrigation

The various sources of irrigation in Tikamgarh include wells, *baories* or *bers, bandhies,* tubewells, reservoirs and canals, and *pokhariyan* or *talabs.*

Wells: Wells are the main source of irrigation and drinking water in Bundelkhand region. *Pucca* (lined) and *kuchcha* (unlined) wells in Tikamgarh district are responsible for about 70 per cent of the total area under irrigation. The area irrigated by wells has continuously increased since the beginning of this century, which shows the tremendous increase in the use of groundwater. Today, water levels in wells vary from 5-10 m in the district.

The very high percentage of irrigation from wells in this district at first sight appears surprising, considering its geological formation. The terrain is rocky and the topsoil is generally of poor quality with a very thin top layer, varying from 6-15 metres (m). Below this upper crust lies a very thick and largely impervious layer of basaltic rock, having little or no water-bearing strata. Despite such poor geological conditions, the groundwater level in the district is generally rather high, especially in the southern parts due to the presence of a large number of traditional Chandela tanks.

Baories* or *bers: *Baories* or *bers* are wells with steps, used mainly for drinking. Most of the *baories* are very old and are said to have been built by *banjaras* or mobile trading communities to meet their drinking water needs. Some of the *baories* built by the kings have beautiful architecture, of which *Rani ki Baori* is one of the finest examples. Unfortunately, most of these *baories* are now filled up with soil and are on the verge of extinction.

Bandhies: *Bandhis* or *haveli bandhis* impound rainwater in bunded fields to grow a *rabi* or *kharif* crop after the removal of water. Since 1985, when soyabean was introduced besides the main *kharif* crops like paddy, *jowar* (sorghum) and *urad,* the area under cultivation for the more remunerative soyabean crop has steadily increased.

Soyabean cultivation has led to the dismantling of *bandhies* on a large-scale, because whereas paddy cultivation requires impounded water, soyabean cultivation needs water to be removed from the field. This has adversely affected the groundwater recharge, leading to a steady lowering of the water table.

Tubewells: Introduced much after independence, tubewells have not been very successful in the rocky terrain of Tikamgarh. Even then, almost all villages have at least one tubewell and by March 1990, 2,253 tubewells were already installed in the district leading to extensive exploitation of groundwater.

Reservoirs and canals: Direct irrigation started in the Bundela period and was extended during the British and post-independence period. According to the *Gazetteer of Tikamgarh* published in 1995, "After 1951, some new tanks were constructed and several old ones renovated for irrigation. The Nagda tank constructed after independence is the largest in the district. The other new tanks constructed are Thagatore, Chita Nullah and Teharka." Lift irrigation schemes from Jamini and Betwa rivers have also been taken up. The area under irrigation of these new reservoirs and canal systems has steadily increased in the last few decades.

***Pokhariyan* or *talabs*:** *Talabs* are natural or artificial ponds, generally having a length and breadth of 10-12 m. Water in these ponds dries up just a few days after the rainy season and then people harvest crops like rice and *pasai* on the pond bed. Till independence, almost every village had at least one *talab*. According to an estimate, there are about 600 irrigation tanks in the whole of Bundelkhand having a total submergence area of 36,000 ha, and 7,000 smaller village ponds having an aggregate submergence area of 21,700 ha.

situated in the middle of fields. These served to satisfy the drinking water needs of the villagers and cattle.

Some larger tanks traditionally had small structures like sluice gates, *chapchas* or small *pucca* (permanent) storage structures built into them for feeding the channels, and for taking water to irrigate nearby fields. But the area irrigated by such structures was typically less than 40.5 ha. The use of tanks for large-scale direct irrigation through canal systems was developed later by Bundela rulers. Several tanks are of considerable size, particularly those at Baldeogarh, Bamhauri-Barana, Lidhaura, Jatara and Virsagar. It is noticeable that none of these tanks with their massive dams, built by the Chandelas and others, were originally intended for irrigation. They were evidently constructed merely as adjuncts to temples, palaces and favourite resorts of the rulers. Their adaptation for irrigation was a modern development.

Bundela tanks

Most of these tanks are bigger in size and used the same site where Chandela tanks existed earlier, such as Virsagar and Sindursagar. Usually Bundela tanks used lime and mortar masonry work and were not as cost-effective or simple as the Chandela tanks. But these structures had *ghats (*solidly constructed steps leading to the water in the tank), *chabootaras*, *kothis* (pavilions) and royal orchards designed to show off the glory of the king who built them.

Not much historical information is available about the builders of these structures and the people who maintained them. Most of the bigger tanks appear to have been built and maintained by kings or rich men. For example, Arjar lake was constructed by Sujan Singh, the ruler of Orchha, Sindursagar of Kudar by rulers of Kudar, Virsagar by Vir Singh Deo I and Madansagar Jatara and Madansagar Ahar by the Chandela king Madan Varman.

The motivation behind the construction of the bigger tanks by the kings and rich persons was mostly philanthropy to meet the water requirement of the local population. Every important village or town had its own water tanks. Often, tank construction was taken up as a relief measure in drought years by kings. Mudara tank in Mudara village is one such example. Tanks like Sudhasagar near Tikamgarh were constructed to beautify the landscape or provide a quiet retreat to the kings. In certain cases such as Futera tank near Kudar, construction or repair of tanks was also forced upon people as a punishment.

During the first decade of the 20th century, rulers of Tikamgarh began to take greater interest in the maintenance of the traditional tanks. According to the *Tikamgarh Gazetteer* published in 1995, it was a time when the former ruler, Maharaja Pratap Singh, seemed to be taking an active interest in both repair of old tanks and new construction activity. For example, in 1909-10 alone, 20 tanks and 103 wells were completed, with an irrigation potential of 943.3 ha. By 1912-13, the irrigated area had increased to cover 36.3 per cent of the cultivated area.

For the purpose of building and maintaining tanks, the system of forced labour or *begaar* was employed by the king. For smaller tanks no data is available in the region. There is no evidence of any established tradition of water distribution or management body in villages. In case of smaller tanks, villagers collectively used to remove silt and repair embankments by *shramdaan*. This practice is being followed in many villages even today, but the community feeling and initiative is rapidly disappearing and there is a growing tendency to look towards the government machinery for even small matters.

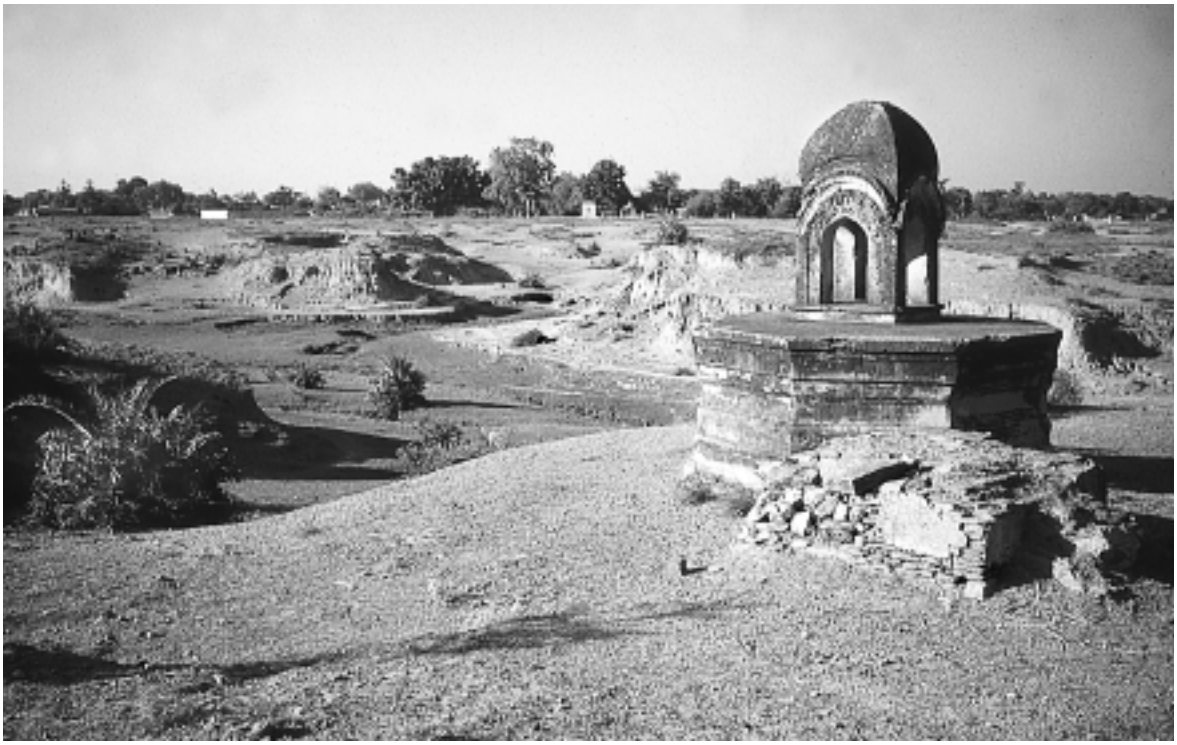
TANK TRAVAILS

Since independence, the irrigation department is maintaining tanks with a potential to irrigate more than 40.5 ha. Most of these big tanks have now been provided with sluice gates and distribution canals. Meanwhile, the soil conservation department has repaired some of the smaller tanks. A few have also been repaired through relief work undertaken under the Jawahar Rojgar Yojana (JRY) by *gram panchayats*. But except for a handful, smaller tanks have hardly been repaired in the last 30-35 years, leaving them in a sad state of disrepair.

Direct irrigation from tanks has both positive and negative aspects. From the point of view of maintaining sufficient groundwater levels throughout the year, direct irrigation from smaller tanks should be stopped. Indirect irrigation through groundwater recharge is provided both by small and big tanks and large quantities of water continue to be drawn from dugwells situated in the command area of these tanks.

These tanks are also a source of indirect irrigation in that they recharge groundwater levels. The tanks, apart from providing direct and indirect irrigation, are playing a major role in fisheries development. Today, the fisheries development programme is being extended to almost all these tanks. Cultivation of *singhada* (water chestnut), *murar* and *kamalghatta* (lotus stems) in these tanks has been crucial to their preservation, simply because leaseholders for the fisheries develop a vested interest in the proper maintenance of the tanks.

The main cause of destruction of traditional tanks has been breaching of embankments which is a result of increasing pressure on land due to population increase and the growing temptation to use the tank-bed for cultivation. In fact, the most important cause



ANUPAM MISHRA

Nothing to guard: An abandoned tank with a guard room

behind the destruction of the tanks is the practice of growing crops in the tank submergence area. Tank-beds, having accumulated silt over centuries, are the most fertile pieces of land in Bundelkhand, known generally for its poor soil quality.

The submerged tank lands are used for growing *rabi* (winter) and, if possible, *kharif* (summer) crops after water recedes from the tanks. The irrigation department leases out tank-beds for controlled cultivation. But leaseholders, in collusion with corrupt *panchayat* and government officials, usually manage to breach the embankments illegally and release the water before the appointed time to take two crops in a year. This is one of the most serious threats to water harvesting systems in the area and there is a dire need to empower local villagers to protect these water tanks through appropriate laws. In case of larger irrigation tanks, irrigation department officials release water as per the timetable set by water utilisation committees. In these cases, leaseholders for agriculture cannot do any major harm.

With growing population and increasing pressure on land, not only are old tanks being destroyed, but construction of new tanks has also become impossible due to the unavailability of common lands. Allotment of common village lands by central and state governments to the weaker sections of society has added to this land scarcity. Although, legally, tank land cannot be given or leased for cultivation, this is being done by showing tank lands as *banjar* (barren) or *usar* (saline). Thus, the only new water harvesting structures possible in the area are check dams, which can be constructed on the numerous *nullahs* flowing through the region.

CONSERVING A HERITAGE

The traditional tanks have been a part of the region's landscape and ecosystem, integrated as they are into the very warp and woof of the people's lives. Heavily silted and in a state of disrepair, they have to be retrieved from decay and restored to their original state.

The trouble and expense incurred is justified because they are useful for *nistar* (human and animal use), direct irrigation and have indirect advantages (like recharging groundwater and wells). They are also useful for the development of fisheries and for cultivation (in submergence areas). There are many more reasons for their better maintenance and repair like their tourist potential, their religiosocial significance and their central place in the maintainence of biodiversity.

A compelling reason for the preservation of these tanks is their indispensibility to the local economy and the livelihood of people in the villages. Finally, preserving a heritage is a national duty that cannot be overlooked for long. ■

Vidisha's Lifeline

When all other sources of water fail, the people of Vidisha still have their traditional sources to fall back upon

Anil Yadav
Ganj Vasoda, Vidisha

Vidisha division in Madhya Pradesh is not a desert where conserving every drop of water is a compulsion. Still, this is what the people have been doing — conserving each drop of precious water. Here it is not unusual to find tanks even in villages situated near perennial rivers.

In Vidisha, the pre-monsoon showers were always accompanied by an announcement (with drum beats) that one person from each household must come out to cleanse the *pakhi* with *Boodhe Nawab* (title given to an aged head of a community). The *pakhi* was a two kilometre long wall of rough, unfinished stones. It prevented water from the hills from flowing away and getting wasted. Instead, it redirected the water towards the village to fill a tank which was the veritable source of life. Over the years, it started looking like a *nullah* because of a constant flow of water through it.

This *nullah* would get heavily contaminated by people and animals wading through it. The stones from the walls would get dislodged and roll off. It would get littered with cowdung and wild shrubs would grow everywhere. The rulers and the ruled, the children and the old, all used to come together before every monsoon to clean it so that pure, clean water could flow to the village tank.

There was a ban on defecation along the tank's banks. If somebody was caught in the act, he was made to carry away the night soil. Second time offenders had their feet tied to a heavy log on the *nawab's* orders. Every Wednesday, there would be an announcement with drumbeats that nobody should go to the tank to ease themselves.

Near the tank was the Motia well which received water percolating from the tank. The Bola well in the tank itself, along with the Motia, was the source of drinking water. There was a *baori* (stepwell) also close to it, yet another source of clear water. At one side of the tank was the *duhela* made after erecting a wall. This 33 metre (m) x 15 m structure was the swimming pool of the *nawab.*

OFFERING INCENTIVES

Planning for the *pakhi* cleansing operations began much before the first break of rains. When the summer was at its peak, *boodhe nawab,* the ruler of the small fiefdom of 28 villages, would appear at the bank of the tank every morning and evening with baskets full of luscious mangoes. He would then throw the mangoes in the tank and scores of children would dive in to retrieve them. This was a sport for the children and entertainment for the *nawab.* It was also a warmup exercise for the cleansing of the *pakhi* within the next few days when the same children would join the adults and the elderly to clean the *pakhi* by cutting off wild grass in its crevices, cleaning it of a year's debris of leaves, dirt and cowdung, so that clean water could come through it to the tank.

This annual ritual continued well into the 1960s after which it died down. A similar practice was followed in Khamb Tale village, about 100 kilometres away till around that period. This village, situated a few kilometres away from Sanchi's historic Buddhist monuments, had its own centuries-old tradition of tank-cleaning. Every family depending on the tank for irrigation had to contribute to the cleaning in proportion to the land it had to irrigate. The temple priest decided who could dig how much of soil from the tank. As long as this tradition was alive, the tank was functional.

In addition to the *tals* and *talaiyas* (small tanks and ponds) of the Gwalior princely estate in Bhalesa and Bhang Basanda tehsils, there still remained 47 big tanks

which deserve mention. In the *chappaniyan kaal* (a great famine), the Gwalior princely states undertook a food-for-work programme, when seven new tanks were built on susbsistence wages. The workers were paid according to the work done. One advantage of the system was that even weak and sick people could do some work to earn their food. The largest of such tanks was built in 1910 in Puraghatera at a cost of more than Rs 1 lakh.

OVERCOMING SALINITY

There is a famous tank at Sironj built long ago. In the 17th century, it was an important campsite for caravans carrying goods from north India to the Surat port. An important regional administrative headquarters since Sher Shah Suri's time, Sironj continued to be a famous centre of cloth weaving and printing till the early 20th century.

Sironj's fame spread to far off places, including the Middle East because of its fine muslin cloth known in India as *malmal* as well as for its printed textiles. French traveller Jean Baptist Travenier also praised the textile in his travelogue. Armenian merchants used to come here to buy cloth. This textile industry, however also happened to be a major source of water pollution. The rolls of fabric to be printed were soaked in the river water and, after printing, long lengths of cloth were held against the flow of the river water with their ends tied to pegs. The river flow used to wash away the extra colour and make the rest of the impression fast and bright. The process made the water of the small Kaithan river tinged with colours. The animals of traders' caravans also contributed to the pressure on the river. Mercifully, colours used for cloth printing in those days were not made of toxic substances.

To sustain all that activity, water was needed. However, the groundwater had become saline. Some believed it was a divine curse.

Sironj people did not lose heart. They made a dam on the *nullah* flowing through the town which carried the runoff from the hills to the south. That led to the creation of a big tank. The Sironj market that exists today was merely a *nullah* then. Habitations like Hadipura, Kahra Bazar, Bada Bazar and Talaiya too are situated on the erstwhile *nullah*. The early town planners had, by removing the *nullah*, allowed the town to expand. On the other hand, they made a proper provision for the drinking water supply of the local people and the men passing by in their caravans as well as for their camels, mules and oxen.

To avoid the salinity of well water, the Sironj people dug their wells close to the tanks. Famous wells like Shakkar kunwan, Mandi ka kunwan, Hammam kunwan and Hijron ka kunwan were among the dozen or so wells that provided drinking water to south Sironj. The Shakkar kunwan was thus named because at a

ANIL YADAV

Kuwan *at Sironj, in the Kaithan riverbed. As the river recedes, these wells meet water needs*

place where saline water was so abundant, it provided water that was sweet like sugar. *Hammams* (public baths) had been a speciality of Muslim rule. As it was impossible to bathe in saline water, they brought water to the public bath from one of the wells of sweet water. Hence, it was known as Hammam kunwan. There are no *hammams* left today but the Hammam kunwan is still around, full of sweet water.

Sironj's lifeline was the Kaithan river. The wells in the town had saline water. The wells were not only saline and insufficient in number for the city population, they were also inconveniently situated away from the northern habitations. To overcome these problems, the local people built more than two dozen wells right in the river. During the monsoons when business was at a standstill and the caravans had stopped arriving, most of these wells were submerged under river water. These were also the days of minimum pressure on water resources. However, soon after *Diwali* festival, all roads were open and business flourished again, increasing water consumption. At this moment, the wells, full of water, used to emerge out of the receding river water one by one.

When piped water supply was introduced in Sironj, the government put up water pipes from Kaithan dam. However, when some residents complained that there was no force in the water flow in the pipes, the water supply department put up a motor pump right at the Hammam kunwan. Today, this old faithful is the only source of drinking water for some of the outlying areas of the town.

Even today, people of areas where there is no water supply, walk through the river's sandy edge, wade through knee-deep water and reach these wells to fetch sweet, potable water. ■

Decline of a Grand Tradition

Mismanagement by government agencies is threatening the existence of over 43,000 traditional tanks in Bhandara district of Maharashtra

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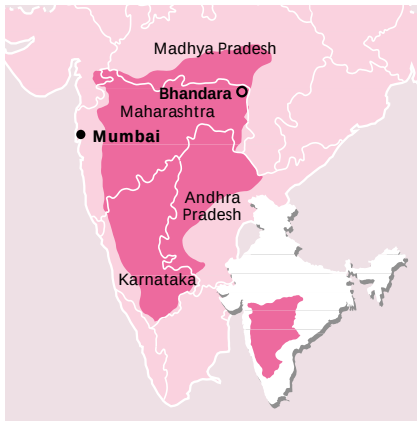
Vidharbha Nature and Human Science Centre, Nagpur, Maharashtra

Bhandara district of Maharashtra has 43,381 tanks, built some 250-300 years ago by a small group of cultivators called Kohlis. These community-managed tanks constituted the backbone of irrigation till the government took them over in the 1950s. Inept management and an alienated local population have almost destroyed these tanks. Water from these tanks is still crucial for irrigation of sugarcane and rice. These tanks meet about 25 per cent of the irrigation requirement in the district, a sharp decline from 78.73 per cent in 1961-62.



Bhandara district is spread over an area of 92.80 hectares (ha) and had a population of 1.84 million in 1981. Historically, the entire district fell within the erstwhile boundaries of Deogarh, Mandla and Chanda kingdoms of the Gonds. The soil of the district is highly varied, locally called as *morand* and *sihar* types. *Sihar* is best suited for rice cultivation, while *morand* is devoted to *rabi* (winter) crops like wheat, linseed and sorghum. In every *taluka* of Bhandara district, the proportion of irrigated area is considerably higher than the state average.

TANKS GALORE

The Kohlis built tanks of all sizes *(see Table 1: Tanks of Bhandara district)*, often with provisions to bring water literally to the doorstep of villagers. Constructed during the Gond kingdom some 250-300 years ago, these tanks in the Wainganga valley ensured protection against monsoon failures. A village called Ashti in Tumsar taluka of Bhandara district has an amazing collection of 56 small and big tanks and 22 *boris* (very small tanks), all traditional structures built by the Kohlis. There is also a network of channels in the village which leads to practically every house, and, in cases of emergency, water can be made available to all households at their doorstep. An efficient system was in place to ensure equitable distribution of water and maintenance of the tanks *(see Box: Equitable water management)*.

Historically, forest lands were allotted to people for habitation and cultivation, through a person called the *patil* or *malguzar*, who established villages with families coming from various places. These villages needed their own tanks for drinking water and irrigation. Even today, these tanks continue to serve as vital sources of irrigation and farming of *singhada* (water chestnut) and *khus* (*Vetiveria zizanoides*). They are also used for freshwater fisheries that provide livelihood to many people.

Depending on the geographical location of the site, the Kohlis constructed two types of tanks. The first type, mostly constructed in the hills of Gaikhuri range of Navegaon and Palsagaon, had catchment areas

Table 1: Tanks of Bhandara district
A network of tanks and channels brought water to every house

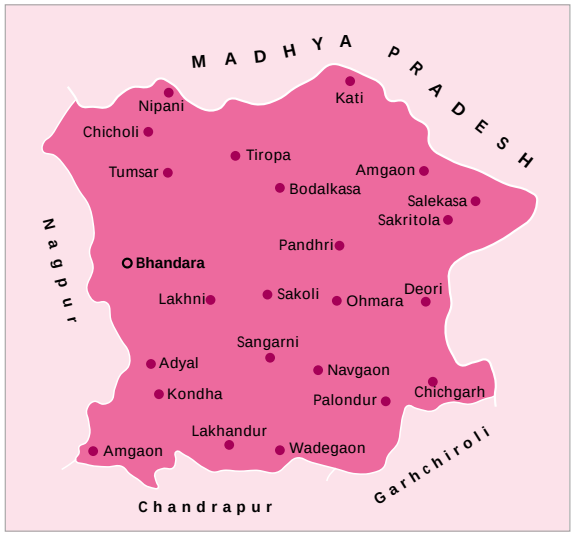
Size of tanks (hectares)	Number of tanks
10 or more	238
4-10	3,007
2-4	7,534
1-2	13,289
Less than 1	19,313
Total	**43,381**

ranging between 100-40,000 ha. The second, smaller in size, was generally constructed in the foothills or on valley slopes by putting up earthen embankments, only a few metres in height, on the lower end of an inclined land plane. Being shallow, water supply often failed in these tanks during summer, particularly in low rainfall years. However, these tanks still continue to be an important source of irrigation and freshwater fisheries.

MYSTIQUE OF THE KOHLIS

The procedure followed in identification of tank sites as well as their construction was fascinating. In an age when no modern level measuring instruments were available, the Kohlis used to decide the height and position of a bund with an indigenously developed knowledge base. For selecting a site, a person would lie on his back in the central part of a selected area and press his toes together with his interwined palms on his stomach. He would then align the lower end of the gaps between the thumbs of the palm and the toes by lifting his head a bit. On a descending slope, this exercise was carried out to decide the height of the bund while, on an ascending side, it was performed to find out the water-spread area. By making such small but meaningful observations, the height of the bund was decided. A similar exercise would be carried out at the centre of the site which would give him the exact site of the bund and the size of the bowl. Legend has it that the great tank of Navegaon was built after careful selection of the site by observing the level of dust and grass particles on trees and surrounding hills.

Bhandara district, Maharashtra



BUILDING WITH EXPERIENCE

The bund of a tank was constructed in stages, over a long time, using black cotton soil or *kanhar mati*, a hard soil with remarkable water-holding capacity. First, a small bund of only a few metres in height was built at a selected site and water was trapped behind it to allow gradual hardening of the bund soil to provide strength to it. The height of the bund was finalised after careful observation for years. In case a bund failed to resist water pressure, the foundation was reinforced by a mixture of stones, oil, lime and jaggery. All *nullahs* or

EQUITABLE WATER MANAGEMENT

Effective water management systems were in place to ensure equitable distribution and maintenance of water supply systems

The 16 anna *malguzari* system was prevalent in the entire Bhandara district. A *malguzar* was appointed by a king to collect revenue and look after the overall administration of an area. The *malguzar* deposited a fixed amount of revenue to the king and in case of surplus revenues generated, the *malguzar* stood to gain. However, during a bad season, he had to bear the losses as well.

To ensure that no loss was incurred, the *malguzar* personally supervised tank building, maintenance and related activities. This minimised crop failures due to water shortage. If there was any damage to tanks, canals or the outlets, villagers repaired them under the supervision of the *malguzar*. For distribution of water, usually there would be a committee consisting of a *malguzar* and 4-5 respected persons from a village. The decision of the committee was binding on all farmers.

This committee used to appoint a person called *pankar*. The duty of the *pankar* was to release water to farmers and ensure that decisions taken by the committee were being implemented properly. The *pankar* supervised maintenance of the canals also. By choice, the *pankar* appointed was usually a landless labourer, and thus had no personal stake in the distribution of water. Each cultivator used to set aside a share of his crop and provided clothes to the *pankar*.

Anybody found guilty of damaging a canal or a tank was denied his share of water for the year and in case he had already availed of his share of water, he was fined in cash or kind. If he failed to pay the fine, then he was denied his share of water next year.

Those cultivators who had worked on tank construction and maintenance were provided water free of cost for their crops. The silt (*pakan*) dug out of a tank bed was utilised as fertiliser in fields. Desilting exercises took place once in three years, and were decided by the *malguzar*. However, any cultivator was free to dig up silt as and when required, with the permission of the *malguzar*.

streams in a catchment area were diverted towards the bund to increase water quantity in the tank. Wherever possible, another tank was constructed downstream to receive the excess water flowing out of the tank.

All these tanks had a gentle slope over which the excess water could flow out. Along with water, eggs of some fish used to flow out for incubation and later, young fish would travel back to tanks over the gentle slopes of the waste weirs. But after restructuring and redesigning of waste weirs by the government in recent years, young fish can no longer come back to tanks, which has badly affected native species.

THE ART OF DRAWING WATER

Different mechanisms called *tudum* or *monga* are employed to draw water from reservoirs for irrigation, depending on the size of a tank *(see Fig 1: Drawing water)*. For a very small tank or a *bori*, a straight tunnel across the base of the bund is constructed using stones. A log is pitched at the mouth of the tunnel and plastered with clay which is removed whenever water is required. For a medium or large tank, a straight tunnel across the base of the bund is constructed using stones over which a stair-like structure (*monghad*) is built, with a hole (*dachcha*) in each side. This hole is stocked with either a stone slab or a wooden log and carefully plastered with clay.

The other method employed is to use a hollow tree trunk across the base of a tank, to which another hollow tree trunk with holes at regular distances is placed vertically. These holes are plugged with cogs which are removed to draw water. This system requires frequent repairs as tree trunks often rot quickly. Very few *tudums* of this kind are found these days because of the stringent forest laws, and the unavailability of wooden logs.

FAILURE OF GOVERNMENT INITIATIVES

As soon as government took over the management and maintenance of these traditional tanks, their decline began. With the Abolition of Proprietary Rights Act (APRA) in 1950, proprietary rights over the tanks were transferred to the irrigation department and the *zilla parishads* (district councils). These government agencies, though entrusted with the responsibility of repair and maintenance, were not adequately equipped to look after the large number of tanks.

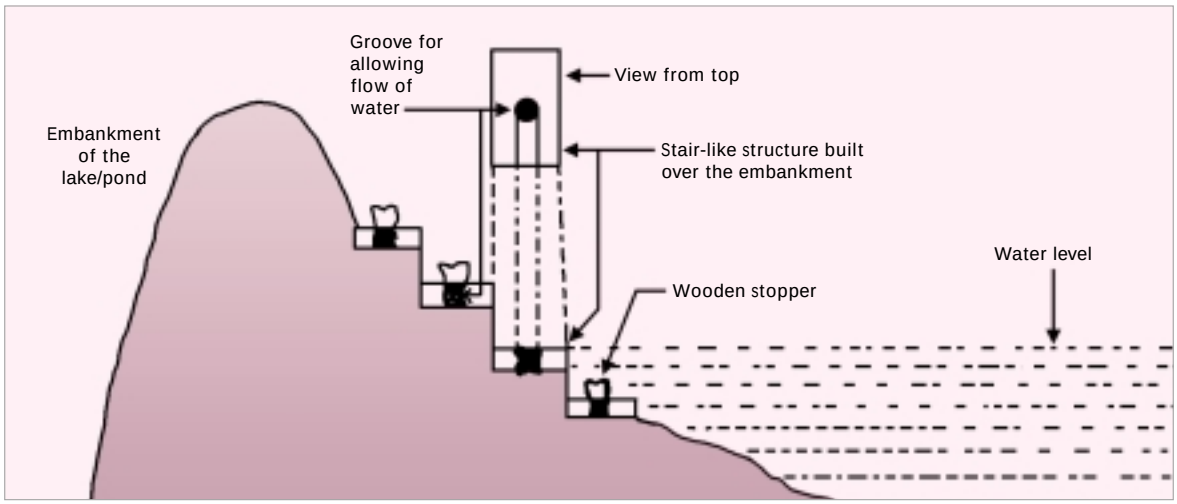
In the late 1960s, the government introduced 'modern techniques' to increase water-holding capacities and improve water distribution systems, replacing most of the traditional local structures with disastrous results. The government failed miserably to maintain the new structures. As a result of these two moves, the local villagers lost their emotional bonds with the traditional water bodies since they no longer had a say in their maintenance or well-being. Neither could they relate in any meaningful way with the complicated structures constructed by the government.

In many places where new structures are left behind as non-functional specimens, people have fallen back to traditional techniques of water harvesting and distribution, freeing themselves from the clutches of an external agency, namely, the government.

At the local level, where people have devised their own simple but effective means of meeting their water requirements, interference by an external agency, which cannot deliver goods, is unnecessary. ■

Fig 1: Drawing water

A sectional view of *tudum* — a mechanism employed in stone dams to draw water from the reservoirs for irrigation



Riches of Rayalaseema

The Rayalaseema region of Andhra Pradesh has a treasure of water harvesting systems, conveyance networks and institutional mechanisms custom-made to suit local conditions

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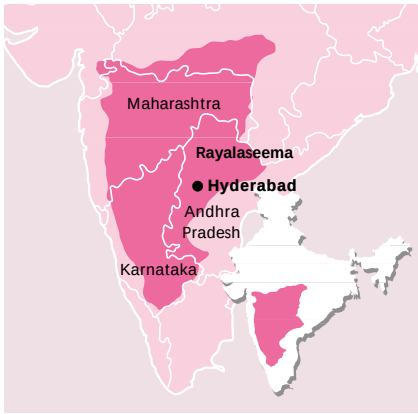
Traditional water harvesting systems of Rayalaseema region of Andhra Pradesh reveal fascinating attempts to capture the water available through either a plethora of harvesting systems or a complex water conveyance network. With the onset of modern water management systems, there has been a decline of these traditional systems. Since the former are cost-intensive as compared to the latter, these have increased the divide between those who can afford and those who cannot. Recent attempts by the Andhra Pradesh government to revive these structures through the formation of water users associations do not hold much hope.



Rayalaseema region lies in the semi-arid region of the Deccan Plateau. Several water harvesting structures exist here with a rich terminology that reflect the various techniques of water utilisation. In Kalahasthi plains, for instance, where the topography is flat with a low gradient and the average rainfall about 1000 mm, the water harvesting systems are the large Kalahasthi tanks, fed through river and reservoir canals. In Palamanda and Akepadu, where the terrain is hilly with wide valleys, and the average annual rainfall about 600 mm and 900 mm, respectively, a series of water harvesting structures interconnected to harvest all the water are found. Another striking difference between these two examples is that in the Kalahasthi plains, great efforts were made towards technological and institutional innovations of judicious application of water, while in the latter, the emphasis was more on creating a series of water harvesting structures.

VARIED INHERITANCE

Palamanda, derived from *palem*, meaning local territory, is located in Chittoor district and comprises of 21 villages. The topography of this subregion comprises of discontinuous hilly terrain with tiers of huge fissured boulders. These hills, an extension of the Seshachal hills of Tirupati, gradually descend into an undulating valley of hard rock, interspersed by patches of black/brown soil, used as agricultural fields, before reaching the plains. The agricultural fields are small in size, built as terraces along slopes, water courses and *jaedu gaddalu* (hummocks). On the whole, the area available for cultivation is meagre.

Akepadu, an ancient feudal area, comprises of 14 villages in Cuddapah district, falling under the jurisdiction of Rajampet taluka of Cuddapah district. It has a similar topography to that of Palamanda, but for the expanses of plainland amidst patches of undulated rocky uplands and mounds with meandering streams, brooks and a small river called Cheyyeru.

Kalahasthi, located on the eastern side of Chittoor district, adjacent to the coastal district of Nellore comprises of a vast fertile basin washed by a seasonal river, Swarnamukhi, and rivulets like Rallakalava and Kalangi. This area is a vast plain area of agricultural fields and meandering streams draining into the Swarnamukhi river.

Warangal district, also in the Rayalaseema region, had its share of water reservoirs built by the Kakatiya kings *(see Box: The legacy of Warangal)*, who, perhaps for the first time,, attempted to provide irrigation to cultivable lands in the plateau regions.

THE LEGACY OF WARANGAL

The efforts of Kakatiya kings 900 years ago still bear fruit

The historical city of Warangal was built by the Kakatiya kings about 900 years back. Existing records indicate an excellent system of traditional water harvesting through the construction of reservoirs, tanks and small *kuntas*. These are in existence even now. The entire area is studded with hill streams, and 3,500 rainfed tanks and 42 medium-sized tanks. The major reservoirs like Ramappa and Pakhal Laknavaram stand testimony to the technical farsightedness of these rulers. Their objective was simple:to harness every drop of rainwater. The kings selected the highest point on the Godavari Krishna drainage divide, which has limited potential. This site was strategic from the defence point of view also. They then proceeded to build a network of reservoirs across river valleys, collecting surplus water upstream and impounding it at suitable locations. They built massive earthen bunds to block the valley and the tank was created. To withdraw the water from these tanks, sluice gates were located on the site. These hydraulic structures helped recharge the groundwater. To commemorate major irrigation projects, magnificent temples were built, one of these temple reservoirs that serve the population even today is the Koneru.

There are no established documents to ascertain the engineering involved in the building of these reservoirs, but a study shows that they had a practical approach to the whole concept. The *bund* was built with a gigantic piece of earth, which had a large top width and bottom base. These medieval kings also studied the hydrological aspects as can be concluded from the presence of feeder channels from the rivers to the tanks located in isolated villages where the local flow is not enough to fill the reservoirs. These rulers were farsighted as they made provisions for flood absorption capacities in the bigger lakes.

The Kakatiya kings also displayed democratic norms as it was observed that the users and the villagers managed the normal operation of the reservoirs. The guidelines prescribed by them are helping even today in managing the new reservoirs as well as the old ones.

These reservoirs have stood the test of time, catering to drinking and irrigation needs. These reservoirs do not have problems of sedimentation. Unlike present day reservoirs, which have a life span of 50 years — the silting up of the Nizamsagar reservoir in less than 40 years, has led to a loss of 65 per cent of its storage capacity, and Sriramsagar on the river Godavari with an estimated life span of 60 years, stand mute testimony to this.

The ancient reservoirs are being used even now. The Bhadrakali and Waddepally tanks have been converted into summer storage reservoirs to deal with the water shortage in summer. The main source, Dharmasagar reservoir, is now filled with water pumped from the old Kakatiya channel. It is indeed the vision of the ancient rulers because of which their technology thrives till today.

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WATER STORAGE STRUCTURES

Water harvesting structures here range from big to small pits.

Cheruvu (tank)

Cheruvus are very popular in Chittoor and Cuddapah districts. These are storage reservoirs of runoff water with an embankment having suitable fittings like *thoomu* (sluices), *alugu* or *marva* or *kalju* (flood weir) and *kalava* (canal). Sometimes, in between the sluice's outward opening and the canal, a masonry or stone carved tub or a shallow pit like structure exists.

Tanks in Palamanda and Akepadu area may be termed as chain tanks. From the high gradient near foothills through valleys to the base level, several tanks are constructed. Each one is connected to the other by *marava kalava* (canal) or *vanka* which carry surplus flows of upper reach tanks towards lower reach tanks. Some tanks may also receive drainage from their own free basin. The tanks in Kalahasthi area are mostly system tanks wherein a canal from nearby river (Swarnamukhi Anakatta) and a reservoir (Mallimadu reservoir) feed the tanks of several villages.

BINAYAK DAS / CSE

The* cheruvu *in B Tamrapadu village of Andhra Pradesh

There are certain differences in tank systems seen in Palamanda, Akepadu and Kalahasthi areas. Most of the tanks in Palamanda and Akepadu are small in size and capable of irrigating *ayacuts* (command areas) of less than 50 hectares (ha). Sometimes, *ayacuts* are as small as 0.4-6 hectares (ha). Many other water harvesting structures are found between chains of these tanks. In contrast, tanks in Kalahasthi are generally large in size, irrigating fields of several villages. Twin tanks are also common. The Thondamandu village tank supplies water to as many as 15 villages.

Tank bunds in Kalahasthi area are usually narrow with short or medium heights ranging from 1.5-3.5 metres (m). The catchment area of these tanks is generally vast, running into hundreds of hectares (ha). In Palamanda and Akepadu, tank bunds are robust and wide and their height ranges between 6-9 m. The base level has several tiers of large stone slabs. But the catchment area is usually small comprising a maximum of 40.5 ha. This design facilitates storage of maximum water in a limited waterspread area. Further, these tanks have one or two main canals or one canal under one sluice. More than one canal takes off from a single sluice in Alatthur, Mallavaram, Madamala and several other tanks in Kalahasthi region.

Kunta (small tank)

Kunta is commonly seen in Palamanda area. It is a smaller version of *cheruvu*, consisting of a small bund, one sluice and one flood weir. It usually irrigates small areas of below 16 ha but an *ayacut* of 6 ha is common. Usually a *kunta* is located in between two tanks. A stream or *morava kalava* (canal) for surplus runoff links them. Sometimes *kuntas* are located at higher gradients. Such structures act as small reservoirs meant for receiving percolation water oozing out of *juedu gaddalu* (hummock) and receive surplus water from tanks when they are situated at lower gradients. Soravalo kunta in Palamanda and Siddappa kunta in Akepadu are examples of these types.

Oddu (artificial *bund*)

Oddu is an artificial bund usually laid horizontally across a *narava* (gentle basin slope). The bund may or may not have sluice and flood weir. The bund is usually 150 metres (m) in length and 4-10 m in height. *Oddus* are predominantly seen in slopes of medium width originating between two hills. They are popularly seen in Palamanda and Akepadu. The main uses of *oddu* are to irrigate fields at higher gradient and to store surplus runoff from hills when located at lower levels. The surplus runoff in the *oddu* is drained into another *oddu* or *cheruvu* downwards.

In Akepadu, a small bund laid across the *vaka* (stream) to store water is also called *oddu*. The stored water is diverted to the fields. A stone slab is pitched in the tank canal to raise water level so as to feed a canal or field at a higher elevation. Dyanapa oddu, Pedda oddu and Chinna oddu are seen in Palamanda.

Anakatta (temporary *bund*)

Anakatta is popularly seen in Akepadu and Kalahasthi regions. *Anakatta* is either a makeshift temporary bund or masonry structure. It is laid either perpendicular against the flow of water in *yeru* (river) as in case of the Swarnamukhi or parallel in the direction of water flow, a few feet away from the bank, as in the case of Cheyyeru in Akepadu area. By these bunds, water level is raised and diverted into a canal through a sluice and taken to fields. The *anakatta* at the Swarnamukhi river near Kalahasthi supplies water to 25 villages. The *anakatta* near Mandapalli of Akepadu area is small, irrigating about 60 ha. Parallel shallow pits of moderate size located in front of the tank bund towards *ayacuts* are also known as *anakatta* in Busapalem and Velavedu in Kalahasthi region. These structures serve to store water percolated from tanks or excess water flowing out of tanks.

Kanju (artificial check dam)

Kanju is a local type of artificial check dam constructed across a stream flowing at lower slopes or base levels. These are very popular in Palamanda. Flat stones are used for building a slanting platform. Its elevated side faces towards the direction of flow. The water level is thus raised and a portion of water is deflected into an unregulated distributary to carry water to *doruvu* (fields). The streams receive water from *javukulu* (oozing hummocks) for about nine months, except in summer. In Jangampalle, at the fringe of Palamanda area, about 30 ha are irrigated by this arrangement. Ankaloni kanju in Bedabolla Vanka near Gayam Vari Palli in Palamanda region irrigates about 30 ha.

Madugu (wide, natural well)

Madugu is a naturally formed, perennial, wide well or a sort of pond of great depth located usually in the beds of *gunjana* (streams or rivulets, full of pebbles and boulders) in Akepadu area. During rainy season, water from *madugu* overflows either into a stream, rivulet or canal which irrigates nearby fields. In summer, water is lifted by electric motor. In Rolla madugu of Akepadu forest, *kapili* (bullock-drawn lift) is still used to lift water. The *madugus* are generally associated with folklore and fairs, Puttangi madugu, Rollamadugu and Hathyarala madugu in Rajampet taluka are all connected and the surplus water drains into Cheyyeru. *Madugus* are used both for irrigation and feeding the rivulet.

V GANGADHAR

The Rayalaseema region has a rich diversity of water harvesting structures

***Kesev* (dugwell)**

It is a sort of well dug in a stream or river bed in the plains. In olden days, water was lifted by *yatam*, a water-lifting device. Presently electric motors are used to lift water for irrigation, popularly seen in Alathur of Kalahasthi area.

***Botta bavulu* (dugwell in tank bed)**

These are wells dug in the tank bed or *oddu* beds in Palamanda area by important village leaders. Most of these are now discarded. In olden days, water was lifted by *kapili*, a bullock drawn device. These might have also been dug to enhance the storage capacity of *oddus*.

***Doruvu* (small pit)**

Doruvu is a small *guntha* (pit) dug by the side of a stream passing through lowlands. Water from the stream is drawn into *doruvu* by means of a conduit. No bund is laid across the stream. Water was once lifted by *kapili*, *guda* (swing basket), or *yathamu*, but now mostly pumpsets are used. In Palamanda area, numerous such structures are now in ruin. The masonry work called *mota*, comprising tiers of stone bed (*soodi rallu*, *pooti maanu rollu* and *done banda*) laid on the pit is also called *doruvu*. A lifting device is installed in this structure. *Doruvus* have specific names like *ankalori doruvu* in Bedabollonka in Palamanda region.

In coastal districts of Andhra Pradesh, numerous pits of three metres depth are dug along the coast to get freshwater used for drinking and irrigation. These are also called *doruvu*. Water is carried in pots and sprinkled in the fields. *Doruvus* are also dug near the periphery of the tank in Pulapattur village in Akepadu area.

***Chelama* or *chelma* (natural springs)**

Chelama is a naturally formed spring in the foothills or in ravines. Depending upon its potential, it is deepened or enlarged by villagers. Many of these are perennial and used for irrigation and drinking. *Chelamas* vary in size and are generally round in shape. A small *chelama* has a diameter of about 2.5 m and big one has about 10-15 m. A portion of *chelma* towards slope direction is drawn into a sort of neck which proceeds further to form a long furrow or canal linked directly to a *cheruvu* or *kunta* or to a feeder channel of a *cheruvu*. *Chelama* is an important source of water supply for small fields of about 12-16 ha for raising two wet crops.

In Palamanda, small pits (sort of farm ponds) are dug at the corner in a terrace field. Sub-surface water along the *narava* (a patch of gentle slope taking off from a certain level on a hillock) gets collected in this pit. One wet crop and one dry crop are grown in about 0.6-1.2 ha area by using water from these *chelmas*. As these water bodies are very important for poor or marginal farmers, special care is taken to protect them. Animals are prevented from entering them. In Akkagarla chelma in Palamanda, a shrine is dedicated to a local deity called Akkagarlu who is supposed to turn intrusions by animals and humans into the water body harmless.

***Dona* (natural pool)**

Dona is a small natural pool of water usually located in hills or rocky places. Some of them are perennial. The

overflow drains into the streamlets and brooks. Humans and cattle mostly use these for drinking purposes. Yeddulakondda dona and Yanadi Banda dona in Akepadu, and Nerella dona, Veera Bhadruni dona and Akkogari dona in Palamanda are examples of such structures. Some of these are associated with local deities and are considered sacred. Water in these structures are protected even in the worst drought conditions.

***Bondalu* or *selalu* (shallow pits)**
These are natural pits of about 1.5-2 m depth seen within the fort or isolated areas of Palamanda and are used for drinking purposes, mostly by pastoral people.

***Padi* (small, shallow pit)**
Padis are small, shallow pits of about five square metres in size. These are formed either naturally or by animals wallowing in them or made by humans, specifically for harvesting runoff. They are generally found inside the forest or on the foothills or pasture lands. The depressions in the tank bed right in front of sluices or middle portions are also called *padis*. People say that water has reached only to the level of *padi*, meaning water level in the tank has not yet reached the sluice level. Water in *padis* is usually stored but in Palamanda this water is also lifted by means of *guda* (swing basket) for irrigation. These pits store rainwater and entry into them is restricted.

***Guntha* (hollow pit)**
In common parlance, *guntha* means a hollow pit. As a water harvesting structure, it is located either in tank beds, stream beds or banks, or in nearby agricultural fields. These are excavated for collection of rainwater or groundwater usually in the foreshore area of tanks or in dried up riverbeds, stream beds at a distance away from the bank or bund where a water pool is found. *Gunthas* are connected to *padis* or water pools or sometimes *botta bavulu* (well dug in tank bed) by means of *sanna kalava* (narrow channels). *Gunthas* are commonly found in tanks at Palamanda and Akepadu and in streams in Kalahasthi.

***Gunta* (bigger hollow pit)**
Gunta is another water harvesting structure, located in a deep slant depression and without any sluices or weirs and is usually meant for collection of rainwater or sub-surface water during rainy season. Its four sides are sometimes stone-riveted and used as *puskharini* (pond) in shrines.

***Pathulu or pathi gunthalu or kopu gunthalu* (excavated pits)**
These are excavated pits in tank beds. The excavated soil is used for reinforcement of tank *bunds*. Sites with groundwater or sub-surface water sources are selected for excavation. These depressions may allow water to ooze out in the lean period.

***Bookenaguntha* (small depression in a well)**
It is a small depression made in the well in order to scoop out water by *bokkena* (metal drum) or leather bag of a *kapila*. Sometimes a *pilla bavi* is also excavated in the well to capture spring and percolation water.

***Guda gunta* (small pit in high gradient)**
It is a small pit containing rainwater fed from a nearby source for irrigating fields at higher gradients. A swing basket called *guda* is used to lift water. This practice is very popular in Palamanda area due to the steep gradient and the small size of the farm plots.

NATURAL WATER SUPPLIERS

The sub-regions of Kalahasthi, Palamanda and Akepadu have various types of naturally formed channels which carry water to various storage structures.

***Kona* (big stream)**
Kona refers to bigger streams running for several kilometres meandering through valleys. *Kona* has specific names and may have springheads. Some of them begin as a *vanka* (streamlet) before becoming a *kona* (for example, the Theegalavanka of Reninthala in Akepadu becomes the Mallakona). Water from *kona* is used for irrigation also. A *kattu kommu* (a barrier across the flow) is laid in *konas* as in Vogeti kona and Gundala kona in Akepadu and through a canal, water is drawn into tanks such as Y. Kota cheruvu in Akepadu region.

***Vagu* or *vaka* or *vanka* (natural drainage channels)**
These are naturally formed drainage channels mostly confined to areas near foothills or in tank catchments / village habitat. These channels travel some distance along slopes to join a reservoir. These are usually disjointed channels connecting a series of water reservoirs like tanks and *oddus* (small reservoirs). They serve as feeder channels to tanks and other storage reservoirs used for irrigation.

***Badava* (narrow short passage on the hill)**
Badava is a naturally formed narrow short passage generally running laterally or along the slant along the slopes. Several of them join a *kona*. A few of them confluence at a vantage point near the foothills to become a *vagu*. Marshy patches in the wastelands in the plains are also called *badavas*. The major use of these channels is to collect rainwater.

***Sela* (puddle)**
Sela is a sort of puddle in a rocky place from which

water keeps flowing. The watercourse may usually lead to another bigger *chelma* within the hill. *Selas* have names like Pandi sela and Ragimamu sela in Akepadu. Sometimes the watercourse may also drain into a *vagu* as in case of Kommi sela in Palamanda.

Gunjana (rivulet)

Gunjana eru is a rivulet, an effluent of the Cheyyeru, in Rajampet taluka in which Akepadu falls. *Gunjana* is a corrupt form of *kunjara* or *eru kunjara* meaning large-sized pools in rivers as habitats of elephants. In Akepadu area, certain long streams are also termed as *gunjana* that originate in distant hills. These are characterised by sudden and rapid gushes of runoff and have perennial *madugus* in them. Vegetikona gunjana and Mushteru gunjana are few such examples. The bed of a *gunjana* is usually covered with pebbles in contrast with an *eru* which has sandy beds. *Gunjanas* drain into *erus* or into *madugus.* Water in the *madugu* is used for irrigation. *Gunjana* seems to have a function of quick drainage of rainwater.

Yeru or eru (seasonal river/rivulet)

Eru is a seasonal river or rivulet into which several *vankas* or *vagus* drain at different places all along its course before it finally joins a bigger river or sea. *Eru* is an important source for irrigation water in Kalahasthi and Akepadu areas. Water flows in the *eru* for about five months from August to December. Sub-surface water is also extracted. Water for irrigation is taken by means of an *anakatta* or *daruvu*. Presently filter points are used.

SPRINGHEADS AND OOZING HUMMOCKS

Springs and patches of hummocks which are marshy lands located at high gradients are seen in many parts of Rayalaseema region though most of them no longer exude water. Three local terms are associated with springs.

Jedu or *javuka* (lands oozing water)

In the upper zones on the hills of Akepadu and Palamanda, certain patches of lands ooze out water. This phenomenon is called *jedu* in Akepadu and *javuku* in Palamanda. These lands are bunded so that the low lying lands receive enough moisture and can be cultivated. A canal dug along the bund at its base level collects percolation water to be supplied to fields. The *jedu* effect is also seen in streams and brooks at lower gradients.

Voota (land oozing water)

Voota is a similar phenomenon as *jedu* but occurs at base-levels or plain lands. This term is usually confined to water bodies and not to patches of land. Certain points in streams, wells, brooks and tanks also exhibit this phenomenon.

Kasim (natural spring)

Kasims are naturally formed springs, artificially deepened or widened. They occur along river beds or by the side of certain tanks like Rayalacheruvu in Chittoor district. Many small springs are seen along the river bed of Swarnamukhi. A canal called *kasim kalava* is dug from the *kasim* along the slope for water supply to the fields. It is almost same like *chelama* but for its occurrence on plain lands or base levels.

Bugga (natural fountain)

Bugga is a small natural fountain or ejection which may be seen in a well or by the river side or several metres away from a tank. Generally perennial fountains are associated with temples or shrines. A *koneur* (pond) is constructed. The source of *bugga* and its connection to its source are not usually known. But in some cases, the *bugga* gets activated, that is water gushes out, when a nearby pond or tank is full with water to its capacity. Such a *bugga* exists in the stream two miles away from a tank called Devasamudram cheruvu in Akepadu area.

CONVEYANCE SYSTEMS

Water from these storage bodies is supplied to agricultural fields through several types of canals found mainly in the Kalahasthi area compared to the other two areas. In the Kalahasthi plains, because of the flat low gradient terrain, reservoir canals, diversion canals and system tanks are predominant. These systems also ensured equity in water distribution *(see Box: Benefit sharing).*

Pedda kalava (main canal)

Canals taking off from the sluice of a tank have specific names. A blanket term of *pradhana kalava* or *pedda kalava* (main canal) is also applied to them.

Keedu or *keetu kalava*

This is a wide but short canal taking off immediately from the sluice before it bifurcates into main canals. This channel usually traverses through a bushy and undulated area. Farmers of Mallavaram and Guthivartipalli in Kalahasthi area refer to this name during the annual cleaning operations of the conveyance system.

Panta kalava (branch of main canal)

Panta kalava is a branch of *pedda kalava.* It brings water nearer to the fields. These canals traverse small distances before they divide into branches of equal size called *nattu kalava.*

Nattu kalava

It is a canal that supplies water to a zone in the *ayacut*. Each zone may have 8-16 ha and is known by a name. One or more contiguous zones are called *nattu*.

BENEFIT-SHARING

Technological systems were designed to ensure equitable water distribution

Tank water is distributed between *ayacutdars* (people living in the command area) by means of shares and turns. *Madava, theerava* and *vanthu* or *pootu* are the terms associated with shares and turns.

Madava
Madava means blocking a canal so as to allow water flow through another canal. This way the *ayacut* is irrigated sequentially.

Theerava
Theerava is sharing of water between two canals in accordance with customary practices. For instance, in Alathur village of Kalahasthi region, half of the total flow is diverted to Alathur *ayacut* and one quarter flow each to Kandriga village and Parlapalli village. *Theerava* is also seen within the *ayacut* for simultaneous irrigation in two or more fields.

Vanthu* or *Poota
Vanthu or *poota* are turns to each *ayacut* or *nattu* (zone) in each *ayacut,* usually each field in an *ayacut* receives water every alternate day or once in three days when water in the tank is in plenty.

Gooti madava
The branch of the main canal is blocked in order to raise the quantity of water and then release it into the field channels so as to augment flow speed, which in turn renders quick irrigation.

Medi madava
Medi madava is also called *ubbeda.* In field-to-field irrigation, water in the upper field is allowed into the lower field by a narrow passage. In order to maintain a certain level of water in the upper field, the height of passage is raised by placing a stone slab or mud so that only surplus water flows into the lower field.

Adda madava
Blocking the main canal at its middle portion so that the water level is raised in the canal and water flows directly into the fields through laterals.

Savu madava
Firmly blocking water flow in a canal by putting stones and grass so that the speed of water flow in a canal does not cause a breach, is a form of control that is used during the operation of turns of canals.

Kondamu* or *Vubbu* or *Oddu
Water level in a wide canal is raised at a certain point by means of mud. This is called as *kondamu, vubbu* (in Kalahasthi area) or *oddu* (in Akepadu). This water is used to irrigate high gradient lands located down the canal course.

Yeda
Blocking the flow of water in a canal to divert the direction of water flow is called *yeda.*

Dala
Bunds of certain fields are prone to percolation. In order to prevent percolation, a tiny bund called *dala* is constructed in the field slightly away from the field bund.

***Pilla kalava* (field channel)**
A field channel branching from *panta kalava* or *nattu kalava* is called *pilla kalava*. These canals are useful to irrigate simultaneously several plots of land.

Dompu kalava
It is the branch of *pilla kalava* to supply water to a *dompu* (a small parcel of land of 1-1.5 ha).

***Bode* (furrow)**
Bode is a series of broad furrows made in a garden field to grow millet and vegetables. Water is passed through the series of furrows.

Yeda kalava
A passage of water traversing between two fields is called *yeda kalava.*

Irupakala kalava
When two different watercourses are to be passed side by side to cater to the *ayacut* of two different villages, the name *irrupakkala kalava* is used. It is a twin canal running parallel to each other separated by a common bund as found in Alathur village of Kalahasthi area.

Gunti kalava
Plots of land with gentle slopes are irrigated by *gunti kalava*, furrows or passages made within the plots to spread water to all corners.

Kunta kalava
A channel drawn from a pit or a puddle dug in the field to supply water to other corners of the field.

Mitta kalava
It is a canal beginning at a higher gradient to irrigate high gradient fields. They generally take off from *mitta thoomu* (sluice at high gradients).

Vuddi
Vuddi means a raised platform or passage. In order to supply water to a zone of higher elevation, a canal is

laid on an elevated platform pitched from a vantage gradient. When two canals intersect, a bridge, sometimes a masonry structure or a simple cavity made of mud or a hollowed sliced trunk of palm tree is laid. These bridges have names like Bagadamma vuddi in Akepadu.

Voorugalava or *vootugalava*

It is a drainage passage made by cutting the field bund in order to drain away all water in the field when the crop is ready for harvest. The water may drain into the lower field till it reaches a *nullah* or may drain into field channels.

Kappu kalava or *vanagalava*

In order to drain out percolated water from a field with low duty crop, a deep furrow is made at the edge of the field. This furrow sometimes is made on all sides of the field. It collects percolated water and drains into field channels. In Palamanda this type of canal is called *kappu kalava* or *vanagalava* in Akepadu.

Voota kalava

It is a canal naturally formed as a passage for percolation water from the hills. This canal drains directly into small-size crop terraces. A furrow is made in the bunds or terraces so that water slowly trickles down from one terrace to the other.

Kattu kalava or *katuva kalava*

It is also called *varava*, meaning a channel that brings water to the tank. It begins at a junction on a stream with a diversionary weir to deflect water into the *kattu kalava*. Customary share and durations of water flows exist between several villages which take water from the common stream. This diversionary structure is called *bogi katta* in Mallavaram of Kalahasthi area.

Yeti kalava

It is a channel dug from the river Swarnamukhi in Kalahasthi area to feed tanks in Alathuru and from Cheyeru in Akepadu region. The *yetikalava* (canal) is dug at certain places on the banks so that water can enter the canal. No embankment is built across the flow of the river. Deflection is achieved by choosing an appropriate gradient.

INSTITUTIONAL FRAMEWORKS

Just as the water harvesting systems are varied, so are the traditional institutions associated with the management of water distribution and conservation *(see Box: In harmony with nature)*. There is no unified, centralised, hierarchy-based management system or organisation. Certain institutions loosely associate together to form a loosely defined organisation. These institutions are *amuji* (voluntary community labour, known as *kudimaramath* in Tamil Nadu), *neerkatti* (water tender), *peddarikamu* (leadership or supervisory monitoring role), *manyam* (donated lands for meeting the maintenance cost, implying the existence of patronage) and *bogikatta* or *kattu kalava* share (share of water due to a tank from a common source).

Amuji

Amuji is a local term in Kalahasthi area and is equivalent to *kudimaramath* (voluntary community labour for cleaning the conveyance system).

The responsibilities of this institution include the construction of bunds along the river, diversion of customary share of water from a common source like a feeder channel (*bogikatta* or *kattukalva*) or water reservoir, and watching the *madava* at different places in the conveyance system. Participation is mandatory though a proxy is allowed. Fine is collected for evasion or non-representation. *Neerukatti or* water tender mobilises the *ayacutdars* or landowners in the command areas for participation in the repair operations.

Peddarikamu

There are no named traditional water associations or water *panchayathis* or water leaders. But a respectable person may assume the status of a *peddarikamu*, meaning guardianship to oversee proper distribution of water and cleaning operations of the water distribution system. In Mandapalle village on the bank of Cheyyeru in Akepadu, *kalava pedda* are found. Their duty is to see that required amount of water flows into the *anakatta* and canal. If the *anakatta* is silted or dried up, excavation of stream bed along the *anakatta* is organized by involving the *ayacutdars*. *Kalava pedda* supervises overall work, whereas *adugulu vese ayana* allocates shares of excavation work to each farmer. In Kalahasthi area, when water is scarce in the tanks, two functionaries assume charge of overseeing water distribution: *kalavapina pedda* monitors opening and closing of canals according to turns and *jamu pedda* monitors the duration of flow of water to the fields. *Poota* refers to 24 hours (or 12 hours in some places) and indicates cycle of turns while *vanthu* refers to order of turns. *Idagolu* (12 hours) and *jamu* (3 hours) are used to calculate duration of irrigation to each *dompu/narava* (a zone in the *ayacut* irrigated by a canal). *Beedu jamu* and *kalava jamu* are extra time given for the first time release of water in a season to a field or in a canal to compensate the extra time required. Nowadays these time readings are observed by illiterate farmers.

The *Peddarikamu* position may be assumed by a single individual who acts as a full time supervisor or by a village *sarpanch* (the elected president of the village *panchayat*) who performs a double role. The functions

IN HARMONY WITH NATURE

In Anantapur district of Andhra Pradesh, traditional harvesting systems are designed to favour decentralisation rather than centralisation

Anantapur district located in Rayalaseema region lies between Kurnool district, Cuddapah district and Karnataka state. There are no perennial rivers in the state. The only rivers worth their name are the Pennar, originating in the Nandi hills of Karnataka, and Chitravathi. The rainfall in the district is meagre, untimely and erratic. Droughts are common.

To deal with the situation, local communities in the district had devised traditional water harvesting systems to meet drinking water needs and, to a certain extent, irrigation needs. These include community tanks, river channels, spring channels, percolation tanks and wells. According to the undated records of the Anantapur Zilla Parishad, there were 1,091 tanks, 243 river channels, 1,221 spring channels and 58,483 wells in the district *(see Table: Collective property)*.

Tanks in the district date back to as far as a millenium. Tank construction was neither a big engineering feat nor a challenge. It was simply an act of harvesting rainwater in big and small natural depressions. The chain of tanks that are found here helped preserve every drop of rainwater. Whenever there is overflow of water from a tank, another tank below this was constructed with the help of local skills. There is a reference to 361 tanks forming a chain during the Vijayanagar empire in the district.

By excavating river channels, a laborious job, small surface flows in rivers and streams are diverted by means of temporary sand dams during the rainy season. When the rivers become dry, the channel beds are excavated with large wooden spades, locally known as *goralu,* drawn by bullocks. These channels are annually cleared of silt and sand by the united efforts of landholders and labourers.

Spring channels are observed in Kalyanpur, Dharmavaram, Kadiri, Tadpatri and Yadiki areas of the district. These are taken from hill streams, springs in tank beds, and, in some cases, from ordinary dry lands. Almost every inhabited village has one or more such natural source of water in the district.

Most of these are improvisations on the natural systems. They are made without disturbing them. For instance, water from the river channels is tapped during periods when the flow is unaffected. This allows for the tapping of a single river at several places distributing the *ayacut* all along the course rather than centralising it at one place. This is why the *ayacuts* developed under river channels are small in size and spread along the course of the river. The command is, thus, spread and decentralised rather than centralised.

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Table: Collective property
Water harvesting systems in Anantapur district

Taluk	Tanks	River channels	Stream channels	Other sources	Canals	Wells	Reservoirs
Anantapur	54	30	299	—	345	16,593	—
Dharmavaram	52	34	179	—	430	2,086	1
Gooty	41	27	121	14	335	3,288	—
Hindupur	191	21	05	02	233	1,028	—
Kalyanadurg	67	15	173	62	450	4,448	—
Kadiri	442	07	161	02	360	7,232	1
Madakasira	99	06	77	—	304	8,062	—
Penugonda	122	26	110	01	352	5,355	—
Rayadurg	11	33	42	25	318	3,791	1
Tadipatri	12	44	54	05	301	3,124	—
Total	**1,091**	**243**	**1,221**	**111**	**3,428**	**55,007**	**3**

Source: 1. Anon(undated), *Anantapur District Gazetteers,* Anantapur, p 278-79
2. Anon (undated), *Anantapur,* Old document in print, Zilla Parishad Office, Anantapur

of this office are monitoring annual and half-yearly operations like cleaning the conveyance system, excavation of the bed of rivulet to tap sub-surface water, conflict resolution and monitoring the daily routine job of the *neerukatti* (water tender).

Neerukatti

Neerukatti is a water tender who usually belongs to the scheduled caste community. There may be more than one person working as *neerukatti,* depending upon the size of *ayacut*. *Nerukattis* are seen in all three areas. *Bandili* or *thoti* is a watchman to drive away stray cattle from entering the *ayacut*. He is also supposed to supervise the bund along with the *neerukatti* during heavy rains. As an institution, autonomy, impartiality and alertness are emphasised in executing the functions of the *neerukatti.*

A *neerukatti* regulates water flow in canals, executes turns of water release in the canal, irrigates individual fields, makes decisions on water allocation in times of scarcity, reports to the monitor about water levels and

state of the bund, disputes and cases of water-stealing. He gets *manyam* (donated lands in lieu for the service). This office is hereditary and several individual heirs exist. As such this office is rotated among the *coparceners* annually or biannaually. The *manyam* and the *mera* (customary annual seasonal payment) have remained unrevised.

Manyamu

Manyamu is assigned or donated land for cultivation to certain functionaries in the village. These lands were given by the erstwhile rulers or *zamindars* to *neerukatti* and sometimes to monitors or certain other farmers. Though the word *dasavandam* is not referred to in the study area, *manyam* holders were supposed to protect the water harvesting structures and undertake maintenance works on bunds and sluices. Meant for generating capital locally for maintenance works, *manyams* are no longer in vogue

TANK TRIBULATIONS

The above institutions facilitated exploitation of a collective good. Labour supply was provided by *amuji*. *Peddarikamu* offered leadership and supervision over internal discipline. The *neerukatti* assumed the role of water-tending as an independent and impartial functionary. *Manyam* generated local capital for maintenance works and was a reward for the functionaries. *Bogikatta* and *kattu kalava* specified customary shares of water due to the village tank from a common source.

The most critical condition in sustaining traditional water harvesting systems thus seems to be the availability of water as a common property resource for a group of individual farmers, who are dependent on each other for equitable access, proportionate incentives and distribution of maintenance burden. Before the advent of electricity in villages some 30 years ago, the above conditions existed for collective maintenance. Emergence of tubewell irrigation as an alternative to tank irrigation has shattered the collective spirit, resulting in the utter neglect of traditional water harvesting systems.

Post-independence, after the abolition of the *zamindari* system, these traditional water harvesting systems have become the responsibility of the government which has ignored these systems and their linkages. The shift towards large centralised systems has reduced these systems to a poor person's asset only.

There is a general decline in traditional irrigation systems in the sub-regions discussed above. In Kalahasthi, modern technology has replaced traditional weirs. Though this has reduced labour for the farmer, it has also reduced their cooperation and interdependence. Borewells and pumps have taken over.

In Palamanda and Akepadu, the introduction of modern technology has deepened the divide between the rich and the poor. With rich farmers developing their own private water resources, they have dissociated themselves from the prevailing traditional institutions. Many of the structures now lie dilapidated.

In 1997, the Andhra Pradesh government decided to hand over the management of the irrigation systems to the users. The Andhra Pradesh Irrigation Systems Management Act was introduced in April 1997. Formation of *neeti viniyogadarulu sangam* (Water Users' Association-WUA) constituted the first item in the Act. Farmers with a total *ayacut* of more than 40 ha are eligible to form a WUA by registering for membership and electing a 4-5 member executive along with a president by secret ballot. One main objective of the act is to facilitate partnership of *ayacutdars* in irrigation management along with the irrigation department. The WUA is expected to take up maintenance work, design water schedules and monitor water distribution. Repair and maintenance works are to be executed by the WUA only and the executive members are prohibited from taking up works as their private works. The WUA is expected to maintain a series of books and accounts.

Though a step in the right direction, the beginning does not bode too well. The act could not ensure the participation of all the farmers. Though it is still early to draw definite conclusions, there are a few shortcomings that can be visualised. The act does not specify any linkages between the statutory WUA and the traditional institutions associated with traditional water harvesting systems. The traditional functionaries are not referred to and the experience and expertise of these functionaries are not taken into cognizance, leave alone establishing linkages.

The emphasis seems to be on management of large water bodies like tanks and canal systems and projects which command an *ayacut* of 40 ha or more. Smaller water bodies and harvesting structures are not referred to and no indication exists in the act as to the protection, rehabilitation or renovation and setting straight the property rights and entitlements concerning these water bodies, watercourses and catchments. Harnessing the potential of various varieties of water harvesting structures and strengthening the interlinkages between these structures to develop an integrated system have not figured in the act.

Institution-building is biased towards the aggrandizement of the office of the president of the executive body of a WUA. Inadequate attention is paid to increasing the managerial capacity of the executive body and the general body of the WUAs. Maintenance and repair works do not have to be justified keeping in mind immediate necessity or potential long-term and short-term benefits that accrue to the *ayacutdars* who do not see incentives for participation in the maintenance or repair works. Institutional mechanisms — local and external — are not clearly defined in order to ensure responsibility and accountability of the executive body and its president. ■

Water Management in the Saora Hills

It must have taken centuries to create the massive terraces that harvest rainwater to grow paddy in the Saora hills of Orissa

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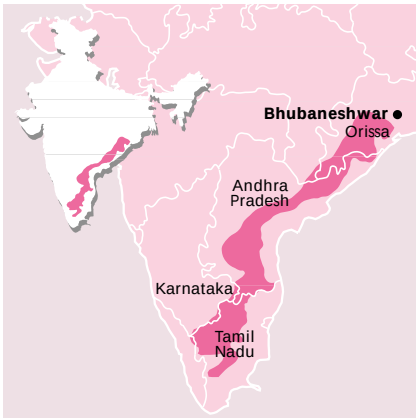
Saoras, one of the oldest tribes in India, harvest rainwater to turn stream beds into paddy fields and thus an inhospitable environment into a habitable one. The Saoras have been engaged in this practice for centuries and some experts feel that the Saora hills may be the original home of the paddy plant in India, if not in Asia. Today, unfortunately, the Saoras are extremely poor people even though good watershed management which uses their traditional water harvesting techniques can greatly increase their agricultural production and income.



Called by various names such as Savaras, Sabaras and Sauras, Saoras inhabit a wide area from Bundelkhand in Uttar Pradesh to Orissa, with most living around the edges of the Eastern Ghats in Ganjam and Koraput districts of Orissa and Srikakulam district of Andhra Pradesh. There are broadly two classes of Saoras: the Saoras of the plains who depend on either rainfed cultivation and wage earning through selling of firewood, and Saoras of the hills, who practice shifting or terraced cultivation and water harvesting on hill slopes.

Hill Saoras live in most inaccessible areas, often

P K CHHOTROY

Row of houses in a Saora village

Ganjam and Koraput districts of Orissa where most of the Saora population lives

hidden in thick forests. Their villages are generally small, varying from 200–800 people. Terraced paddy fields of the Saoras in Ganjam district of Orissa and Palakonda in Srikakulam district of Andhra Pradesh show great ingenuity.

TAMING HILL SLOPES FOR CROP PRODUCTION

Conservation of rainwater and improvement of water regime in hill slopes are the main objectives of terracing. Using stone-packed contour bunding, Saoras lay out small terraced fields on the hill slopes and grow paddy. By means of water channels, they regulate water flow from natural hill streams and irrigate the terraced fields. As flow irrigation is not possible in an undulating topography, the runoff water is stopped at different levels and allowed to soak deep into the soil. This results in availability of adequate moisture at root levels, which helps in better crop production.

In Koraput district, the soil is tilled at an elevation of 60-125 metres (m) above the mean sea level. Rice is grown in terraced stream beds on hillsides, locally called *jhola* (low land). The word *jhola* is used to describe the method of using stream beds for cultivation. The Saoras reclaim gullies and ravines, often

P K CHHOTROY

A terraced field with a channel to bring in and drain out excess water in the Saora hills

P K CHHOTROY

A terraced field in the Saora hills

appearing as cradles between two hills, and convert them into paddy fields by levelling and terracing stream beds. Drains on both sides of the fields are built to take out excess rainwater. Taking advantage of the perennial springs appearing in the area, Saoras irrigate narrow terraced fields during late winter and summer months. Terrace cultivation is common in the hilly tracts of Ganjam, Gajapati, Koraput, Nawarangpur, Rayagada, Baud and Khondmal districts of Orissa.

The terraces are puddled usually during February and March, after which sprouted paddy seeds are broadcast in nursery beds. Two varieties, early as well as late types of paddy seeds, are mixed together and sown at the same time. The early variety gets ready around May while the late variety is harvested in November. This is done to raise one additional paddy crop before the arrival of the monsoon and to let the late variety establish itself and be able to face the brunt of torrential streams. Researchers have recently discovered many varieties of wild paddy in Koraput district of Orissa.

Saoras inhabit ecologically fragile areas of limited agricultural potential and have limited resources. Any disturbance in human-land relationship results in food scarcity and the shortening of recuperative cycles of forests. Cultivation on the same hill slope year after year by the Saoras has resulted in land denudation, soil erosion and infertility, leading to severe food scarcity. Meagre income from forest products further adds to food shortage.

Fortunately, the Saora hills are blessed with an average annual rainfall of 1,300 millimetres (mm) which can help to increase agricultural production of the region by conserving rainwater through prudent watershed management. There is a need for appreciating the Saora skill of terrace cultivation, rationalising the technology, identifying the gaps and then addressing them. There is a need to conserve rainwater, which flows out as runoff, whereas this should be harnessed by constructing water harvesting structures. Identifying hydrological units and developing them in an integrated manner should be the new strategy for water management. The village should be identified as the basic unit of a watershed. The objectives of each watershed programme should be to promote sustainable utilisation of the natural resources by the community involved while encouraging restoration of the ecological balance. Criteria should be defined to measure the impact of the watershed programme in terms of structures built and benefits accrued.

Given the extent of degradation of natural resources — the soils have eroded and many streams have lost their perenniality — a fragmented approach of building a check dam here and a farm pond there, will not suffice. Only then will the fortune of the Saoras change. ■

United They Work

Modern modes of water harvesting can neither substitute traditional systems nor do they suit the unique land-water situation that exists in Kendrapada district of Orissa

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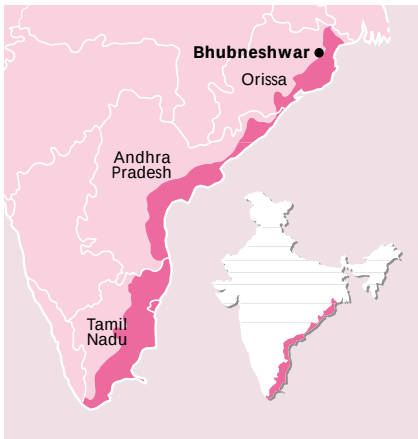
In Kendrapada district of Orissa, different water harvesting systems had been locally devised over centuries to suit varying soil and water conditions. Adoption of alien models of agriculture and water management is today threatening both traditional water and land management practices. Modern methods have provided the much needed freshwater but they have also led to the decline of traditional systems and increased conflicts between water users. Replacement of traditional practices is a process being encouraged by the state government.



Kendrapada, located in the coastal plains of Orissa with a coastline 480 km along the Bay of Bengal, suffers perennially either from waterlogging, floods or saline seawater ingress. Kendrapada contains a large number of water bodies like rivers, *nullah*s (drains), creeks, *jore*s (narrow, long water bodies) and ponds. Every village has more than one river or *nullah* passing through or along it. There is a profusion of small private ponds and a large number of creeks with mangrove ecosystems and *jore*s, which probably owe their origin to gradual filling up of creek mouths.

The availability of freshwater in the area largely depends on the monsoon, flow of water in rivers, and the strength and pattern of tidal flows. Severe floods, waterlogging and saline seawater ingress often create acute scarcity of freshwater for both irrigation and domestic use. The pattern of water availability has also given rise to four different land varieties locally known as *bheda*, *dhoiya*, *luna* and *madhura (see Box: A symbiotic relationship)*. Field research in three villages of Kendrapada district reveals that agriculture is based on the overall water situation.

A VARIED TRADITION

Various water harvesting systems such as flow irrigation, community ponds and domestic ponds have evolved over time that serve the dual purpose of irrigating water-scarce land as well as draining waterlogged land.

Flow irrigation

Flow irrigation is one of the most viable methods of irrigation in semi-waterlogged areas. A network of *nullah*s connects land to a river and other minor flow sources. When there is sufficient water in the river, water flows into *nullah*s by opening the sluice gates at the origin of *nullah*s. When there is less water in the river, water is lifted by motor pumps into *nullah*s from where it flows to the fields.

Jantasaja is a traditional water-lifting device which is used to bring water to individual fields that do not receive gravity flow of water. It is also used to drain excess water from the fields. It is a canoe-shaped structure, with a lever in the middle. On pressing it down, water enters the *jantasaja* and, on raising it, water flows out in the opposite direction. People have also started using motor pumps to lift water from small *nullah*s for irrigation. When one field is filled with water, a breach is created in the bund to allow water to flow to nearby fields. *Nullah*s also work as drainage channels during periods of waterlogging.

Community ponds

Every village has at least one common community pond, mainly built before independence, varying from 0.2-1.61 hectares (ha) in area. With huge bunds that restrict the ingress of saline water, they still remain functional and serve as important sources of water.

A SYMBIOTIC RELATIONSHIP

Agricultural practices and water harvesting systems developed side by side to suit each other in Kendrapada

Based on land topography, different paddy varieties are cultivated, which differ in their water resistance values. Since agricultural land is constantly under threat of flood and waterlogging, both by river and rainwater, the use of waterlogging resistant varieties is the dominant coping mechanism. The overall cropping pattern in all land varieties, thus, is entirely dependent on the intensity and regularity of waterlogging.

***Bheda/bandhua* land (semi-waterlogged area)**
Bheda/bandhua lands are semi-waterlogged areas separated from rivers and major surface waterbodies by large bunds. These bunds have sluice gates for irrigating fields, using rivers and other nearby water bodies during water scarcity periods, and act as drainage devices when there is waterlogging. Late maturing varieties of paddy are used in *bheda/bandhua* lands. These varieties can withstand between 10-15 days of waterlogging. Depending upon availability of water, a second crop is also taken in *bheda* land.

***Dhoiya/juaria* land (waterlogged area)**
Dhoiya land is a waterlogged area situated along river banks and is often flooded by river waters. It is waterlogged for long periods and only traditional paddy varieties like *potia*, which has a waterlogging-resistant value of 32 days of complete submergence, are grown here. Other crops like pulses and vegetables are also grown.

***Luna* land (saline land)**
Luna in Oriya means salt. *Luna* land is situated on river and creek banks that are flooded by saline water for about 4-6 months in a year. With the onset of monsoon, freshwater replaces saline water, preparing the land for cultivation in which only a single crop of salinity-resistant paddy is grown. Application of chemical fertilisers or pesticides is not required. The land receives enough nutrients with the saline water that enriches the soil.

***Madhura* land (reclaimed saline land)**
Madhura land is located in the tidal zone area but is no longer affected by tides due to artificial structures built to block the incoming tide. After construction of embankments in 1972, this type of land became non-saline, rainfed land where one crop of paddy is possible during summer. Even now, a slight increase in salinity due to occasional ingress of saline water renders the land uncultivable for 3-5 years.

P K NAYAK

Luna ***or saline land along river and creek banks. Flooded by seawater between 4-6 months in a year, the land needs salinity-resistant paddy varieties***

THE UBIQUITOUS DOMESTIC POND

Almost each house in a village has its own pond. Due to the recurrent problems of floods and waterlogging, houses are built on raised earthen platforms. Digging a pond in one's backyard provides earth to raise the level of the house, as well as the backyard. This results in a common housing pattern along the main village street, with a backyard behind every house and a pond at the end of the backyard.

Typical house distribution in a village is linear, along both sides of a more or less straight main street. Thus, ponds also form a parallel line to the row of houses. During a flood, water is diverted to ponds, and bunds

are breached to allow free water movement between adjacent ponds. This provides a good drainage channel for floodwater and also protects agricultural fields and houses by slowing down the flow of water.

During periods of water scarcity, domestic ponds provide water for irrigation, especially for fruit and vegetable crops grown in the backyard. Coconut, banana and other fruit trees are grown on bunds of these ponds. When there is a crop failure, this backyard horticulture provides a small but reliable source of income. Ponds also provide a regular supply of fish for domestic consumption, and sometimes for sale as well.

Ponds are the main source of drinking water in most of the areas. Irrespective of water quality, a majority of people use this water for cooking. Pond water is most significantly used in making *pakhala* (slightly fermented water rice, which is an integral part of diet in villages in Orissa) for which tubewell water is unsuitable. During floods, the pond water becomes unpotable and drinking water becomes scarce. Faced with no other source of drinking water, villagers then collect rainwater for drinking. Installation of tubewells during the last decade has however greatly improved the drinking water scenario in the area.

IMPACT OF MODERN IRRIGATION SYSTEMS

Modern irrigation systems have increased the availability of freshwater. They have also led to a decline in the more equitable traditional water harvesting systems and water transport systems. Agricultural practices have changed, adversely affecting both soil and water quality.

The villagers hae suggested some measures for improving the utility of ponds. These include:

- The height of the bunds around them need to be increased and the pond embanked on all sides so that the flow of flood water in to it, which damages the water quality and silts the pond, can be controlled.
- A small sluice gate should be provided in the bund for inflow and drainage of water.
- In October-November, the water hyacinth in the pond should be removed.
- In June-July when freshwater starts flowing, the sluice gate should be opened to get freshwater into the pond, along with fish. After a temporary opening the gate should be closed.
- Regular and timely purification measures, like bleaching and cleaning, should be carried out.

P K NAYAK

A community village pond in Kendrapada

Increased availability of freshwater

One of the positive impacts of modern irrigation schemes introduced in the area has come from the construction of Hirakud dam on the Mahanadi river and Rengali dam on the Brahmani river which have changed the salinity pattern of the rivers and adjoining land areas. The Rengali project is much more directly related because it is built on the Brahmani river which is the principal river of Kendrapada district, alongwith its numerous tributaries.

When there is less flow in the river as in summer, tidal water travels up the river much further, turning the river water saline. But since the construction of these dams, water is released regularly from the reservoirs during summer which maintains the water flow in the rivers, thus checking saline sea water ingress to a great extent. It also provides irrigation opportunities in summer. However, other seasonal saline rivers like the Dhamara, Baruni and Kochia continue to cause salinity to agricultural lands in the region.

Changes in water transportation systems

Lift irrigation from rivers is a major form of irrigation during water scarcity periods. When there is a shortage of water in rivers and supply through sluices is not possible, water from rivers is artificially lifted using pump-sets to storage tanks, from where it is supplied through *nullahs*.

The government-owned Lift Irrigation Corporation of Orissa has set up deep tubewell points at various places in order to provide irrigation. Each point has an *ayacut* (command area) of 20 ha and can supply water only to lands within this area.

Pollution of water resources

Earlier, saline water deposited sodium chloride salt on land and subsequent flows of freshwater deposited fertile silt. Without any artificial chemical inputs, the entire system of agriculture was successfully managed by the seasonality of water.

These methods of cultivation are now being replaced by increased use of chemical fertilisers and pesticides, which increases agricultural output, but has an adverse impact on soil and water quality. Freshwater sources in the area are getting affected and constant waterlogging is expediting percolation and seepage of chemicals that gradually reach various water sources.

Conflict over water sharing

Centralised sources of water for irrigation such as river lift points, sluice gates and even pumpsets, on which a large number of people depend, have become major sources of conflict between users. The lack of any set rule or understanding between users about timing, amount or order in which water should be used is the main cause of these conflicts. One of the most alarming fallouts of such conflicts is the gradual abandoning of traditional technologies like *jantasaja* for private motor pumps. Anyone using traditional equipment loses out on the amount of water available and this is forcing farmers to abandon old ways of irrigation and use of water. This creates inequity amongst the local people, as a large number of farmers cannot afford these modern facilities.

MEANINGFUL INTEGRATION

The number of conflicts between water users is on the increase, specially in the summer months when water is scarce. The reasons behind these conflicts vary. Conflicts may arise between the users of *jantasaja* and motorised pumps over distribution from the lift point, from the sluice gate, over pond waters, and at times of saline floods.

The cause of increase in conflicts has been the addition of new water harvesting structures that do not integrate with the traditional ones. Moreover, these systems favour the economically strong and do not address means of conflict resolution.

In the traditional modes of water harvesting, the major dependence of each farming household was on *jantasaja*, which allowed people to operate independently. The new methods introduced brought serious competition to the area. Anyone who uses the *jantasaja* now faces the risk of getting less water as compared to one who deploys a motor pump. This has resulted in an abandonment of traditional methods of water harvesting. However, not all farmers are capable of using new methods since they can ill-afford to do so. In spite of repeated conflict arising due to this inequity no effective long-term solutions have been attempted. What is therefore required is not only a numerical increase in water harvesting systems, but systems that are able to integrate with the existing traditional ones, which were more equitable.

New modes of water harvesting are not completely divorced from the traditional, existing ones. Farmers use a mix of old and new methods, depending on the water situation. For example, if there is sufficient water in ponds, *nullah*s and other sources, *jantasaja* is preferred because it provides cheaper irrigation. But when the level of water is low and water has to be lifted from a considerable depth, motor pumps are used. However, the growing use of pumps is resulting in greater pressure on groundwater sources and an increase in conflicts between water users. For reasons of sustainability of water resources and reduction in conflicts between those who can afford new methods of water harvesting and those who cannot, there is a need for the coexistance of the old and new methods. ■

Pakistan: Different Strokes

Arid areas in Pakistan continue to keep rainwater harvesting traditions alive. For many this is what makes the difference between life and death

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The key to meeting growing food requirements of Pakistan is water. While all available cultivable land is already being cultivated and little additional land is available for expansion, it may be possible to expand double cropping in highly productive soils. The catch? If water is available.

Only 53 per cent of the population in Pakistan have access to safe water — 79 per cent in urban areas and 40 per cent in rural areas. Even within urban areas, only four in every 10, have piped connections to their homes.

In rural areas, 95 per cent of the population obtains its water supplies from groundwater. Even in urban areas, with the exception of Sindh, groundwater is the major supply source, accounting for almost all the water used in the cities in North West Frontier Province and Balochistan, and over 90 per cent of that in the urban areas of the Punjab. In Sindh, 92 per cent of the urban areas depend on surface water supplies. Surface water is polluted, except near the headwaters in the mountains, and is unfit for human consumption unless treated or boiled.

The primary source of water for agriculture in the country is the surface water from rivers. Infiltration from rivers, canals, water sources and fields is the main source of groundwater, which is a secondary source. There is an absolute limit to the amount of water available in the Indus Basin. The present reservoirs are not capable of storing surplus water in high flood years for later use; all the monsoon rains they store are needed in the following *rabi* season**.** Diversion losses are very high: almost 41 per cent by the time the water reaches the farmgate.

Necessity has promoted community-level local rainwater harvesting in Pakistan. In the desert clusters of dwellings are scattered and communities are collectively involved in harvesting rain. This has helped improve water availability, which in turn has reduced migration. The primary source of water is rainfall, as the available groundwater is usually saline. These areas lack any public irrigation sources with the result that humans and livestock face acute water shortages. In the deserts of Tharparkar, Nara and Cholistan when rain fails, it causes drought and famine. The only option available for these desert communities is to harvest rainwater through appropriate local techniques. When practiced at homestead level, it gives the added advantage of availability at accessible distances, to be fetched by anybody, irrespective of age and sex. There is, thus, an improvement in household water security, with respect to domestic water needs.

There are a number of harvesting techniques practised in the country. The water harvested is used for domestic purposes, for livestock needs as well as for meeting agricultural requirements. These systems include *tankas* in Tharparkar, *tobas* and *tarais* in Cholistan, and *talais* and *rod kohi* systems in Dera Ismail Khan.

The biggest disadvantage of rainwater harvesting is its total dependence on the rainfall pattern. Considering global climate change and variability and unpredictability of rainfall, the concept of rainwater harvesting becomes most vulnerable. Rainwater harvesting is a function of intensity of rainfall, catchment area and storage capacity. However, as the catchment area and storage capacity can be manipulated, sufficient rainwater can be collected even under very low and unpredictable rainfall.

Another cause for concern is the low mineral content in rainwater, which has caused health problems among

humans and animals in Pakistan. In some parts of the Thar desert, deficiencies in sodium and chlorine have been detected due to prolonged use of rainwater for drinking and use of non-saline (sweet) groundwater.

CHOLISTAN: WATER IN THE SANDS

The Cholistan desert, an extension of the Great Indian Desert, is located in the southern Punjab province, with a total area of 1.03 million hectares (mha). It is one of the hottest and driest parts of Pakistan. With a population that is pastoral, lack of surface water sources and poor quality groundwater makes rainwater harvesting vital. This harvested water is stored in natural or artificial depressions called *tobas (see Box: Tobas – a perfect match).*

In the first millennium before Christ, Cholistan was a cradle of civilization commonly known as the Hakra valley civilization. This was when the river Hakra flowed through the region. The river supplied permanent water until 1200 BC after which its flow became irregular. The Hakra civilization that flourished here was one of the longest in the course of world history. No one is sure how this great Aryan civilization ended. Probably a variety of problems such as hostile invading tribes, changes in the course of the river and depletion of irrigation facilities contributed to the ultimate disappearance of this great civilization.

Aridity is the most striking feature of Cholistan with wet and dry years occurring in clusters. The mean annual rainfall varies from 100 mm in the north to 200 mm in the south and reaching 250 mm along the India-Pakistan border. Most of the rainfall is received during the monsoon period occurring mostly as heavy showers, highly variable in both temporal and spatial scales.

Based on topography, soil and vegetation, the desert can be divided into two geographic regions: Lesser Cholistan (northern region) which borders canal irrigated areas and covers about 77.7 hectares (ha), and Greater Cholistan (southern region) covering 1.81 ha. Lesser Cholistan consists of saline alluvial flats (locally called *dahars*) alternating with low sandy ridges.

Pastoral system

This desert supports a population of 100,000. The economy is predominantly pastoral, with the people having practiced a nomadic lifestyle for centuries. Habitats are small and scattered. The nomads own large herds of camels, cattle, sheep and goats. The area is not served by a modern communication system and the inhabitants of the desert use camels as a mode of transportation.

TOBAS – A PERFECT MATCH

With no source of water in the desert, rainwater is harvested in natural depressions or artificially created ponds in the desert

With absence of surface water availability, poor quality groundwater and an uncertain government-aided supply of water for, at best, a mere 70 days, the residents of Cholistan desert have been storing the rainfall they receive, in depressions — both natural and artificially created. The water is available from 4-8 months on an average, sometimes prolonging to 10 months or a year.

Tobas are the simplest and most commonly used means of storing harvested water in excavated pits, ponds or reservoirs. Their popularity stems from them being economical and without the need of any materials. To increase amount of water that can be stored, people have often innovated. Ditches of different sizes in the area to collect maximum rainwater effectively were constructed. In some places the pond was connected by channels and sub-channels to catch runoff efficiently from catchment area for pond storage.

Each of the 480 communities of Cholistan has its own *toba* and well. Most *tobas* are named after the clan living near the *toba*. Normally 10-50 families live around one *toba*. The inhabitants around one *toba,* usually belong to the same blood family or clan. *Tobas* belonging to the same clan are generally located close to each other, often within one kilometre radius.

Tobas meet drinking water for nomads and their livestock. The water is also used for agriculture. At the start of the rainy season, livestock graze within 1-2 kilometres radius of each *toba*. This distance increases to about 15 kilometres as the season progresses. During October and November when water resources become almost totally depleted, each clan moves its herds to semi-permanent centres equipped with a series of traditional (hand-dug and unlined) wells and *kunds* (usually lined).

The drying up of the *toba* is common, after which the inhabitants either have to depend upon well water, which is brackish and harmful or they migrate to some settlement nearby or to irrigated areas. The desert dwellers normally let each other take refuge in each other's *toba*, during times of drought and water shortage. However, conflicts have arisen when the water is not shared.

Most of the wells and *tobas* are centuries old, built several generations back. Sometimes new ones are dug. Digging and desiltation, whenever required after 4-5 years, is a community effort. Cooperation is usually not a problem as the people are related.

The quality of water in the *tobas* often deteriorates on storage and local herbs or alum are used to clean the water for domestic needs. Though these ponds are the lifeline of the desert, often these are not at appropriate sites, as a result of which water is wasted rapidly and cannot be used for a long period. Major causes of water loss are seepage and evaporation. Lack of regular cleaning reduces their water storage capacity.

The pastoral system is characterized by mass migration of animals and people throughout the year in search of water and forage. The onset of monsoon and distribution of rainfall mainly dictate the pattern of movement of nomadic herders. Around the months of March or April, nomadic households move towards surrounding irrigated areas forced by rising temperatures in the desert and decreased feed and water resources. The incentives for this movement are temporary employment opportunities within the irrigated farming communities, grazing of livestock, drinking water for human and animal use, and readily available markets for livestock and livestock byproducts. Farmers in the irrigated area in turn obtain sufficient labour for crop harvesting and other farming operations and animal manure to enhance soil fertility through camping of livestock on fallow fields. The nomads and their herds return back to the deserts around July or August with the news of first monsoon showers. Distances travelled during this migration vary from 10-100 kilometres. In the desert, vegetation is the main source of feed for grazing livestock. All livestock are indigenous breeds well suited to the environment.

The life of the pastoralist revolves around water. There are no permanent, natural bodies of surface water in Cholistan. Factors like low rainfall, high rate of water infiltration into the sands, and high evaporation rate prevent the natural accumulation of surface water. The area faces acute shortage of good quality water. Most of the groundwater is saline. Though the government of Punjab provides canal water to 2.6 mha of Cholistan, this water is provided for only 70 days in a year, the availability of which is also uncertain. Majority of the population of Cholistan, thus, depends on *tobas.*

The secondary source of water in Cholistan is groundwater, available at a depth of 30-40 m, mostly brackish and saline and unfit for consumption. According to the Cholistan Development Authority, the water in Cholistan is brackish even 250-280 m below. However, when *tobas* dry out, this water has to be used.

Harvesting rainwater

It is as if the soils of the Cholistan desert were designed to harvest rain and store it in *tobas.*

Cholistan has two natural advantages. It has a broad natural catchment area, an important prerequisite for rainwater harvesting on a large scale. It will be virtually impossible to build an artificial catchment area on such a scale at some other place.

Secondly, the soil of the catchment area in Cholistan is conducive for rainwater harvesting. Cholistan consists of four physiographic features: rolling sand dunes, shifting sand dunes, inter-desert channels, and *playas* haphazardly distributed in the area. *Playas* are the beds of ephemeral dry lakes formed in depressions, where the inland drainage terminates. They have a flat and hard surface, with salt incrustation at the surface. The *playas,* locally called *dahars,* and surrounded by sand dunes are the best catchments for harvesting of rainwater, since these are mostly leveled with poor vegetation, shallow to moderately deep, poorly drained soils and with very high compaction. With poor infiltration rates, these soils are favourable for rainfall harvesting.

About 17 per cent land of Cholistan is under such small catchments. The beds of these *dahars* are so leveled that even an inch of water would spread over the beds like a sheet, for miles. Due to high rate of evaporation, however, the rainwater in these *playas* dry up rapidly. The dissolved salt and suspended material brought in by the flow are deposited as thin layers of crust on the surface of the catchment. The size of these catchments or *dahars* varies from a few hectares to several thousand hectares sloping southwestward, which is the direction of the natural general slope in the area.

Most of the wells and *tobas* are centuries old, which were built by the predecessors of present generations. In case of need, new *tobas* are dug with community involvement. Some communities have built *pucca tobas* of bricks and clay.

THARPARKAR: WHERE TRADITIONS ABIDE

In the southeast corner of Pakistan lies a vast sandy territory, very different from the adjoining Nara and Indus valleys, known as Tharparkar, contiguous with the Indian desert in Rajasthan. This represents the easternmost link of the great Afro-Asian desert chain, stretching eastwards from the Sahara. The territory is so vast that it forms nearly one-third of the total area of Sindh province. The total area is 2.30 ha. Excepting Tharparkar large areas of Sindh province are in the arid zone, which represents about one-half of Sindh province.

Thar district consists of Diplo, Mithi, Nagarparkar, Chachro and Umerkot subdistricts. With the exception of Nagarparkar region, the landscape is covered with fossil sand dunes that are covered with some vegetation. Between the dunes are flat areas locally known as *pats.* The soils of the *pats* contain enough soil fines (clay and silt) so that the soil is productive when sufficient water is available.

Unlike many other deserts, this desert is not desolate, inhospitable and barren territory. In fact, life abounds. Tharparkar supports 950,000 people or 8.8 per cent of the total rural population of Sindh and over a million heads of livestock. It is neither entirely barren nor rainless. Since it is not quite uninhabitable and presents a variety of plant growth, it cannot be termed as a typical desert. It is rich in flora and fauna, which, despite overexploitation through centuries, is abundant in quantity and rich in variety. There are about 80 plant

species occurring in this desert in varying density.

However, like arid regions all over the world, Tharparkar is confronted with the problem of water scarcity. The climate is arid, with low and erratic rainfall usually, received between July and September. The average rainfall is between 200-300 mm, not uniformly distributed over the region. Droughts are common occurrence and occur in a 4-5 year cycle. The potential for development of surface water resources is more limited than other arid areas of Sindh province. Surface water cannot be imported from the Indus river because its mean elevation is higher than the barrage area. There is, however, potential for some small localized water resource development in the form of rainwater harvesting and runoff control.

Abject poverty

Living in abject poverty, the question before the people here is not one of development, but of survival.

Water is a scarce commodity and human beings and their livestock depend on wells and ponds for their water requirements. The major economic impact of a drought for the residents of the arid zones is on the well-being of their livestock. Residents either lose parts of their herds or are required to move their herds to the irrigated areas of Sindh. In this situation, if the traditional rainwater harvesting technologies are improved and strengthened, then the residents may avoid this frequent loss.

The main land utilization is pastoral and the people take advantage of good rainfall years to raise agricultural crops. The patches of low ground between sand hills known as *tali/tal/dhar* are used to raise crops if and when sufficient rainfall occurs. The extent of such cultivated patches in the whole desert varies each year according to the amount of rainfall received.

ITDG / SRI LANKA

Agriculture from rainwater

Traditions in the Thar

The inhabitants of Tharparkar have been practicing various rainwater harvesting and collection techniques for centuries. Traditional water harvesting systems being practised in the region include *tarais*, *tankas* and *dhands*.

The soil of Thar, being composed of loose and very porous aeolian sand, absorbs rainwater and percolates straight down to the groundwater reservoir so that practically nothing remains on the ground surface. The valleys in between the sand dunes are filled in with *playa*-like deposits containing more silt and clay ingredients and as such they are less permeable than the aeolian sand. It is in these valleys and artificial hollows that rainwater is diverted and collected in the form of ponds, locally known as *tarais (see Box:* Tarais *of the Tharparkar).*

Usually every valley or *dahar* has one such natural depression developed by the dwellers of adjacent villages for collecting rainwater. The shape and size of such rainwater reservoirs varies, depending upon the size of catchment and type of soil in the valley. In addition to these rainwater reservoirs, the local farmers also build bunds and diversion structures for collecting water in their fields and for recharging shallow wells. On a smaller scale, rainwater is also collected by the individuals in their houses by constructing paved courtyards and from the rooftops of their houses The water then is stored in underground water tanks locally known as *tankas.* Similar underground water storage tanks are also built by farmers in their fields where hard clay surface is available.

In Tharparkar, water harvesting is an urban as well as rural phenomenon, undertaken both at the individual and community level.

Tarai: Some years ago, only *tarais* were used to store water at community level, for human and animal needs. Now, these *tarais* are used only for watering the cattle. *Tankas* are used for human needs.

The *tarai* is made in a narrow valley in between stabilized sand dunes. A small section is converted into a reservoir by erecting bunds at two ends. During the rainy season the rainwater accumulates in this reservoir. Due to highly porous soil and high rate of evaporation, the *tarais* dry up within 1-5 months after the rains end.

In the absence of any windbreak or other device against soil erosion, the beds of these reservoirs are often silted up due to deposition of fine sands blown in by the wind and periodical re-excavation is needed. Maintenance of the *tarais* is usually done by the beneficiaries themselves under local leadership. The women

TARAIS OF THE THARPARKAR

When the captured surface water dries up, wells dug nearby capture the percolated rainwater

In the Thar, rainwater is collected in the form of ponds, locally known as *tarais*. While the surface water that is available directly from the *tarais* is short-lived, the water that seeps down is available for a longer duration.

The availability of water in a *tarai* depends on its size, the permeability of layers lying beneath the water accumulated, the amount of rainwater available, the intensity of evaporation and other factors. The water it holds is fresh and sweet and is used for drinking, domestic purposes and cattle watering. Though almost every village in Thar has a *tarai*, the larger ones deserving mention include Gadro Tarai, Chappar Ji Tarai, Chelher Tarai, Khinsar, Mithi, Jahero and Lunio Tarais.

Tarais exert significant influence on top-seated aquifers: their water seeps slowly down to the groundwater reservoir and freshens the brackish or saline *in situ* water, making it suitable for drinking and other purposes. Most of the wells now in operation have, therefore, been dug close to *tarais*. A wooden foundation, in the shape of a wheel, is placed at the bottom of these wells and the sides are then lined with wicker, a work of green branches and brushwood. In localities in the interior, where the depths of wells vary between 40-100 metres, they are lined with burnt bricks.

Local knowledge is used to identify sites to dig wells. The site selected is the lowest depression at the bottom of the valley. Traditionally, these wells are dug by private expertise and financed at the village level.

bring the clay that is removed from the *tarais* home for plastering and so an automatic system of desilting has been developed.

The rainwater so collected has an impact on the quantity and quality of groundwater in the regions surrounding these *tarais*. These are a source of recharge of shallow wells. The inhabitants, to withdraw groundwater that has infiltrated from the seepage, dig wells near the *tarais*. This water is generally of good quality and is a major source of drinking water for the residents during the dry season.

The grasslands thrive on the rainwater. Suitable patches are also brought under various crops. The rainwater that falls on the sand dunes does not move as runoff, but is absorbed into the ground. As soon as it penetrates into the soil a large quantity of water is held by the roots of the perennial plants for renewal and growth. In barren space, a substantial quantity of water evaporates. The rest, due to high porosity of soil, percolates down.

The size of *tarais* varies between 60 m x 60 m to 120 m x 120 m, with catchment areas between 1-2 square kilometres. Most of the *tarais* in this range are natural, but improved and developed upon by humans.

There have been successful attempts by government departments like the Sindh Arid Zone Development Authority (SAZDA) to improve the potential of *tarias*. One *tarai* was improved by simply raising the bund around it and reshaping and smoothening the area, which channelised water into the *tarai*. It now holds water all year round during an average rainfall year.

Tankas: Rooftop water harvesting is common across towns and villages of the Thar. Rainwater that falls on the sloping rooftops of houses is directed into an underground *tanka* (small tank) built in the main house, or in the courtyard. Normally the first spell of the rain is not collected as this would clean the roof and the courtyard from the dust. Subsequent rainwater is collected in the *tankas*, one of the most reliable methods of water harvesting in Tharparkar. Whenever there is less rainfall these household tanks are filled up with water from neighboring *tarais* and ponds. In some houses to counter the summer heat of the desert, an underground room is built next to the tanka. Since the room has a common wall with the *tanka*, it remains cool. During summer afternoons, the whole family moves to this water-cooled room. From a paved or concrete courtyard of 100 sq m area, 18,000 litres of water can be harvested in a rainfall of 200 mm.

Almost every household in Tharparkar has its own *tanka*. Shapes and sizes vary, mostly being either square or round and 3 m x 1.2 m in size, with depths varying between 2.5 m to 15 m. The mouth is usually covered with a lid. On one side a hole is made for collecting the water from rooftop. Some houses use a plastic pipe to suck out the water from the *tanka*, whenever required. The storage capacity is enough to meet the needs of a family of 10-12 members, for a whole year.

While rich people construct *tankas* using reinforced cemented concrete (RCC) or brick mortar, the poor construct sandy clay-walled, round shaped ones. The former also enhance runoff by using polythene on rooftops and paving courtyards with concrete. These innovations also reduce contamination of rainwater.

Round shaped *tankas* are of two sizes, those that are 2.5 m deep and those that are 4 m deep. A well is dug to construct the round shaped *tankas*. A mixture of ash and water is plastered to strengthen the sandy clay walls of the well, which is then cemented.

Tankas are also built in farmhouses. A small catchment area is built of clay or cement. The *tanka* is round shaped and made with bricks. Water is collected

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Round-shaped* tanka *to store precious rainwater to meet drinking water needs throughout the year

by plastic sheets. During the harvesting season people use this water for drinking purposes which is available for 3-4 months.

Individual farmers can increase water supply for themselves, their livestock and irrigation using 1-2 hectares of catchment in and around their farms and collecting the runoff in the farm pond. Chemical sealants and soil covers like wax asphalt and graveled plastics, which have been found feasible in other arid areas of the world, can be tried. With the improved catchment it will be possible to harvest water even with 10 mm rainfall. The pond should be excavated in an existing depression of the farm and the soil obtained from the excavation should be used for embankment around the pond. The size of pond may differ with the size of catchment but it should be made impermeable for saving water losses from seepage.

Dhands: In the Nara region adjoining Tharparkar, between the sand hills, depressions or troughs locally known as *dhands* exist, which collect rainwater during the rainy season. *Dhands* are scattered throughout the region. These naturally occurring depressions present a good opportunity for rainwater storage, for domestic and livestock consumption and possibly even for some small-scale agricultural production.

A major constraint of using *dhands* is that these do not hold water all year round. After the rains the *dhands* are filled with water but depending on weather (rainfall and evaporation), seepage and evaporation losses and intensity of use by the local population, the *dhands* dry out before being refilled by the next rains. Contamination of water, often by dead animals, also restricts water use for human and livestock use.

Though seepage losses pose a problem for water storage in the *dhands*, people take advantage of this by installing dugwells near the *dhands*. This seepage water is used mainly for human and livestock consumption. The geology of the areas around the *dhands* is such that this water is available near the ground surface, allowing residents to use dugwells for extraction.

Some of the problems associated with practising rainwater harvesting and utilising the harvested water in Tharparkar include:

- High variability of rainfall;
- animals in the range areas of Tharparkar do not receive sufficient common salt in their daily ration. Both sodium and chlorine are necessary for animal life, and farm animals usually do not secure enough of these two minerals in the feed they eat. To furnish these two minerals in the feed, common salt (sodium chloride) should be supplied particularly in the Tharparkar, where the soil is non-saline and the drinking water in most of the watering points also is sweet because of rainwater;
- high evaporation rates exceed precipitation, and open bodies of water experience high losses due to evaporation;
- development of the arid zone is likely to lead to less migration, often tied to the need for water and feed

for livestock. By increasing the water supply and thereby reducing the need to migrate, more people will remain in an area, which could lead to greater land degradation around settlements; and,
- waterborne diseases.

DERA ISMAIL KHAN: HARVESTING HILL TORRENTS

The North West Frontier Province (NWFP) encompasses an area of 0.10 mha with a population of about 20 million. The province is inhabited by two main sociological classes, the 'settled' and the 'tribal'. The settled area is divided into six administrative divisions: Peshawar, Malakand, Mardan, Bannu, Hazara and Dera Ismail Khan (D.I. Khan). D.I. Khan is the southernmost division of the NWFP province.

D.I. Khan division has two districts – D.I. Khan and Tank. D.I. Khan division is situated on the west bank of the Indus river and is bounded by the Suleiman range on the west, Bhittani range on the north and Marwat range on the east. On its southwest lies D.I. Khan division of Punjab province. The annual average rainfall, erratic and uncertain and in the form of intense showers that often cause floods, ranges from about 180 mm in the south to about 305 mm in the north.

Though the public departments concerned with drinking water claim that they are catering to more than 90 per cent of the population of D.I. Khan district, the ground reality is different. Connections have been provided but water supply systems are non-functional. As the water provided is from ground resources, it is brackish. If this water is used for cultivation, next time that land cannot be cultivated.

A large population depends on capturing rainwater. If they do not do so then the only option available to them is migration.

The *rod kohi:* harnessing flash floods

The *rod kohi* system or hill torrent system of irrigation is typical for hilly areas, facing flash floods / hill torrents. Through a system of channels the water from these torrents is diverted to a network of fields. The water so collected in the fields is allowed to percolate and is used for *rabi* cultivation in September / October.

D.I.Khan has a huge wasteland locally known as *damni* area. This area is frequently subjected to hill torrent flooding. Five major hill torrents called *zams*, along with a number of small ones, traverse the region. Flash floods of shorter duration and higher magnitude hit the area, generally during the monsoon, part of which is utilized by the local people in a traditional system of irrigation called *rod kohi*. Since 1880, concerted efforts have been made to utilize the area for agricultural purposes by managing flood flows of *zams* originating from the Suleiman range. The *zams* bring a large quantity of water laden with silt when they descend from the *darahs* or gorges. The water is used by the landowners through a network of *gandis/sads* (bunds constructed across the bed of the torrents), in the piedmont area, enroute to the Indus River. The floodwater is diverted into terraced fields with high embankments which are generally filled from about 1-1.5 m after which the water is released to the next field and so on through *khulas* (shallow channels). This system of diversion continues till either the floodflows are completely exhausted or all the fields are filled. Once the fields are filled, the water slowly percolates into the soil and the fields are used for *rabi* cultivation in September / October.

As all the lands attached to each *sad/gandi* are irrigated, the *gandi* is intentionally breached to allow the water to move to the next *gandi* in the series.

The *rod kohi* system is governed by rules and regulations established by the local community more than a century ago called *Kulyat* and *Riwajat-i-Abpashi* (rules and regulations for irrigation). These provide detailed information related to distribution of flows to the riparian. Settlement officers, without violating the basic governing principles or the established rights of different villages and their people, however, have made minor changes, modifications and adjustments, from time to time.

The total *damni* area under *rod kohi* irrigation system is 263,730 ha, inclusive of the 23,500 ha being irrigated by Chashma Right Bank Canal under gravity flow conditions.

Some of the major problems for effective management of this system include:
- Non-availability of earth moving machinery at the appropriate time;
- inadequate humanpower for constructing temporary diversion dykes during the hot months of June and July, when sufficient water, shelter and fodder are not available;
- the embanked cultivated fields are scattered plots with great stretches of wasteland between them, resulting in high mobilization cost for farm labour and machinery;
- short-lived high peaks and flows not conforming with the crop water requirements of the area;
- flood flows generally impregnated with high silt charge which preclude the possibility of economical management through reservoirs;
- banks of channels irregular in height and width which create over-bank flooding in various reaches of a channel;
- the major *zams* have a number of tributaries and offshoots which outfall into each other. This makes the entire management system highly complex;
- the channels frequently change their course which

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Talais, ***collectively constructed to harvest rains to meet domestic requirements***

makes the locations of the cross-drainage structures on canals and roads unpredictable; and,

- continual neglect and improper maintenance, causing the channels to silt up at different places. The channels are, thus, unable to accommodate the full water discharge. This results in spilling / overflowing the banks and scouring to form ravines (*khads*). These ravines ultimately join the ones scoured out by neighboring torrents, further aggravating the flood situation. The water, thus, does not flow in its proper course on which bunds have been erected. The floodwater continues to flow unchecked and goes waste. In addition, it causes damage to land and property.

Domestic rainwater harvesting

The system for rainwater harvesting for domestic purposes in D.I.Khan is almost similar to the *toba* system in Cholistan. Vast lands consist of plain natural catchment areas, where the people dig depressions for collecting rainwater, locally called as *talais* (ponds). Earlier, the *talais* were dug with hand by the village residents, but now tractors are used for digging. Digging and desilting of a *talai* is a community-level activity. A committee is formed to monitor and organize the digging. The committee collects money from each household for hiring a tractor and labour for desilting or digging. The committee consists of village notables (*maliks*), the Imam (Muslim clergy) and elders, formed temporarily according to need. Although the *talais* are constructed collectively by the community, no collective agreement exists regarding the use of water, so the management of collected water is not good, and at times, the water finishes before the new rains.

In D I Khan, in stark contrast to Tharparkar and Cholistan, great importance is given to the security of *talai* water. A small room is constructed on the banks of the *talai* and a person — *rakha* — is appointed to take care of the talai water so that no animal or human being can pollute the water. The village community pays him for his services, mostly in kind. ■

This paper is an edited version of the paper Wisdom of Tradition: Rainwater Harvesting for Domestic and Agricultural Purposes in Pakistan *by Amjad Farooque, a study coordinated by the Sustainable Development Policy Institute, Pakistan. This was prepared as a country report commissioned by the Disaster Mitigation Programme of the Intermediate Technology Development Group, Sri Lanka, as a part of the programme of activities for Duryog Nivaran, a South Asian network for disaster mitigation.*

Sri Lanka: Varieties of Water Harvesting

Rainwater harvesting in Sri Lanka offers yet another example of how the poor use available resources to meet their needs

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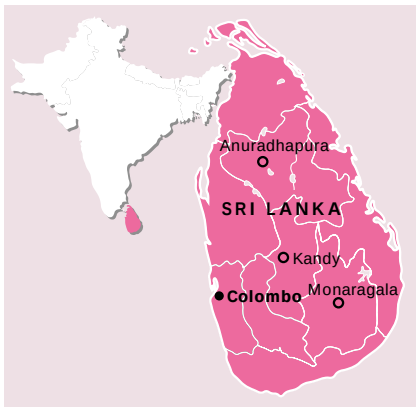
Sri Lanka has had a strong tradition of harvesting rain using palm leaves, tree trunks and even rocks. These systems are still in use, often in places to augment the water available from modern piped and tubewell water supply systems, or where modern systems cannot reach. A study conducted by the Intermediate Technology Development Group (ITDG) in Sri Lanka in Monaragala, Kandy and Anuradhapura districts indicate a whole variety of systems that have been revived.



Sri Lanka is an island nation with a high rainfall, receiving an average of 13.1 million hectare metres (mham) of water. Due to its seasonal rainfall pattern, 5.1 mham (39 per cent) is wasted away as runoff, out of which 3.3 mham (65 per cent) escapes into the sea. Even if some of this runoff is harvested, it can improve water supply to rural communities. Neglecting traditional rainwater harvesting systems in the dry zone in favour of tubewell water has caused problems as the tubewell water has become brackish due to rusting or because of well yields becoming low due to overexploitation. In such situations, people have to travel long distances in search of safe drinking water.

According to the predictions of the water resources secretariat in Sri Lanka, there will be a 1,400 million cubic metre (mcum) deficit of water in the northern dry zone by the year 2000 and, in the capital city of Colombo, the water demand will double. This situation, therefore, emphasises the need for sourcing additional water to face the deficit situation. Rainwater harvesting appears to be the only solution as groundwater levels are depleting and withdrawals from perennial rivers are already causing seawater ingress due to overextraction.

At present, rainwater harvesting for domestic purposes remains mostly with the rural communities, where seasonal rainwater harvesting supplements the domestic water needs in the short-term. Sri Lankan rural communities have innovated different types of rainwater harvesting methods to avoid water scarcity situations. While most of these are short-term solutions, some have provided water for longer periods. These are specially found in temples of Sri Lanka where large cement masonry tanks were used to collect rainwater to meet all water requirements of the temple.

Rainwater harvesting is not a new concept to South Asia. In 5th century BC, Sigiriya rock fortress in Sri Lanka possessed one of the best architectural wonders of rainwater harvesting in the form of a series of ponds on top of the fortress. Besides the Sigiriya rock fortress rainwater harvesting system, there could be a number of such systems existing mostly associated with ancient temples. However, few appear to be documented.

WATER SUPPLY AND SOURCES

In Sri Lanka, the designed per capita water consumption is only 140-160 litres per day as compared to 700 litres in the US and 250 litres in France. Access to drinking water supply and sanitation is, however, higher in Sri Lanka than in neighbouring countries.

The National Water Supply and Drainage Board is the key government agency responsible for water supply. However, it concentrates mainly on the urban sector that receives nearly 75 per cent of the total public investment flow for the sector. This naturally neglects rural areas, which have a larger percentage of people — 80 per cent — of the country's total population of 18 million. A joint study conducted by the Sri Lankan government and United Nations Children's Fund indicated

that urban water supply coverage was 89 per cent while rural supply coverage was 60 per cent. Water is mainly supplied through piped water supply schemes, dug-wells and tubewells. However, the high coverage levels can be misleading since this does not take into account different levels of service or performance of the schemes. Water pumping systems are facing problems. When supplies are drawn from rivers close to the points of discharge to the sea, the reduced seasonal river flow often causes backflow of sea water, increasing the salinity of water drawn by central water supply schemes. In crowded urban areas, chances of tapping groundwater for drinking purposes are very remote because of the contamination caused by sewage and septic tanks.

In rural areas, natural spring water has been supplied through gravity systems to clusters of houses. Depending on location, the water supply coverage varies. The scattered nature of settlements in the dry zone and hill settlements in the central and southern wet zone have denied rural communities domestic water through conventional water supply sources. Some of these communities face severe water scarcity problems due to climatic variations and geographic locations. Overexploitation of groundwater through tubewells and wells for agricultural purposes has led to water table depletion, causing low water yields and brackish water due to rusting of tubewells.

All sources of water supply in the country derive water from the rainfall received. Rainfall in Sri Lanka exhibits significant regional and seasonal variations *(see Table 1: Silver drops everywhere).* The seasonal and spatial high intensity, short duration rain creates large runoff losses.

There are eight coherent rainfall zones in Sri Lanka *(A-H in Table 1)* and there is adequate precipitation all over the country to initiate rainwater harvesting at individual or community level to alleviate water stress.

Broadly, traditional rainwater harvesting in Sri Lanka can be categorized as follows:

- Rooftop water harvesting using various indigenous temporary gutters;
- open air rainwater harvesting techniques; and,
- tree trunk water harvesting *(see Box: Contemporary rainwater harvesting).*

A study was conducted in Kandy (wet zone) Anuradhapura (dry zone) and Monaragala (intermediate zone) districts in Sri Lanka by the ITDG. The three districts were selected from the three agroecological zones to represent the variation and diversity in rainwater harvesting techniques. Kandy district receives rain from southwest monsoon from May to September while Anuradhapura and Monaragala receive rain from northeast monsoon in December and January. Besides the main monsoon periods, the first intermonsoon rains are received from March to April by Kandy district, while the second intermonsoons rains, from October to November, are received by Anuradhapura and Monaragala.

MONARAGALA DISTRICT

Monaragala, located to the southeast in Sri Lanka, receives rain from the northeast monsoon in December and January after the intermonsoon period from October to November. The agroecological climate varies from wet to intermediate to dry. The water requirement, therefore, varies.

The main sources of water in the district are protected dugwells, unprotected dugwells, tubewells, piped water supply and natural streams and canals. The water users in this district can be categorised according to the social and income status and location of residence. Those who are rich and reside in areas of water supply have access to this facility.

Table 1: Silver drops everywhere

Seasonal rainfall (millimetres) in coherent rainfall zones of Sri Lanka

Season		A	B	C	D	E	F	G	H
First intermonsoon (March-April)	M SD	122.3 58.8	239.4 91.7	133.6 79.3	349.7 113.9	480.5 129.1	354.8 105.8	228.2 91.7	277.9 103.2
Southwest monsoon (May-Sept)	M SD	199.8 91.7	244.1 116.5	330.5 124.7	920.7 311.5	1681. 391.2	997.3 253.2	296.2 81.3	337.7 116.7
Second intermonsoon (Oct-Nov)	M SD	526.5 186.1	479.6 151.3	546.5 183.7	625.4 185.0	805.1 189.7	615.3 161.9	493.0 141.7	452.9 144.3
Northeast monsoon (Dec-Feb)	M SD	392.9 213.6	314.9 156.3	633.8 292.0	297.8 117.5	430.2 149.2	467.1 179.6	733.1 283.3	387.9 162.1
Annual rainfall (Jan-Dec)	**M SD**	**1,240 305.1**	**1,278 257.3**	**1,644 370.3**	**2,189 448.8**	**3,397 491.7**	**2,432 334.1**	**1,752 328.0**	**1,455 295.5**

Note: *M: mean SD: standard deviation A-H: rainfall zones*

Source: L Chandrapala 1996, Long trends of rainfall and temperature in Sri Lanka, in Y B Abrol, Sulochana Gadgil and G B Pant (eds), *Climate Variability and Agriculture,* Narosa Publishing House, India.

CONTEMPORARY RAINWATER HARVESTING

As success in rainwater harvesting spreads contributions by the beneficiaries also increase

Most of the rainwater harvesting systems have local community innovations, developed in the past to suit a particular situation at a particular period of time. Adopting the same for the present day context needs scientific research and inputs before being accepted as alternatives for present water scarcities.

The government's Community Water Supply and Sanitation Project (CWSSP) adopted rainwater harvesting as a means of alternative water supply source for rural communities in 1995. The implementation of the rainwater harvesting project was totally demand driven with 20 per cent equity participation from the beneficiaries and 80 per cent from the project. The success of this approach has encouraged policymakers to accept rainwater harvesting as an alternative means for domestic water supply.

With adequate rainfall all over the country, harvesting rain was a feasible option to provide safe drinking water to many communities living in hill settlements in the central hill country and to those living in the northcentral and southern dry zones. In the latter two areas, communities either had no access to safe drinking water or the available groundwater was too brackish to drink. In the southern dry zone, salinity of groundwater was a major threat to human consumption. Due to these unsuitable conditions, people usually spent long hours and travelled long distances to collect safe drinking water from a nearby town supply source or from community wells. In a village called Suriyawawe (situated in one of the driest part of the country) people sometimes travel as much as 10 kilometres to collect safe drinking water. Due to difficulties of collecting safe drinking water, people in the dry zone had their own traditional rainwater harvesting systems. However, these were mostly used only during the rainy season and their collections were limited to household utensils as there was no system of storage.

The technology adopted the traditional wisdom of harvesting roof runoff, merged with new technology, and five cubic metre cement mortar tanks were constructed at the household level to harvest and store rainwater. These tanks were of two types: surface tanks made of ferrocement and underground tanks made of brick mortar. The total cost of these tanks varied from Sri Lankan Rs 7,000-9,000 (US $90-115) depending on the type of tank.

The first experiment of organized rainwater harvesting began in a village called Dematawelihinna in Badulla in the central hills of Sri Lanka. The acceptance of these tanks as a reliable means of water supply can be judged by the current spread of this technology. At present there are about 6,500 such tanks constructed in five districts in Sri Lanka. While the initial implementation of rainwater harvesting tanks was by the CWSSP, it is now being taken up by a number of non-government organisations, as a means of water supply to poor households in rural Sri Lanka. The beneficiary contribution in construction has increased from 20 per cent to 50 per cent and given a better sense of ownership.

Some of the advantages of rainwater harvesting in household tanks include:

- Better maintenance as the storage tank is individually owned;
- improvement in household water security;
- better water quality;
- user friendly technology, easy to understand, build and maintain; and,
- long life span of the tanks, which is more than 10 years.

People in the rural areas depend on tubewells and dugwells. Though tubewells were a good source of providing safe drinking water to rural communities, these are mostly restricted only to the main road. Thus, the people who live in the interior do not have easy access to drinking water. Some of the tubewells constructed are non-functional due to technical defects and are not repaired on time, and so the facility is a waste.

It is the people, who do not have access to any source of safe drinking water or to groundwater, who are most vulnerable. It is these people who also offer the most potential as rainwater harvesters. These people mostly live in hilly terrain, and to reach and access groundwater, they need to drill more than 30 metres (m) deep. Piped water systems are not feasible due to high costs. These people, therefore, have to travel long distances to collect safe drinking water. Usually, these people collect water from natural streams and canals for their domestic purposes. However, when streams run dry during the peak dry period (June-August), they tend to dig small water holes in stream beds to collect water. Unfortunately, in most cases, water from these holes is brackish and unfit for drinking.

A number of indigenous rainwater harvesting techniques are being practiced by these people. These include rooftop water harvesting using various types of indigenous techniques, including temporary gutters, tree trunk water harvesting and open air direct rainwater harvesting. The basic limitations of these techniques include limited storage capacity, contamination of collected water due to poor water management practices, and mosquito and other small insect breeding in open storage tanks.

Rooftop water harvesting

Rooftop water harvesting is practised using a variety of materials as gutters. While the economically better off use manufactured materials as gutters, the poor depend on natural resources.

Tin sheets: This is a technique where people use tin sheets formed into the shape of a gutter, tied with jute

or coir ropes and attached to the full length of the roof. At the end of the gutter, royal palm leaves or barks of trees are used to form a funnel shape to avoid splashing of water at the point of exit.

Users of tin sheet gutters practice the 'first flush' system for at least 30 minutes before they store water for consumption. Storing water is the main problem for most users, most of whom collect as much water as possible in kitchen utensils. However, those who are more organized collect water in 200 litre barrels or small cement open tanks constructed under the gutters. These tanks usually hold 225-350 litres of water. These users close the storage vessels or tanks with *cadjan* leaves (these are dried coconut leaves that are woven together and used as thatch by the poor), polythene or tin sheets. However, as the system of storing is not very secure water cannot be used for more than 5-7 days depending on the family size. The water, thus, collected is mainly used for drinking which is boiled or filtered before consumption.

Bamboo gutters: In most rural households in Monaragala, houses do not have gutters to collect rainwater. Therefore, they either have to construct permanent gutters, in which case the cost will be high or use temporary gutters like banana stem files, royal palm leaves or install semi-permanent gutters using bamboo. Bamboo gutters last a longer time than other temporary fixtures and collect water from the full area of the roof. Some households use folded royal palm leaves at the end of the bamboo gutters to avoid water waste through splashing or spillage.

Banana stem files: This technique is used mostly by the poorer community. Banana stem files are tied to a corner of the roof firmly. At times of heavy rains, the banana stem files are supported by props to prevent falling under heavy water pressure. The problem with this system is that banana stem files have to be replaced frequently as they tend to break with 3-4 days of heavy rains. Users of this technique collect about 6-7 pots of water under average rain conditions. This technique may appear primitive but it is very useful to the poor who do not have the capacity to buy polythene sheets or galvanized sheets.

Arecanut (*Areca catechu*) sheaths: This technique uses arecanut sheaths as a temporary gutter to collect rooftop runoff. The quantity of water that can be collected using this system is limited and the sheath needs to be replaced at least once every two weeks.

Open air rainwater harvesting

In open air rainwater harvesting, a number of materials are used to capture the rainfall directly from the skies.

Royal palm (*Borassus flabellifer*) leaves: In this technique a large royal palm tree leaf is placed on a wooden stand in the open air. The rainwater is collected directly and is thus cleaner than roof runoff water. This method appears to have been extensively used in the past. At present with most houses having good roofs, people have got used to rooftop water harvesting systems. Under good rainfall conditions a large royal palm leaf can collect as much as 200 litres of water per day. This water is specifically used for drinking only. Though this technique gives good quality drinking water, the only disadvantage is that it takes a long time to establish a strong system that can withstand strong winds and heavy rains. The other disadvantage is that royal palm leaves decay within two weeks of use. Hence, these leaves have to be replaced every two weeks during the rainy season.

Polythene sheets: This technique is used with a polythene sheet 3 metres (m) x 3 m in size, spread across in the open air devoid of trees, to collect direct rainfall. The water thus collected is cleaner than roof runoff.

The polythene sheet is mounted on four wooden poles at the four corners and a hole is made at the centre. Usually, small pots and kitchen utensils are used to collect water under this system. This is an *ad hoc* technique, which is installed prior to rain. Some households use this technique by tapering one side of the polythene sheet instead of the central hole. The drawback of this method is that a lot of water is wasted in heavy rains. A polythene sheet of this size can collect approximately 7-8 pots (85-100 litres) of water within an hour on an average rainfall day. While this technique collects clean drinking water, it is expensive to buy polythene sheets and the polythene sheet is vulnerable to damage under heavy wind conditions.

Galvanized sheet: This technique uses a 2 m x 1 m galvanized sheet in the open air to collect direct rainfall. The galvanized sheet is tied from the two corners in the shape of a boat. The sheet is mounted on four or six poles in the open air. Users of this system say that they can collect only limited quantity of water, sufficient for about two days for a family of 7-8 members. Usually, on an average rainy day, households could collect 6-7 pots of water per day from this method. While this system collects clean drinking water, the drawback is that it is costly to purchase galvanize sheets and the sheet can rust if not maintained properly.

Tree trunks: There is evidence that in the past, people constructed boat-like structures from large tree trunks and lifted it in the open air to collect direct rainfall. These structures were about 2.6 m in length with a similar depth cavity constructed to collect rainwater.

Natural rock cavities: In one temple in Monaragala there is evidence to suggest that rainwater was collected in large (4 m x 1 m) rock cavities constructed on large rock surfaces. According to popular folk belief, water collected in rock cavities lasted for a long time and at times Buddhist priests used this water to wash their robes. Presently, people in the neighbourhood use this water for drinking during the rainy season.

Tree trunk water harvesting

Tree trunk rainwater harvesting is widely practiced in most parts of Sri Lanka and is a deep rooted tradition of the rural farmers. A banana stem file, a dried royal palm leaf or a tin sheet formed into a down-pipe is tied to the tree trunk to collect the water that seeps down the trunk. People employ this technique to collect good quality water, but in small quantities, usually 15-20 liters per day. The collected water is essentially used for drinking as the traditional water sources like dugwells often get contaminated during the rainy season. Traditionally, people have used coconut (*Cocos nucifera*) to collect rainwater. People believe that the leaf symmetry of coconut palms can filter falling rainwater and so the quality is better. However, others believe that due to the leaf symmetry of the coconut trees, there is a higher tendency for contamination and so use other trees like jackfruit (*Artocarpus heterophyllus*) and mango (*Mangifera indica*) for harvesting rainwater.

The collections from this technique are limited to daily requirements of households. The main reason for inadequate collection is lack of proper collection and storage facilities. Most of the water is collected in small pots and buckets. Due to their poor economic condition the people do not have extra containers to collect or store water and so whatever water is collected is consumed during the day itself. Though a good system to collect and use safe drinking water, this does not provide sufficient water security for most of these households.

ITDG / SRI LANKA

A ferrocement tank captures a good amount of rainwater

KANDY

Kandy district is situated in the central hills in Sri Lanka, consisting of 3,184 villages with a population of approximately 1.2 million and an annual average rainfall of 2,500 millimetres. The district has vast potential for rainwater harvesting.

Being an urban town, most of the population gets the benefit of having piped water supply, unlike other districts. Some 79 per cent of the population is supplied from some source of water, mostly within reachable distances. Often, the population that receives piped water supply does not get enough. Some 21 per cent of the population still depends on natural spring water and rainwater harvesting. Those living in a hill terrain have constructed small tanks at foothills where natural spring water is available. Families who depend on tubewells sometimes have to leave them due to water contamination or rusting of the galvanised iron pipe. Most of the people, who do not have access to safe water live in hilly terrains, have to travel to long distances to collect water. Given the hilly terrain in Kandy, this is not easy. Rainwater, thus, appears to be a good source of water.

The socioeconomic condition of rainwater users indicates that they do not belong to the poorest category of people residing in the area, but are people who do not have an assured supply of water like settlers in hill terrains, or those who practiced rainwater harvesting prior to piped water supply being provided. Almost all of the rainwater harvesting practitioners have tile or asbestos roofs, cement floors and brick walls, conditions suitable for roof runoff collection. There are private entrepreneurs (cement-brick makers) in Kandy who harvest rainwater for their brick-making business, because they are unable to get adequate water from the central water supply system. In this area water is supplied once in two days.

The water harvesting systems used here include rooftop rainwater harvesting, open air rainwater harvesting and tree trunk water harvesting. Rooftop runoff collection, is practiced in most houses in Kandy district where the water supply is inadequate to meet the demand of the household.

In a temple in Kandy, the rooftop runoff has been captured in a 'Corose,' a large diameter container made out of steel. It is believed that these containers were used during the Dutch period to store sugarcane juice. According to the chief priest of the temple, this container was brought by two elephants to the temple. The water is used for washing and bathing purposes. There are seven such containers in Kandy district. One is in the kitchen of the Sacred Temple of the Tooth (Dalada maligawa), and others are mostly in temples and big mansions (*walawes*) of the Kandian dynasty. However, there are no records to say that any one of the other containers were used for collecting rainwater for domestic use.

Tree trunk water harvesting is undertaken by using an arecanut (*Areca catechu*) or *kithul* (*Caryota urens*) leaf sheaths tied to a trunk of a coconut, arecanut or *kithul* tree. This technique is widely used during the rainy season by those who cannot afford to construct more expensive water harvesting systems. The water thus collected is used for drinking purposes though only a limited quantity can be collected.

Shallow spring water is directed into large storage tanks where natural spring water is available and where no ready source of water supply exists. These structures are constructed at foothills of mountains and at the base of valleys. Some of these structures are constructed by local government authorities to supplement water supply in the district.

ANURADHAPURA

Anuradhapura, in the north central province in Sri Lanka, is categorized as a dry zone, where a number of irrigation schemes have been undertaken. The population is large, and keeps increasing as refugees migrate from the war-affected northern districts. This puts a further burden on drinking water supply.

People of Anuradhapura use water from protected and unprotected wells and tubewells for domestic use. For non-potable use, natural streams, irrigation tanks or unprotected wells are used. Unprotected wells are usually used by the low income section of the community.

During the wet season, most of the primary sources of water (dugwells) have adequate water, thus householders do not have to leave the premises to collect water. However, in the dry season, most of the primary sources of water run dry and households have to search for other sources of water outside their residences.

The rainwater users in Anuradhapura can be divided into two groups: those who cultivate under Mahaweli Irrigation System and those who depend on rainfall. Some households collect rainwater through roof catchments. Royal palm leaves are used by poor households, mostly by those who do not have permanent roofing. In these houses, the roofs are mostly *cadjan* or straw and so there is no provision for fixing gutters to collect rainwater. Besides, they are too poor to invest on gutters. These households use large surface palm leaves to collect rainwater directly to a constructed rectangular tank of usually 1,130-1,270 litre capacity or into small pots and buckets. The palm leaf is mounted on four sticks tapering towards the tank.

Harvesting rainwater through tree trunks is a common occurrence in the Mahaweli areas of Anuradhapura. Due to the Mahaweli irrigation scheme these people have few problems of water. However, during the wet season, these households harvest rainwater through tree trunks. Usually, coconut (*Cocos nucifera*) and jackfruit (*Artocarpus heterophyllus*) trees are used to harvest water. People tie coconut leaves to these tree trunks to harvest water that comes along the tree trunk. People drink this water because they have no better source of drinking water. Collecting rainwater during rain also gives these people a ready source of quality drinking water close to the house itself. This prevents them from going out in search for well water specially during the rainy season.

ITDG / SRI LANKA

Poverty breeds ingenuity. Rooftop rainwater is diverted into a tank through a recycled jerry can using a polythene sheet

Another technique is to attach a long (2-3 m) polythene gutter to two roofs tapering towards the same side. The roof catchment is large enough to collect sufficient quantity of water for domestic use and on an average rainy day, about 25-45 litres of water can be collected.

Harvesting rainwater with inverted umbrellas

Rainwater is harvested by using an inverted umbrella in a galvanized bucket. This technique is used in combination with other rainwater harvesting techniques, since only a limited quantity of water can be collected due to a small catchment area. The water collected is used for drinking purposes.

Rainwater harvesting experiences in Anuradhapura district indicate that householders collect rainwater not because of the lack of drinking water but because of the better quality of rainwater. Capacity to collect and store sufficient rainwater is limited due to the poor economic status of these households. ■

This paper is an edited version of the paper Wisdom of Traditional Collection of Rainwater for Domestic Use in Sri Lanka *by R de S Ariyabandu, prepared as a country report commissioned by the Disaster Mitigation Programme of the Intermediate Technology Development Group, Sri Lanka, as a part of the programme of activities for Duryog Nivaran, a South Asian network for disaster mitigation.*

CHAPTER 3

Rural Water Harvesting Programmes

- It is heartening to see the revival of traditional water harvesting systems in various ecological regions of India. Communities, in the face of extreme adversity, have revived or created new water harvesting systems. In many places, these efforts have withstood the effects of recurring drought.

- There are several exemplary examples. Artificial glaciers are created at lower altitudes in the cold desert of Ladakh; and, in coastal Kerala, rooftop rainwater is directed into ferrocement tanks.

- Often the catalyst has been a non-governmental organisation. In Alwar, Tarun Bharat Sangh has motivated more than 650 villages to manage their rainwater endowment. Its efforts have revived five rivers.

- But governments are also learning. Jhabua in Madhya Pradesh is an outstanding example of a government-run watershed programme, run through participation at the lowest level and accountability at the highest level.

- Gujarat has many examples of community involvement in water harvesting. Check dams have both recharged groundwater and empowered women.

- In Bihar, a new *ahar* and *pyne* system was constructed by the villagers themselves to meet irrigation requirements and ended up recharging the groundwater.

- In Karnataka, farm ponds have improved soil moisture regimes and boosted yields. In Kerala, springs are being tapped to meet drinking water needs. In Tamil Nadu, revived *ooranis* are catering to potable water needs. Tanks are being desilted. In Pondicherry, soil erosion has been arrested by check dams, bunding and tree plantation.

- Rain is being captured in several countries. In Southeast Asian countries, ferrocement tanks find widespread use in capturing rooftop rainwater. In Israel, microcatchments have proved to be more efficient in harvesting rain. In Kenya, rainwater harvesting has contributed significantly to alleviating poverty and improved agricultural production.

- The success of these efforts reveals the diversity of traditions, technologies, needs and potential of these systems. It also indicates that communities want to take water management into their hands.

Rural Water Harvesting: Trans-Himalayan Region

Learning from Nature

By strengthening old reservoirs and creating artificial glaciers, the rural development department of Leh has provided the local population of Ladakh with more water

Chewang Norphel
Leh Nutrition Project, Ladakh, Jammu and Kashmir

The rural development department of Leh has renovated a number of old reservoirs and created artificial glaciers to augment water availability for cultivation in Ladakh. Ancient water reservoirs and snowmelt streams are the only sources of water in Ladakh and the main challenge is to find ways to get sufficient water during the crucial spring season for timely cultivation.

Ladakh is a highly elevated, cold desert where people live at altitudes exceeding 4,000 metres (m) above mean sea level. Spread over an area of about 9.9 million hectares, the region has a population of about 135,000, nearly 85 per cent of which depends on agriculture. Situated in the rain shadow region of the upper Himalaya, Ladakh receives an annual average rainfall of 50 millimetres (mm) between May and July. It is really water from melted snow that sustains life and most people live along glaciers and snowmelt watercourses.

The agricultural season begins in Ladakh in April with melting of snow in the fields. The melting of snow is often late, delaying the availability of water for irrigation and the sowing of crops, adversely affecting production. During the rest of the year, from August to April, very little water comes down the streams, as temperatures at high mountain peaks do not allow snow to melt. The potential for improving agricultural production is thus restricted to the traditional turn of water sharing and distribution system prevalent throughout the year.

Ancient water reservoirs exist where water is collected from little snowmelt streams during night hours. In the morning, water is allowed to enter small irrigation channels through a hole in a *bund* of the reservoirs to flow onto selected fields by turns, according to set conventions. Collection and distribution of water is still managed through established conventions that ensure equity. Since these were based on established traditions, no one dared to improve upon them to improve efficiency. Centuries-old reservoirs existed in dilapidated conditions.

The rural development department of Leh conducted a detailed study to examine possibilities to increase the capacity and efficiency of these traditional water reservoirs and then undertook renovation and enlargement of selected reservoirs. Main and sub-channels leading to fields were repaired. More than 200 water reservoirs have been either constructed or renovated in Leh district alone. Under the Watershed Development Programme, 10 traditional water harvesting systems have been promoted in villages like Sakti, Chemday, Karo, Nang, Stakmo, Skumpata, Gongma, Sabo, Ayu and Manu. In many cases now, the night duties of the farmers to guard the reservoir are no longer necessary as these reservoirs now have sufficient capacity to meet the needs of water the next morning.

A FROZEN FORTUNE

Though improving the capacity of traditional reservoirs has increased water availability, the problem of providing water early in the spring season for timely sowing still remained. A new technique called 'artificial glaciers' has been developed to deal with this problem. For centuries, farmers in the area experimented with various methods to develop artificial glaciers or ice-blocks by diverting water from *nullahs* or streams to low terraces, located at the base of mountains, and shaded by these mountains by virtue of their geographical location. Farmers would then spread locally available charcoal produced out of wood and shrubs to

help form ice-blocks on these terraces. These ice blocks would melt much earlier than the ice in the higher reaches of the mountains and thus provide water sooner than was possible by the melting of the glaciers. This technique has now been more or less forgotten.

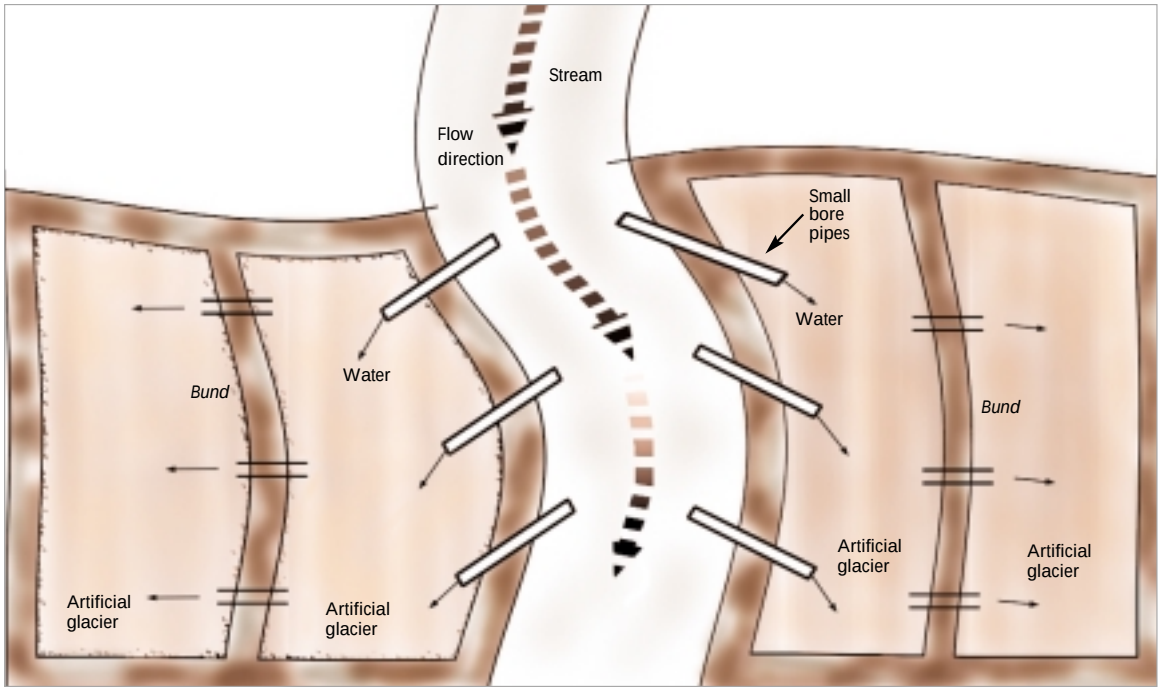
But, inspired by the idea, the rural development department of Leh decided to construct artificial glaciers by diverting water from streams towards terraces built at low mountain terrain. Small pipes of 12.7 mm diameter were laid on the bed of channels, crosswise at every three metres to let the water seep through them on the lower side of the channels *(see Fig 1: Small solutions)*. To tap more water flowing through these pipes, dry *bunds* parallel to water channels were constructed in a series at a distance of 6-30 m, according to the nature of slopes. The entire catchment would then freeze during winter. These artificial glaciers begin to melt in early spring, as these are located at much lower altitudes than natural glaciers. The melted water is then directed towards agricultural fields. Since artificial glaciers are located near the fields, farmers are able to time the sowing with precision. Springs are also recharged. Experiments to use artificial glaciers carried out in various villages on a trial basis have proved to be quite cost-effective and successful. ■

C NORPHEL

An artificial glacier in the Nang village of Ladakh

Fig 1: Small solutions

Storing of water in fields in late autumn to make artificial glaciers through small bore pipes with water from a flowing stream. These glaciers melt earlier than the mountain glaciers and, thus, help farmers to start cultivation early in the spring



AKHILESH / CSE

OPPOSITE PAGE: ***Ladakh is a high altitude desert with a mere 50 millimetres of annual rainfall. Inhabitants of this harsh terrain survive on using snowmelt through traditional water harvesting systems that have been in place for centuries.*** (PIX: SONAM DAWA)

Modernising Traditional Systems

The Bhoruka Charitable Trust, a voluntary organisation, is using polymer technology to increase runoff into artificial wells (kundis) *in Rajgarh block of Churu district, Rajasthan*

R P Bisht
Bhoruka Charitable Trust, Rajgarh, Rajasthan

Churu district in Rajasthan is facing acute drinking water scarcity due to poor groundwater quality and lack of water sources such as rivers and canals. To deal with the situation, Bhoruka Charitable Trust (BCT) is encouraging villagers to build and renovate *kundis* (tanks), *johads* (ponds), *talabs* (permanent ponds) and dugwells. It is using polymer technology to increase runoff from catchment areas into *kundis.*

Piped drinking water does not reach many villages. In places, where pipelines exist, supply is irregular and inadequate, particularly during summer. Thus, the only option for quality water supply in this region is harvesting and storage of rainwater through *kundis* and *johads.* Unfortunately, *kundis* are getting neglected or destroyed in places where piped water supply is being provided.

Rajgarh block, situated in the northeastern part of Churu district, is characterised by sand dunes and a flat terrain. The highly porous soil of the area

ANIL AGARWAL / CSE

The sanctity of a temple is enhanced by the presence of a* kundi *— one of many such structures in Churu district of Rajasthan. A* kundi *is an artificial catchment (see arrow), created anywhere in the desert, with a slope that leads the rain falling in it to an artificial well in the centre. The amount of rainwater captured depends on the nature of the surface of the catchment. Polymer technology is being used by Bhoruka Charitable Trust to increase this runoff

encourages high infiltration as well as rapid evaporation of rainwater. The block receives an annual average rainfall of about 350 millimetres (mm) within 10-15 days, in the form of two to three thunderstorms. An annual average evaporation loss of about 250-350 mm greatly reduces natural recharge of groundwater. Though there is good groundwater potential in the region, in most places water is saline, with pH varying from 7.5-9.5, has high content of total dissolved solids and low to high concentration of fluorides, nitrates and bicarbonates that are harmful to health. This groundwater, therefore, cannot be tapped.

BCT is encouraging a return to traditional rainwater harvesting systems. These sources can be easily created and maintained even in distant, isolated locations. Rainwater collected in *johads* and *kundis* improves the groundwater level and provides better recharge to wells situated close to these structures.

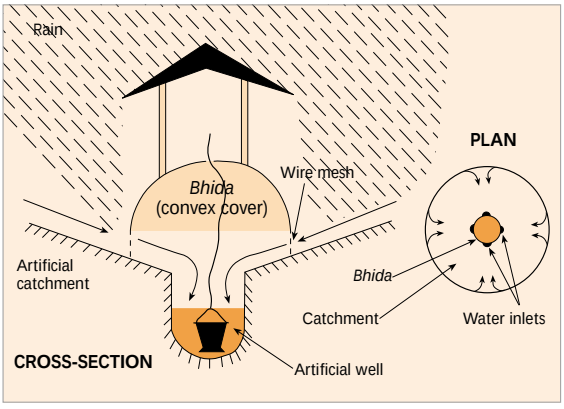
Kundis are probably the most logical traditional water harvesting systems designed for harvesting drinking water, given the ecology and groundwater quality of the region. The *kundi* consists of a circular catchment area sloping towards the centrally located storage structure *(see Fig 1: Water trap).*

The quality of water from a *kundi* is good and if maintained properly, no serious water contamination occurs. Maintenance is easy: the *kundis* are desilted and cleaned periodically before the onset of monsoon. The catchment area is cleaned and protected. Cattle grazing and entry with shoes is strictly prohibited. Even the rooftop of the *kundi* is used to harvest rains. The drawing of water is easy and time-saving.

Churu district, Rajasthan

Fig 1: Water trap

Kundis are roughly around six metres deep and two metres in diameter, the sides of which are plastered with lime and ash



Local materials such as silt, clay, lime, ash and gravel are traditionally used to construct the catchment area of a *kundi*. They do not make a completely impermeable layer. As a result, a substantial part of rainwater is lost due to uncontrolled seepage. Efforts are now being made to enhance runoff in a joint research project of the National Geophysical Research Institute, Hyderabad, Indian Institute of Chemical Technology, Hyderabad and BCT, Bhorugram. The project has identified ways to generate 60-75 per cent runoff, depending on the intensity of rainfall, using new techniques in polymer science. Water-based non-toxic polymer solutions that permeate the highly porous sandy soils are used to increase runoff into *kundis*. These polymers act as binders and reduce permeability and infiltration rate of the sandy soil. Use of water-repelling chemicals, in combination with these binding agents, results in better runoff.

BCT has been using a polymer spray in catchment areas of *kundis* for some years now. The cost of polymer treatment is about one quarter of the traditional catchment construction cost. Presently, field and durability trials are in progress at five sites in Rajgarh block of Churu district.

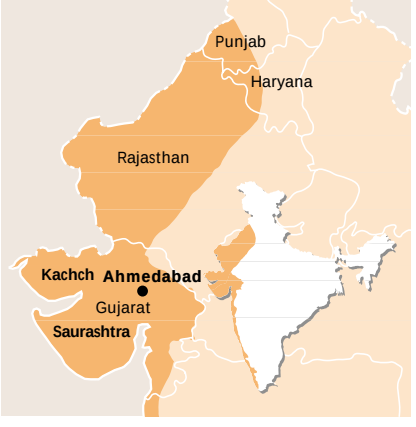
In *dhanis* (hamlets) and schools, located away from villages, water can be made available from *kundis* at a much lower cost than pipeline supply. Considering the average drinking water consumption to be 30 litres / day / head, a *kundi* of 100,000 litres capacity can meet the annual drinking water requirement of a family consisting of 9-10 members. Similarly, considering the average drinking water consumption of a student as two litres / day, a *kundi* can meet the water requirement of about 210 students of a school for 240 working days in a year. ■

Many Times Over

Aquifer recharge structures in Kachch harvest more than their constructed capacity

K C B Raju
Vivekanand Research and Training Institute, Mandvi, Gujarat

Vivekanand Research and Training Institute (VRTI), a non-governmental organisation, based in Mandvi, Gujarat has designed a number of innovative water recharging structures to harvest the meagre rainfall, most of which is often erratic and wasted away as floodwaters into the sea. These structures permit repeated recharge of aquifers by utilisation of the periodic floodwaters, made possible by rapid percolation of water .



Kachch district really has no choice. An area of 4.57 million hectares (mha) is bounded in from all sides — in the west, south and southeast by the sea, in the north by the Great Rann and in the east by the Little Rann**.** The region can thus only depend on the meagre annual rainfall of 338 millimetres (mm), which is erratic, unreliable and often received in a few showers *(see Table 1: Rainfall endowment)*. There are about 97 rivers and rivulets which are of the ephemeral type *(see Table 2: Harnessing rivers)*. Ten rivers flowing north and eleven rivers flowing south have been harnessed through minor and medium irrigation projects. Though the storage capacity created through these projects is about 571 million cubic metres (mcum), due to recurring droughts, these projects could irrigate only about 25 per cent of the command area between 1987-1996. In addition, a number of the minor irrigation schemes have silted up, many of them up to 50 per cent of their capacity.

Mundra and Mandvi talukas of Kachch were once

Table 1: Rainfall endowment
Nomal and extreme rainfall (millimetres) and its variability (1901 to 1979)

Station	Normal	Extreme	Year	In a day
Bhuj	342	1,311	1959	468
Anjar	343	982	1979	350
Rampar	365	1,139	1975	353
Bachau	383	989	1979	257
Mundra	439	957	1959	350
Kandla	433	893	1967	186
Naliya	452	1,372	1959	443
Mandvi	402	949	1967	333
Lakhpat	338	957	1959	389
Nakhtrana	382	864	1979	265
Khadva	345	988	1961	280
Khadir	381	853	1959	178

AMIT SHANKER / CSE

One of the many check dams built by VRTI

Table 2: Harnessing rivers
Water resources in Kachch are limited

Water resources	Number	Capacity (mcum)
Medium irrigation projects on rivers and rivulets	17	286.26
Minor irrigation projects on rivers and rivulets	160	284.31
Total surface water sources	**177**	**571**
Groundwater	—	**517**
Total		**1,088**

Note: *mcum: million cubic metres*

known as the green belts of the district. Aquifers existed at 30 metres (m), which supported thousands of open dugwells. All these wells are now dry.

VITAL STATISTICS

Though there are about 30,000 wells and 200 tubewells for irrigation, in only 378 out of the 904 villages — a mere 42 per cent — have access to these.

Groundwater is being overexploited in the region *(see Table 3: Dangerous reliance)*. In places where there is a heavy reliance on groundwater with subsequent decline, aquifer recharge assumes great significance. Direct recharge through recharge tubewells will improve water quality as well as provide availability at a faster rate than gradual percolation from check dams.

There is a potential aquifer in the southern coastal area, at a depth between 100-150 m, capable of supporting thousands of dug-cum-borewells. However, due to heavy withdrawal for irrigation, the water levels have fallen below sea level causing seawater intrusion into these coastal aquifers, spoiling the quality of groundwater.

The most prolific aquifers of the area occur in the Bhuj region, from where most of the rural and urban water supply is being met. There are about 600 tubewells here at depths of 150 m supplying water through pipes upto 60 kilometres (km) away.

Due to recurring droughts since 1984, groundwater development in seven out of nine *talukas* exceeds annual recharge through precipitation.

The solution therefore lies in rainwater harvesting. Being a drought-prone area, surface water storages go dry during drought years. It is imperative then to store water in sub-surface structures and maximise groundwater recharge. While even minor irrigation schemes take years to complete, the construction of small check dams are economical and beneficial. Such structures are useful in areas where no wells exist and the underlying rocks contain saline water. In areas where wells exist and are utilised for irrigation, it is important that the aquifers feeding these wells be recharged. In addition, these rocks offer massive spaces for storing water.

AQUEOUS INTERVENTIONS

VRTI has been involved in rainwater harvesting since 1988, striving to utilise every drop of rain available by

Table 3: Dangerous reliance
Groundwater potential of Kachch district is being overexploited

Details	Name of *talukas*									
	Mandvi	Nakhatrana	Bhuj	Bhachau	Lakhpat	Anjar	Rapar	Mundra	Abdasa	Total
Total groundwater recharge (mcum/year)	60.41	56.19	196.79	30.66	25.54	24.24	58.46	45.23	19.55	**517.07**
Utilisable groundwater recharge (mcum/year)	51.35	47.76	167.27	26.06	21.70	20.60	49.69	38.44	16.62	**439.49**
Gross groundwater draft (mcum/year)	63.75	53.26	76.82	45.54	3.26	26.68	56.95	39.37	15.96	**381.56**
Groundwater balance (mcum/year)	Nil	Nil	100.45	Nil	18.14	Nil	Nil	Nil	Nil	**118.59**
Level of groundwater development (%)	124.14	111.51	45.92	174.75	15.02	129.51	114.67	102.42	95.84	
Category (a) Present	Over-exploited	Over-exploited	White	Over-exploited	White	Over-exploited	Over-exploited	Over-exploited	Dark	
(b) 5 years hence	Over-exploited	Over-exploited	White	Over-exploited	White	Over-exploited	Over-exploited	Over-exploited	Over-exploited	

Note: *mcum* : *million cubic metres*
Nakhatrana : *Considering 5 mcum/year pumping for water supply*
Bhuj : *Considering 10 mcum/year pumping for water supply*
Bhachau : *Considering 5 mcum/year pumping for water supply*
Anjar : *Considering 15 mcum/year pumping for Kandla/Gandhidham*

K C B RAJU

By constructing recharge structures like sub-surface dykes in riverbeds, the water holding capacity increases manifold

construction of check dams, percolation ponds and sub-surface dykes *(see Fig 1: Rayan's wealth)*. To harvest as many floods as is possible, the site of the sub-surface dyke is selected to ensure that the water intercepted in the first flood percolates down to make the structure empty, thirsting for more and ready to receive the next flood.

Till March 1997, 64 storage tanks, 39 percolation tanks, five sub-surface dykes, and 96 recharge tubewells had been constructed. The total storage capacity created is 4.82 mcum. However, since every year at least two floods occur, the actual recharge capacity average can be considered as 9.64 mcum. The surface storage capacity created through storage tanks is 6.74 mcum. The total capacity thus created is 16.38 mcum.

The presence of recharge structures in riverbeds and waterbodies has many advantages. The structures are easy to construct; no submergence of land takes place beyond the riverbed; there is no evaporation loss; no conveyance losses; cost of construction and maintenance is low; many floods can be harvested in a single year; and, due to the direct recharging of the deep aquifers, there will be a fast improvement both in the water level and also the quality of groundwater.

RECHARGE ACTIVITIES

1. The Bhujpur sub-surface dyke

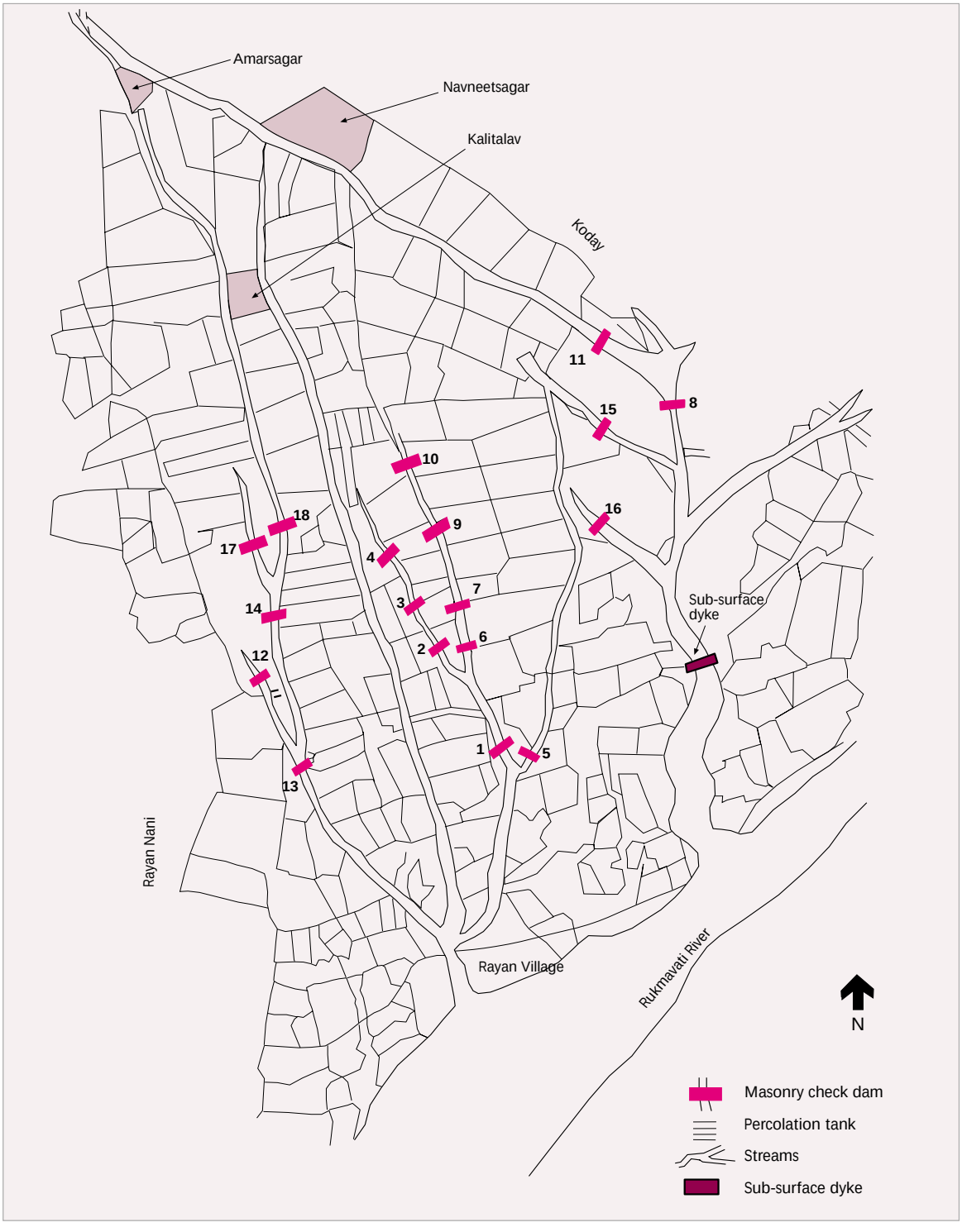
Bhujpur village is situated in Mundra taluka, about 16 km away from Mundra, on the Mundra-Mandvi road. The annual average rainfall is 440 mm. The Nagmati river which flows through the area has a catchment of 11,600 hectares. Whenever the river is in spate, groundwater is recharged. With a couple of irrigation dams in the upper reaches only, beyond Bhujpur, the runoff goes directly into the sea.

To harvest runoff, a surface dyke with four recharge tubewells, 60 m deep were constructed. A low check dam, two metres in height, 120 m long and 30 m wide downstream of the dyke was constructed to intercept flood discharge. The constructions were made before the onset of monsoon.

Nagmati has a big catchment, and therefore there is a continuous inflow of water into the water harvesting structure. Yet there is no overflow of the dam nor a decrease in the reservoir level. This implies that the extra inflow is being converted into groundwater recharge. During the southwest monsoon of 1994, the recharge recorded was 1.19 mcum as against the created storage capacity of 0.21 mcum. Water levels in open dugwells increased — something that the villagers had not witnessed for a long time. The water quality also improved as indicated by a substantial decrease in the total dissolved solids. During the year 1997, Kachch received rainfall of 610 mm between May and September and all the rainwater harvesting structures overflowed twice and some times three times. This has resulted in rise of water level by more than 19 m in Bhujpur area with significant improvement in groundwater quality.

Fig 1: Rayan's wealth

Location of water harvesting structures and sub-surface dyke in village Rayan



K C B RAJU

Table 4: Pushing underground
Volume of water recharged because of rainwater structures in Rayan Project

Water harvesting structure	Constructed Capacity (cum)	Quantity of water recharged (cum)					
		1989	1990	1991	1992	1994	1997
1	2,280	5,657	2,422	2,033	5,358	6,439	5,000
2	1,164	2,471	1,165	1,083	2,679	4,153	1,800
3	1,064	1,889	1,064	826	2,281	4,198	1,800
4	1,129	1,430	1,128	707	1,978	4,694	1,300
5	763	1,540	1,528	776	1,598	2,906	1,400
6	1,750	1,568	1,750	1,456	3,509	6,306	3,000
7	1,208	2,365	1,207	1,006	2,624	3,872	2,000
8	1,547	2,953	1,,547	1,237	4,156	5,623	4,000
9	689	1,346	689	661	1,509	2,631	1,400
10	420	876	420	304	420	1,170	400
11	3,465	9,422	3,465	3,323	8,470	8,470	7,500
12	1,888	3,166	1,888	1,583	3,861	8,810	3,300
13	3,375	5,940	5,989	2,970	3,375	8,760	4,500
14	2,859	6,944	4,985	2,530	5,388	8,026	4,500
15	4,959	1,319	4,959	2,050	12,301	13,596	11,000
16	2,486	4,054	2,486	2,372	6,185	7,982	5,000
17	1,228	2,328	1,226	1,085	1,228	4,580	1,100
18	1,346	2,246	2,283	1,132	3,088	3,596	2,000
Public Tubewell-1	11,098	8,901	5,750	–	16,326	33,078	30,000
Public Tubewell-2	10,080	–	31,752	–	25,325	44,197	40,000
Public Tubewell-3	20,718	–	23,248	–	12,657	19,933	15,000
Public Tubewell-4	53,800	–	–	–	–	–	175,000
Sub-surface dyke	51,507	–	103,014	49,907	100,160	141,644	85,000
Total	**180,823**	**66,415**	**203,965**	**77,041**	**224,476**	**344,664**	**406,000**
Rainfall (mm)		310	191	62	716	1014	611

Note: *cum: cubic metres, mm: millimetres*

2. The Rayan project

The project area in village Rayan is spread over 750 hectares (ha). Executed in 1989-90, 18 check dams, four percolation ponds, one sub-surface dyke and 11 recharge tubewells have been constructed. Even in low rainfall years, the recharge structures were able to significantly improve groundwater levels as well as quality. The quantity of water recharged is above the constructed capacity indicating repeated recharge *(see Table 4: Pushing underground).*

3. VRTI campus

In the VRTI campus in Mandvi, an old dugwell with a bore has been converted into a recharge well by filling the open portion with sand and providing gravel and a coir pack around the tubewell portion in the dugwell section. The campus is about two kilometres from the sea and under tidal influence. The depth of the dugwell is 25 m, with a 25 centimetres diameter tubewell going down to 100 m from the bottom of the dugwell. The floodwater from the roads along the campus, is diverted into a pond constructed within the campus and connected to the recharge well through a pipeline. Every year the silt collected in the dugwell is removed and a metre of sand is replaced to keep the filter mechanism in operational condition through the year.

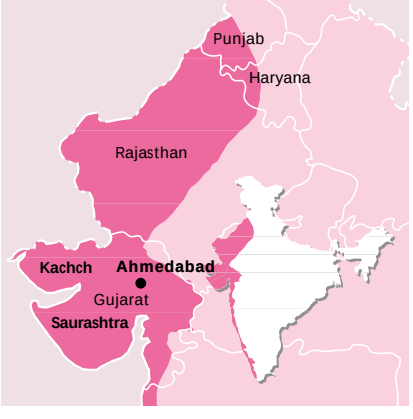
Under the guidance of VRTI, a number of farmers have tapped floodwaters to recharge aquifers. Every abandoned well is used for recharge after diverting the floodwaters through a filter bed. ■

The Awakening

Inspired by a voluntary organisation called Saurashtra Lok Manch (SLM), farmers in the Saurashtra-Kachch region have recharged more than 300,000 wells and tubewells

Shamjibhai Antala
Saurashtra Lok Manch Trust, Rajkot,Gujarat

The 125 lakh population living in the Saurashtra-Kachch region of Gujarat suffers from acute water shortage. Recent efforts by a voluntary organisation called Saurashtra Lok Manch (SLM) has succeeded in motivating a large number of farmers to recharge wells using the monsoon rainfall. More than 300,000 wells and tubewells have been recharged to greatly improve the availability of water. This has been possible by mass literacy drives organised by the organisation coupled with the willingness of the people to help themselves.



Groundwater accounts for 85 per cent irrigation in the region, drawn continuously from 700,000 wells and one million borewells. Groundwater is withdrawn even during the monsoon season. As a result, the water table has been going down by an average of 2.5 metres (m) every year and ingress of seawater has been gradually turning the groundwater saline. Millions of hectares of agricultural land and thousands of wells have become useless due to salinity. There is another disturbing activity being undertaken in the water-scarce regions of Gujarat. Bores for mining groundwater are going deeper and deeper, up to 300 m, even up to 600 m. While it is possible to recharge bores that are at higher levels — 75-100 m — recharging of bores at 300 m is almost impossible, since these are confined aquifers. The cost will also be prohibitive.

In the absence of any political will, the state government has failed to address the problem in any significant manner.

Spread over an area of 11 million hectares (mha), the region receives an annual average rainfall of about 500 millimetres (mm), most of which runs off to the sea due to the lay of the land. Apart from a few small dams used exclusively for drinking purposes, there are no major rivers or dams in the region.

The region went through a severe drought between 1985-87 when more than five thousand villages suffered acute water shortage with disastrous loss of life and income. Fortunately, in 1988, the area received heavy rainfall during the monsoon. This was the year when some enterprising farmers, spurred by the horrifying experiences of the drought, arrested water in wells by making narrow canals in farmlands that directed water into the wells. The efforts yielded instant results and the farmers reaped bumper crops, both in winter and summer. The seeds for a mass movement were sown. Inspired by these examples and determined to reduce the plight of the local population, an non-governmental organisation called the Saurashtra Lok Manch (SLM) was formed in 1989 to accelerate adoption of water conservation measures on a large scale.

TWIN TACTICS

SLM adopted a two-pronged strategy: spreading water literacy amongst the masses *(see Box: Jal Yatra – The road to success)* and motivating the people to participate actively in well recharging. To create awareness, SLM distributed booklets, posters and leaflets in a large number of villages free of cost, under a programme called Jal Sanchay Abhiyan (water conservation movement) to spread awareness about water harvesting systems. The distributed literature mainly explained the need and ways of recharging wells and tubewells during the monsoon. Hundreds of letters were also sent by SLM to concerned organisations and persons to increase mass

JAL YATRA — THE ROAD TO SUCCESS

Jal Yatras *have been crucial to the well recharging movement*

People's participation was essential for the success of the water harvesting movement. To contact a large number of people in rural areas, Sardar Jal Vahini, a *jal yatra* was organised by Saurashtra Lok Manch (SLM) and the state information department. Under this programme, 700 villages in Rajkot district were visited where the importance of well recharging was explained and relevant literature distributed amongst the villagers.

Another Jal Sanchay Jan Jagriti Yatra was organised which was spread over a period of 10 days during July-August in 1996. The *yatra* traversed some 3,000 km through six districts of Saurashtra. During this period, 100 group meetings were conducted in different villages and 101 farmers, who had contributed to the water conservation movement, felicitated. A large number of religious heads, local politicians and leaders from other organisations attended these meetings. An exhibition van, with audio-video film shows, was one of the main attractions of this *yatra*.

The movement spread quickly to the whole of Saurashtra-Kachch region. Cooperatives, voluntary institutions, *panchayats* and registered trusts joined in the effort to educate and install water harvesting systems. A series of water conservation programmes were implemented and more than 300,000 wells and tubewells successfully recharged ushering in a new phase of prosperity in the area.

The *yatra* received wide media coverage and around 100 articles were published in different newspapers and magazines. This water conservation effort is unique in that more than 300,000 wells and tubewells were recharged within a short period by local farmers. As farmers recharged wells and tubewells on a large-scale, water table in the area increased significantly.

awareness about the importance of water harvesting.

Public meetings at district and *taluka* levels and *gram sabhas* (village assemblies) in villages were organised, under a programme named Lok Jan Jagriti Abhiyan (mass awareness programme) . Besides the Jal Sanchay Abhiyan and Lok Jan Jagriti Abhiyan, workshops were also organised. Well and tubewell recharging exhibitions were held on more than 50 occasions.

Every opportunity was availed of to spread the message of water conservation. SLM contacted a large number of religious leaders who helped spread the word about the need for water conservation and harvesting. SLM's appeal to various religious heads in Junagadh and Rajkot to activate their followers in water conservation movement had a visible impact on the people of the area. Other religious heads and saints were also requested to intensify the campaign. SLM took advantage of traditional community marriage ceremonies called *samuh lagnotsavs*, where between 10,000-15,000 people usually gathered. It addressed these large gatherings to impress upon the listeners the importance of water harvesting.

WATER, DOWN UNDER

Recharging of borewells and wells is easy and inexpensive, requiring simple technology. This allows for subsurface storage of rainwater. The technology may vary depending upon the location of the well. In sloping areas, if the well is located at the lower end of the slope, it is easier to direct rainwater into it from a *bund* constructed for the purpose of collecting the rainwater. A 1.8 m x 1.8 m filter pit filled with different sizes of rubble can be constructed to ensure that dirt, mud and clay in the runoff is retained in the filter pit and only clean water gets into the well. Ideally, the pit should have bigger sized rubble at the bottom, with smaller ingredients gradually filling it upwards. The uppermost part of the filter pit should have a layer of big grained sand, leaving 150 mm free. This pit should be connected by a cement pipe to the well.

After sufficient rains, the well fills up and due to the increase in the weight of water column, water enters into the surrounding subsoil through the sides of the well. In this way the well enhances recharge to the groundwater aquifer which increases the availability of water in the dry season.

When the well is situated at the higher end of a sloping catchment, the design needs a little modification for the flow of water. The well is connected to a filter pit as usual. A trench connects a waterbody created at the lower end of the slope to the filter pit at the top of the slope. The depth of the trench, which is 0.3 m at the bottom of the slope, is gradually increased as it reaches the pit at the top of the slope. Thus, water flows to the filter pit due to gravity flow.

When the well is situated near the bank of a river or rivulet, it is connected by a 300-450 mm pipe to the river bed itself. Two to three layers of sand-filled cement bags are put across the course of the river to check rapid runoff of rainwater. To enhance the seepage of water, filter pits of 2.5 m x 2.5 m x 2.5 m dimensions are dug into river beds at every 500-1,000 m distance, alongwith with zig-zag obstructions in the river bed to slow down the water flow.

It is also possible to divert water from a nearby river or canal to recharge a well. A gutter having a diameter of about 0.3 m is connected to the well. The gutter pipe is connected to a filter pit at the other end to filter the water which then enters the well through a polyvinyl chloride (PVC) pipe *(see Fig 1: From the sky)*.

Expenditures for constructing the systems may vary depending on the location of the well and topography of the land, and may range from Rs 500 to Rs 1,000.

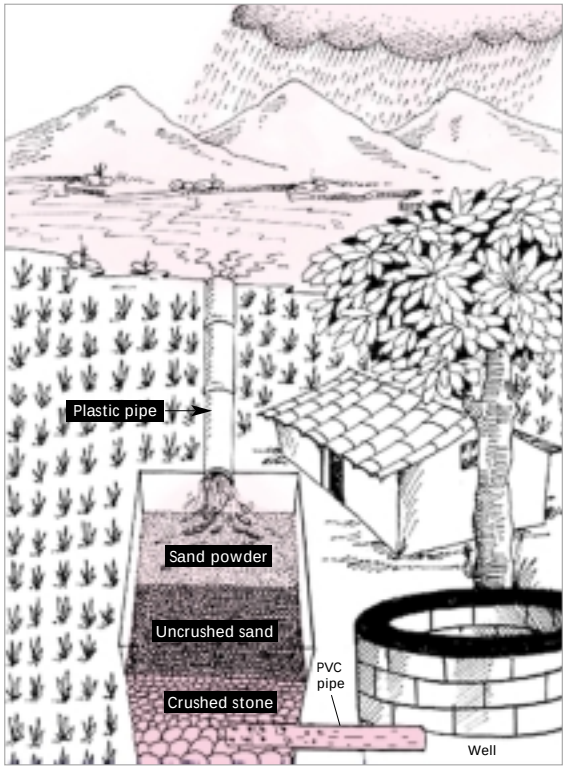
A few precautionary measures are necessary to

ensure the efficiency of the recharging systems. Firstly, it is important to adapt the recharging systems according to the topographic nature of the land. The well should not be filled to the brim, since it would affect the well lining; and, water should only be allowed to fill the well till a level of one metre below the ground level. A filter pit should always be used when recharging wells to prevent soil particles and debris from entering the well and contaminating the water.

The method to install borewell recharging systems for drinking purposes in households and small institutions is quite similar, which aims at harnessing rainwater falling on rooftops. The rooftops are first washed to avoid dirt and other contaminants from entering the borewell with the flow of water. All the outlets from the rooftops, except the one leading to the borewell, are closed. A plastic pipe connects the terrace outlet to the mouth of the borewell to collect all the rainwater. Excess amount of water stored in underground aquifers flows back into the well as the water level in the borewell recedes *(see Fig 2: Recharge from the roof)*. Depending on the length of the piping required, the system may cost between Rs 15-200. Instead of spending several lakhs of rupees on small irrigation tanks, such systems can provide remarkable results even during low rainfall periods. The opening of the bore can be closed after the rains. Water can also be stored in the traditional system of underground closed tanks, which were directly connected to the roof, so that the rain which fell on the rooftop or the terrace could directly enter the tank. ■

Fig 1: From the sky

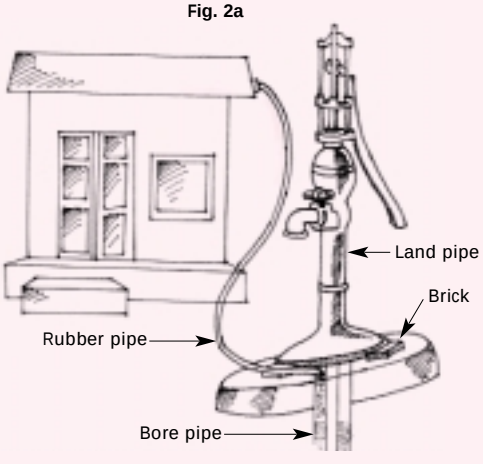
Diversion of water from nearby river/canal for recharge of wells



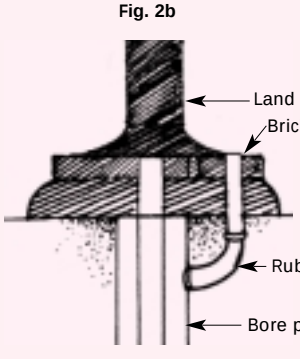
SAURASHTRA LOK MANCH

Fig 2: Recharge from the roof

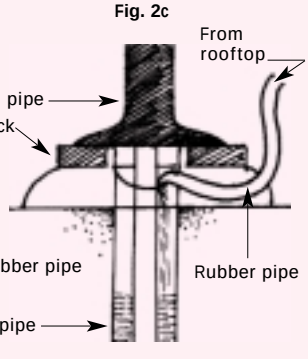
Rooftops can be used to recharge the groundwater using handpumps or borewells



A normal handpump connected to the roof by a rubber pipe helps rainwater to enter the bore



A rubber pipe is inserted in the open bore which is kept open with a piece of wood or brick after lifting up the handpump



Alternately, a T band is fitted in the bore pipe and then a rubber pipe is fitted to avoid uplifting of handpump

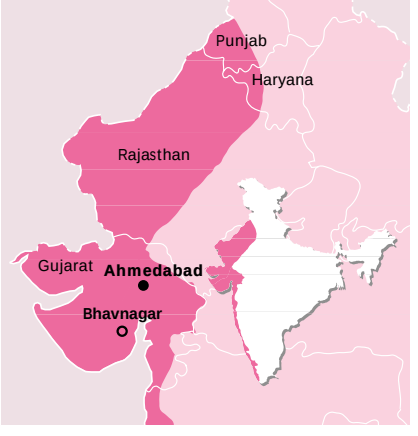
SAURASHTRA LOK MANCH

Women and Water Harvesting

Active participation of women has been crucial for tackling drinking water shortages and land salinity in Ahmedabad and Bhavnagar districts of Gujarat

Nafisa Barot and Salil Mehta
Utthan, Ahmedabad, Gujarat

Utthan's attempts to meet drinking water shortages in parts of Ahmedabad and Bhavnagar districts have met with success. An Ahmedabad-based non-governmental organisation (NGO), it has constructed 21 lined ponds with the active involvement of local village communities. More than 300 families have participated in building rooftop water harvesting structures. Village water and resource management committees have been formed in both Ahmedabad and Bhavnagar districts. Bhal *samitis* (federation of local villages) have been formed in Ahmedabad district.



Ahmedabad district suffers from highly saline groundwater. Bhavnagar has no perennial sources of water and is threatened by ingress of saline seawater.

Every year, the government of Gujarat declares more than 12,000-13,000 villages out of a total of about 18,500 villages as 'no source' villages, that is, villages which do not have a dependable source of drinking water. Although the number of villages keeps fluctuating, no declining trend has been observed, indicating a problem that is widespread, chronic and deep-rooted. A number of problems like salinity, seawater ingress, high fluoride content and depletion of groundwater sources lead to severe drinking water shortage. The response from the government has been typical. Despite a variety of problems, the state government has tried to deal with these problems by introducing the usual solutions such as utilising groundwater sources, constructing large irrigation dams not meant for drinking water anyway, and introducing piped water supply and tanker services during lean seasons to all regions, without taking into consideration specific problems of individual areas. Water supply through pipelines and tankers have been the most favourite schemes of the government and, in Gujarat, hopelessly out of context. Local communities have, however, begun to take up local-level initiatives to overcome chronic drinking water shortages. Utthan began its work in 1981 in the coastal areas of Ahmedabad district commonly referred to as the Bhal region and later shifted its focus to Bhavnagar district.

SALINITY STALKS THE BHAL

Evaporation of surface water in Ahmedabad district, especially in the Bhal area, is generally very high. Surface water gets contaminated, particularly in areas close to the sea coast, through upward movement of saline underground water. Though the water table is quite high, it is marred by salinity that is three times higher than seawater. In such a hostile environment, potable drinking water is the first casualty.

Most villages located in Dhandhuka block of the district are situated along some natural depressions, which are the only source of water. In a good monsoon year, villages have potable water supply for 4-5 months after which salinity sets in. But in a weak monsoon year, communities survive by digging *virdas* (hand-dug pits in dry shallow ponds or streams) or fetch water from distances of up to 10-12 kilometres (km).

Some villages receive piped water supply from the Hingoli scheme. Initially envisaged to cater to 52 villages, the scheme has been stretched to more than 75 villages. An underground tank, commonly known as sump, is the collection point of piped water in villages, from where it is drawn manually by villagers. Being a single and often erratic source of potable water in a parched region, sumps often become sources of conflict. In the days when the pipeline would provide a maximum of

PIPE DREAMS: SHATTERING PONDS

During Utthan's interaction with the women of the Bhal region, the women explained their water management cycle using pond water before the introduction of a piped water supply to the region

The women would use *pallar pani* (excellent quality fresh rainwater) from the large puddles that would collect in grass patches surrounding villages. Women preferred not to use piped water even when it was supplied during the monsoon. In winter also, the women used pond water. By the end of winter the quality of pond water would decline, turning saline due to seawater intrusion.

The women explained that this was not always the case. Earlier the pond water would not decline even in summer months.

Ponds were ubiquitous. Each village had more than one pond. While one was used exclusively to meet domestic drinkng and cooking needs, and was therefore well protected, the others were used for non-potable uses.

These ponds were managed by the *panchayats.* The entire village would participate in cleaning of the pond as well as desiltation before the monsoon. In the event of these ponds drying up, shallow wells would provide water for sustenance till the arrival of the monsoon.

And then came the pipeline with a pipe dream: water supply at the doorstep. Most *panchayats* consented not fully understanding the implications at that time. Which they now have, with hindsight.

This was the beginning of their dependence on external sources for the most basic requirement of life — water. This was also the beginning of disempowerment. Most *panchayats* stopped managing the village's common property resources. They collected money from the village communities so that the Gujarat Water Supply and Sewerage Board (GWSSB) could manage the pipeline. Slowly the problems of centralised systems started creeping in.

Powerful communities in the head reach villages near the source would break the pipeline and take away more water. Due to the poor quality of the pipeline installed, it would break frequently. Its dependence on scarce electricity supply prevented water from flowing over long distances. The water could not be lifed to overhead tanks. Through breakage and pilferage, polluted water would seep into the pipeline. Complaints by the people went unheard and lay unattended. These people had no rights over the quality and quantity of water that they received. Since these villages were listed as 'attended' in official documents, the villagers were not eligible for any assistance. They were simply the passive receivers of a system which had been installed without their understanding or involvement.

2-4 litres per person per day, the conflict sites would shift to where the tanker would come and wait. Tankers — if these came — would provide 4-5 litres of water per person per day. The requirement of water for other needs — cattle, washing, bathing and others — would remain largely unmet. To avoid violent conflicts between men, women and children have to do the hard work of drawing water from such sources.

DOWN MEMORY LANE

Large areas along the coastal parts of Dhandhuka used to be thickly covered with mangroves and *piloo* (*Salvadora persica*) trees till about 30-40 years ago. But with increasing water scarcity and degradation of the environment, local people have been forced to migrate. For example, the population of the bustling port town of Dholera has dropped from 15,000 to 5,000 over the last 3-4 decades.

Almost all villages in the area used to have at least one pond for drinking and other domestic usage. During dry months, shallow wells provided enough water. Women still prefer to use *pallar pani* (excellent quality fresh rainwater), from the large puddles of water collected in grass patches surrounding the villages, over piped water, till the end of winter, when the water quality starts deteriorating due to salinity and turbidity *(see Box: Pipe dreams: shattering ponds).*

Introduction of piped water supply only led to disappointment. It raised high hopes of quality water becoming easily available and in sufficient quantity. But in reality, both the quality and quantity of water supplied, left much to be desired. With the introduction of piped water, both the use and management of pond water rapidly deteriorated, as the practice of community participation led by the *panchayat* in cleaning and desilting the tanks disappeared. The piped water option had raised many hopes of clean and assured water supply, but in reality it destroyed the self-sufficiency of villagers for water usage without providing an alternative. Villages located at the tail-end of the piped water supply particularly suffered the disadvantages of a highly centralised distribution system. Disruptions and contamination due to pilferage, ingress of polluted water, and increasing salinity at the supply source, made piped water unreliable.

UTTHAN'S APPROACH

To deal with these problems, Utthan initiated its work through the Mahiti project in 1981. When Utthan first made contact with communities in Rajpur, Mingalpur, Mahadevpura and Khun villages of the Dhandhulka block, men cited the 'unproductive saline wasteland' as the main reason for migration. Women, on the other hand, insisted on the severe drinking water problem as the foremost reason for all difficulties. While men were

less sure, women were convinced of their right to water *(see Box: Women play a stellar role)*. Utthan then decided to evolve alternatives to meet drinking water demand, making saline land productive and promote income-generating activities. Local communities suggested that the water resources must be augmented at common property levels by desilting existing ponds and building new ones for drinking purposes to benefit the whole village. Villagers suggested the use of some sort of lining material on the bed and inner walls of new ponds to prevent salinity seepage from below and of the harvested rainwater. They had seen such materials being used for lining of irrigation canals where they had worked. Villagers were also aware of rainwater harvesting using rooftops that existed in a temple at Dholera town.

Rahtalav was the first village to initiate the experiment in 1985-86 where villagers contributed both in terms of labour and other resources *(see Box: Ponds with a silver lining)*. Success of the project inspired villagers to put forth new proposals to Gujarat Water Supply and Sewerage Board (GWSSB) for obtaining support for such ponds, sowing the seeds of a long battle. Accepting these proposals meant that GWSSB was accepting that an alternative to the pipeline was available. Moreover, GWSSB had no provisions for excavating new ponds or reviving traditional sources. Most of its funds were earmarked for pipeline or borewell schemes. The board could not even include it under its water scarcity budget, as water tanker services were given priority. This led to conflict between the villagers and GWSSB.

Facilitated by strong media coverage, the small community initiative gathered itself into a visible force by 1986-87. 1n 1987, the Council for Advancement of People's Action and Rural Technology (CAPART) and National Rural Employment Programme (NREP) supported demonstration ponds in seven villages, but the GWSSB was still not convinced. In 1990-91, the government and the World Bank were finally forced to look into people's alternatives and sanction money towards a 'pilot project' for 12 villages. Continuous visits and meetings with engineers, GWSSB officials and ministers eventually paid off. Meanwhile, rooftop water collection in household tanks was demonstrated successfully and had become equally popular.

BHAVNAGAR'S BANE

Heavy and rapid runoff to the sea leaves little time for rivers and other aquifers to get recharged in Bhavnagar district. Excessive withdrawal of brackish water for

WOMEN PLAY A STELLAR ROLE

Despite all odds, often against their own menfolk, women led the fight against water scarcity

In the face of traditional resentment against women taking active part in community initiatives, women in rural areas of Ahmedabad and Bhavnagar showed exemplary courage and fortitude. Village *sarpanches* (heads of village councils) were extremely critical of women being part of the decision-making process. In the villages of Mingalpur and Bhangadh, women fought with the respective *sarpanches* and other menfolk over the sites of the lined ponds. Women had to face violent reactions from their own menfolk often for similar reasons. Despite these disadvantages, women took active role in the decision-making process of the village *pani samitis* (water councils) and contributed 80 per cent of the labour for constructing the water harvesting structures. Their strength perhaps came from the fact that they were most affected due to inadequate water supply.

With help from the government anti-corruption department, these women successfully broke the stranglehold of entrenched local moneylenders who were the prime stumbling block towards achieving an independent decision-making mechanism. A number of women were beaten by their own men when they were threatened by the moneylenders. The women stood united until the battle was won.

In situations of conflict within the communities and also with outside interest groups, women played the crucial role of pacifiers, averting potential violence. They also acted as negotiators between two disputing factions, finding mutually acceptable solutions. Such equanimity and foresight of the women has been pivotal for the success of the water harvesting projects in the region.

ANIL AGARWAL / CSE

The onus of domestic water supply lies with women and children, whatever the source

PONDS WITH A SILVER LINING

Ponds stage a dramatic return thanks to the women in the region

Coming full circle, the failure of piped water supply in meeting water demands brought the village community back to the source it was traditionally using: ponds. The innovation of these traditional systems, started out as a joke, but when implemented, produced fantastic results. "Let us put wax paper at the bottom of the pond after excavating them as deep as possible, to prevent underground salinity mixing with the freshwater stored in the pond. This is used for irrigation, why not for drinking water?"

The joke was taken seriously. Village Rahtalav was the first to initiate a pilot demonstration pond in 1985-86. The entire village participated. Though it was a drought year, the water that collected in the pond was available in summer, when all other sources had dried up.

The impact of this demonstration was tremendous. However, conflicts soon arose when the community put forward a proposal to the Gujarat Water Supply and Sewerage Board (GWSSB) for obtaining support for such ponds in all those villages that suffered from similar drinking water problems. Accepting lined ponds as an option meant that the board would have to accept that an alternative to piped water supply did indeed exist. Besides, the board had no financial provisions for excavating ponds, since most of the money was earmarked for pipeline supply and borewell schemes. Though the board could have very well accepted ponds as an alternate in times of scarcity, tanker services were the preferred option. Even if encouraged under scarcity provisions, it would have resulted in digging a few pits just before the monsoon arrived. What the communities were demanding was that village-level lined ponds be accepted as schemes by the government, rather than random digging of pits.

While the men appeared resigned to their fate, the women refused to accept defeat. They had seen for themselves the advantages of collective action and a viable alternate water source. They did not believe in just sitting back.

Their countless visits to meet the engineers in the district *panchayat*, officials in GWSSB and ministers bore fruit. Facilitated by strong media coverage, what began as a small community initiative in Bhal in 1982 gathered momentum and became a formidable force to reckon with by 1986-87. It culminated in a people's movement in a resource-poor region asserting their rights to the building and management of natural resources.

Some technical problems still dog these lined ponds. Cleaning of the filter is difficult since it is located underground. In some villages, the runoff rainwater gets mixed up with the high tide seawater, affecting quality. Sometimes cracks appear in the side slopes of the ponds. However, none of these problems appears insurmountable, especially when compared with the situation that existed before these ponds came into existence.

The demonstration of lined ponds in these villages has resulted in the setting up of a Bhal *samiti*, a people's organisation comprising villagers from various village organisations who help in promoting the acceptability of these ponds. Some 50 per cent of the 94 members are women.

agriculture and industry has led to the saline wedge shifting upstream. The increased salinity has severely affected drinking water quality.

The *talukas* of Ghogha, Talaja and Bhavnagar, bordering the Gulf of Khambhat, constitute the work area of Utthan in Bhavnagar district, which does not have a single perennial or major river system. A distributary of Shetrunji main canal goes through the area, meeting the irrigation demand of a number of villages along its course. In some villages, the department of irrigation fills tanks with canal waters originally dug as part of famine relief work. However, adequate and good quality drinking water is a rarity, forcing almost 80 per cent of the local population in the district to migrate for about eight months every year.

Inherent salinity of land and increasing ingress of seawater due to the area's proximity to the sea are the two main factors behind water scarcity. Proliferation of salt farms has greatly contributed to land degradation, discouraging vegetation and accentuating the loss of mangroves. To make matters worse, reasonably large deposits of lignite have attracted a host of industrial activities. The Gujarat Power Corporation is setting up a thermal power plant which will see a number of villages in and around the project area lose huge tracts of fertile land.

The one advantage that Bhavnagar had over Ahmedabad was greater awareness amongst its communities about the state of their natural resources and government development programmes. In Bhavnagar too, women were more concerned about shortage of water for drinking and other domestic purposes. The situation, however, was not as bad as in Ahmedabad district. Traditional water harvesting structures such as stepwells and community tanks, largely found to be defunct now, were reliable sources not very long ago.

Utthan started working in Bhavnagar in 1992, at a time when a major piped drinking water supply scheme by the government of Gujarat under the Ghogha Regional Water and Sanitation Project (GRWSP) was proposed to be set up to supply water to 78 villages and a town, through a 200 km long pipeline from the Shetrunji dam. Utthan decided to use its experiences gathered in Ahmedabad, where similar government efforts to provide piped drinking water had wrecked havoc with the availability of water. In order to prepare the people to meet the adverse

impacts of the proposed pipeline project, a comprehensive survey of a few villages was carried out by Utthan in 1993-94 and priority areas were identified for intervention.

Utthan worked with local communities to identify and implement strategies to meet the challenge of water scarcity and situations that would arise out of the proposed water supply scheme. As a first step, a resource appraisal survey, a database on the programme area, and a pre-appraisal drive among the communities coming under the GRWSP was undertaken. Communities were aware of roofwater collection tanks (RWCTs) from examples in Ghogha, Talaja and Bhavnagar towns and were keen to build similar structures. They were confident that the GWSSB would help them in their efforts. Utthan played the role of an implementing agency for RWCT schemes on pilot projects sponsored by GWSSB.

Construction of lined ponds and rainwater harvested through rooftops has increased water availability in both the districts. It has reduced drudgery and anxiety suffered by women in particular and have had a visible impact on health, in terms of improved hygienic conditions, reduced number of diarrhoea cases and increased attendance of children and teachers in schools. Many villagers, mainly women, are evolving a holistic water plan with rooftop water tanks for drinking purposes and 2-3 community ponds for other requirements. Both in Ahmedabad and Bhavnagar, water committees and resource management committees are functioning as effective and alternative village level institutions for promotion and continuation of these efforts.

OUTCOMES

In both the Bhal region of Ahmedabad and Bhavnagar, the impact is visible at the micro- as well as macro-level. The impact at the micro level includes:

- Creation of lined ponds;
- involvement of more than 300 families in making rooftop collection tanks in their households;
- formation of water committees and resource management committees as alternate village level institutions;
- formation of Bhal *samiti* in the Bhal region;
- involvement of *gram panchayat* as an implementation agency; and,
- a sea change in the attitude of communities in the area from one of demanding government services and facilities to one where the villages develop their own resource management plans and get it approved by the government. This encourages control and ownership by the communities.

The impacts at the macro-level include:

- Formation of PRAVAH — a network of voluntary organisations and individuals who are concerned about rural drinking water issues;
- formation of a technical committee within CAPART to examine the feasibility of developing watershed development programmes in saline and flat coastal and non-coastal areas;
- formation of a state-level rainwater harvesting and recharging committee by the GWSSB. This committee has been entrusted with the task of identifying suitable rainwater harvesting and recharging projects;
- empowerment of women's groups in villages of Bhal — not only did they take on the men in the village, but also developed the courage to take on the authorities; and,
- a gradual shift in the rural drinking water state government policy. Borewells and tankers are no longer the only solution that the government is willing to look at.

LESSONS LEARNT

Utthan has also learnt some lessons along the way. These include:

- Local wisdom and knowledge cannot be ignored;
- traditional knowledge and modern knowledge have to complement and supplement each other;
- if women are given a chance and enough room, they are efficient managers of basic resources like water;
- involvement of women not only changes the texture of development but brings about empowerment as well;
- decentralised drinking water systems become more sustainable if women are involved because they are their basic users;
- livelihood problems in a resource-poor region can be addressed only if these are tackled within a decentralised management framework; and,
- when it comes to a crunch, in a water-starved region, quantity comes before quality.

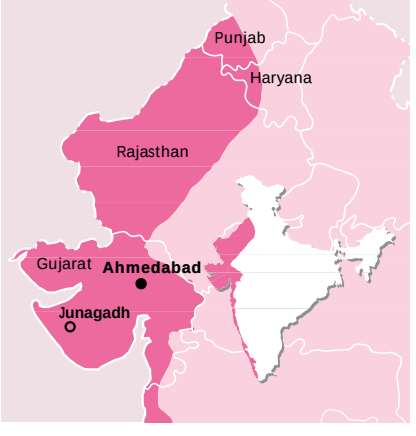
A number of questions are still raised about the feasibility and sustainability of such alternatives. Can pond water be made more potable with slow sand filtration technology. Can rooftop water be preserved for a long period? Can communities really manage their common property resources, when the pipeline option has failed despite the fact that communities did not need to pay any money towards its maintenance? Why did the traditional systems cease to exist if they were so reliable and efficient? Can the new alternatives themselves be made technically more user-friendly? Through different projects and consultations with village communities, Utthan's members are trying to answer these questions and identify solutions. ■

Manna from the Rooftop

The Aga Khan Rural Support Programme is promoting rooftop water harvesting to ease the water problem in salinity-affected villages of Junagadh district of Gujarat

Sibabrata Choudhury
Professional Assistance for Development Action (PRADAN), Keonjhar, Orissa

Located along the coastal belt of Saurashtra region, Junagadh district faces the twin menace of water scarcity and increasing salinity in available groundwater. Experiences in Mongrol block of Junagadh district in Gujarat show that rooftop water harvesting can be a cost-effective and dependable solution.



Surrounded on three sides by sea, the Saurashtra region, resembling an inverted saucer, can be considered a confined aquifer, barely receiving any drainage from the rest of the mainland. The annual rainfall, varying between 300-500 millimetres (mm), is the only source of water. Every 2-3 years, the region receives less than normal rainfall.

The land in Junagadh district is characterised by an underlying layer of porous limestone strata. While being conducive to groundwater recharge, it is also quite vulnerable to saline seawater ingress, caused by excessive exploitation of groundwater by farmers. The government policy of providing cheap, subsidised electricity for irrigation to farmers is further contributing to its overexploitation. Immediately following the monsoon, water in existing wells becomes useless due to excessive salinity. During such periods, the government has to provide drinking water through tankers to places where piped water supply does not reach.

FAILED INITIATIVES

While government strategies, too centralised to meet the water scarcity challenge, often do not deliver, it is important to devise local methods of making water available. Under government initiatives, water is pumped through pipelines to various destinations from a central source of potable water. The pipeline often runs for 20 kilometres, passing through different villages and terrain, running the risk of sabotage and pilferage. This water is finally delivered through a common standpost in villages, managed by *panchayats*. During extreme scarcity months, water tankers fetch water from distant sources and distribute it at selected points in villages.

Water supplied by both these methods is inadequate, unpredictable and characterised by high costs. Both methods make extensive use of groundwater sources without making any provision for their recharge. In the long run, such water sources run dry or become contaminated, resulting in the source of water gradually going further away from the point of consumption. One of the reasons for failure of these initiatives is that they are too centralised, with consumers having little control over them.

RAY OF HOPE

To meet water needs locally, the Aga Khan Rural Support Programme, India (AKRSP-I) initiated a rural drinking water programme in the salinity-affected villages of Mangrol block in Junagadh district in 1995. The programme comprised of three components, namely, technical, training and agriculture.

The technical component included construction of underground structures to harvest water from rooftops for domestic consumption, sinking of community-managed shallow wells with provisions for using runoff water as recharge, and manual withdrawal of water. Installation of wells and handpump recharge structures were also part of the programme.

Training was usually conducted in small groups, with emphasis being laid on water quality, efficient

Table 1: **Roofs to taps**
Blueprint of a rooftop rainwater harvesting system

Parameter	Unit
Annual average rainfall	400 mm
Average household members	7
Need of water for drinking and cooking	8 lpcd
Water requirement for a month	1,680 litres
Water requirement for 10 months	16,800 litres
Roof area	100 sq m
Total amount of rainfall falling on the roof 100 sq m x 400 mm	40,000 litres
Wastage	50 per cent
Water available for storage	20,000 litres

Note: *mm: millimetres* *lpcd: litres per capita per day*
sq m: square metres

water storage and use. The agriculture component of the programme promoted cultivation of low water consuming, saline-tolerant crops like *chikoo* (sapota, *Achras sapota*).

USING ROOFTOPS AS CATCHMENTS

AKRSP-I had been promoting 20,000 litre capacity water harvesting structures for storage of rainwater *(see Table 1: Roofs to taps).* The figure of 20,000 litres was arrived at, after considering the household strength to be seven with a daily per capita drinking water requirement of seven litres per capita per day (lpcd) on an average. AKRSP-I's initiative of rainwater harvesting using rooftops has been largely accepted by the community which views them as a possible solution to their acute drinking water problems.

CRITICAL CRITERIA

For rainwater harvesting to succeed, programmes should meet some basic requirements

The quantity of water made available through rainwater harvesting should meet basic domestic needs.

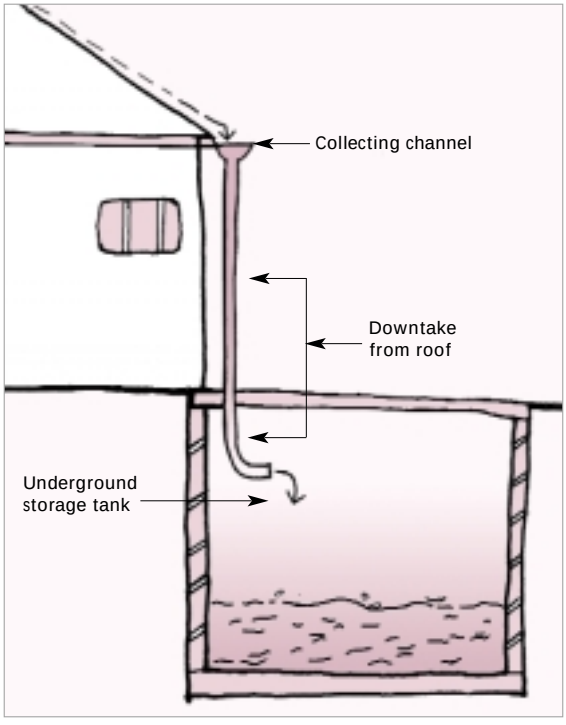
The water should be potable.

Water sources should be dependable, protected and sustainable.

Control over the water harvesting system should be local.

Economic and ecological costs for providing water should be minimal.

Fig 1: **Silver drops**
Rooftop collected rainwater stored in an underground tank



RAHUL RANADE

The first spell of rain is utilised to clean the rooftop and usually let off as waste. A first-flush device may be used to ensure that runoff from the first spell of rain does not enter the system. This system can be as simple as installing a valve. Rainwater collected after the initial spell is considered to be relatively pure and safe for human consumption. It is stored in underground tanks, using plastic pipes fixed to the edge of the roof *(see Fig 1: Silver drops).* Bleaching powder is applied to prevent contamination and maintain the quality of the stored water. Airtight covers of the storage tank protect the water from sunlight and impurities, allowing negligible evaporation.

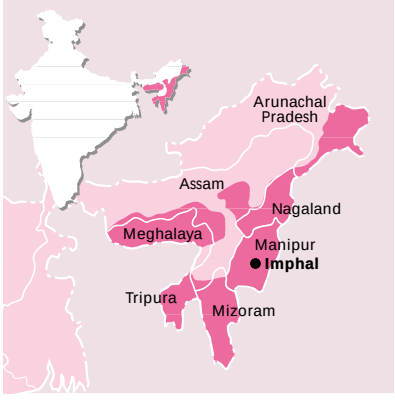
An average rooftop rainwater harvesting structure costs around Rs 18,000. It requires cleaning once a year, and periodic application of bleaching powder. Though the initial investment is a little high, the relief it brings is enormous. Considering the lifespan of a structure to be 20 years, the annual average expenditure for the structure comes down to only around Rs 900. Maintenance is also cheap. Compared to this, other available methods for procuring potable water are far more expensive. Built close to households, control over these structures by the members of the household is total. However, for rainwater harvesting efforts to succeed, certain minimum criteria must be met *(see Box: Critical criteria).* ■

Quality Matters

Modern water purification techniques are being introduced in Manipur to improve water quality from local water harvesting systems

L Jelshyam Singh
Wanjing Women and Girls Society (WWAGS), Wanjing, Manipur

Water used from both community and private ponds is unfit for drinking in Manipur due to microbial contamination. Yet these constitute the main source of drinking water. Introduction of Horizontal Roughing Filters (HRF) and Slow Sand Filters (SSF) is now improving the quality of drinking water.



In Manipur, both traditional and modern systems of water harvesting are practised. Water is used from various natural sources such as rivers, ponds, lakes, springs and brooks. Water for domestic use is mainly drawn from streams. A small 30 centimetres (cm) deep hole is dug in a place close to a stream where the main body of water cannot touch it, allowing natural filtration to take place.

In the hilly areas, water from springs and streams is used for all purposes, including drinking. In the rainy season water in these sources gets muddy, yet only a few take the trouble of boiling it before consumption. Efforts are now on to put up fences at sources of these springs using locally available materials and protecting trees in upper reaches of hills. In some places, gravity flow systems are being used to harness water, which is collected through polyvinyl chloride (PVC) pipes from the source of a spring and passed through a filtration chamber, consisting of pebbles and boulders of different diameters, before reaching the distribution chamber.

Use of rainwater from rooftops is not new in Manipur. With the introduction of tin roofs, water collected from rooftops is being used for drinking. Recently, community rooftop water harvesting systems have also been introduced in areas where households are lying in close proximity to each other.

However, ponds continue to remain the most important source of water for domestic use. A thin white cloth or alum is used to filter water from community or domestic ponds. Though this water is not contamination-free, experiments conducted by Manipur University revealed that this water becomes fit for drinking only after proper filtration.

During 1992, a London-based non-governmental organisation, Water Aid, launched its water harvesting programmes in Manipur. The organisation selected some prominent local organisations to elicit local support and ensure implementation of the programmes.

FILTERING FILTH

Lack of awareness about sanitation issues, which leads to contamination of drinking water, is a serious problem. However, with the introduction of HRF and SSF technology to treat the available water, there has been a marked improvement in the quality of water, especially for drinking. The HRF system acts as a filtration and sedimentation unit. It consists of a rectangular box with three layers of graded gravel material of 15 millimetres (mm), 10 mm and 5 mm size, kept in separate compartments of 1.5 metres (m) length each. The vertical depth of a filter bed is kept at around 1.7 m, and the filtration rate between 1,000-2,000 litres per square metre per hour. As water goes through the HRF, about 50 per cent of the suspended particles are removed in the first compartment, 30 per cent in the second, and the remaining 20 per cent in the third compartment.

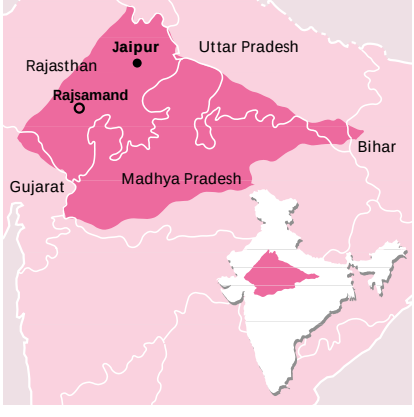
In Slow Sand Filtration (SSF), the water is passed through a porous bed of filter medium which reduces the number of microorganisms like bacteria, viruses and cysts present in the water. The quality of water is improved by the removal of suspended and colloidal matter and change in chemical composition. A SSF unit consists of a box containing a supernatant raw water layer, followed by a bed of filter medium and a system of storing and draining the filtered water at the bottom. ■

Relying on Old Sources

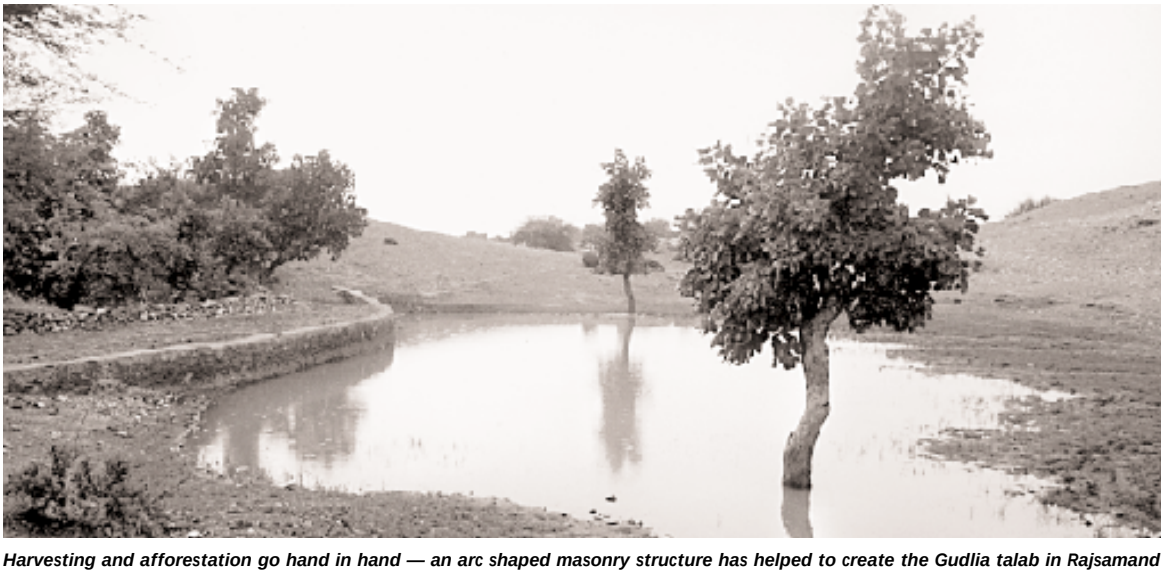
By adding new structures to existing traditional water harvesting systems, the Mewar Krishak Vikas Samiti (MKVS) has increased water availability

Ganeshlal Gurjar
Mewar Krishak Vikas Samiti, Rajsamand, Rajasthan

Rajsamand district in southern Rajasthan has a rich legacy of rainwater harvesting structures of different sizes. Unfortunately, these are today in a sad state of disrepair. A local voluntary organisation called the Mewar Krishak Vikash Samiti (MKVS) has been trying to revive some of these traditional structures along with some simple interventions to resolve the acute water scarcity faced in the district.



Traditional water harvesting structures that exist in the district include large water reservoirs like Rajsamand and Jaisamand, with a headwall height of 10-30 metres (m). Medium-sized water harvesting structures like *talabs* (lakes or large reservoirs constructed in natural depressions or valleys) were traditionally constructed by villagers on community lands, using lime masonry walls on the sides, with soil as the filling material between the walls. Important historical water harvesting structures like the Kharasan talab were built with a masonry spillway to accommodate peak rainwater runoff. The masonry wall in a structure like the Kharasan talab was constructed in the shape of an arc, supported by an earthen embankment on the downstream side and a curvature on the upstream side to give more strength to the structure.



G GURJAR

Harvesting and afforestation go hand in hand — an arc shaped masonry structure has helped to create the Gudlia talab in Rajsamand district

G GURJAR

When the capacity is exceeded, the spillway in Gudlia talab helps the excess water to flow away, thus preventing damage to the structure

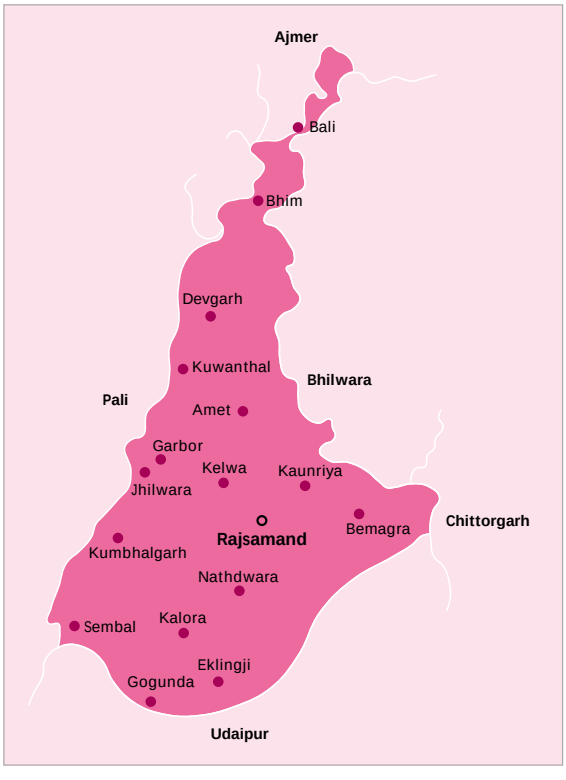
Smaller structures like *nadis* (ponds) with 1.5-12 metres depth were constructed in valleys by strategically building earthen embankments across natural depressions. These earthen embankments were supported on both sides by hollow stone masonry walls filled with *murrum* (laterite pebbles). *Nadis* collect water running down from relatively impervious upper reaches and have water storage capacities that vary between 0.4-7 million litres. The drainage basins of these structures are of various shapes and sizes, varying from 8-2,000 hectares (ha).

Nadis, which once served as the principal drinking water sources in the area, received their water supply from erratic and torrential rainfall. Since the runoff was from sandy and eroded rocky basins, large amounts of sediments were regularly deposited in them, resulting in quick siltation.

The MKVS has been working in Rajsamand district for the upliftment of local farmers. It has constructed 20-30 *nadis* with a command area in excess of 500 ha in Lambodi, Gudlia, Kharasan, Hakiawas and Bhairu Das Ka Kheda. The organisation has added systems like spillways to the *nadis*, in the absence of which these structures were often damaged earlier. To prevent *nadis* from silting up, the MKVS has promoted afforestation of the drainage basin and constructed silt traps. Since farmers construct these structures on their own fields using locally available materials, the cost of construction ranges between Rs 2,500-10,000 and is thus affordable.

The experience of MKVS indicates that traditional water harvesting structures can be used to great advantage in southern Rajasthan. They are inexpensive and can be constructed and maintained by local farmers and labourers. People's participation is necessary for the ultimate success of these structures. ■

Rajsamand district, Rajasthan

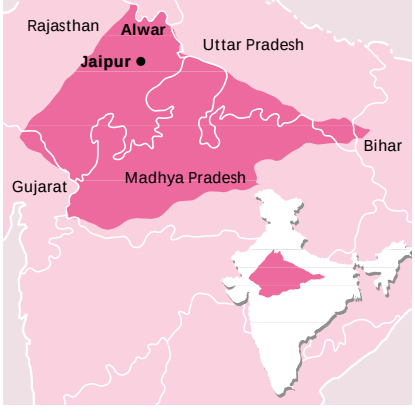


Dramatic Turnaround

A silent revolution has swept across hundreds of villages of Alwar district. Dead rivers have been revived, bringing crops back on barren fields. All this has become possible through the revival of traditional water harvesting structures

Richard Mahapatra
Centre for Science and Environment, New Delhi

There was a time, not so long ago, when the district of Alwar in Rajasthan lay parched. Rivers had run dry and scores of traditional water sources lay dilapidated and disused. Villagers left in droves to cities to find a better life. All that has changed over the last 16 years since 1984, due to the efforts of an Alwar-based organisation called Tarun Bharat Sangh (TBS).



TBS has been able to mobilise people from more than 650 villages to rejuvenate about 3,000 traditional water harvesting structures (TWHS) called *johads*. *Johads* are small earthen check dams that capture and conserve rainwater, improving percolation and groundwater recharge. The results have been outstanding. There has been a general rise in the groundwater level by almost six metres (m) and a 33 per cent increase in the forest cover in the area. The most spectacular effect has been on the five rivers that used to go dry immediately following the monsoon. These have now become perennial. The perenniality of these rivers is the result of the 20 per cent increase in groundwater recharge.

For every Rs 100 invested in *johads*, the agricultural production has risen by Rs 400 per capita per annum. All this prosperity has come through the use of only three per cent of the total rainwater that falls over the region. Income of the rural population has increased. Annual migration of the male population to cities in search of livelihood has come to a near halt. People are now able to address issues like health and education. At the core of this success lies the emergence and proper functioning of popular and local institutions like the *gram sabha* at village levels. Villagers have worked tirelessly to tackle the problem of water scarcity and ecological degradation, to bring back water in their rivers and forest cover that had completely disappeared.

DESPOILING THE SOIL

The district of Alwar in Rajasthan and its adjacent areas had experienced unprecedented ecological degradation in the last 50 years. Huge tracts of forests on the Aravalli mountain range had been cut down for commercial gains, turning land infertile and water sources scarce. As traditional water sources disappeared and no new initiative to augment water supply was taken, a large percentage of the population was forced to migrate to urban areas to support itself and its families.

The area around Alwar, located in the semi-arid zone of Rajasthan, was not always denuded of forest cover and reeling under such acute water shortage. The Gazetteers of the erstwhile princely state of Alwar say that the Aravalli range of mountains here had dense forest cover, teeming with rich biodiversity. The Alwar state gazetteer of 1885 described the Aravallis as a dense green patch and the fountainhead of many rivers, sustaining a thriving civilisation and effectively halting the march of the Thar desert towards Alwar and Delhi. Forest department records maintained by the rulers of Alwar show that the forest cover in the princely state was 60 per cent of the total land area between 1885-90, most of which was located on the Aravallis.[1]

During the last century, the forest cover in the area dropped alarmingly. Remote sensing satellite data now show a mere 28.6 per cent area on the Aravalli as green, as against the specified 60 per cent by the national forest policy.[2]

Traditionally, forests were categorised according to specific community uses and protected accordingly. Several categories like *kankar bani, rakhat bani, dev bani* and *rundh bani* existed with very specific purposes. For example, *rakhat bani* could only be used in times of severe drought and that too only after a community decision to that effect. The state had no jurisdiction in such matters, except in the case of the *rundh bani* forests. Although *rundh bani* were managed and used by the rulers of the state, the ultimate ownership of the land always lay with the local communities.

The slide towards degraded forest land and water scarcity began with the introduction of the Alwar Rajya Forest Act in 1888 by the then maharaja of Alwar. It curtailed the ownership of the community over forests and its resources and began the process of declaring large areas of choice forest lands as game and hunting reserves of the rulers.[3]

In 1938, another British-inspired legislation called the Alwar Rundh Act was introduced that declared forests as the property of the state, paving the way for large-scale deforestation. The British empire needed huge supplies of wooden sleepers for railway tracks and the rulers of Alwar traded in timber for making profit. Mindless deforestation followed and great stretches of forest disappeared. Within 15 years, contractors cleaned out most of the dense forests but for game or hunting reserves like Sariska. Only sparse forest areas survived the furious assault, ultimately to be cut down by a later generation.[4]

Another major blow to the Aravalli forests came in the 1940s, when the king of Alwar allotted the remaining dense forest areas to some 20 charcoal contractors, representing mostly British firms, for commercial exploitation. The contractors used chemicals to destroy forest areas stretching up to Jaipur. The process of forest degradation was not yet over. With the nationalisation of forest lands looming large on the horizon, the local *zamindars* who had ownership rights over the forests, sold the trees as timber without a second thought.[5]

Although large-scale deforestation took place prior to independence, illegal felling of trees for commercial gains in the last two decades has also greatly contributed to the present plight. According to remote sensing data, Rajasthan had only 1.7 per cent area under actual forest cover in 1980-82, with the Aravallis showing as brown on the map, indicating non-existence of any substantial green cover.[6] In 1984, out of the 2.14 million hectares (mha) of notified forest area in the Aravalli, only 0.61 mha had actual forest cover.[7] The Aravalli range running through Rajasthan accounted for 50 per cent of the total barren hill surface of the 1.53 mha of the Aravallis.[8] Compared to this, in 1972-75, the actual forest cover in the Aravallis was 1.05 mha.[9] It is, therefore, apparent that the Aravallis lost around 40 per cent of their remaining forests during this period. Illegal and systematic commercial felling of trees, backed by corrupt government officials, was the main reason behind such destruction. Not surprisingly, the vanishing forests of the Aravallis have also created 4.34 mha of wastelands in their wake.

Numerous waterways emerging from the Aravallis such as Mahi, Sabarmati, Som, Jakham, Kothari, Banas, Luni, Liladi, Sukdi, the Ruparel and Arvari had already dried up because of the destruction of the hills.[10] In Alwar district, the monsoon rainfall had become erratic with the duration of the monsoon season shrinking

RICHARD MAHAPATRA / CSE

A degraded Hazariwala watershed in Alwar district

from 101 days in 1973 to only 64 days in 1985 and 55 days in 1987.[11] The monsoon season has now stabilised at 55-60 days. The total number of rainy days in a year has declined from 60-80 days in 1973 to 18-30 days between 1987-1995.[12]

AND WHEN TREES WERE GONE...

The demise of the forest cover meant the end of a rich and vibrant ecology, supported by an ancient tradition of extensive water harvesting, through local structures called *johads*. Following the destruction of the forests, some 2,500 *johads* built mostly by former kings and local lords over the centuries were buried in the ensuing extensive land erosion. Rivers and small watercourses also went dry with heavy siltation. With the destruction of water sources, agriculture suffered severely due to lack of irrigation. Steadily decreasing income from agriculture and animal husbandry forced villagers to abandon their traditional profession and villages. It added to the general pattern of degradation and neglect, resulting in the demise of some 10,000 wells.[13]

Large-scale land erosion also resulted in easy runoff of rainwater, making groundwater recharge negligible. The groundwater table in the area dropped alarmingly which became evident in the water levels in wells that dropped from 5-10 m in the 1960s to 100-150 m in the 1980s. Thanagazi block in Alwar district achieved the distinction of being declared a 'dark zone' by the irrigation department which pointed to the non-existence of groundwater in the area.[14]

As traditional sources of water started failing in the district, the severe shortage of water for both agriculture and domestic use had a devastating effect on the population of the area. Agricultural production nosedived and income levels fell, forcing villagers to migrate in large numbers to towns like Jaipur, Delhi, Ahmedabad and Surat in search of employment. According to district agriculture records, most villages used to cultivate only 10-20 per cent of the available agricultural land. Migration reached alarming proportions as witnessed in Thanagazi block, where more than 80 per cent of the male population in the age group of 17-35 years migrated in 1985. People who stayed back had to survive on meagre supplies of water, often fetched from distances of up to 10 kilometres (km). Maintaining livestock became an uphill task with fodder and grass being in short supply. With forest resources gone, agricultural production dwindling and income from livestock heavily reduced, survival itself was at stake.

BREAKING A STRANGLEHOLD

In 1985, TBS decided to break this vicious cycle of poverty and migration by reviving the traditional water harvesting structures called *johads*. The traditional knowledge store pertaining to land and water resources management of the villagers has been the key to all TBS activities. With the involvement of local villagers, TBS has been able to build some 3,000 water harvesting structures in over 650 villages. TBS follows a clear guideline — while villagers contribute labour and local material, TBS supplies external resources like cement or diesel for tractors, apart from imparting technical advice and assistance.

At the core of all TBS activity is a village-level organisation with a representative from each family called *gram sabha* (village assembly). The *gram sabha* has emerged as the most powerful institution in villages that looks after all development activities. Crucial decisions like site selection of a dam or tank, its size and the percentage and mode of community contribution towards building such a structure is decided by the *gram sabha.*

Once a village feels the need and agrees to work with TBS for building or renovating a water harvesting structure, the *gram sabha* along with an elected head is formed, in a general meeting held in the village. The *gram sabha* meets once every month on the no-moon day, as traditionally villagers devote this day to community work. One of the unique features of the *gram sabha* is that villagers can recall any elected member for non-performance or misconduct.

A resource committee is simultaneously formed at the very outset to prepare a clay demographic map of the village to have an overall view. Through door-to-door meetings, the committee assesses various problems confronting the village and the community's views on the site and size of the proposed water harvesting structure. Based on the committee's report, the *gram sabha* decides the exact site which is then marked on the clay map of the village, which also symbolises the beginning of work.

The *gram sabha* forms five sub-committees to look after various aspects of the work. The construction committee looks after all construction works and decides the mode and magnitude of villagers' participation. The forest committee enforces a ban on felling of trees and monitors regeneration of forest in the catchment areas of the water structures. The grazing committee prevents stray grazing, particularly in protected areas like regenerating forests. The water committee manages the created water resources and looks after distribution of water between users as decided by the *gram sabha.* However, all final decisions are the prerogative of the *gram sabha*, with the committees functioning as its implementing arms.

It is interesting to note that all these efforts by the villagers have been in spite of the government and not because of it. TBS has always had to fight the *panchayats* and the state government. The conflict revolves around

the ownership of common lands on which the *johads* were built, and the resources generated by these structures. When TBS began working inside the proposed Sariska National Park and the Tiger Reserve, the forest department opposed it, serving notice of demolition of a dam in the core of the reserve. Ironically, this dam revived the Ruparel river.

The essence of the conflict has been the informal *gram sabha* which gets the support of the whole village, making the formal *gram panchayat* (elected village council) virtually insignificant.

SHOULDER TO SHOULDER

Till 1997-98, the water conservation structures had cost Rs 15 crore out of which Rs 11 crore was contributed by the villagers in cash or kind. In 1989, TBS adopted the norm that construction projects would only be undertaken when a village agreed to contribute at least 25 per cent of the total cost. Earlier, after assessing the economic and ecological conditions of a given village, TBS used to contribute financially on a case-to-case basis. Usually labour and materials for construction of *johads* were provided by villagers, while the cost of skilled labour and other specialised materials needed was provided by TBS. This arrangement continued till 1997, when the minimum share for communities was fixed at 33 per cent *(see Table 1: Participatory effort).* By this time, the economic condition of people in the area had improved and they started contributing even in cash, in addition to participation through labour. For example, Bhaonta-Kolyala village does not need financial help from TBS anymore and is now contributing 100 per cent towards construction work. It is also maintaining 14 water harvesting structures through contributions by the villagers, both in cash and kind.

Table 1: Participatory effort

Financial contribution of village communities in *johad* building has been increasing

Year	Minimum financial contribution of the community (in per cent of total cost)	Number of participating villages
1985-86	2	1
1987	2-5	18
1988	10	45
1989	25	97
1990-94	25 (50 per cent in case of structure benefitting a few families)	500
1995-96	30 (60 per cent in case of structure benefitting a few families)	550
1997-98	33 (67 per cent in case of structure benefitting a few families)	650

Source: Rajendra Singh 1999, *personal communication*, quoted in Richard Mahapatra 1999, Waters of Life, *Down To Earth*, Society for Environmental Communications, New Delhi, March 15, 1999, Vol 7, No 20, p 35

THE KEY CHANGES

Till now, TBS has constructed 3,000 water harvesting structures in 650 villages, regenerating 0.65 mha of land. One of the most striking features of the structures that have been built is that no engineer in the conventional sense has been involved *(see Box: Rural engineers).* The structures have stood the test of heavy rains and floods, without being washed away. The results of the efforts of communities in these villages to collectively manage water have extended beyond the benefits of water availability *(see Box: Rajendra reminisces).*

RURAL ENGINEERS

The rustic engineers of Alwar have accomplished what trained engineers can only dream of. None of their structures have failed

One of the most striking factors of the work executed by Tarun Bharat Sangh (TBS) is that in all their efforts, no qualified engineer has been involved. All the construction work — right from planning, site selection and design to execution — is undertaken by the villagers themselves.

The work is undertaken under the guidance of *gajdhars.* Traditional rural enginners, with no formal degree to boast of, *gajdhars* used their knowledge — what they term as old *grameen* (rural) technology — for constructing rainwater harvesting structures like *johads*. These *gajdhars* passed on this indigenous knowledge to subsequent generations. Currently, for training the rural youth, a nine month training programme, 'common property resource management training programme' is conducted by TBS, where the rural youth is trained on how to build water structures and the art of *grameen* technology. To start this programme, the members of TBS searched for *gajdhars* all over the district.

The selection of the site where the water harvesting structure will be built is done by these engineers. They locate the bunding area where the *johad* has to be constructed, the catchment area and the reservoirs. A measurement register is maintained by them.

Gopal Singh, a *gajdhar*, acts as a guide for villagers from nearby villages. After people approach him, he visits the site and makes recommendations.

These engineers have constructed more than 3,000 structures. Till date, there has been no report of a structure collapsing.

RAJENDRA REMINISCES

Tarun Bharat Sangh (TBS) has been the strength behind motivating villagers to harvest and manage their water requirements and needs. At the CSE conference, Rajendra Singh, secretary of the Alwar-based organisation reminisces

Villages in Alwar district of Rajasthan proved the government wrong. Once declared a dark zone by the government, where no development can take place, water resources have been revived and groundwater levels improved. All this has happened not because of the government, but in spite of it.

As water levels improved, so did agricultural yields. Fodder is available and forests have improved. Economies have revived and migration has halted.

As the people realised the value of the *johads* (check dams) and *talabs* (ponds) — water harvesting structures that they built — increasingly, more villages came forward and built these structures. When the villagers in Gopalpura built a *talab*, and the villagers from surrounding villages witnessed their prosperity, small *talabs* came up in these villages also. Women have also constructed a few *talabs,* like the Suratgarh talab. The Gopalpura semilunar *talab*, built by Dhanna Gurjar, has been designed to take care of the fast flow of water. The slope of the catchment is steep, and so the water flows fast. In order to hold the water, a convex structure has been so designed.

Some people may think that villagers do not have foresight. This indigenous structures have proved beyond doubt the role of traditional wisdom in recharging the groundwater and reviving rivers.

In these villages, water has been the foundation of self-reliance The impact of *johads* and other water harvesting structures has extended beyond their waterholding capacity. The community spirit has been revived. Villagers are playing an active role in the management of the river Arvari that their efforts have revived. The people feel empowered and confident to deal with other issues that face them. The women are empowered and are contributing to village governance issues.

All this has not been easy. There are conflicts in the village and between villages. Arriving at a social consensus is not easy, and can take up to years. Then, there has been the government to deal with. Various departments like the forest, irrigation and revenue departments have hindered the efforts of the villagers. To add insult to injury, once the river was revived and contained fish, the government claimed rights over the water and wanted to award a fishing contract to a private contractor from Jaipur. The villagers refused and the government had to finally give up its fishing claims.

It is to the credit of the villagers that they have overcome these hurdles in their goal of self-reliance and self-governance.

It is a sign of the communities' acceptance of the usefulness of *johads* that financial contributions from the villagers have increased from a mere three per cent of the total cost in the beginning in 1986 to up to 90 per cent in some villages.

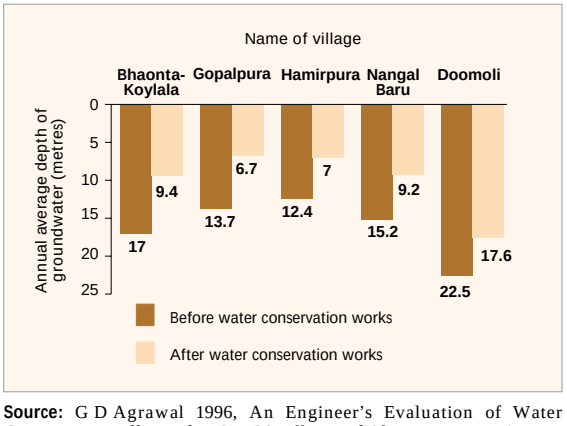
According to an independent study conducted by G D Agarwal, former head of the department of civil engineering, Indian Institute of Technology, Kanpur, in 36 villages, a *johad* with a storage capacity of 1,000-1,500 cubic metres per hectare has raised the annual average groundwater table by about 6 m *(see Graph 1: Groundwater rise, and Box: Trial by fire).*[16] For example, water that could be found in the Bhaonta-Kolyala village at 17 m depth in 1985 is now available at just 9.6 m.[17]

One of the most spectacular results of this rise in groundwater level has been the revival of five rivers — Bhagani-Teldehe, Arvari, Jahajwali, Sarsa and Ruparel, which run through the area where these 3,000 *johads* have been built. These rivers used to remain dry throughout the year barring a few days during the monsoon season, but they have now become perennial. As many as 250 villages located on the banks of these rivers have surplus water available right through the year.

The barren hills of the Aravalli are slowly being covered by regenerating forests. Officially, the forest cover is now 40 per cent, a clear rise of 33 per cent in the last 15 years. Today, 70 per cent land is under vegetative cover. Barren lands previously not under cultivation are now productive. In most villages, all the available cultivable land is under cultivation. Out of the 0.65 mha work area of TBS, 0.40 mha is already regenerating or is under planted forest cover.[18]

The availability of water at a shorter lift height has

Graph 1: Groundwater rise



Source: G D Agrawal 1996, An Engineer's Evaluation of Water Conservation Efforts of TBS in 36 Villages of Alwar District, *mimeo*

OPPOSITE PAGE: ***Jahajwala bandh: Under the leadership of Tarun Bharat Sangh, villagers of Daivry, Bankala and Rada have created a reservoir of water along the margins of Sariska Tiger Reserve in Alwar district, Rajasthan.*** (PIX: ANIL AGARWAL / CSE)

TRIAL BY FIRE

An impact assessment by an engineer and a hydrogeologist explains the reasons for the dramatic turnaround in Alwar district

Few know about the economic benefits of building *johads*. An investment of Rs 100 per capita on *johads* raises the economic production in a village by as much as Rs 400 per capita per annum. This was the finding of G D Agarwal, former professor and head of the civil engineering department at the Indian Institute of Technology, Kanpur, who assessed Tarun Bharat Sangh's (TBS) work in Alwar.

In August 1995, Agarwal took up an evaluation of water harvesting structures built by villagers with TBS's help. His study covered 36 villages where TBS had been working. Agarwal's report, An Engineer's Evaluation of Water Conservation Efforts of Tarun Bharat Sangh in 36 Villages of Alwar District, is based on extensive data collection and scientific analysis. Here is an edited version of some of the very pointed remarks about TBS's work and the reasons for its success.

- An interesting aspect is the extremely low cost at which these structures have been created, which vary between a low of Rs 0.2 per cubic metre (cum) of storage capacity to a high of three rupees per cubic metre. The overall average cost for the structures studied comes to Rs 0.95 per cum. No engineering organisation would be able to build water harvesting structures at such low costs. Their costs would vary between Rs 15-20 per cum.
- It appears amazing that as many as 36 per cent of the water harvesting structures had the right capacity, even when no calculations had been done, and 13 per cent had a capacity which was more than required. All crucial engineering decisions regarding the structures were taken by villagers and TBS workers on the basis of their traditional knowledge, experience and gut-feeling with little or no engineering experience. Their gut-feeling was not too bad.
- The best proof of adequacy and safety of these water harvesting structures is that these works have stood the test of time and the ravages of intense rainfall in 1995 and 1996, when scores of structures designed by engineers and maintained by the government failed and created tragic floods. The crux lies not in design or construction but in maintenance and protection.

In October 1996, S K Lunkad, professor and head, geology department of Kurukshetra University, and Dinesh Kumar Mishra, a flood control activist, examined 16 of the structures assessed by Agarwal. Both found the selection of the site, design and construction most appropriate.

There can be no better rural investment than that on *johads*. The economic and ecological miracle of regeneration in Alwar district is being brought about by using just a small percentage of the rainfall. This small percentage is being used for irrigation, and has made a tremendous change. R N Athavale, eminent scientist at the National Geophysical Research Institute, Hyderabad visited some areas in Alwar where TBS had worked to assess the hydrological changes brought about by the water harvesting structures. Because of the considerable work that has been done in arresting runoff and storing it in small-sized reservoirs in the catchment area, there has been a transfer of the water to aquifers and addition to soil moisture through artificial recharge and water conservation at farm level. This has resulted in a reduction in the quantity of water available for seasonal (monsoonal) runoff.

The streams have changed from seasonal to perennial. The stream water in the non-monsoon season is clear, with no suspended matter and the flow is gentle. This indicates that this stream water is contributed by the groundwater system, and that though there is a reduction in seasonal runoff, there is no substantial reduction in the total runoff (discharge) from the stream.

also meant a substantial reduction in expenses on diesel for water pumps. In the last 15 years, the cost of diesel consumption has come down almost threefold.

One of the best indicators of the overall prosperity generated in the area is the rise in sale and availability of milk cake. Availability of water has given way to improved livestock rearing, increasing milk production almost tenfold. It also shows that the local population now has an increased purchasing power to consume this amount of milk. In 1985, where only 11 milk cake shops existed in Alwar district, there are now 100 shops selling 20 tonnes of milk cake every year.[8]

THE STORY OF THREE VILLAGES

Bhaonta-Kolyala

The village Bhaonta-Kolyala is situated on the periphery of the Sariska Tiger Reserve Forest. The village has 232 ha of land in which it used to raise only one crop even during a normal rainfall year.

The Bhaonta-Kolyala village suffered four consecutive years of severe drought between 1984-87 when all the 30 wells in the village failed to bring forth water despite the use of diesel water pumps. The *johads* built at Gopalpura village, just 20 km away, gave the villagers of Bhaonta-Kolyala similar ideas. In 1986, the annual *pani yatra* of TBS also passed through the village spreading the wisdom of *johads* *(see Box: Building up awareness)*.

In March 1987, the village formed its own *gram sabha* and began to convince the surrounding villages to protect forests and repair old *johads* by voluntary labour participation. An *aam sabha* (public meeting) of eight villages was held which decided to take control of development works and not depend on the government any more. TBS needed to contribute just 25 per cent of the cost of the renovation projects.

The villagers and TBS workers soon discovered an old *johad* on the slope of the Aravallis, buried in silt. Its natural drainage course was mapped by the villagers

and a tentative site for a *johad* was finalised. Encouraged by large participation and success in mapping the water course, villagers began building a 272 m long, 12 m wide and 4.2 m high *johad* on the site chosen by the *gram sabha*.

The catchment area of the *johad* consisted of barren hills with 1,200 hectares (ha) of notified yet barren forest land. In 1988, the work on the *johad* started and the monsoon rains filled it up. But soon soil erosion threatened its survival and it was decided that the 1,200 ha of barren forest land be regenerated through extensive afforestation efforts. The villagers clamped a ban on felling green trees and stray grazing and as the forest land started showing signs of regeneration, it was declared a sanctuary by the villagers.

Impressed and emboldened by their own success, the villagers started work on an ambitious project to build a 243 m long water harvesting structure with a 6.5 m tall concrete dam wall on the upper part of the catchment in 1991.

It took three years to finish the project with villagers contributing 70 per cent of the estimated cost of Rs 3 lakh. But even before the dam could be completed in 1994, its impact was already visible in the surrounding areas as the percolation rate of water in this dam was one metre per hour. The impact of the percolating water was felt in villages located 20 km downstream where all wells became full of water.

Inadvertently, all the water harvesting structures built in the area gradually contributed to the revival of a dead and long forgotten river called Arvari. The watercourse mapped by the villagers prior to the commencement of the *johad* building activity happened also to be the origin of the river.

By 1995, the village landscape was dotted with 22 water harvesting structures with catchment areas ranging from 100 ha to 2,000 ha. It formed an interlinked web of many small watersheds that virtually conserved every drop of rainwater.

Because of these structures, the annual migration of male members to the towns has totally stopped since 1995 and all the 30 village wells maintain water throughout the year. With the increasing moisture content in the soil, and careful bunding and protection of farm lands to curb soil erosion, the people of Bhaonta-Kolyala are bringing in large areas of earlier uncultivated land under cultivation. Today, 25 per cent of the 140 ha of uncultivated land is being cultivated.

With growth in prosperity, there is a growing concern for the welfare of the community. The *gram sabha* has established a *gram kosh* (village fund) for maintenance of created structures and for community welfare work. Each family contributes one-fortieth of its annual income to this fund or gives one day of voluntary labour participation every month for community work.

Gopalpura

Situated in the semi-arid zone of Rajasthan with an annual average rainfall of 600 millimetres, Gopalpura village used to raise only a single crop even during

BUILDING UP AWARENESS

Tarun Bharat Sangh has organised more than 200 marches and countless meetings in villages to spread* johad *building activity

One of the most effective means of spreading the message of water harvesting has been the *pani yatra* (water tour) which was started in 1986. Every year Tarun Bharat Sangh workers along with local villagers travel from village to village on foot, to share experiences in water harvesting with the aim of mobilising at least 100 villages to take up water harvesting every year. The *yatra* continues for one and a half months, usually covering 450 villages along the Aravallis, covering some 300 kilometres. In 1997, out of the 450 villages covered by the *yatra*, work in 100 villages has already started and requests from another 100 villages are being processed. A traditional occasion is the *rakhi* day, when villagers tie *rakhis* to trees around villages which creates a palpable emotional bond between the trees and the villagers, ensuring the future safety and well-being of the trees. (*Rakhi* is a thread that a sister ties on her brother with the hope that he will protect her.) As word spread from one village to another, within 13 years, between 1986 and 1998, the number of participating villages covered grew to 650 *(Graph 4: Promoting environmental self-reliance on page xxv).*

AMIT SHANKER / CSE

As the impact of* johads *and water conservation spread through word of mouth and through* pani yatras*, several villages have started* johad*-building activities

AMIT SHANKER / CSE

A vigilant farmer watching over his sugarcane crop in Gopalpura

normal rainfall years. Only 30 per cent of the available land in the village was under cultivation, out of which only nine per cent could be irrigated. In 1986, while the village was in the middle of a severe drought that stretched from 1984 to 1987, TBS launched its *johad* building efforts in the village.

The villagers joined in the restoration efforts of an old water tank called Chauntararwali johad. TBS distributed foodgrains in exchange of labour participation. Desilting and deepening of the *johad* bed was completed before the monsoon and the *johad* successfully harvested runoff from the surrounding denuded hills.

Inspired by the success of this structure, villagers participated in large numbers in building more water harvesting structures and many villagers who had migrated to cities in search of work, returned. A huge structure of 275 m length and six metres width, named the Mewalwala dam, was built with villagers providing both labour and land. The voluntary donation of land by the villagers was significant as it showed their keenness in building these structures. With the completion of seven more tanks built with voluntary labour participation of the villagers, the village became self-sufficient in water.

In the *kharif* season, the irrigated land increased from 33 ha in 1987 to 108 ha in 1994. Similarly, in the *rabi* season, the irrigated land area increased from 100 ha to 190 ha. Almost the entire increase came from irrigating traditional farming lands, evident from the fact that the increase in total land under cultivation was only marginally less than four per cent in the *kharif* season and around 10 per cent in *rabi* season.

The second step was to bring back greenery on the hills by checking soil erosion. Some 60 ha of barren hills located in the catchment area of these tanks were declared reserved by the villagers and extensive afforestation activities were launched, along with a strict ban on grazing on the hill. To secure the regenerating forest cover, the hill area was fenced off by a stone wall to keep away grazing cattle.

These efforts elicited opposition from an unexpected quarter. The entrenched and non-functional *gram panchayat* felt threatened by the activities of the *gram sabha* formed to build *johads.* It felt its position of authority and importance slipping away and opposed the villagers' participation in TBS-led water harvesting projects. The *panchayat* chief connived with the local government officials to allow a colony of bonded labourers to settle down inside the village-protected forest land. The government land officials declared the stone wall constructed to keep the cattle out and the trees planted illegal and levied a fine of Rs 4,950. As was

expected, the new colony started destroying the forest cover, causing tension between the Gopalpura gram sabha and the *gram panchayat*. However, as the villagers continued with their resolute protection of the forest land and strong protests against the unreasonable encroachment, the district magistrate ultimately had to apologise to the villagers and the government provided 10.2 ha of land and Rs 10,000 to the *gram sabha* for a fresh afforestation programme.

Following these activities, the water column in the village wells registered a 13 m increase in the column height between 1987-1997.[20] The water available during summers also shot up from a water column height of three metres in 1987 to 10.5 m in 1999. Food production also doubled. The overall prosperity of the village is now reflected in many social changes. A school was set up in 1994 in the village where the attendance rate is almost 100 per cent. Problems like fetching drinking water from great distances by women and children have become a thing of the past.

Bishnoi

Bishnoi is a small village of 2,500 people with 25 wells and 150 ha of agricultural land. Till recently, only 10 per cent of the land was being cultivated and the village witnessed 80 per cent of its population migrating to towns in search of livelihood. But all that changed in 1996 when a rally called *Aravalli Bachao Yatra* (Save Aravalli March) passed through the village.

Inspired by the aims and methods of water harvesting propagated by the *yatra*, the villagers decided to form their own *gram sabha* in the same year and build a huge *johad* to catch water from at least 20 surrounding hills. TBS came forward to assist the villagers with expertise and contributed 50 per cent of the three lakh rupees spent in building the tank.

The *johad* successfully stored the runoff from the hills during the rainy season which lasted right through the year. By 1997, all the land was put under cultivation and the agricultural production of the village went up by 100 per cent. As life took a turn for the better, even girl children started attending school in 1998. The villagers in Bishnoi are now planning for a better and permanent structure for the school.

REVIVAL OF THE ARVARI

The 45 km long Arvari river, with a watershed area of 50,300 ha, originates in Thanagazi block of the Alwar district. According to the Alwar State Gazetteer,

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Dams like this in Bhaonta-Kolyala village have raised the groundwater table and revived the Arvari

this river was known as the Pratapgarh Nullah in the 19th century and was considered as the main groundwater recharge source for the 75 villages located on its banks. But, over the last few decades, the river used to have water only during the monsoon season.

In 1986, the villagers of Bhaonta-Kolyala built a huge dam close to the river to store water from the surrounding Aravallis, hardly realising that by storing and allowing natural percolation to take place, new life was being injected into the river. The revival of the river was more a matter of coincidence rather than a result of deliberate design.

Beginning with the Jogiwala johad built on a small monsoon stream flowing into Arvari, many smaller *johads* were gradually constructed by the villagers to arrest water coming down the slopes of the hills. As the *johad* building campaign gathered strength, a total of 238 water harvesting structures came up in the catchment area of the river after 1986 *(see Fig 1: Dotting the landscape)*. Collectively, all these structures were recharging groundwater which became visible in the rising water columns of the once dry wells.

The result of this large-scale water harvesting in the catchment area of the river manifested itself in 1990, when the river continued to have water till October. Its water retention capacity gradually but steadily increased over the years, till it became perennial in 1995, except in 1999 when after the area suffered two years of consecutive drought, the river dried up in December. The villagers are now managing the river by forming the Arvari Sansad or Arvari Parliament.

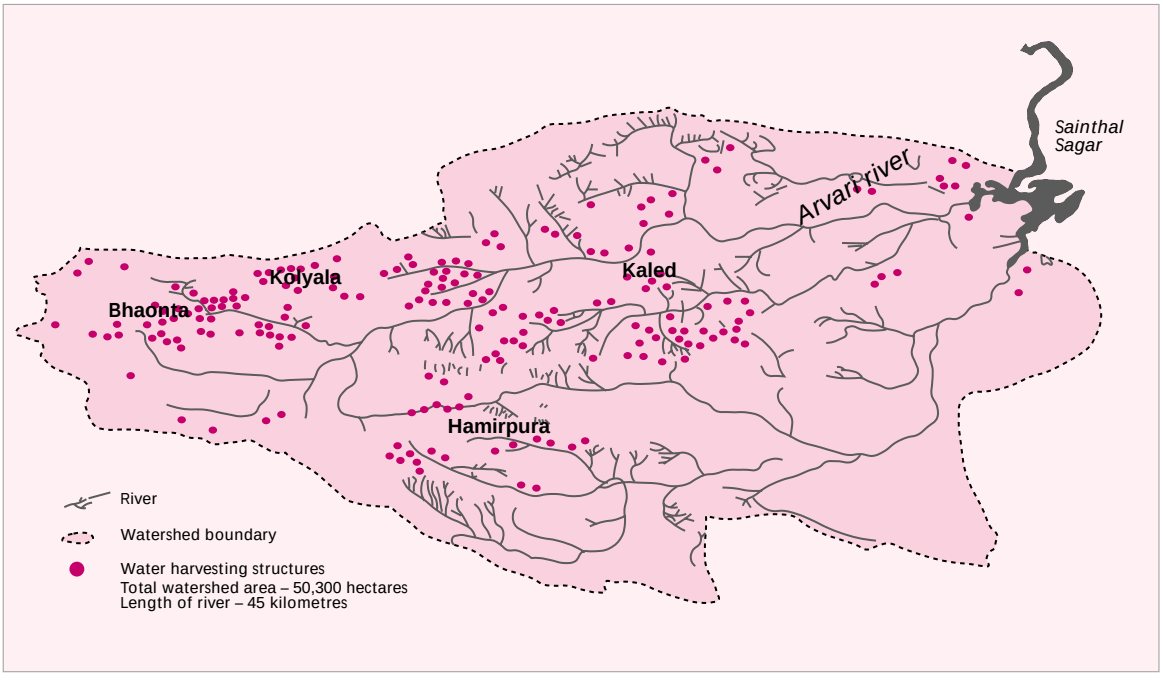
RIVER OF THE PEOPLE

With the return of water in the Arvari, fish also returned. Villagers living close to the rivers revived the tradition of feeding the fish on full moon nights and completely prohibited fishing. But to their utter surprise, in 1996, the Rajasthan government issued a fishing licence to a Jaipur-based contractor for Rs 18,600. Irate villagers not only refused to allow the contractor to catch fish in the river but also declared ownership of the river. Soon the fight over the fishing contract became a battle over the ownership and management rights of the river between the government and villagers. Villagers sat on a 'save the aquatic life *satyagraha*' on the banks of Arvari river in December 1996. It was followed by a *satyagraha* held to protest against the Rajasthan government's betrayal of the villagers' trust in January 1997. The *satyagraha* continued for two months, eliciting support from all quarters of the society and finally in April, the government bowed to the popular pressure, cancelling the fishing contract.

On January 26, 1999, when the country was

Fig 1: Dotting the landscape

Over 200 water harvesting structures today exist in the 50,300 hectare Arvari watershed



TARUN BHARAT SANGH

AMIT SHANKER / CSE

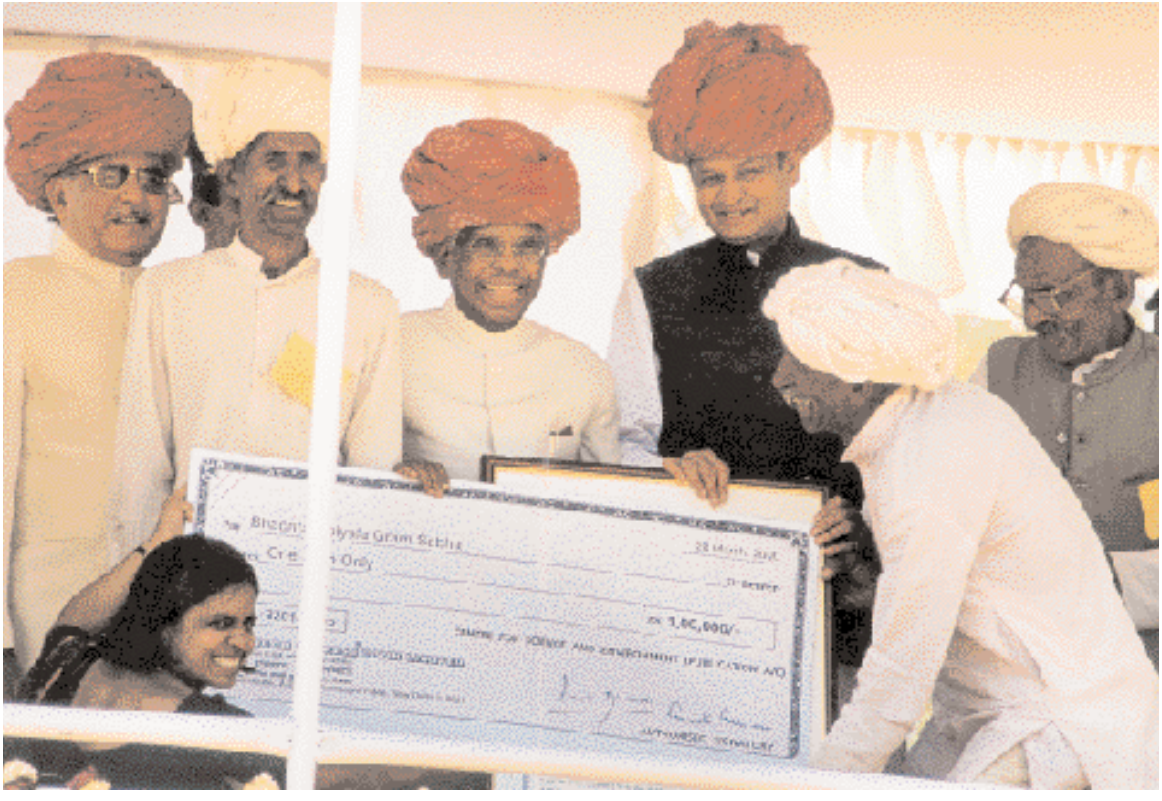
The Arvari — a river revived. The people behind this 'miracle' trust no none but themselves for its management

celebrating the 50th anniversary of the republic, the villages along the Arvari river formed an Arvari Sansad to manage the river. On the bank of the river in Hamirpura, representatives from 34 *gram sabhas* gathered and declared the formation of a parliament and adopted a constitution to manage the river.

The foundation of this parliament was laid during a mock public hearing organised by the Tarun Bharat Sangh on the banks of the Arvari in December 1998, when villagers had voiced their rights on the river. When it came river managment, everyone felt that the role of coordination between the needs of various villages must lie with the government. In this context, Anil Agarwal, the director of the Delhi-based Centre for Science and Environment and a 'judge' for the public hearing proposed a river parliament for the river, where the villagers themselves could coordinate their needs amongst themselves. The proposal was accepted and the villagers themselves decided to adopt a charter to manage it.

The Arvari parliament has a two-tier structure. The first body consists of one representative from each village located on the bank of the river. The second body has representatives from each identified cluster of villages. To coordinate the functioning of the parliament, there is one secretary, assisted by two other villagers.

The Arvari Sansad met for the second time in June, 1999. It decided to stop the proposed setting up of a brewery by a private company which wanted to take advantage of the increased barley production, an essential raw material for breweries, in the area. To safeguard against overexploitation of groundwater, the parliament adopted elaborate rules to be implemented through village level institutions. The use of tubewells in farms located along the course of the river which had caused a noticeable decrease in water flow into the river would be stopped. Water-intensive crops like chilli, vegetables, sugarcane and wheat along the banks of the river had necessitated the increased use of tubewell water. However, farmers who had lost land due to the rising level of water in the river were allowed to use tubewells till *Holi* (the festival of colours). This would compensate for some of their losses while ensuring that enough water remained during summer. Farmers were also allowed to dig shallow wells at a distance from the river to obtain



AMIT SHANKER / CSE

President K R Narayanan went to Hamirpura to award the* Down To Earth-*Joseph C John best environment community award to villagers of Bhaonta-Kolyala

groundwater after *Holi*. The parliament found 70 per cent compliance of its directives from the previous convention. Farmers failing to comply with the directives of the parliament would not be allowed to irrigate their lands.

One of the significant decisions that took place during the third session held in village Bhaonta in December 1999 was that members of the parliament would assist other villages interested in organising a river parliament in their region. A review of the implementation of the rules revealed that none of the villages had violated the norms, though a few stray cases did come to the fore. Decisions were taken on the spot and solutions found by the people themselves.

In the fourth meeting held in June 2000 in Devka-Devra village, the relationship between the members of the *sansad* and the *gram sabha* were discussed. It was decided that the parliament members would assist the *gram sabha* in implementing the rules of the *sansad.* The youth members in the *gram sabha* would be informed and trained in traditional methods of common property resource management. This would help them to develop their skills in resource management.

An emergency meeting of the parliament took place in October 2000 in village Bhikampura to discuss the drought-like situation and what measures could be undertaken to mitigate the effects of consecutive monsoon failures. This was the third abnormal monsoon year. It rained for a mere two days. People were concerned that with summer peaking in April and May 2001, there should be no water shortage. A few crucial decisions were taken as part of a comprehensive drought strategy: careful use of water resources, sowing minimal water-requiring crops and a campaign to spread the word in all the 70 villages on the steps that needed to be taken. Each drop of water and each straw of fodder would be used judiciously. Less water-intensive crops, or crops that can grow in arid conditions, like mustard, barley, gram and *tara,* an oilseed crop, would be cultivated. It was also decided that water would not be lifted directly from the river, barring the landless. On October 2, a *padyatra* (pilgrimage on foot) was flagged off to caution the villagers of the trying times ahead and what they could do to save water and their crops.

Groups of villagers, many on their own initiative, are coming from Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra and Uttar Pradesh to visit these villagers and the parliament members to understand and to learn how to manage water resources. ■

Laporiya's Labour of Love

The people of Laporiya have dyked degraded pasturelands to harvest the rain. The ecological change has been dramatic

Laxman Singh and Jagbir Singh
Gram Vikas Navyuvak Mandal Laporiya, Block Dudu, Rajasthan

Till the 1970s, the pastures of Laporiya — a village in the Dudu block of Jaipur district — were barren and degraded. Today, the same area that was described as a drought-prone zone, having saline soil, denuded pastureland and starving livestock by the government, has adequate water for irrigation and domestic purposes and green pastures which support their livestock.

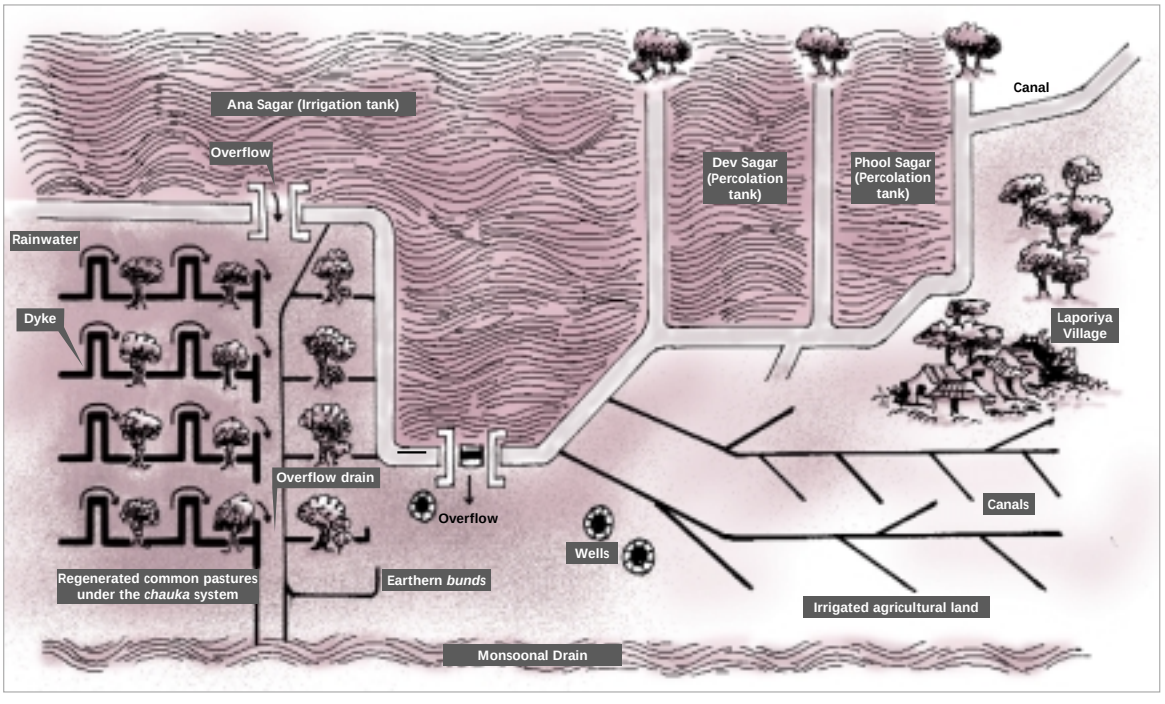
Laporiya is a village of 189 families, all of whom are agro-pastoralists. Located in a semi-arid region, their livestock survives on the surrounding pastures, which had become degraded and barren. The soil conservation department advocated trenches and contour bunding for irrigating the land. But this was found inadequate, as water could not be spread on the pastureland by this method. Neither did this promote the natural growth of grasses, some varieties of which required shallow water for their growth. In 1990, Gram Vikas Navyuvak Mandal Laporiya (GVNML), a civil society group of Laporiya, mobilised the village community to undertake the revival of its ecology. They formed a *gram sabha*, consisting of 11 village elders. Four years later, work was initiated on 50 hectares (ha) of pastures to integrate the denuded

GVNML

Revering water: Villagers performing a* puja *on the banks of the village pond

Fig 1: Green tanks

The square *chaukas* (bottom left), enclosed in dykes, spread rainwater over a large area to regenerate pastures



ASIAN WATMANET

land into a single project unit. To complete the project, the villagers contributed labour in the form of *shramdaan* (voluntary labour) and the result was a system of *chaukas*, a marvel of ingenuity in the face of odds.

THE *CHAUKA* CATCHMENT

This unique method of harvesting water involves rectangular plots of land or *chaukas*, which store rainwater in dyked pastures. The 66 metres (m) long and 132 m wide enclosures are arranged in a zigzag pattern and lie along a small gradient. About 1.5 m high dykes are built along three sides that lie towards the lower part of the land / gradient. Trees are planted on these dykes to give them additional support to withstand rain *(see Fig 1: Green tanks)*.

When it rains, water is collected in the lower half of the *chauka*, which is dyked. As the amount of water stored in the enclosure rises, it flows into the neighbouring *chauka*, and so on, gradually spreading water over the entire pasture. At the same time, this process prevents the water from rising above the level that prevents growth of natural grasses, which cannot survive in deep waters. After reaching the last *chauka*, the water flows into a monsoon drain. This system not only provides adequate water for the villagers, but also promotes the recharge of groundwater.

Even at the height of summer, when the grass all but dies out, the roots can be seen lying dormant and binding the soil. After the first showers, they spring back to life.

The key to the success of the project is its adaptability. The dykes have been built keeping in mind the pathways that the people use. There was no restriction on grazing in the *chaukas* earlier as the emphasis was on impounding water and improving the soil. Now the people of the village plan to restrict grazing to alternate *chaukas*. The size and shape of the *chaukas* also varies according to the topography and needs of the people.

Though this system is effective and practical and many neighbouring villages facing the same problem have come to the residents of Laporiya for consultation, government agencies refuse to accept the model for promotion in other villages until it has been tested and approved by scientific institutions.

MOVING BEYOND PASTURES

Regeneration of pastures — as important an achievement as it may be — is merely one of the several successes of the people of Laporiya and the civil society group it created. Three tanks and the resplendent

greenery all around testify the effort put into ecological conservation in the past decade. In 1994, along with the restoration of the pastures, the old village tank, which was in a state of neglect due to siltation and breach of dykes, was also restored. As a result of this, there was a bumper harvest in 1996. In the downstream area of the tank, the irrigated area rose to 300 ha, and for the first time in 20 years, wheat was grown in Laporiya. The tank, due to which the agricultural production of the village increased more than 12 times, was not a mere engineering structure for the villagers. The songs sung by them had a special place for the tank, and it soon became the hub of the social life of the village. Due to the prosperity it brought to the village, the tank was named Ana Sagar (sea of foodgrain).

Restoration of the Ana Sagar was followed by the construction of two percolation tanks, Phool Sagar (sea of flowers) and Dev Sagar (sea of the gods), built to recharge groundwater and to meet all the other needs of the villagers and their livestock. Right beside the latter is a well that is covered by an impressive canopy. There is also a platform used to feed grain to the birds, under which there is a godown used to store the same.

Two of the village elders played a leading role in the completion of the project. Kalu Dada, who is well known through the village for his communication skills, inspired and encouraged the community and was seminal to the mobilisation of the people. The second, Ram Karan Badana, is one of the most skillful *gajdhars* (indigenous engineers) of the village, and led the people when plans had to be devised and implemented. These men represent the collective wisdom of village communities, and it is this indigenous wisdom which guides organisations like GVNML and leads to the invention of ingenious systems such as the *chauka* method of rainwater harvesting.

The organisation is spreading the message of the need of water conservation through *padyatras* (marches). Today, though GVNML's work has spread to over 50 villages, their ultimate aim is to be able to dissolve itself into the people. To reach a stage of development where the village community does not need any kind of assistance and the people are strong enough to face any problem and find a solution for it independently.

When the monsoons failed yet again in 2000, it was for the third consecutive year. The rainfall was a mere 100 millimetres. The efforts of the villagers in water conservation and monsoon capture in the *chaukas* have lessened the severity of drought. Grass and fodder is available for the livestock and wells have water. Though the organisation is getting several requests to build similar systems in neighbouring villages, finance is a constraint. ■

GVNML

To mobilise villagers about the need of water conservation, a* padyatra *organised by GVNML walks from village to village

Revival through Rivers

Small water harvesting structures built across the river Kali-II by N M Sadguru Foundation in Dahod district have infused it with new life. The river is now a perennial source of water

Harnath Jagawat
N M Sadguru Water and Development Foundation, Dahod, Gujarat

Through the efforts of N M Sadguru Water and Development Foundation, a non-governmental organisation based in Dahod, Gujarat, several local rivers and rivulets have been revived in the tribal regions of western India by building a series of community-based, small-scale water harvesting structures. The transformation that a series of small check dams on the river Machhan have brought about is amazing. Agriculture is now possibe where there was not enough water even for domestic use *(see Box: The Machhan miracle)*.

Such locally designed, small-scale water harvesting systems have potential for widespread application. The Kali-II river, approximately 35 kilometres (km) long and with a catchment area of 24,000 hectares, flows through the semi-arid undulating plains of Dahod and Jhalod talukas of Dahod district in Gujarat. During the last 50 years, several changes in the river have been witnessed. While the elderly get nostalgic about the nature of this river 50 years back, in the recent past, this river would run dry for about 6-8 months every year following the monsoon.

But now history has been recreated. The river runs perennial once again. This has been possible by the

SADGURU FOUNDATION

A check dam constructed by Sadguru Foundation: holding enough water for irrigation

THE MACHHAN MIRACLE

A healthy mix of engineering and public participation in capturing rainfall along the river Machhan works wonders

Before 1994, the people of Thunthi Kankasiya village in Dahod district were facing a serious water crisis. About 78 per cent of them used to migrate for at least 10 months. There were no wells in the village. The farmlands were of no use as there was no water.

In 1994, the people of the village began the construction of a series of check dams with the assistance of the Sadguru Foundation on the river Machhan. The foundation got involved in this project at the request of the villagers.

The approach of the government was typical. When the director of the foundation, Harnath Jagawat, was discussing this water management project with government officials and politicians, he was made a laughing stock. How could the foundation work in the region on water management when there was no water to speak of, they wondered, scarcely realising that the source of water was rain.

Work on the first check dam began in April-May 1994. The dam was complete in a record 85 days, such was the level of enthusiasm amongst the people. The technical details of the dam were worked out by the engineers in the foundation.

A series of dams were later built along the Machhan to slow down the runoff and impound water for irrigation. An intensive watershed project by stone trenching and bunding, terracing and planting trees in the area was carried out.

The cascadal reservoir model has been successful. This involves building of small dams near the source of the river and the construction of a series of small irrigation structures downstream. The water trapped in the dams recharges groundwater. With no rainfall being allowed to escape and all of it being captured, there is water available in all the 23 wells of the region.

The transformation has been total. Because of the check dams, a reservoir of 453,070 cubic metres has been created. The river that used to dry up four months after the monsoons has enough water to meet irrigation demands despite the drought. This has been possible because of constant groundwater recharge due to the watershed interventions.

The residents are entirely responsible for managing the dam. Almost the entire population of the village is now above the poverty line. The average annual household income level has increased from Rs 8,000-9,000 to Rs 35,620 *(see Table: Waters make wonders).*

Table: Waters make wonders

Impact of integrated watershed development and water harvesting

Thunthi Kankasiya village	Status prior to 1991	Present status
Perennial drinking water in wells	Nil	23
River dams	Nil	1
Water availability (months)	4	12
Irrigation coverage (hectares)	Nil	135
Land under cultivation (hectares)	85	153
Number of crops per year	0-1	2-3
Annual agricultural production (tonnes/hectare)	0.9	4.0
Migration rate (per cent)	78	5
Average duration of migration period (months)	10	2
Income per household	8,590	35,620

AKHILESH / CSE

The river Machhan flows in spite of the drought in the year 2000. This has been possible because of the construction of check dams

Dahod district, Gujarat

building of a series of eight small masonry check dams *(see Table 1: Dammed to survive)* at appropriate distances across the entire length of the Kali-II. While earlier the people would just cross the river at a convenient place, there is now a need for bridges to cross it.

The natural resource base has expanded. These check dams have changed the ecology and economy of the region. Water available for irrigation has increased and groundwater levels improved. Water is now available throughout the year for people and cattle.

Table 1: Dammed to survive
Check dams built on river Kali-II

Name of check dam	Number of beneficiaries	Area irrigated (hectares)
Chosala	95	68.7
Patadiya	80	111.2
Gultora	153	121.4
Dadgarh	100	121.4
Padatiya-II	71	58.2
Tadagola	90	28.3
Sharda	54	48.6
Kaligam	71	60.7

With the rise in food production due to increased irrigation, seasonal migration of people living close to the river has dropped from around 70 per cent to less than 10 per cent. All this has taken place without displacing a single person.

TINY WONDERS

These water harvesting structures may be technically small. However, each of these benefits an average of 100 families. Relatively big structures serve upto 500 families.

The Kali-II is not an isolated example of water harvesting in the region. A series of small check dams along the courses of 35 rivers and rivulets such as the Khan, Kali-I, Machhan and Hadaf in Gujarat and the Pat, Sangas, Ranek, Negdi and Kikarva in Rajasthan have been built. These dams are spread over a 60 km radius, cutting across the borders of Gujarat, Rajasthan and Madhya Pradesh. Most of these rivers and rivulets, on which these dams have been built, have now become perennial.

THE HUMAN ANGLE

Initiative and participation of local people have been crucial in building and maintaining these structures post-construction. Under the technical guidance of the foundation, local supervisors are trained to build these structures. Two persons, generally, a man and a woman, are selected by the community to supervise the entire process of construction. Once the construction work is over, management of the constructed structures is entrusted entirely to these communities.

The success of these structures clearly shows that similar work can be carried out in all vulnerable and poor tribal regions of the country. More than 70 per cent of the total tribal population in India is concentrated in the six states of Bihar, Orissa, Madhya Pradesh, Gujarat, Rajasthan and Maharashtra and is broadly located in a contiguous tribal belt of central-west India. Despite the region being rich in natural resources, people of this region are among the most backward and poor in the country. Fortunately, the area receives an annual average rainfall of about 1,000 millimetres (mm) which could be combined with the topography and the existing natural network of drainage systems very profitably.

Considering that there are 46 districts in the above-mentioned region, there is a potential of building approximately 46,000 small water harvesting structures. If, on an average, about 100 families benefit from each water harvesting structure, about 46 lakh families and about 230 lakh people could benefit from building such structures. ■

Jhabua: A Green Miracle

A combination of political determination and eager communities can create ecological miracles. Jhabua has shown the way

Richard Mahapatra
Centre for Science and Environment, New Delhi

The regeneration of Jhabua — a poor tribal district of Madhya Pradesh, situated on the border with Gujarat — is an outstanding effort by a state government to involve the people on a large-scale in integrated land and water management, probably the first of its kind in India. The state-wide programme was initiated by Digvijay Singh, chief minister of Madhya Pradesh, after he was inspired by the work of Anna Hazare in his village Ralegan Siddhi in Maharashtra.

In 1985, Jhabua was just a moonscape. Thirteen years later, the land is being nursed back to life with care. The programme, entitled the Rajiv Gandhi Mission for Watershed Development (RGMWD), started in 1994 and is now six years old. Already, satellite imagery is showing changes in the number of waterbodies and the extent of the green cover. Trees are beginning to grow and there is grass. Dugwells have water and are often overflowing. All this, in a place that was chronically drought-prone in the 1980s. It is the result of political will combined with eager participation of local communities.

JHABUA DOWN THE AGES

Jhabua is an upland region of western Madhya Pradesh. Once a heavily forested area, Jhabua lost its natural wealth over the last 45-50 years. Almost 80 per cent of its forest is severely degraded. Of this, more than 30 per cent of forest land is without any tree cover. The reasons are many and range from government-aided plunder by contractors to clearing up for agricultural activities and population pressure.

As the uplands were used for cultivation without terracing, the humus and fertile layer of soil was lost and soil erosion accelerated. Free grazing further affected the vegetative cover of the land. The district was dotted with rock-exposed hillocks. The intensive cultivation on uplands led to an ecological disaster, resulting in loss of land productivity, decline in employment opportunities, and distress outmigration of people.

Jhabua's topography is undulating. There is rapid runoff in the district, which has an annual average rainfall of 830 millimetres (mm). As such, post-monsoon water is almost non-existent. Moreover, there is wide variation in annual rainfall from year to year. This has resulted in extensive hill, gully and ravine soil erosion.

Both Jhabua and its adjoining areas in Dhar district were, thus, on the threshold of an ecological disaster, which spelt doom for the populace. The impact was greater on the tribal people as 83 per cent of the district's population are tribals, mostly Bhils, whose survival is closely linked to forests.

During 1966-68, Jhabua witnessed its first famine since independence. There was another severe drought in 1985 when Jhabua recorded only 308 mm of rainfall, the lowest since 1911. It also witnessed the first food riots after independence. Migration out of Jhabua for jobs continued into the 1990s, ranging between 57-66 per cent. In almost all landholding categories, except large farmers, more than one-third of the household was migrating.

RESCUE MISSION

The situation changed in the mid-1990s, when the Madhya Pradesh government launched the RGMWD programme, in October 1994. A decentralised and time-bound mission, it started with the objective of improving 1.2 million hectares (mha) of land stretched over several

ANIL AGARWAL / CSE

Jhabua was a moonscape in 1985 with barren hills and vast tracts of unproductive agricultural land dotting the landscape...

SUNITA NARAIN / CSE

AMIT SHANKER / CSE

...However, with the implementation of the Rajiv Gandhi Mission for Watershed Development in 1994, the hills are getting back their lost cover and there is increased availability of grass, water and food

Table 1: Mission extensive

Number of villages in undivided Madhya Pradesh under the Rajiv Gandhi Mission for Watershed Development

	1996-97			1997-98[3]			1998-99			1999-2000		
	EAS	DPAP	Total	EAS	DPAP	Total	EAS	DPAP	Total	EAS	DPAP	Total
Districts[1]	42	25	NA	45	25	NA	61	25	61	61	31	61
Blocks[1]	354	134	NA	419	134	NA	459	134	459	459	134	459
Milli-watersheds[2]	488	165	653	585	165	750	624	173	797	624	173	797
Microwatersheds	3,220	1,151	4,371	3,863	1,176	5,039	4,461	1,253	5,714	4,461	1,253	5,714
Villages	4,817	1,874	6,691	5,864	1,963	7,827	6,182	2,016	8,198	6,182	2,016	8,198
Coverage (ha)	2,193,255	730,144	2,923,399	2,622,614	768,710	3,391,324	2,662,587	824,092	3,486,679	2,662,587	824,092,	3,486,679

Note: *EAS: Employment assurance scheme DPAP: Drought-prone area programme ha: hectare*

1. *Total blocks and districts covered by EAS and DPAP could not be ascertained as in some places the programmes are overlapping.*
2. *Milli-watersheds cover 5,000-10,000 hectares, consisting of several microwatersheds (500-1,000 hectares); the figures for 1997-98 are till November 1998 only since the government changed its documentation process at that time.*
3. *The number of blocks covered by the two programmes in 1997-98 was not available.*
4. *The total area under coverage is cumulative of both EAS and DPAP.*
5. *The total area under coverage in 1998-99 and 1999-2000 is identical because there was no increase in the fund allocated.*

Source: Rajiv Gandhi Mission for Watershed Development, Bhopal

watersheds, by the year 2000, with each watershed project finishing within four years. It envisaged greening more than 2.9 mha — approximately one per cent of the country's total land area — spanning 6,691 villages, through 5,024 watersheds *(see Table 1: Mission extensive).*

Today, Jhabua has become a model district in watershed management. The mission has broken all rules. The people, instead of bureaucrats, are the decision-makers. The mission, introduced in the undivided state's 61 districts, has also transformed the local economy. Approximately 14 million human-days of employment have been created in Jhabua alone. Some 218 microwatersheds cover 124,000 hectares (ha) at an estimated cost of Rs 44.47 crore.

The mission's guidelines, keeping in view its objectives, for selecting a watershed are:

- Acute shortage of drinking water;
- soil erosion and poor water resources, causing a decrease in agricultural and biomass productivity;
- preponderance of wastelands;
- extensive land degradation;
- large population of Scheduled Castes and Scheduled Tribes dependent on watershed resources;
- actual wages being lower than minimum wages; and,
- a watershed that is contiguous to an earlier developed watershed.

MAKING ALL THE DIFFERENCE

What is different in this programme is the mode of implementation *(see Table 2: Changing times).* In the last 50 years, most programmes and schemes meant for the people have not included them. When the end-users are not involved, the system simply does not work. In this watershed mission, attempts were made to put all the responsibility on the people, with the government working only as a facilitator. It was time for the villagers to take over. Other factors that contributed to the success of the programme include coordination of the programme at all levels, financial systems that reached out to the people, and the integration of forest management into land and water management.

Putting people first

The first and most important aim of the mission was to make the programme a totally people-oriented one. The people were involved in the concept, planning,

Table 2: Changing times

Conceptual change in watershed management

Lacunae in previous watershed management programmes	How Rajiv Gandhi Mission for Watershed Development tried to mend them
Projects were implemented in an isolated and segmented manner by different departments	All watershed activities were put under the Rajiv Gandhi Mission for Watershed Development for a coordinated approach
Relief operations were *ad hoc* and did not include soil and water conservation, the region's most important problem	All employment generating schemes focus on soil and water conservation and seek to make them sustainable
There are no proper guidelines for implementing agencies on watershed design and planning	The mission decides the plans and designs with an area-specific approach and gives priority to indigenous knowledge
People were not consulted for their own needs and to determine what suits their land the most	People are the focal point of solving problems

Source: Manoj Srivastava 1998, Rajiv Gandhi Mission for Watershed Development, Jhabua, Madhya Pradesh, *personal communication*

implementation and maintenance of land and water conservation activities in their watershed areas.

For instance, the villagers play an active role in managing the funds provided for the watershed programme. Nearly 80 per cent of the funds for the programme are put in a bank account managed by watershed development committees made up of village people.

The mission experimented by greening the anti-poverty programmes, to regenerate the lost environment and also create jobs. It had its leadership in R Gopalakrishnan, a bureaucrat, who is now the coordinator of the Rajiv Gandhi Missions of the Madhya Pradesh government. His experience in Jhabua in the drought-stricken mid-1980s inspired him to look for a green anti-poverty system. In the late 1980s, he had read *Towards Green Villages: A Strategy for Environmentally-Sound and Participatory Rural Development*, a study prepared by the Centre for Science and Environment. The study had argued that the large investments that the country was making under rural employment programmes could greatly benefit the poor and improve the local economy if it was directed towards ecological regeneration activities under people's control.

All watershed activities under various departments were pulled into one body in a major effort to convert community demand into community action. This entailed:

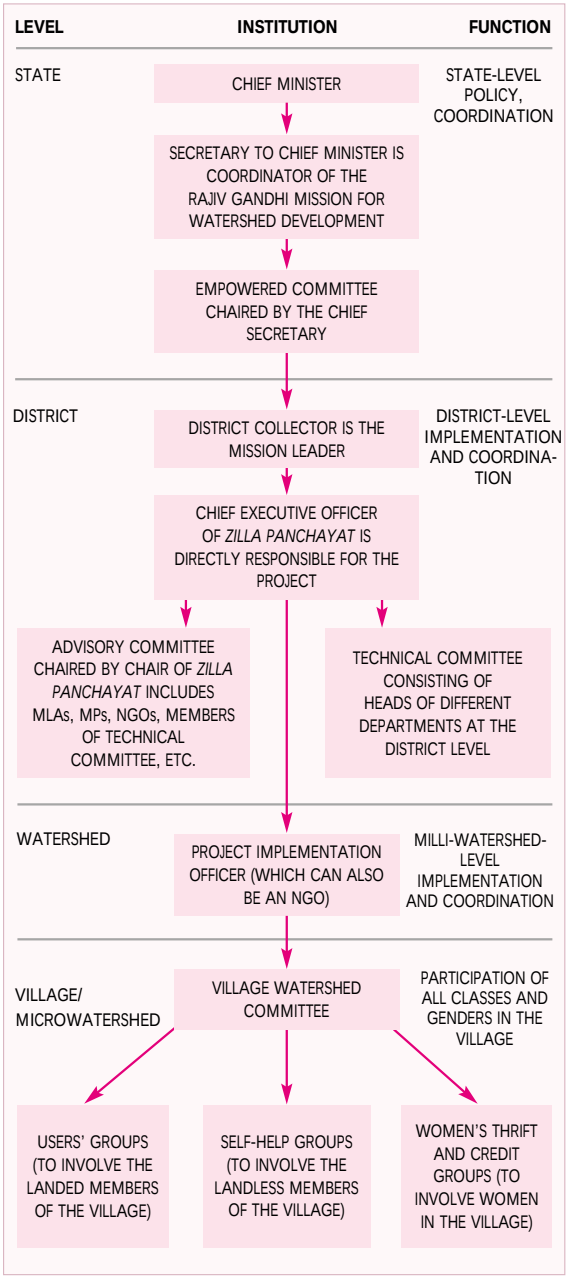
- Establishing multi-disciplinary coordinating structures at watershed, district and state levels to act as facilitators for community organisations;
- capacity building, planning and implementation and promoting community action processes;
- making rural people the key actors in the programme from planning and implementation to maintenance, monitoring and management for which necessary community institutions at the village level were evolved;
- harnessing all available techno-scientific resources to support the decision-making process of the people;
- developing a 'cascade' approach to the idea of land and water conservation, whereby it was seen as a completely integrated group of soil conservation-water impounding structures, each drawing upon and adding to the other; and,
- involving people's representatives and members of *Panchayati Raj* institutions.

Coordination at various levels

The institutional complexity of the programme is extraordinary. The programme created several tiers of institutions to promote a people's movement for watershed management at the state, district and village level — at the state level, for policy coordination; at the district and milli-watershed level, for implementation and coordination; and, at the village level, to ensure that all villagers acquire an interest in the effort *(see Fig 1: Getting bureaucrats involved)*. These institutions helped deal with the lack of inter-departmental coordination and intra-village community tensions that mark all watershed programmes.

Fig 1: Getting bureaucrats involved

Structure of institutions created to support a people's movement to undertake watershed development in Madhya Pradesh



Significantly, not one new bureaucrat was recruited or a new department created.

With the chief minister's secretary as the coordinator of the mission, RGMWD was given high executive status. This was indicative of the state government's will in the mission, and was also a clever move to make all officials accountable to the chief minister's office.

At the district level, the collector is the mission leader, which again puts all the officials under the highest authority at the local level. So the mission has introduced a single-command system from the top, while giving flexible powers to the commanding authority at the operational level. It is the political will at the highest level that has made possible a single-command structure at the government level, thus skirting bureaucratic turf battles before bestowing power on the people. Serious efforts have been made to give local communities powers of decision-making and control over resources.

Integration with JFM

Combining the principles of joint forest management (JFM) and watershed treatment was a new approach that was adopted in Jhabua. The JFM-watershed treatment started in 1994, with the formation of 20 village forest committees, the executive body under JFM that protects forests with the help of the forest department. An intensive JFM awareness programme was initiated in villages.

With the adoption of the JFM-watershed treatment combination, tree felling has reduced drastically. In 1992-93, 1,412 tribals were arrested for tree-felling. In 1994-95, it came down to 676 and, according to forest officials, it has declined even further. People believe that forest degradation is the root of their misery. While JFM has protected the forest, the watershed programme has made land fertile and helped recharge groundwater. In November 1997, 22 *gram panchayats* handed over 4,000 ha of village land to be declared as forest area for afforestation.

Of Jhabua's total forest area, 60 per cent (100,950 ha) is now under JFM and the 344 village forest committees cover 420 villages. The committees have 72,656 members, of which 43,953 are males and 29,703 are females. Ironically, now more villagers are guarding the forests than forest guards — one forest guard and two villagers for every 1,000 ha.

Financial arrangements

RGMWD is funded by both the state and the Centre. According to Central government guidelines, all funds under the drought-prone area programme (DPAP), funded by both the state and Central government, and the integrated watershed development programme (IWDP), funded entirely by the Central government, are to be spent on watershed treatment. Similarly, 50 per cent of the funds from the employment assurance scheme (EAS) are earmarked for it, apart from sectoral funds at the district level, and Jawahar Rozgar Yojana (JRY) funds at the *panchayat* level *(see Table 3: Financing the future)*.

According to the guidelines for watershed committees prepared by RGMWD, once a watershed plan prepared by the watershed committee is sanctioned, the District Rural Development Authority (DRDA) releases 75 per cent of the total money to the committee. The rest is kept for administrative expenses of the project's implementing agencies (PIA). The money is transferred into the account of the watershed committee and its secretary is the statutory operator. Every fortnight, the watershed committee meets to take decisions about various watershed activities, with the consent of other villagers, who are also invited to the meetings. The committee reports on the progress of the activities to the PIA at the watershed level which in turn reports it to the mission leader at the district level. Expenses incurred on the activities are put before the *gram sabha* for its scrutiny.

The watershed committee maintains two accounts — the project account and the development fund account. The first is meant for the money released by DRDA, and provides the daily expenditure of the project. The second is a fixed deposit account, for which 10 per cent of the total project cost is set aside. This is for post-project maintenance of all assets created during the implementation of the project. When villagers volunteer labour, a part of the respective wage is also kept in this account.

Both the Central and state governments send their share of the money to the *zilla parishad* (district council). The *zilla parishad* then disburses the money in the following way for a standard project period of four years:

Table 3: Financing the future
Source of money received by the *zilla parishad* for watershed development

Employment Assurance Scheme		Drought-Prone Area Programme		Integrated Watershed Development Programme	
Central government	State government	Central government	State government	Central government	State government
80 per cent	20 per cent	50 per cent	50 per cent	100 per cent	–

Source: K G Vyas 1998, Rajiv Gandhi Mission for Watershed Development, Bhopal, *personal communication*.

RICHARD MAHAPATRA / CSE

With the help of watershed-based soil and water conservation measures, the soil has improved, leading to increased fertility

- 0.2 per cent is kept by the *zilla parishad* for its own administrative expenses and for training of PIAs;
- 20 per cent is given to PIAs (five per cent for training of watershed development committees, users' groups, etc.; five per cent for community organisation; five per cent for entry point activities; and, five per cent for administrative expenses of PIAs); and,
- 79.8 per cent is given to watershed development committees (WDC), of which 75 per cent is for watershed treatment works and 4.8 per cent is for administrative expenses of WDCs with which they can keep a full-time secretary and two paid volunteers.

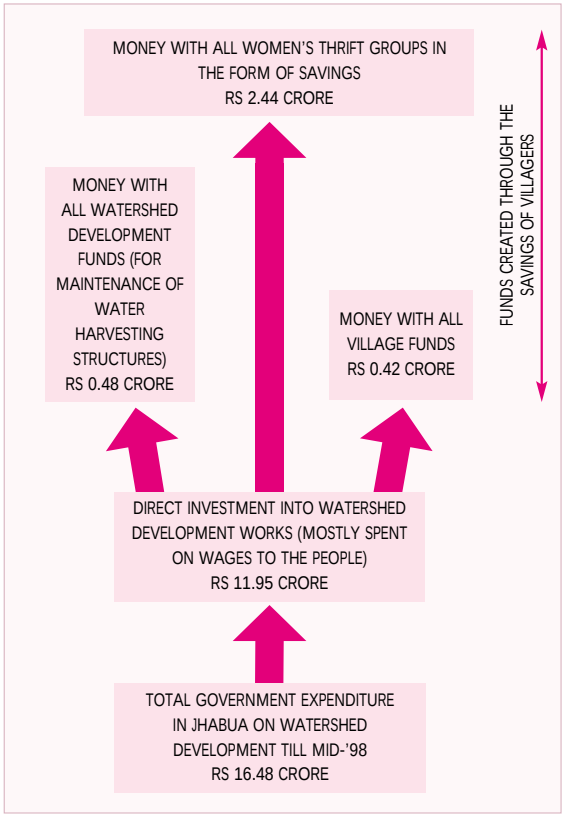
In Jhabua, the total expenditure till mid-1998 was Rs 16.48 crore, which means a total expenditure of just Rs 1,104 per hectare. Of the Rs 16.48 crore, Rs 4.53 crore (about 30 per cent) was spent by the project implementing agencies. A substantial amount of Rs 4.53 crore — about 60 per cent — was spent on what is called entry point activity, that is, activities that help to build up the credibility of the government, community organisation, and on training and capacity building, all of which is necessary for good institution building and social mobilisation at the village level. About Rs 11.95 crore was handled by the village watershed development committees, and went as direct investments into watershed development work, a large part of which was spent as wages for the employment generated *(see Fig 2: Investment to prosperity — a ground reality).*

Saving schemes

The programme encourages villagers to save a part of their wages as a watershed development fund (WDF), for future use for the management of the watershed. This is a mandatory fund developed through 5 per cent contribution of the cost of all works on community land by all users, 10 per cent contribution of the cost of all works on private lands owned by non-Scheduled Caste and non-Scheduled Tribe villagers, and 5 per cent contribution of the cost of all works on private lands owned by Scheduled Caste and Scheduled Tribe villagers.

WDF is thus a fund that is developed from contributions from all members of all user groups (that is, groups of land-owning people). Self-help groups (that is, groups of landless people) are not expected to contribute to this fund. WDF is to be used for the repair and maintenance of the soil and water conservation structures created under the programme after the project comes to an end in four years. The fund is entirely controlled by the community, and neither the *panchayat* nor the officials of the rural development department have any control over it. Withdrawals from the fund are jointly signed by the chairperson of the village watershed

Fig 2: Investment to prosperity — a ground reality
Management of watershed development finances in Jhabua district



Source: Chief Executive Officer 1998, Jhabua Zilla Panchayat, *personal communication*, quoted in Anil Agarwal 1998, The house that Digvijay built, in *Down To Earth*, Society for Environmental Communications, New Delhi, December 31, p 35

committee and a representative of the *panchayat*.

Savings are also encouraged through a *gram kosh* (village fund) for use by the village for collective activities as per the wishes of the community, and *bairani kuldis* (women's thrift and credit groups), which women can use to help each other with soft loans *(see Fig 2: Investment to prosperity — a ground reality)*. All WDFs of Jhabua together have Rs 0.48 crore (some 35 per cent of the total expenditure on the programme), all *gram kosh's* together have Rs 0.42 crore (about 3 per cent of the total) and all *bairani kuldis*, with 17,297 members, have a total deposit of about Rs 2.44 crore (about Rs 1,400 per member or about 18 per cent of the total expenditure). In other words, the programme has not just resulted in an improvement of the local ecology, but also in an improvement of the collective and individual financial security of the local villagers.

ECONOMIC GAINS FROM ECOLOGICAL WEALTH

Watershed development in Jhabua has greened the environment and improved the economic status of the people. Dramatic changes can be seen in water availability, afforestation, agricultural production, food security, fodder availability and migration rates. It has also empowered women *(see Box: Wonder women)*.

Water availability

The foundation of any watershed programme is water and soil conservation. In the the case of Jhabua it means arresting the water that falls on the hill slopes instead of allowing it to carry away precious topsoil. The water is collected in a way that it percolates into the land and recharges the groundwater. Where necessary, small tanks have been made. Some 143 new tanks were built

WONDER WOMEN

Managing watershed programmes have empowered the women of Guraiya

There was a time when people from other villages were not interested in getting their daughters married to men from Guraiya village. The reason? During summer, the women had to walk to the river Bebas, three kilometres away, and carry back their drinking water. Now it is the other way round. The women of Guraiya do not like to be married elsewhere. The women have been empowered and now live on their own terms, something that would not perhaps be possible elsewhere, in any other village.

Under the Rajiv Gandhi Mission for Watershed Development (RGMWD), the village has metamorphosed. The once-brown and barren landscape is now a verdant green and water shortage an unpleasant memory. All the members of the Guraiya Watershed Committee are women.

The empowerment process has not been easy. The women had never participated in any decision-making and even the village *sarpanch* was against their involvement. It was only after Smita Ghate, the then collector of Sagar district, stepped in that the women started opening up and participating.

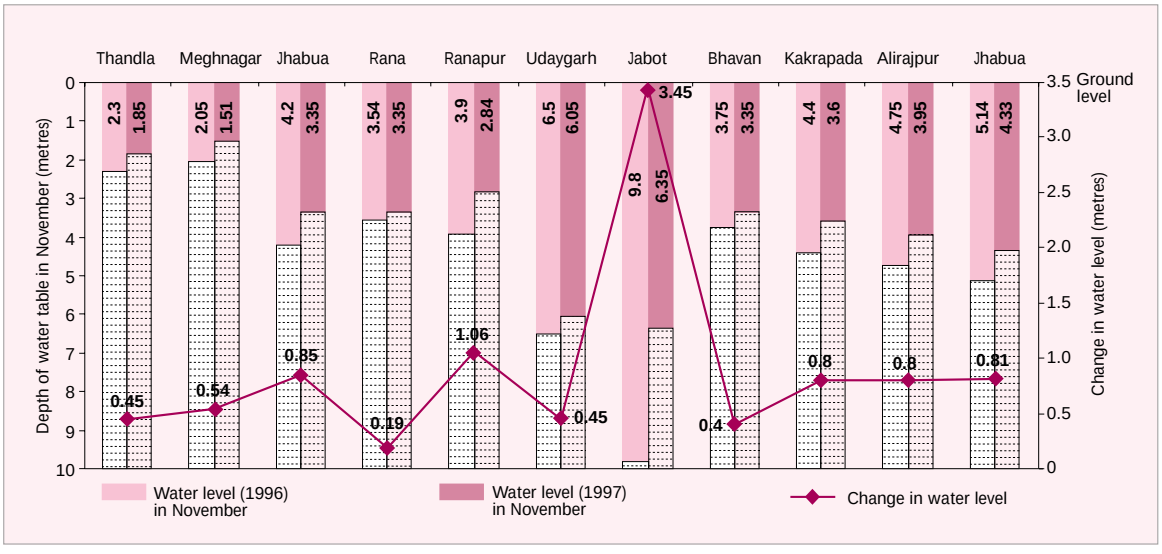
In the first phase, the women were trained in health care and sanitation. A committee of 12 women was formed for the work of the RGMWD. With the help of government officers, these women took up the task of building check dams and cattle-proof trenches. They have constructed a 18,124 metre (m) long contour trench, a 2000 m long cattle-protection trench, 5,145 staggered trenches and three boulder check dams.

The committee has set up a nursery, where 700,000 saplings have been planted and has started three savings and thrift groups, accounts of which are open to public scrutiny.

There has been a startling behavioural change in the women. They have become more confident and are sure that they can handle the work even without government support.

Graph 1: Rising levels

Rise in the water table in villages of Jhabua district



Source: Soil and Water Conservation Department 1998, Madhya Pradesh Government, Jhabua, *personal communication*

and the groundwater table has increased by 0.64 m on an average in 19 microwatersheds *(see Graph 1: Rising levels)*. The irrigated area increased to 1,115 ha in 18 microwatersheds studied, which is nearly double the irrigated area of 1994-95.

Afforestation

The protection of land in the watershed and planting of various species of benefit to the local people (like bamboo, *anwla* and *neem*) has shown a 66 per cent reduction in wasteland area in 11 microwatersheds. District officials estimate that over two million trees have regenerated. The regeneration rate has been far more rapid as compared to lands where only JFM programmes have been implemented because the water conservation efforts increase soil moisture and, therefore, plant growth. In turn, there is a more rapid increase in economic returns to the poor people involved in watershed management.

Agricultural production

With increased irrigation, agricultural productivity is rising. In seven microwatersheds studied, the cropped area has increased by seven per cent and the cropping intensity of the cultivated land is also rising. The *rabi* area (winter crop) has increased.

Food security

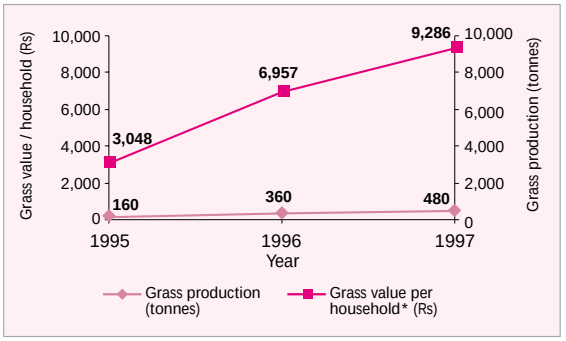
Food availability has increased by a minimum of one month to about four months. Some 313 village-level grain banks have been established to ensure timely availability of foodgrains on easy credit.

Fodder availability

Possibly the earliest benefit has come from rapid regeneration of grass and, thus, increased fodder availability Some estimates suggest a 5-6 times increase in grass from the regenerated lands. This change can be seen with the data from the Hathipahwa watershed, where work started in 1995-96. The watershed covers 231.26 ha, used by Ambakhoda and Badkua villages *(see Graph 2: Green growth)*. It covers village agricultural land, government forest land and government revenue land. Before the

Graph 2: Green growth

Increased grass production and resulting incomes in the Hathipahwa microwatershed



Note: *The project covered 81.26 hectares (ha) of revenue land and 150 ha of forest land. The entire project area has been used to calculate grass productivity.*
**The total number of households in the project area is 105.*

Source: District Collectorate 1998, Jhabua, *personal communication*

work started, the land had no vegetation. The six tanks in the watershed would rarely fill up. Villagers had to buy grass from markets in neighbouring Gujarat. There was a regular seasonal stream of distress migration. But now — with watershed management and stall-feeding of cattle — the people of the watershed sell grass every year and seasonal migration has almost disappeared. The change has come in just three years simply from the economic benefits coming from increased grass production. Apart from earning money from selling grass, villagers have started keeping better breeds. Villagers have recently got 14 high quality cows and buffaloes. Increased water availability has increased vegetable production which are sold in the local market.

Money lending and migration

The watershed development programme is already having a substantial social impact. Dependence on local moneylenders has gone down. A study of select micro-watersheds revealed that loans from moneylenders had gone down by 22 per cent. Distress migration has reduced considerably.

LOOKING AHEAD

Some of the main issues that arise now in the context of Jhabua's success are:

- What will happen after the government withdraws?
- What about power conflicts?
- What will happen when the forest grows enough to affect grass production?
- Is Jhabua replicable? *(see Box: Is Jhabua replicable?)*
- Does watershed development stand the test of drought? *(see Box: Dry Jhabua)*

One of the main concerns is what will happen after the mission withdraws and the community takes over the job of maintaining the watersheds. Past experience shows that many successful programmes have failed once they are totally entrusted to the people, because of inherent flaws in making themsustainable. Will the past repeat itself in Jhabua and Dhar? Once the officials and the PIAs withdraw, the age-old problem of linkage between government and people is likely to crop up. Presently, people seek the PIA officials' help for sanctioning money or checking technicalities. As many as 17 account books are to be maintained in a single watershed unit by the local people, most of whom are illiterate. It may not be practical to maintain so many books. However, the government has ensured that the success continues. Grassroots organisations that are non-political and thus have credibility among the villagers, have been constructed. These will serve as pillars of watershed activities. When the government was planning a national programme on watersheds, this institution building was given priority and, as Madhya Pradesh has shown, the institutions have

IS JHABUA REPLICABLE?

The answer is yes and no, because success depends on a number of factors

The Rajiv Gandhi Mission for Watershed Development has not worked in many districts as well as it has in Jhabua, especially in many districts where the local mission leader, the district collector, has failed to show enough interest and enterprise. Therefore, despite all the planning and thinking, social mobilisation is not possible unless there are committed officials at all levels. The role of the project implementation officer is just as important as that of the district collector, which in turn is as important as that of the chief minister.

The second factor for failure can be the village community itself, especially where the community does not display an adequate spirit for cooperation and unity, specially where caste system holds sway, society is stratified and male dominated.

Even within a district like Jhabua, whose tribal people display a strong community spirit, things can go wrong if the entry process for the project is hurried through. Instead of undertaking a detailed process of social mobilisation, that is, developing a variety of village-level groups, an exercise which involves and educates all interest groups about the benefits of the project, if a quick meeting of the village *gram sabha* is called and a watershed committee is set up through nominations, few people in the village will get involved or educated about the project. The project will suffer as a result.

Widespread corruption poses another threat to the programme. Good rural development, especially one that is based on good natural resource management, demands decentralisation of power and government expenditure. Any politician who tries to do such a thing will fall foul of his colleagues at all levels — from the national and state to the district and village levels. Everybody wants decentralisation, but only up to their level. When money reaches the public directly, and in a manner that is transparent, then nobody is able to siphon it off. In a country in which corruption is a tidal phenomenon, which operates from the top all the way down to the *panchayat* level, where pelf and pilferage are the bottomlines of the political system, effective decentralisation will only earn political ire for the politician, rather than political support.

The watershed development programme in Madhya Pradesh has not received the political support that it should get. In fact, there has been an undercurrent of political opposition to it. Fortunately, the people have electorally supported the chief minister who has empowered them to manage their own lands.

For the moment, the Madhya Pradesh watershed develop-

DRY JHABUA

Jhabua survives the 1999 monsoon failure

In Gelhar Choti, a village in Jhabua district, a microwatershed management project was launched under the Rajiv Gandhi Mission for Watershed Development (RGMWD) in 1996. Since then, a lot has changed. The underground aquifers have been recharged and all the eight handpumps in the village yield water throughout the year.

Even government officials here admit that this has been possible because of the participation of the people. Most of the people here have stopped migrating since they have found employment in the village itself. Even in the face of the 1999-2000 drought — it only rained 439 millimetres (mm) as against the annual average of 980 mm — they were doing quite well. They were confident that their handpumps were not going to dry up. This was because for the past four years, people had been able to capture rain through microwatershed projects. Earlier, even in normal years, life was difficult as there was no water in the area. Today, not only has the cultivable area increased due to water availability but their yield per hectare has also doubled.

The success of Gelhar Choti *(see Table 1: The watershed boom)* has caught on to nearby villages. The village of Umari, about 30 kilometres away, after facing severe crop damages and drinking water crises has realised the importance of watershed management projects and is demanding the same. Elsewhere migration has not increased due to monsoon failure *(see Table 2: Staying home).*

Table 1: The watershed boom

Water availability has improved agriculture

Area (hectares)	1996	1999
Area under irrigation	13	91
Area under wasteland	161.27	44.01
Kharif area	112.84	203.10
Rabi area	68	141.60
Kharif yield	2.30	4.10

Source: Manish Tewari 2000, Rainwater Harvesting, Standing the test of drought, in *Down To Earth*, Society for Environmental Communications, New Delhi, Vol 8, No 16, January 15, 2000, p 38

Table 2: Staying home

Effect of watershed development on migration

Name of the block panchayat	Number of people who migrated in 1999	Number of families below the poverty line	Number of people who usually migrate from the block
Petlawad	578	18,669	3,863
Thandala	7,178	11,525	10,648
Meghnagar	3,964	12,607	19,050
Jhabua	19,871	14,850	23,731
Rama	4,348	9,588	12,817
Ranapur	7,915	8,976	19,473
Udaygarh	5,990	5,210	12,546
Bhabhara	10,563	4,796	12,546
Jobat	816	7,067	7,293
Alirajpur	10,925	7,806	8,588
Sondava	9,975	7,806	26,038
Kathivada	3,000	9,041	18,635
Total	**85,123**	**115,256**	**180,286**

Source: District administration reports 1999, Jhabua, Madhya Pradesh

proved to be effective.

The *panchayat* institutions are facing parallel power centres. To avoid conflict, district authorities have made many *gram panchayat* members watershed committee secretaries. However, the usual conflict between the two power centres will be there regarding the ownership.

As fodder has been given importance as an economic and area-specific need, doubts arise about what will happen when the forest grows enough to affect grass production and whether this will not affect the cattle. Officials say it will not because, with the availability of fodder, people will prefer more productive cattle than many non-yielding animals. It will bring down the demand for fodder and compensate for the decline in grass production.

The 1999 monsoon failure was a good testing ground to evaluate watershed programmes in the face of drought. Jhabua proved that good watershed programmes can withstand monsoon failures *(see Box: Dry Jhabua).*

The people involved in making Jhabua a success are confident that this programme will be sustainable. This confidence stems from the fact that the mission has made sure that the institution of the watershed committee and other supplementary organisations, such as women's banks, become new power centres of people at the lowest level. Once people see the benefits, it is very hard to see the programme failing.

Today, Jhabua towers over other efforts and it is up to the people if they want to continue to reap benefits of good land and water management. And up to other states, if they want to follow the example of Madhya Pradesh. ■

The Need for Check Dams

Realising the potential of small water harvesting strutures, G T Bhimte writes about his efforts to promote check dams

G T Bhimte
Bhopal, Madhya Pradesh

When I was serving as executive engineer in Madhya Pradesh between 1987 and 1990, I came across small dams, nothing more than permanent rainwater harvesting systems. When I was carrying out the construction of Gurraiya stop dam near Chhindwara, a politician came up to me and said, "You are fulfilling my dream of the last twenty years." If these small efforts have to be promoted on a large scale, it is important that the message reaches government officials and engineers. When the then collector of Chhindwara, Antony deSa, saw these small dams, and the benefits thereof, he gave me full freedom to take up the construction. I then made a survey of Chhindwara district and realised the tremendous scope there for such structures. One site near Chikhalikala village, 16 kilometres away from Chhindwara on the Chhindwara-Nagpur highway was ideal, and a check dam was constructed.

I was then transferred to Hoshangabad district where the then collector, Ajita Bajpai Pande, was equally enthusiastic about rainwater harvesting. It was thus possible to construct several of these small dams in this district also.

In all, some of 50 such small structures were constructed, at costs varying from Rs 1-2 lakh. I consider this work of great significance. If constructed sincerely to a height of about one metre, these structures can change the future of the country.

There was still an unsatisfied thirst in me which wanted to work more. During my last posting in Bhopal, with great difficulty, in 1993, I managed to get the construction of one more check dam, the Salaiyya dam over the river Kaliasote, costing three lakh rupees.

I was in for a pleasant surprise. When Pravesh Sharma, who was collector of Bhopal at that time inspected the Salaiyya Dam, he was so impressed with the potential of this dam, that he sanctioned four more works:

- Hinotia (cost Rs 8 lakh), on the river Kaliasote;
- Doulatpur (cost Rs 3 lakh), on the river Kerwa;
- Inayatpur (cost Rs 4 lakh), on the river Kerwa; and,
- Gol (cost Rs 3 lakh), on a tributary of the Kerwa river.

The construction was completed fast. While Hinotia was completed in four months, the others were completed in two months.

The results of these dams are heartening. Though small, these structures have tremendous recharging and overflowing capacity. The crop output has doubled over thousands of hectares.

In 1996, in my village Sanpuri in Kirnapur tehsil, Balaghat district, I advised Likhan Kaware, a farmer, to take support of an old bridge and empty cement bags, at a cost of Rs 300 to capture water. Not only did he benefit but so did his neighbouring farmers as well. There was water in the *nullahs* right up to June.

Thus, if change is required within a short period, there are options available. Water can be successfully retained in *nullahs*. All that is required is to fill empty cement bags with soil, sand and then stitch them. These bags can then be placed in *nullahs* in the shape of check dams up to a height of about one metre. The top width should be kept at one metre (m) and the base at 1.8 m. The water that passes above and through should be of little concern since some water will still be retained.

Flowing water can be stopped virtually anywhere with stones, rocks, under old bridges and in *anicuts* and with almost any locally available materials. This is important if we want to increase the food production and achieve a true green revolution. If these measures are taken on a large scale, realisation will dawn on these villagers as to why they have been deprived for so long. ■

Jaldhar Model: Capturing the Raindrop

The Jaldhar model, wherein a portion of the land is turned into a water collection pit, has increased the soil moisture over 2,000 hectares of the Chotanagpur plateau

Dinabandhu Karmakar
Professional Assistance for Development Action (PRADAN), New Delhi

The Purulia district-based team of Professional Assistance for Development Action (PRADAN), a New Delhi-based non-governmental organisation, has found a simple solution termed Jaldhar to harvest rain and save paddy crops from frequent rain failures. The idea is simple — a portion of the farmland is left aside for rainwater harvesting, holding back rainwater in the land itself. In lands where the slope is less than two per cent, the rain is collected in a pit 1.2 metres (m) to 1.52 m deep, covering five per cent of the area of the plot. In regions where the slope is 2-8 per cent, PRADAN does have an alternative: the 10 m x 30 m model.

Originally designed to meet paddy requirements, this technology is being used for land reclamation over 2,000 hectares. While the model is still evolving, it has found acceptance among farmers in the districts of Ranchi, Chatra, Godda, Dumka, West and East Singhbhum districts in Bihar, and Purulia and Bankura in West Bengal.

The Eastern or Chotanagpur plateau comprises of more than thirty districts of south Bihar, western West Bengal, north Orissa and eastern Madhya Pradesh. The region has an undulating terrain inhabited mostly by tribals. Agriculture, livestock raising and gathering of various forest products form the basis of livelihood. Agriculture is dominated by the monsoon or *kharif* paddy cultivation *(see Box: Rice and rain)*, along with some coarse cereal crops.

Drying up of crops during the flowering stage is a common phenomenon in paddy lands in this region. In fact, in most parts, paddy crop regularly fails due to rain failure in September and October, commonly known as *hathia sukha.* Although the region receives an average yearly rainfall in excess of 1,000 millimetres (mm), the erratic distribution of rainfall, coupled with the poor water retention capacity of the soil and depleted vegetative cover create droughts in the region. The solution, therefore, lies in capturing this water and storing it for the period when it is required.

SIMPLE YET EFFECTIVE

Jaldhar technology seeks to address problems associated with the erratic nature of the adequate rainfall. Based on various field experiments conducted between 1989 and 1993 in Purulia district of West Bengal, there are two variations of the design, depending on land type. While one design is applicable for small plots where the slope is less than two per cent, the other is for plots where the slope is between 2-8 per cent. For slopes greater than eight per cent, the technology may need modification.

The five per cent Jaldhar model is designed for level (with less than two per cent slope), terraced and bunded paddy fields. The Jaldhar 10 m x 30 m is the technique for treating sloping lands, including small hillocks.

The five per cent model

The objective of the five per cent model is simple: to ensure that all small landholdings have their own waterbody, possible by catching all the raindrops that fall on the plot, by digging a pit, thus preventing the rainfall from escaping as runoff. This entails digging a pit of approximately 1.5 square metres (sq m) size, occupying five per cent area of each individual plot. The plot is properly levelled and bunded to allow water to accumulate to a height of 100 mm, letting the surplus rainwater spill into the pit. This pit also facilitates the sub-surface flow of water to downstream plots

RICE AND RAIN

Cultivation of rice in this region is completely at the mercy of the monsoon

Almost every stage of rice cultivation, from sowing to reaping, depends on the monsoon. The amount, the time and the duration, all are key factors which determine whether there will be a satisfactory harvest or not. Given below is a sample of a rain and rice calendar:

January: The precipitation varies from nil (once in ten years) to 48 millimetres (mm), rarely. If there is any precipitation, it is generally ignored by farmers, except in a few cases where some farmers plough their nursery bed for the next *kharif* paddy.

February: The rainfall varies from nil (once in ten years) to 41mm. Agricultural practices for paddy lands are generally similar to what the farmers do in January, only more farmers start ploughing their nursery beds for ensuring *kharif* paddy. A few of them also plough their main fields.

March: In March, the range of precipitation varies from nil (once in five years) to as high as 81.6 mm. Preparations during this month for *kharif* paddy are similar to the previous month.

April: In April, the range of precipitation varies from nil (once in ten years) to as high as 107.3 mm. Agricultural operations are generally like that of the previous months.

May: This is the month of nursery raising. The precipitation varies from 14.1mm to 112 mm, which falls between 2-12 days. Farmers start sowing seeds in nursery beds in the third week of May. Effective rain in this week is important. In case there is no significant rain, farmers delay sowing. This rain also helps in preparing land, specially uplands for direct seeding of paddy. The early May rains are used to prepare the land. Rain in the second half of May helps in sowing seeds, germination and subsequent growth and inter-culture which continues till June.

If the rain is delayed the farmers wait for a week. If the seeds have been sown and then the rains fail for more than 15 days, this proves to be disastrous for the nursery. Seedlings wilt and there is no way to save the nursery. Even if there is a heavy spell within a short period resulting in significant runoff, this cannot be stored by farmers. If there is heavy rain this is also bad news for farmers, who feel that wet nursery seedlings are weak and unable to withstand either drought (prevalent in uplands) or the pressure of deep water (prevalent in lowlands).

June and July: Farmers start raising nurseries in May with the hope that monsoon will break in the second week of June. Keeping in mind the optimum age of transplantable seedling, good rain in the second week of June is very important. Some 50 mm to 100 mm of rain in or around the second week of June facilitates easy transplanting. Any heavy rain ahead of this time may add to the soil moisture but most of the farmers are cautious enough to harvest it in their land as seedlings are not ready. No worthwhile water harvesting measures exist to preserve this water for further use.

In absence of other alternatives, if there is no rain in time (that is, in second week of June) farmers wait till there is sufficient rain. If it gets delayed, seedlings become over-mature. Seedlings, when over-aged in the nursery, lose their inherent vitality for vegetative growth. After transplanting they do not produce enough tillers. This ultimately reduces the number of earheads per unit area. Size of earhead also becomes shorter resulting in reduction of output. Thus, in case of delayed transplanting, farmers, as a safeguard, transplant a greater number of seedlings per hillock so as to compensate for the reduction of tillering. This often results in shortfall of seedling supply. Farmers then have to leave a part of their holding (generally uplands) uncultivated.

Experience shows that in some years the rains are delayed by a month or so. Farmers continue transplanting till the end of August.

In case of short-duration paddy varieties and in case of delayed sowing, plants start flowering within a short period of transplanting, virtually without any worthwhile vegetative growth leading to a sharp reduction in output.

In general, July rains are more reliable than June rains. If, however, after effective rains in the first half of July, there is a dry spell up to mid-August, farmers stop transplantation till the second half of August, the last chance for farmers to transplant. The fields already transplanted, however, suffer from shortage of water. Crops wither and weeds dominate the crops. Intercropping cannot be practised. Upland paddy suffers the most.

To cope with these problems, farmers prefer to cultivate the tall *Indica* type paddy which is able to withstand dry spells. These have longer vegetative growth periods and can successfully be grown even if the seedlings are two months old.

August: Rains in mid-August offer the last chance for transplantation. These rains are considered good maintenance rains for vegetation growth.

September: These rains determine the fate of the paddy on uplands and medium uplands that constitute more than 60 per cent of the paddy lands in this area. If there are no rains, then all the previous efforts are nullified.

The number of effective rain spells is very important. Some 25 mm of rain at seven days interval can assure the survival of paddy. The uncertainity of rainfall during this period is acute since the monsoon is receding. In 1988, the total upland paddy cultivation failed to produce any grain in Purulia district because of September rain failure. Lowland paddy does not normally suffer.

October: Useful for longer duration paddy. Storms arising out of the low pressure formed in the Bay of Bengal cause serious damage to the standing crop.

November and December: Generally dry months. Heavy downpour can hamper harvesting and post-harvesting operations.

When is a farmer happy with the amount of rain that falls on the field? Generally, farmers take note of precipitation when it is more than five mm in one spell. The effectiveness of rain depends on three factors: the type of soil, the location of the plot of land, and the inherent knowledge and foresight that the farmer has in capturing and utilising this resource.

The water requirement varies depending upon the physical requirements of the soil. The location of the farmland also plays a vital role. If the farmland is situated downstream of a big strech of a slopey land, it will receive runoff water from the land above and thus the water supply to the land will increase. Land situated below a water harvesting structure also benefits. In the end, the awareness level of the farmer, the capacity, the knowledge of the farmer and the willingness to plough the plot with every rainfall, so as to preserve and improve the soil moisture regime, will eventually be the deciding factor.

and improves the moisture regime of the area as a whole *(see Fig 1: The harvesting fives)*.

The core idea of the five per cent model of *in situ* water harvesting is that every plot should have its own water pit capable of holding back rainwater which otherwise would flow out. The quantity of water collected in the pit should be enough to irrigate the plot during dry conditions and it should also facilitate sub-surface flow of water to downstream plots and help improve the moisture regime of the area as a whole.

The pit should provide a critical moisture of 50 mm. If the area of the plot is A, then the critical water requirement is A x 5 centimetres (cm).

Here, area of the waterbody is five per cent of the plot area, that is, one-twentieth of the plot area.

Suppose the depth of the waterbody is D,

then, $1/20 \times A \times D = (A \times 5) - (A \times 5 \times 1/20)$

$= A \times 5 (1-1/20)$

$= A \times 5 \times (19/20)$

$A \times D/20 = A \times (19/4)$

or, $D = 19/4 \times 20 = 95$ cm

So depth = 950 mm

With the rate of water loss through evaporation and seepage going up during dry spells, there is a need to go for deeper pits of 1.62 m depth.

To harness the full potential of the five per cent model, attention should be given to the nature of the soil and the types of crops that can be profitably raised on it. Due to the light texture and low organic content in the soil of the plateau, its waterholding capacity is rather low, particularly in the fallow lands located on the slopes. Here cultivation of sunhemp, *dhaincha* and *mung*, and the use of green manure help in increasing both physical and chemical properties of the soil.

When the five per cent model is practised on bigger plots, it will necessitate bigger pits which can also be used to rear fish. The experience of producing fingerlings from seeds in such pits has been encouraging.

DINBHANANDU KARMAKAR

Aerial view of a five per cent pit with* bund *plantation at Bhalukanjri, Orissa

For better exploitation of residual moisture, a second crop can be taken like oilseeds and pulses which can be grown using residual moisture. A good late October rain has helped farmers sometimes to even raise vegetables in some villages. Though the original design for five per cent technique was evolved to save paddy crops, it has been used later to reclaim fallow lands also.

The Jaldhar 30 x 40 technique

The Jaldhar 30 x 40 technique derives its name from calculations done in terms of feet. The core idea employed is plotting of unterraced and unbunded lands and creating water collection pits in each plot to retain runoff. Water seepage from a large number of such pits travels downstream below the earth to recharge the soil moisture regime, enabling vegetation to grow with less water.

Fig 1: The harvesting fives

Layout of the plots and design of a plot, a pit and a *bund* — five per cent model

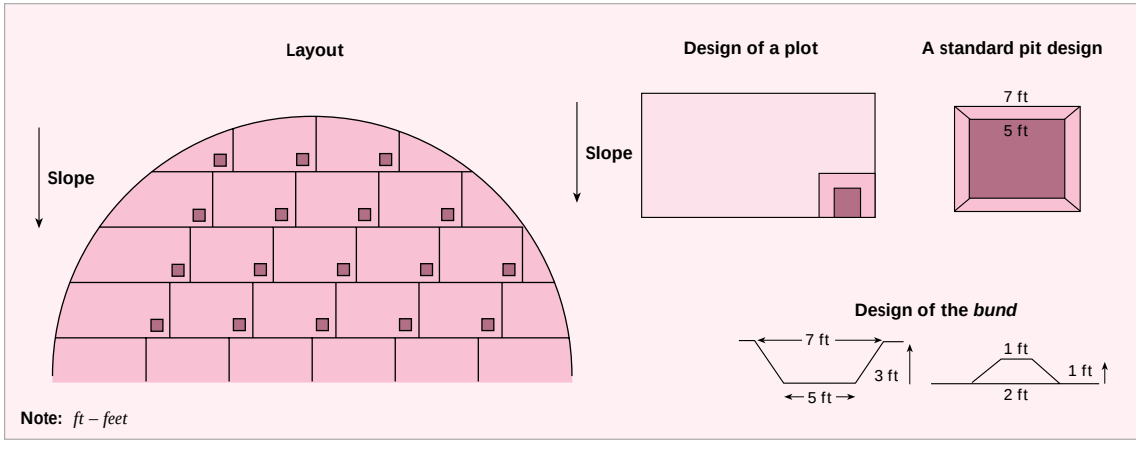
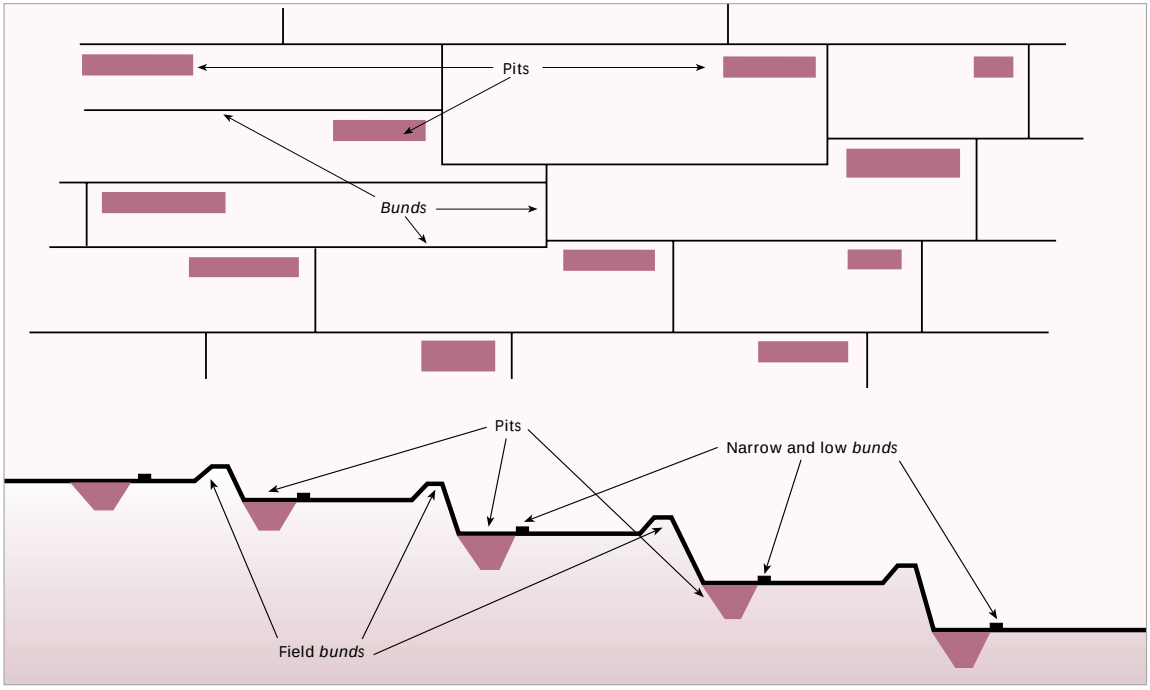


Fig 2: Catch water — harvest rice

Location of five per cent pit in a stretch of paddy lands — aerial view and cross-sectional view



Upland areas are divided into smaller plots and a water collection pit is dug in each plot. When the land slope is more than eight per cent, the design may need some modification. In the current design elaboration, the discussion is limited to lands having an average slope of 3-5 per cent.

The pit area should consist of 3-4 per cent of an individual plot with a depth of around one metre and located at the lowest point of the plot. This will include the layout, design of plot, and design of pit and *bund (see Fig 2: Catch water — harvest rice)*. Plots should be chosen in a staggered fashion so that the pits are also staggered as far as possible to enable uniform seepage of water across the slope. Each plot size is maintained at 9 m x 10.7/9 m (along the slope) x 10.7 (across the slope). Hence, the area of each plot will be 111.5-130 sq m. The volume of each collection pit is kept to 2.9-3 cubic metres (cum). The earth dug out from the pit is used to construct *bunds* on the plot.

The soil required to prepare the *bunds* of each plot (9 m x 10.7 m) is equal to 21.3 x (2+1) / 2 x 1 or 31.95 cum. This is nearly equal to the volume of earth dug from each pit. Added amount of soil should be placed on the *bund* across the slope because it faces greater pressure of the runoff. Along the slope, *bunds* merely act as runoff dividers between individual adjacent plots.

In estimating the volume of a pit and the plot size, attention should be given to the following factors:

- The whole patch should be self-carrying and no runoff from outside the treated plot should generally influence it;
- slope of the land and its locational directions;
- porosity, permeability, waterholding capacity, existence of impervious layers below the top soil; and,
- peak rate of rainfall and the rate of permeability.

It, however, does not mean that an individual farmer has to examine all these factors before treating the land. These are relevant only when the technique is replicated in a completely different geophysical terrain.

Where the depth of soil is greater, it absorbs larger amounts of moisture from the collection pits given sufficient time and then, when the surface dries up, water comes up through capillary action to meet the moisture need at the root zone of the crops. But in most places in the plateau, the topsoil depth is rather shallow and it is also porous. Often, there is also a semi-impervious layer below it.

After rainfall, 60-70 per cent of the percolated water gradually moves along the slope to increase the moisture regime of lands at the lower slope. With this kind of intensive moisture conservation, wastelands have also been brought under productive cultivation on a sustainable basis through agroforestry, horticulture, fodder cultivation, or vegetables and upland paddy. ■

Dihra's Dividends

For the villagers of Dihra in Bihar, constructing a traditional ahar *and* pyne *system threw up unexpected foes and bonuses*

Sanjeev Ranjan
Dihra village, Patna district, Bihar

Dihra is a small village in Patna district, 28 kilometres (km) southwest of Patna city. Three main rivers pass by the three sides of the village. These rivers are Ganga (15 km from north side), Sone (10 km from the western side) and Punpun on the eastern side. Punpun, which originates in the Chotanagpur plateau, and Sone, which originates in Madhya Pradesh, eventually merge with the Ganga. When the Sone canal failed to meet irrigational demands, the villagers tore a leaf out of history and constructed a water harvesting system based on the *ahar* and *pyne* system of Bihar.

The Sone canal system, which was conceived in 1853 and completed in 1875 by the British government, is the most important and extensive irrigation network in Bihar. Patna district is irrigated by a part of the Sone canal system, which starts from Dehri-on-Sone.

Years of lack of maintainence, encroachments and erosion of the embankment due to cattle grazing and vehicular traffic took their toll on the Sone canal, which was used to irrigate agricultural fields in Dihra. The bed got filled with silt, sand, mud and garbage. The water-holding capacity decreased, leading to numerous problems for the farmers of this region. The main crop of this area is paddy, which needs a lot of water. Since the canal was not providing sufficient water for the paddy crop, conflicts arose amongst farmers over water issues when fields started to dry due to insufficient water. So some of the big farmers started to bore tubewells in the area. They sold the tubewell water to the small farmers at a high rate of Rs 25 per hour, that too after repeated requests.

Due to misuse, the groundwater level started declining. Earlier, a borewell at a depth of 15 m would provide water. By 1995, the required depth was 20 m. The borewells started giving less water, and finally went dry.

FORGOTTEN TREASURES

Dihra had a *pyne* and a small *ahar*, but due to sufficient supply of water from the Sone canal, both had been forgotten. Using the water from the *ahar* was a labour intensive process. On the other hand, water from the Sone canal could be availed by simply cutting through the walls of the Sone sub-canals and diverting the water into the field.

A *pyne* is a channel constructed to utilise water flowing through rivers to fields where its water is distributed amongst the villagers. Most of the *pynes* flow within 10 km of the river and their length is not more than 20 km. Their depth is not much either. Given the slope, they facilitate irrigation largely within a short distance of their origin. To raise the water level in the *pynes*, they were temporarily blocked at suitable lengths. In some cases, they were impounded at the tail-end to store the excess water. Alternatively, small *pynes* led off from *ahars* for distribution of water. Usually their use is limited to September, when the water demand is acute and the supply is limited.

An *ahar* is a rectangular catchment basin built at the end of a *pyne*, which has an embankment on three sides. It's bed is not dug out. *Ahars* were sometimes built at the end of small rivulets or artificial channels like *pynes* to assure constant water supply. Sometimes the *ahar* beds were also used to grow a *rabi* (winter) crop after draining out the excess water that remained after *kharif* (summer) cultivation. But cultivation of *ahar* beds was not a very common practice, as it was used only for *rabi* crops, grown in those months when the *ahars* did not contain water. Unfortunately, these beds soon came under *kharif* (summer) cultivation also, because in the year of drought, these were often used to grow paddy. Both the *ahar* and the *pyne*

carried water during the rainy season (from July to September), acting as a reserve against scanty or untimely rainfall *(see Fig 1: Water insurance)*.

CREATING A TRADITIONAL SYSTEM

There is a seasonal stream called Pachahuan, which flows through Dihra in the rainy season and falls into the river Punpun. This water was used for cultivation by using pumpsets or *dhenkuli* (a basket with ropes on each end, used for lifting water). The stream span in this area is 2 km long and 100 m wide.

In July 1995, a group of four youngsters realised that the waters of the Pachahuan could be stopped and its bed used as a reservoir for the community's irrigation needs. What this meant was basically creating an *ahar* and *pyne* system.

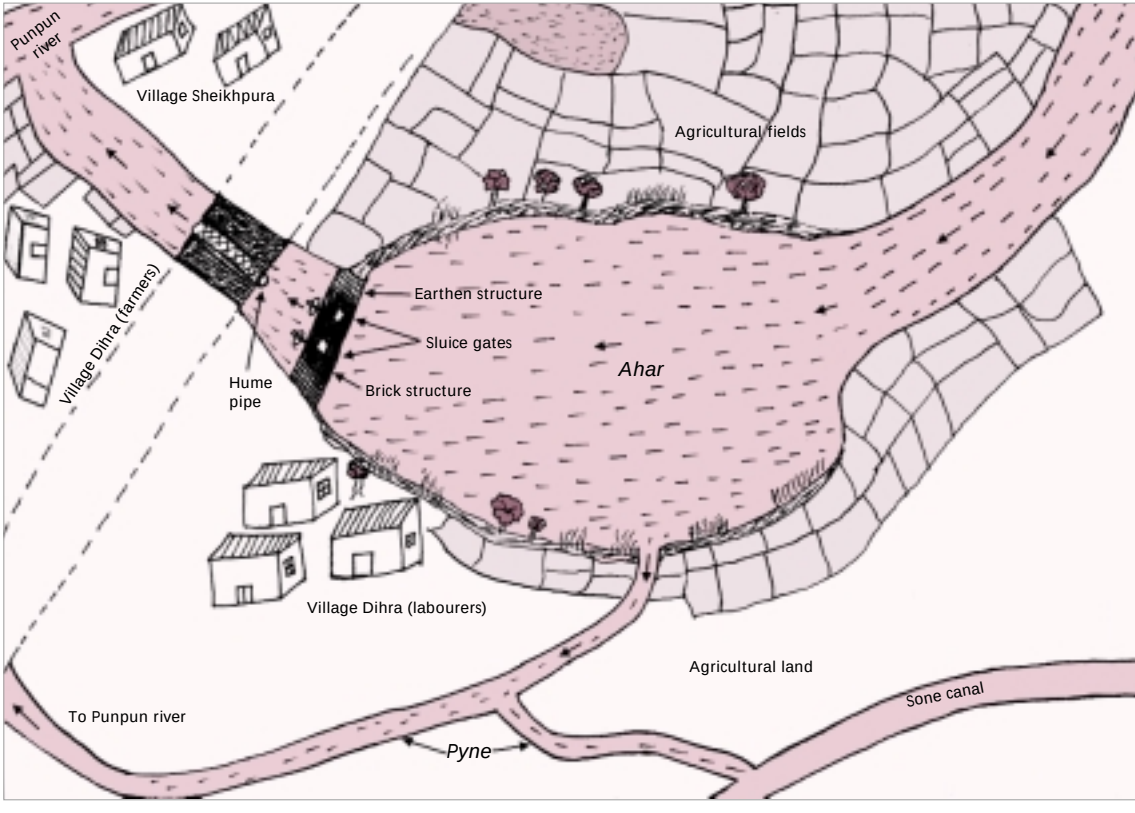
Through the *panchayat*, these youngsters explained the idea to the villagers. There were many in the village that expressed grave doubts. With the support of the *panchayat mukhia* (chief), the block development officer (BDO), was approached, who explained his helplessness regarding lack of funds. Help came from a civil engineer, who visited the village, and after a survey of the river and the topography of the village, made a blueprint of the project. His advice was to desilt the riverbed, raise both sides of the river, and make an earth embankment fitted with two sluice gates. The project cost, as estimated by the irrigation department, was an unaffordable Rs 3.5 lakh. This meant a contribution of Rs 350 per 0.20 ha from each villager given that the land of the village is 200 ha.

The villagers did not want to hand over such a large amount, especially to young boys. They were fearful that the police, government or the neighbouring village, who was also using the river as their source of water, might lodge a case against them. They were then assured that accounts would be maintained by people chosen by the villagers themselves, and that the government would not lodge a case against the village because they knew about and supported the project. This was confirmed by the *mukhia* who told the villagers that the BDO supported the plan, and there was no risk of litigation.

There were still many in the village who were

Fig 1: Water insurance

The *ahar* and *pyne* system of Bihar acts as a reserve against erratic monsoons. A *pyne* is a channel constructed to utilise the water flowing thorugh several hilly rivers. An *ahar* resembles a rectangular catchment basin with embankments on three sides



unwilling to pay. The division between the rich and poor farmers is very large. Out of the 29 families in the village, only five can be classified as 'rich farmers', the rest are poor. The poor farmers, who had small plots of land, were willing to pay the contribution. But the rich farmers, who had very large plots of land, and hence would need to donate a large amount, were reluctant to pay, especially since their plots were not near the river. After a series of negotiations, the amount was settled at Rs 100 per 0.20 hectare of land. A year later, only Rs 1 lakh had been collected, and Rs 2.5 lakh were still needed. This money finally came from various government sources like the BDO, Jawahar Rozgar Yojna and other donors.

Work started in May 1995. The riverbed was dry, as the river had been blocked by temporary methods. After a month of hard voluntary *shramdaan* (labour) by the villagers, the project was completed by mid-June 1995.

These efforts bore fruit. Some 80 ha of land are now, in the year 2000, being irrigated through the project. The size and shape of the river has been changed to a rectangular *ahar*, which is called *naya* (new) *ahar*. The people are growing two cereal crops and one crop of vegetables a year, which are sold in Patna and give good returns. The socioeconomic situation of the poor villages has improved. A team of people has been set up under the *mukhia* to monitor the supply of water. The *ahar's* water is divided equally and used for irrigation purposes only. In the rainy season, a lot of fish come from the river and, in September, the fishing rights in the *ahar* are sold. The money obtained is used for repair of embankments and for the benefit of the villagers. The tiled roof of the village primary school has been repaired and a *chabootra* (a round-shaped structure constructed for sitting) constructed in the village *chaupal* (where the village meetings are held).

THORN IN THE FLESH

In March 1997, the villagers received a notice issued by the irrigation department, informing them that the villagers had no rights on the fish from the *ahar*, as it belonged to the department. The villagers had no business to sell the fish, this prerogative lay with the irrigation department. The irrigation department threatened the villagers with police action.

The villagers were not willing to take this lying down. They undertook a *dharna* (protest) in front of the irrigation office at Naubatpur. The news spread like wildfire and thousands of villagers assembled outside the office, raising slogans against corrupt officers. Left with no choice, the villagers of Dihra were finally granted permission to use the *ahar's* water and sell the *ahar* for fishing purposes.

Their troubles did not end there. In 1998, the person to whom the fishing rights in the *ahar* had been sold to, was visited by people belonging to a Naxalite (Maoist) group. They asked him for Rs 5,000 — the same amount the *ahar* was sold to him for — as *rangdari* (extortion) tax. One morning the people noticed a poster warning them that whoever dared to catch the fish would be punished. One night while fishing the fisherman was attacked and beaten mercilessly by a group of anti-social elements. The fish-catch and net along with his pumping set was stolen.

The villagers were again up in arms, literally this time. They first lodged a first information report (FIR) with the police. They realised that the only way to save their land was to unite and work together. Six groups each of six young and responsible people each were organised to patrol the village at night. They applied for a gun licence and on receiving it, procured arms and ammunition. When a senior member of the communist party was informed of the incident, he assured the village community and promised that this would never happen again. Though the people of Dihra have never again experienced any such unpleasant incident, they still remain alert.

REAPING UNEXPECTED BENEFITS

But the rewards that the villagers received after these two bitter experiences made all the efforts worthwhile. Due to misuse of groundwater through tubewells, the water table had declined. Four tubewells near the *ahar* had gone dry. In 1998, one of the villagers suggested that the borewell pipe should be dug out and using two pipes, a new well could be bored. The well owner got in touch with an agency specialising in this field, who suggested that the borewell should at least be checked before digging it out. On checking, the borewell started giving water. Due to the revival of the river and the holding of water in its bed, the groundwater had been recharged, as a consequence of which the water level had risen. Unwittingly, the villagers had undertaken what they now know as groundwater recharging.

The villagers have changed their cropping pattern from the water-intensive sugarcane to less water using crops. The costs of agriculture has come down since diesel pumpsets are no longer used to withdraw groundwater. Community action has removed the invisible wall that existed between the farmers and labourers who live in different areas in the village.

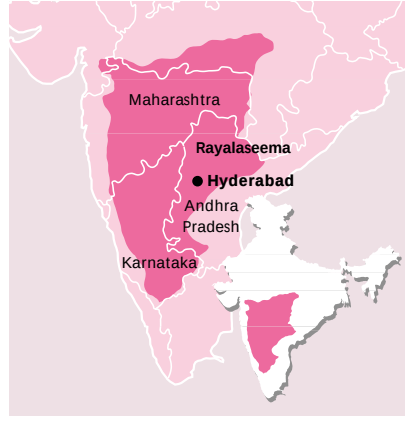
The impact has been felt in neighbouring villages also. For instance, in Khajuri and Skeikhpura, villagers have realised the impact of groundwater misuse. They have revived defunct water harvesting systems. In both the villages, the *pyne* connected to the Sone canal has been deslited and the *ahars* made functional. All this has been undertaken by the villagers themselves, without any external assistance. ■

Major Solutions through Minor Structures

To deal with water scarcity, NGOs and various political parties have convinced the Andhra Pradesh government to develop a plan to construct new minor irrigation tanks and restore dilapidated ones

B N Chetty
Janavikas Society, Kurnool, Andhra Pradesh

Destruction of traditional tanks and overexploitation of wells in Rayalaseema has compounded the chronic problem of water shortage. Over 40 per cent of wells now lie abandoned, leading to a decrease in agricultural income and animal husbandry. In 1990, 56 per cent of the population was living below the poverty line. Bowing to the demands of local non-governmental organisations (NGOs) and various political parties, the irrigation and command area development department of Andhra Pradesh has initiated efforts to create and restore minor irrigation and percolation tanks to overcome the acute water scarcity.



Out of the eight districts declared as drought-prone, the four districts of Kurnool, Ananthapur, Cuddapah and Chittoor with a population of 110 lakh, comprise the Rayalaseema region. Located in a rain shadow zone, Rayalaseema has been facing droughts almost every alternate year for nearly a century. About 50 per cent of the average annual rainfall of 550 millimetres (mm) is received over 5-7 days and the number of rainy days with 25 mm and above rainfall are less than 10.

Nearly 75 per cent of the population is engaged in agriculture despite the inadequacy of rainfall coupled with infertile land and poor moisture retention capacity of the soil. Traditionally, the presence of a large number of big water reservoirs had helped the region to overcome the lack of rainfall *(see Box: A rich legacy)*. Their decline makes rainwater conservation important. ■

A RICH LEGACY

Large, ancient reservoirs were key to the ecological equilibrium in Rayalaseema

Rayalaseema has a rich legacy of large water reservoirs such as Anathasagaram and Bukkarayasagaram, designed and constructed during the 15th and 16th centuries. Rulers of Kakotiya, Chola and Vijayanagar empires constructed these tanks. These waterbodies maintained the ecological equilibrium of the area. They were built using diverse technologies. The names of some of these ancient tanks like Vishnusamudram and Brahmasamudram (*samudram* means sea) suggest an abundance of water in the region in the past. Thick forest covers, locally referred to as sacred groves, are still preserved around some of these traditional waterbodies by local people in the name of gods and goddesses.

Population explosion and destruction of the natural environment have resulted in an unsustainable, impoverished water regime. The ever-extending boundaries of townships and residential colonies are encroaching upon traditional tanks and waterbodies, leading to their deterioration.

Many tanks have been converted into stadiums, bus stations and industrial estates. The temple town of Tirupati is today without water. In Chittoor, Ananthapur, Hindupur and Cuddapah, people receive only 42.5 litres of water per capita per day (lpcd) against a requirement of 112.5 lpcd.

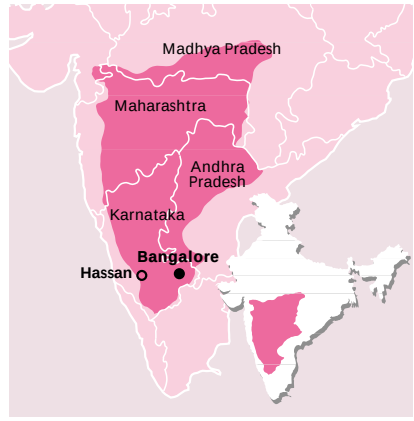
The efforts of the irrigation and command area development department to restore and create minor irrigation and percolation tanks need more money and public support for undertaking large-scale watershed and afforestation programmes. The first step of setting up field networks to initiate a large-scale watershed programme has already been taken up by a few local non-governmental organisation with the setting up of Paryavarana Parirakshana Samithis in all the four districts of the region.

Networking Farm Ponds

A network of farm ponds spread over 700 hectares has improved the soil moisture regime in Arasikere taluka, Hassan district, Karnataka

G N S Reddy, C Doreswamy, K Raghunath and S Basanth Kumar
BAIF Institute for Rural Development, Sharadangara, Karnataka

To encourage *in situ* rainwater harvesting for sustainable dryland farming systems, Bharatiya Agro-Industries Foundation (BAIF) Institute for Rural Development took up excavation of 330 farm ponds in Adihalli watershed, spread over an area of 700 hectares (ha) in Arasikere taluka of Hassan district in Karnataka. This approach was based on a traditional concept where structures were dug out in strategic locations, locally known as *kalyani*.



In the rural environment, it is not always possible or feasible to construct check dams to harvest water and improve the soil moisture regime. One of the disadvantages of check dams is that the community upstream is denied the benefits of the check dam. In such a scenario, a series of ponds, constructed along contour lines and connected to one another, allow easy access to water and a better soil moisture regime.

Farm pond technology is a low-cost option for water harvesting. Each farm pond costs about Rs 5,000 and can be used in all watershed areas. Farm ponds can be scattered in a decentralised manner all over the catchment, making water available over a maximum area, with least costs. While the rainwater is captured upstream, seepage makes water available downstream also. If the pond lies on the land of a farmer, then the onus of cleaning the pond lies with the farmer who can also harvest the silt. Over time, these ponds attract a number of different birds resulting in an increase in the local biodiversity.

POND PARTICULARS

The project, initiated in January 1997, covers 350 families spread over three villages and three hamlets. The annual rainfall is between 500-700 millimetres, received in two peaks. The soils are red, shallow and sandy, with high porosity. Coconut is the main commercial crop and finger millet is the staple food crop.

In the preparatory phase, family-level micro-planning was undertaken to involve all the families in the project planning process. Participatory rural appraisal (PRA) exercises were carried out to understand the community's perception and to plan community-based activities. Communities were encouraged to carry out developmental activities in their lands on their own, and not hire labour through contractors. All family members were trained in different aspects of watershed management through village-level training, classrooms and visits to sites where ponds were already functional.

Once cooperation was assured, field *bunds* were constructed across the slope. *Bunds* were formed by creating a trench across the slope instead of the traditional pit method for excavating the soil. The trench-cum-*bund* helped retain maximum soil moisture and water *in situ*. The *bund* size was restricted to a width of 0.3 metres (m) with a horizontal distance of about 25 m between them. This trench-cum-*bund* was used for plantation of mixed species of forestry trees up to a density of 1,000 trees/ha. The fields were planted with dryland fruit species such as tamarind, cashew and mango.

A series of farm ponds varying between five and 15 in number were dug on contour lines (imaginary lines connecting points at same elevation). For every two hectare area of catchment, one farm pond measuring about 8 m x 8 m x 3 m, with a capacity of 0.175 million litres was excavated, at the cost of Rs 5,000.

The ponds were either shaped as stepwell type ponds

with less storage capacity, or as deep-cut ponds. These ponds were not lined with any impervious material in order to allow maximum percolation. Each pond had a silt trap, normally in the form of a pit, 1.3 m x 1.3 m x 1 m in size, just before the inlet. The inlets and outlets of the ponds had stone pitching as reinforcement. These ponds occupy approximately 0.5 per cent of the total land area and are regularly desilted for maximum percolation.

These ponds are located in a horizontal line to allow the trench-cum-*bunds* to act as conducting channels for water. The horizontal pattern of pond construction was deliberate, as water flowing vertically down is bound to gather velocity and carry away great amount of silt down the valley, damaging the fields upstream. The horizontal flow of water also helps to retain water for a maximum period in the upper reaches. Once a pond is filled with rainwater, the excess amount flows into the next pond through these conducting channels. The last pond in the chain, discharges the remaining water into a check dam, located in a *nullah* into which farm pond chains on either side can discharge excess amount of water. Most of the silt gets trapped in the ponds themselves, and thus the water coming into the check dam hardly carries any amount of silt. In addition to traditional masonry check dams, earthen check dams with ferrocement cores were constructed at one-third the cost of the masonry ones.

BUMPER HARVEST

A total of 330 ponds were excavated in the Adihalli watershed of Arasikere taluka of Hassan district *(see Fig 1: The Adihalli example)*. With each pond having a capacity of 0.175 million litres, in one filling as much as 50 million litres can be harvested. Most of this water pecolates down, and in a normal rainfall year these ponds can be expected to overflow at least three times. These ponds also help in harvesting runoff during 'stray rains' in summer. With the first peak of monsoon in June-July, all the ponds overflow. With subsequent rains, the ponds get filled up. With the second peak of rains in August-September, when maximum rains are received, the ponds overflow more than once *(see Fig 2: Flowing ponds)*.

As enormous amounts of water percolates down in the upper reaches of the watershed, particularly due to the horizontal nature of connection between the ponds, this seepage is seen for extended periods accumulating at the check *bunds*, even after the farm ponds dry out.

The percolated water helps in maintaining a good soil moisture regime, allowing farming of crops and vegetables even after the monsoon. The increased moisture regime also ensures that irrigation needs of coconut orchards, the main crop of the area, are considerably reduced.

Flow of water in the drainage line for a longer

Fig 1: The Adihalli example
Farm ponds in Adihalli watershed project, Arasikere taluka

BAIF INSTITUTION FOR RURAL DEVELOPMENT

A restored farm pond

Fig 2: Flowing ponds

Water level in farm ponds in relation to the rainfall

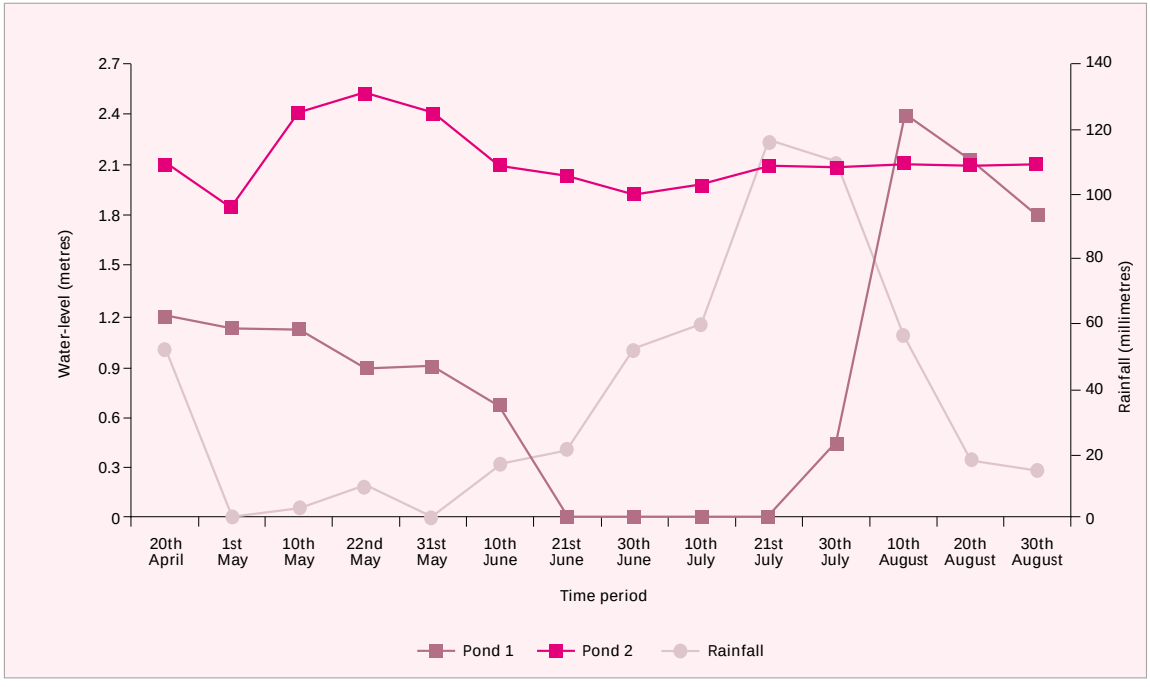


Table 1: Advantages galore
Advantages of a farm pond over other water harvesting structures

Farm pond	Other structures (check dams, earthern bundings, others)
Occupies less area, leading to small exposed water surface and less submergence of land	Occupy more area, leading to more exposed water surfaces and more submergence of land
Deep water column, less evaporation and greater percolation	Water column is less, exposed area is more, leading to more evaporation and less recharge
Sub-surface flow is more	Sub-surface flow is less
Generates more employment for the families in the watershed area	Less employment opportunities, since it requires skilled labour
Major portion of money goes to local people	Major portion goes to materials which are not available to the local people
Easily manageable by local people	Require skilled labour and heavy investment
Protects and increases the rest of the structures of the drainage line because of *in situ* conservation of soil	No ponds in the upper reaches. Danger of breaching and siltation of structures
Benefits more people, especially poor and marginal farmers	Benefit less number of people
Equity in water distribution	Unequal water distribution in the watershed
Very effective microclimate management	Little effect on the microclimate
Energy efficient structures, using natural gravity flow of the terrain	Require additional energy to bring water back to upper reaches

duration was also reported. Medicinal plants such as *Aloe vera* and *Withania somnifera* were grown on the mounds formed around the ponds after soil excavation which fetched a return of Rs 2,000 per year per mound. Many vegetable and fruit species were also planted on the mounds to meet the need of the families locally.

Some of the ponds that retained water for more than six months were used for rearing fish. Such ponds can hold up to 85 fingerlings of common carp variety and produce 120 kilograms of fish per pond. The silt harvested regularly from ponds improved soil conditions.

ADVANTAGE FARM PONDS

One of the main advantages that farm ponds have over check dams is a more equitable distribution of the harvested water *(see Table 1: Advantages galore).* A series of ponds located in the upper reaches of the watershed help to retain good soil moisture regimes throughout the watershed. While the stakeholders upstream have easy access to water, percolation of groundwater and seepage into the valley provides water in the lower reaches of the valley. The check dams are fed even in the dry periods with the seepage water in the valleys. This seepage increases over the years as the subsoil strata gets saturated with water during the first or second year of execution.

The ponds also attract birds, which further stimulate the onset of a series of developments which can be collectively termed as pond ecology.

Three indicators were chosen for monitoring the effects of these ponds — water levels in the openwells, monitored on a monthly basis; water level in selected ponds, monitored on a daily basis; and, the yield of coconuts in 20 selected gardens. The farmers reported better performance of their coconut gardens with reduced irrigation needs. They reported longer duration of water in the drainage line even after the rains subsided, with seepage feeding the check dam with clean water, devoid of silt.

While the results look promising, there is a need to evaluate the performance of ponds over a long period of time. The ecological impact of *in situ* soil moisture conservation with no runoff reaching the valleys needs to be assessed as do impacts of long-term waterlogging in the low-lying areas. With ponds in black soils tending to cave in, there is a need to design ponds for several soil types, using stabilising methods if required. Issues relating to the riparian rights of farmers downstream and cost-sharing mechanisms need to be worked out. In the present case study, farmers downstream with coconut gardens tend to get maximum benefits in spite of no runoff reaching the valley, due to the seepage effect. Cost-sharing mechanisms also need to be identified. ■

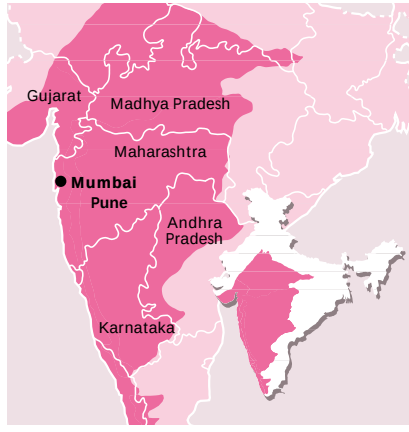
Rural Water Harvesting: Central Highlands / Deccan Plateau / Western Ghats / Western Coastal Plains

Small but Powerful

To meet the water requirement in 43,000 villages of Maharashtra, small water harvesting structures are a viable option

Suryakant Kulkarni
Socio-Economic Development Trust, Pune, Maharashtra

Modern water harvesting structures have failed to supply adequate amounts of water to more than 43,000 villages in Maharashtra. These 'big' projects are big on cost and size, but 'small' in terms of the water that has been provided. Traditional water harvesting systems that capture rainfall offer a better option to meet water requirements and attempts to renovate and use traditional water sources like recharge wells, canals, *bandharas* (small dams) and farm ponds to harvest rainwater are already underway. Maharashtra has a rich tradition of building water harvesting structures *(see Box: Whittling down a tradition)*, which unfortunately eroded with the British policy of collecting taxes in the form of cash rather than kind. A non-governmental organisation (NGO) called VANARAI operating from Pune has been motivating people to revive traditional *bandharas* to augment water availability. A *bandhara* can be built easily with locally available materials such as cement bags filled with sand and stones to stop water flow in a stream. It is an effective and economical method of storing small quantities of water and can be used on a large scale.



Farm ponds and small pits can also harvest large amounts of rainwater. For example, a pit of one cubic metre (cum) size can store 1,000 litres of water. Farmers can substantially improve soil moisture regime of their lands by allowing adequate number of such pits. If a farmer can have 1,000 such pits, one million litres of water can be stored in a farm at a time. During the rainy season, at least 2-3 million litres of water can thus be stored and allowed to percolate. It can greatly support the internal soil moisture regime and crop production. Large-scale adoption of such activities will not only improve crop production but will also augment groundwater aquifers for winter crops and drinking water needs. There are about 158 million hectares (mha) of wasteland in India and if small water harvesting pits can be dug on a large scale, more water can be harvested than the entire capacity of existing dams, at a very low cost.

Given the increasing fragmentation and reduction in landholding sizes, conserving water in thousands of such small ponds and pits is a more viable option than large percolation tanks proposed by the state soil conservation department. According to the department, the minimum size of a percolation tank needs to be 84,950 cum which necessitates a huge catchment area.

Fortunately, the Maharashtra government has officially approved of ponds as effective rainwater harvesting systems and earmarked funds for their regeneration. The government has launched a scheme with the stated aim of 'every village should have a water tank'.

Rooftop water harvesting has been traditionally practiced in Maharashtra in times of need. The United Nations Children's Fund (UNICEF) has recently extended support to build water harvesting structures, which has proved to be quite popular.

Another option is to recharge wells which are lying unused and abandoned or dry wells which capture excess rainfall during the monsoon. These structures have been successfully used in the Saurashtra region.

HIGH PRICE FOR LOW RETURNS

Traditional water harvesting systems have been the victims of both colonialism and capitalism *(see Box: Whittling down a tradition)*. Introduction of modern irrigation systems in Maharashtra has cost the society

WHITTLING DOWN A TRADITION

Building stepwells and tanks in temple premises had been an old tradition in Maharashtra. The introduction of British laws broke the back of this glorious tradition

Princely families supported the construction of stepwells and tanks in temple premises, as exemplified by the legendary Ahilyabai Holkar who constructed a large number of such structures in Maharashtra, as well as in Madhya Pradesh and Gujarat. It was usual for each village in Maharashtra to have several tanks. Bhandara district is an outstanding example of this tradition where 43,000 traditional tanks are the main source of drinking water and serve 78 per cent of the total irrigated area. It has also been a common practice in Maharashtra to divert river water to tanks through canals. Till the 18th century, surface flow from steeper slopes was directed to Mastani and Katraj dams from where water was supplied to Pune through a siphoning system. But with the introduction of British administered laws, these structures gradually lost their use and deteriorated.

Traditionally, tax was collected in the form of grains from local landlords by kings. Even early British rulers needed to maintain enough foodgrain stocks to be able to pay their employees. During droughts, landlords paid wages in the form of foodgrains that helped people survive. Later, the British started collecting taxes in the form of money, instead of grains. This forced people to transact in monetary terms. Farmers shifted to cash crops like cotton and oilseeds. As the British were interested only in collecting money, they increased prices of commodities to promote production which also led to speculation. It was attractive business for them. As production increased, trading increased and so did the tax collection.

This had an unfortunate impact on the existing production infrastructure. As people started trying to produce more, traditional water harvesting systems became incapable of sustaining this profit-oriented agriculture and new systems were introduced. To promote and protect this trend, the British laid down laws which were suitable for developing large-scale irrigation systems. For example, an irrigation dam gave no right to people in the catchment area over its water, while people in the downstream area were using water from the same dam, reaping large harvests. Ironically, this produce was often sold back to people living in the upper catchment areas.

After 1947-48, the need for huge amounts of water was felt to increase foodgrain production. In the 6th, 7th and 8th five year plans alone, India spent more than Rs 11,000 crore on building big irrigation dams. The approximate cost of these irrigation systems (according to 1994-95 base prices) comes to Rs. 30,000 per hectare. While the price paid for constructing such structures was enormous, the returns have been rather meagre.

dearly, both in terms of heavy investments and unequal distribution of returns. It has contributed to economic disparity amongst users and fragmentation of society into strong and weak sections. People with access to adequate water have become stronger, like the sugarcane lobby in Maharashtra, cornering all locally available resources, while a section of the population fails to raise even one crop in a year.

This has forced poor farmers to migrate to cities. To cope up with the large demand of water from cities and the agriculture sector in rural areas, huge dams and canal systems are constructed to impound water from large catchment areas. Unfortunately, often people living in catchment areas are denied the benefits of these schemes.

VANARAI

Bandharas ***built with cement bags across streams cater to local needs***

Despite spending huge sums on such projects, the number of 'problem villages' (villages without a sustainable or adequate source of drinking water within the village) is on the increase. The number of problem villages had grown to an alarming 16,000 villages by 1998. The gravity of the situation can be guessed by the large number of water tankers now needed round the year to provide water to thousands of villagers.

The challenge to meet the demand for water is not a small one. In Maharashtra alone, there are 43,000 villages but only 250 major dams and 2,000 dams in all. These are supposed to supply water to 8 lakh people. On a national scale, India has 329 mha of land, 0.56 million villages and 100 crore population. It is highly unlikely that the nation will be able to meet its requirement of water from these large structures alone. To reduce the huge shortage of water, there must be small and local water harvesting structures in every village.

Attitudes towards the use of water resources must change and cheap, community-based and sustainable methods adopted. People need not depend on governments and bureaucrats for the management of essential resources and must find the will and the way to control their own resources. ■

Springs of Hope

Development and utilisation of existing springs through community participation and government support can improve the water situation in Kerala

P Basak and K N Remani
Centre for Water Resources Development and Management (CWRDM), Kozhikode, Kerala

Springs constitute one of the safest, easiest and cheapest sources of drinking water in Kerala, a state that faces the paradox of drinking water shortage despite high annual rainfall. The presence of numerous reservoirs, tanks, ponds and wells makes the regular occurrence of drought and water scarcity all the more incredible. An uneven rainfall pattern, with heavy concentration periods followed by dry periods, is one of the main causes of this problem. The terrain of the state allows easy runoff of rainwater and aggravates the problem of drinking water scarcity.

Besides the problem of quantity, there are also concerns about the quality of drinking water. Out of the 1,196 'problem villages' that do not have access to perennial sources of water within three kilometres, only 70 have been provided with safe drinking water. Excess fluorides in deep groundwater sources, salinity in coastal Kerala, and excess iron in lateritic regions deter the utilisation of available sources of water. Under such conditions, it is important that a number of unconventional as well as traditional sources of water be examined as options.

The Centre for Water Resources Development and Management (CWRDM), Kozhikode, has carried out a detailed investigation of the location, number, discharge characteristics, present utilisation patterns and future

CWRDM

Spring water diverted into a storage tank for use by the community

Table 1: Springs of Kerala
Basinwise distribution of springs in Kerala

River basin	Number of springs	River basin	Number of springs
Chandragiri	6	Chalakudy	5
Karingote	2	Periyar	10
Kuppam	5	Muvattupuzha	3
Valapattanam	15	Bhavani	5
Telichery	14	Meenachil	20
Kabbini	24	Manimala	7
Kuttiyadi	29	Kallada	1
Korapuzha	2	Ithikara	1
Chaliyar	15	Vamanapuram	2
Kadalundi	16	Neyyar	6
Bharathapuzha	23	Others	22
Keecheri	3	**Total**	**236**

potential of springs in Kerala. A total of 236 perennial springs have been identified in the state, and their discharge and utilisation assessed, 80 per cent of which are situated on the western side of the Western Ghats *(see Table 1: Springs of Kerala).*

A large number of springs in the midlands and high ranges of Kerala are virtually untapped. Water from one spring alone, with a 50 litres per minute (lpm) average discharge, can cater to the domestic needs of about 100 families with an average of five members. Hence, development and utilisation of existing springs through community participation and government support can improve the water situation in Kerala. Since the present water demand cannot be met only by centralised systems of water supply, a judicious mix of modern and traditional sources like springs can help to create sustainable water supply.

With the objective of utilising springs, CWRDM has developed six decentralised community drinking water supply schemes in Kasargod, Kannur, Palakkad, Kottayam and Thiruvananthapuram districts. These structures with a total capacity of 31,500 litres have been developed at a cost of Rs 140,940 and serve 1,730 persons *(see Table 2: Springs to doorsteps).* ■

Table 2: Springs to doorsteps
Spring-based water supply schemes developed by CWDRM

Location	Summer discharge (litres per minute)	Storage capacity (litres)	Total cost (rupees)	Number of persons benefitted
Chembapuzha (village), Kasargod (district)	3.0	5,000	15,000	200
Chittariparamba (village), Kannur (district)	4.2	5,000	35,000	250
Thachampara (village), Palakkad (district)	18.0	5,400	26,155	100
Teekoy (village), Kottayam (district)	7.0	4,000	20,000	80
Melukavue (village), Kottayam (district)	10.0	7,500	28,000	1,000
Kollayil (village), Thiruvananthapuram (district)	20.0	4,600	16,785	100
Total		**31,500**	**140,940**	**1,730**

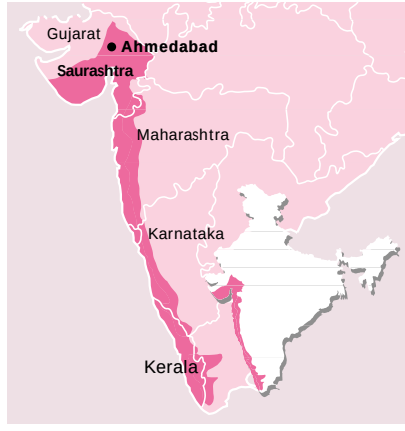
Recharged Wells

Efforts to recharge wells in the parched Saurashtra region of Gujarat have yielded encouraging results

B J Vasoya
Water Management Forum, Ahmedabad, Gujarat

Gujarat faces severe water shortages. The potential for surface irrigation being particularly low in the Saurashtra region of the state, harvesting rainwater through recharge wells is providing welcome relief.

Over the years, groundwater has been excessively extracted, leading to large-scale ingress of seawater which has been turning the land up to one kilometre inwards of the coastline saline each year. Drop in groundwater in north Gujarat is also increasing fluoride concentrations, a serious health hazard.



About 78 per cent of the total irrigated area in Gujarat is served by wells alone (0.73 million dugwells and 4,000 tubewells) which has caused severe groundwater depletion. As quality water becomes increasingly scarce, the need to harvest rainwater becomes obvious. This water can be harvested and stored in surface reservoirs or in sub-surface aquifers. Surface storage can be in large reservoirs made by constructing large dams, in smaller reservoirs by constructing a number of small dams, by building small check dams, or in small farm ponds.

The options for storing the water in sub-surface aquifers include diversion of the rainwater to recharge dugwells or domestic bores; to the aquifer for tubewell recharge; to aquifer zones by constructing diversion channels in the areas of underground reservoirs; and, by constructing recharge wells in river beds.

To explore water harvesting possibilities, the Institution of Engineers (India) has established a national Water Management Forum (WMF) at its headquarters in Ahmedabad. The forum provides information about cost-effective methods for conservation and use of water to concerned organisations. It provides information about devices to recharge dugwells with appropriate filters; cheap methods to construct small farm ponds for protection of rainfed crops; and, projects for watershed management. The institution also educates water users about economical utilisation of stored and canal water, including the use of sprinklers and drip systems in agriculture.

To involve users in the management of water sources, WMF and Saurashtra Lok Manch Trust jointly toured 101 villages over 10 days to educate the rural people about the importance of water in all the districts of Saurashtra region. The techniques of diverting rainwater to recharge dugwells, tubewells and handpumps were explained to the villagers in *gram sabhas* with photographs, maps and video cassettes.

ASSESSING ACTIVITIES

WMF assessed the performance and benefits of water harvesting for recharging wells through a pilot project carried out in three different types of *talukas* of Bhavnagar district *(see Fig 1: Diversion benefits)*. One *taluka* had an above average number of wells, another average number of wells, and the third, below average. Each farm generally had a well and out of 95 wells under the study region, 77 had been recharged. The average cost of labour and materials like cement, sand and pipe for each recharge well came to around Rs 1,167. This expenditure was small enough for an average farmer to afford. In about 74 per cent cases, the quality of water improved *(see Table 1: Bright future)*.

Though provisions were made to filter soil, sand and stones out of the water, some impurities still managed to seep in and, hence, it became necessary to clean the wells and filter tanks periodically. About 60 per cent of respondents were found to be cleaning the wells

Table 1: Bright future
Effect of groundwater recharge on quality of water in Bhavnagar district, 1996-97

Category of farmers	Effect on quality of water after recharge	
	Improved	No change
Small and marginal	16	2
Semi-medium	15	3
Medium	17	1
Big	17	1

every year just before the onset of monsoons, while 32 per cent respondents cleaned them only once in 1-2 years. The remaining respondents cleaned them after 2-3 years.

FARMER'S CHOICE

When farmers were asked for their suggestions, they generally felt that more check dams should be built to store river water and existing, but failed, wells, should be utilised for storing rainwater. A farm pond should be constructed in each farm near the well, so that the percolated water can be stored in these wells. Furrows should be made across the slope of farms to minimise surface runoff.

The farmers suggested that village level committees be formed to develop programmes for recharging both private and public wells and handpumps and construct farm ponds, check dams and percolation wells on river beds. The need for having a single information centre in each *taluka*, which can assist farmers in water harvesting and management techniques, in coordination with government and non-governmental organisations (NGOs), was also felt. The study thus revealed that well recharging activity is becoming popular in Saurashtra and consumption of water in the area is going up *(See Table 2: Recharge and consume).*

Table 2: Recharge and consume
Changes in water consumption in Bhavnagar district, 1996-97

Category of farmer	Increase in consumption (litres)	
	Per household	Per capita
Small and marginal	761.11	150.55
Semi-medium	1,000.00	181.82
Medium	1,050.00	164.35
Big	1,483.33	230.17
Average	**1,073.61**	**183.72**

Fig 1: Diversion benefits
Recharging the depleted aquifers with water diverted from rivers

AKHILESH / CSE

Enterprising farmers were already optimising yields by using stored water in cases of monsoon failure or insufficient rain. It was noticed that increased income has increased the use of fertilisers and pesticides.

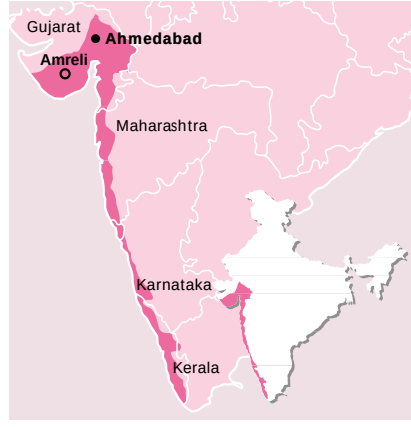
WMF is planning a *Bharat Yatra* (India tour) to create awareness about water harvesting, to be undertaken in five phases. Each phase will cover 4-5 states and will take about 45 days. NGOs, public trusts and other concerned people in respective areas will be encouraged to actively participate in the WMF programme. ■

Drought-Proofing Parched Lands

Numerous water harvesting structures built by villagers in Kundla taluka, Amreli district, Gujarat have changed the ecology and the economy of the region

Manubhai Mehta
Kundla Taluka Gram Seva Mandal, Savarkundla, Gujarat

For decades, people living in Savarkundla taluka of Amreli district in Gujarat have been suffering from acute water shortage. Villagers have built a number of small rainwater harvesting structures in the last decade to create additional water storage capacity of 3.5 million cubic metres (mcum) in the area.



Located in a drought-prone region, Savarkundla taluka of Amreli district receives between 400-650 millimetres (mm) of rain annually, more than 90 per cent of which is received during June to August. Acute water shortage is felt, particularly during below-normal rainfall years. Every third year, a drought hits the area and every second year is a scanty rainfall year. Only 9.9 per cent of the total cultivated area is irrigated.

The *taluka* is divided by a hilly ridge called Lammdhar running north to south. The northern portion of the *taluka* is flat and somewhat saline while the southern part is quite rocky. As there is no big river in the *taluka*, the main source of irrigation has traditionally been openwells. Excessive exploitation of these sources in recent years has resulted in the groundwater table receding alarmingly.

Kundla Taluka Gram Sewa Mandal (KTGSM) has been active in the area for more than six decades. Its workers have built up a strong relationship with the villagers and helped them overcome the chronic water shortage.

CHECKMATED

KTGSM took up construction of a series of four check dams in the early 1990s on one small rivulet to impound rainwater. Deep cuts and erosion along the course of the rivulet were plugged to increase water flow. The check dams had a positive impact on the wells situated nearby. Wells that would dry up by February now had water even during summer.

Encouraged by the success of the experiment, KTGSM planned similar projects under the state government scheme called the *sarvodaya yojna*. In 1992-93, KTGSM supported the building of about 50 *bandharas* or earthen *bunds*, in which farmers contributed 50 per cent of the total cost.

With these structures catching the imagination of the people, a project to harvest runoff through people's participation was prepared by KTGSM. The ministry of rural development sanctioned a project covering 33 villages in the hilly region of Kundla taluka with an outlay of Rs 2.96 crore, to be implemented within three years from 1994-95 to 1997-98, under the Jawahar Rozgar Yojna.

After detailed discussions with the villagers, it was decided that a village level committee of the beneficiary group would implement the project and 20 per cent would be the quantum of cost shared by way of cash, kind or *shramdan* (voluntary labour) by the villagers. KTGSM would release the remaining 80 per cent to the group as soon as the work was completed. An agreement was made that the completed work would be measured in the presence of beneficiaries and bills would be prepared within two days.

Workers were trained in surveying, designing, planning, accounting, computer operations and organising local bodies to share responsibility. No tenders were invited and structures were designed and constructed by the beneficiaries themselves, using available resources and humanpower. Local villagers accepted responsibility for maintaining the structures. A series of workshops, meetings and exposure tours generated

confidence amongst the project leaders and the beneficiaries. The Participatory Rural Appraisal (PRA) method was used to identify problems and find solutions, including selection of sites.

Water harvesting structures were built downward from the ridge to the valley and other associated activities like tree planting, wasteland development, land treatment and grassland regeneration programmes were also taken up.

Some 826 *nullah* plugs, 78 check dams and 30 percolation tanks were completed and land treatment covered 3,711 hectares (ha) of farm land. The work was done in half the allotted time, during slack agricultural periods.

TURNING POINT

The KTGSM programme created 3.5 mcum of water storage capacity at a cost of one rupee per 160 litres which led to an increase of 5-15 metres in the water table in wells in surrounding areas. The increased water availability has also increased the agricultural income by Rs 7.35 crore. Active participation by villagers ensured low construction costs and has allowed smooth maintenance of these structures by the villagers using locally available materials. The total project cost came to Rs 3.35 crore out of which the beneficiaries contributed Rs 1.04 crore. The actual amount released by the government was Rs 2.41 crore.

Confident villagers are now planning micro-watershed development in eight more villages. The extent of villagers' enthusiasm is reflected in the 2,100 proposals that have been received by KTGSM for building similar structures.

These water harvesting structures have helped disadvantaged groups. The total number of openwells affected is 2,480, of which small and marginal farmers own 1,315. Water from these wells is irrigating 4,043 ha of land. Farmers are now constructing earthen *bunds* in rivulets at their own expense. Already 16 groups have constructed check dams under the state government's scheme called 'have your own check dam'. A maintenance fund of Rs 1.235 crore, accumulated by the beneficiaries through contributions, is being maintained in a bank. In Kundla taluka, a *poonam sabha* (full moon day meeting) is held every month by the *gram sewa mandal* for the villagers to discuss and sort out problems. These *sabhas* have proved crucial to the success of the programme. ■

Amreli district, Gujarat

MANUBHAI MEHTA

Check dam in village Khodiyana built by the villagers themselves

Women's Power

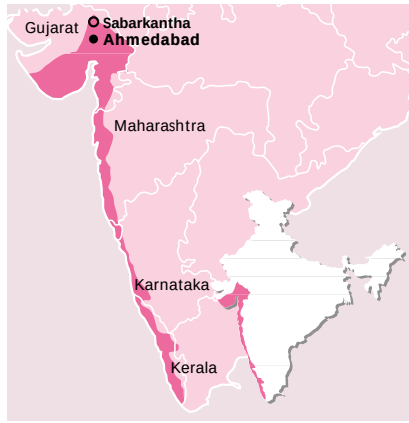
The efforts of women in the villages of Rameda and Ravatwada in Sabarkantha district in arresting runoff have yielded good dividends. There is water in the wells and money in their coffers

Manish Vaidya
Manav Kalyan Trust, Sabarkantha, Gujarat

In the 1950s, women of Rameda and Ravatwada developed a technique of rainwater harvesting by themselves. The rudimentary technology was simple: a stone *bund* (*nullah* plug) was first made and earth filled in the front, followed by cutting and filling valleys between the hills to reclaim land.

Their efforts over the years have yielded results. With their small pieces of farmland and livestock providing a healthy source of income, living standards have improved.

What is perhaps most exciting is the social change that conserving rainwater has brought about. The cohesion between women has increased as a result of increased interaction while harvesting water. These women are more aware about their rights and collectively fight for them. Their status in their own family as well as their community has also risen. Their participation in matters of village governance has improved.



THE DISTRICT

Sabarkantha district consists of 10 *talukas* spread over 739,000 hectares (ha), occupying 3.77 per cent of the total area of Gujarat and supporting approximately 4.5 per cent of the population. Geographically, the district is divided into two regions, namely, the north-eastern hilly region of the Aravali hills consisting of Khedbramha, Malpur, Vijaynagar, Meghraj, Bhiloda and a part of Idar talukas; and, the relatively flat plain region consisting of Prantij, Himmatnagar, Bayad and Modasa talukas. Majority of the population in the hilly *talukas* is that of Garasia tribals, a farming community.

The Aravali hills comprise the catchment area of the six rivers flowing in the district. These are Sabarmati, Hathmati, Meshvo, Vatrak, Harnav and Khari. None of these are perennial and with a large flow. The average annual rainfall is 795 millimetres (mm) which falls in approximately 40 rainy days, with the northeastern *talukas* in the Aravali hills receiving more rainfall than the rest. The rainfall is unimodel and spread over the months of July to September. However, the incidence of drought and scarcity (in terms of less than the average annual rainfall received) is high affecting all the 10 *talukas* of Sabarkantha. This uncertainty of rainfall is a serious detriment to rainfed agriculture.

Water management is thus of crucial importance for any land utilisation in this region, especially in the undulating marginal lands.

THE PLACE

Rameda and Ravatwada are two villages under Bhiloda taluka of Sabarkantha district. The land is undulating, with slopes varying between 15-50 per cent, most of which is degraded forest land. These two villages are covered with small hills with a slight slope. About 40 per cent is cultivated and 60 per cent is wasteland.

Fifty years ago the whole area was fully covered with forests, which were the basic means of livelihood. People depended on forests and cattle rearing for their daily needs.

With the passage of time they looked to agriculture, but did not settle at one place. They were doing free land cultivation. Wherever they found suitable land they started cultivation. To make land cultivable, they used to spread the leaves and wood of *saag* trees on the land (normally between small hills) and set it on fire. After clearing the remaining grass and bushes, the land would be ready for cultivation. They would continue to cultivate it for a period of time. When the land degraded

Sabarkantha district, Gujarat

they migrated to another place for cultivation using the same process. This led to reduction of forest cover.

Post-1942, the *thakurs* (landlords) owned most of the land. After independence, there was confusion regarding the ownership of the forest land, causing conflict between the government and the *thakurs*. The *thakurs* thought of exploiting this situation by cutting down the forests and selling big logs of wood commercially. Factories to produce charcoal were established by contractors who used the remaining wood. As a result, the forest was destroyed on a mass scale, leading to the end of forest-based livelihoods.

Government efforts to regenerate forests also proved unsuccessful. The introduction of new species did not suit local conditions. This led to growth of plants like lantana which could not be used as fodder, fuel or for any other purpose. These plants even prevented the growth of other useful plants. In the absence of productive forests, farmers became desperate for alternatives. Agriculture and labour became their livelihood and the pressure on land increased.

In 1955, the state government made a survey to grant these communities land for permanent settlement. Land was given to some of them. In the beginning, due to primitive methods of farming, they were not very successful in getting good returns from the land. They grew maize and pulses. Though these farmers were interested in cultivating paddy, the main problem was water availability. They started searching for a new pattern based on retaining fertility and moisture of the land, leading ultimately to development of new techniques.

WOMEN TO THE RESCUE

The women of Rameda and Ravatwada rediscovered the techniques of rainwater harvesting in the 1950s.

As there were no big pieces of land for them to own, the men from these two villages worked as migrant labour for seven to eight months, away from their lands, and returned during the monsoon season for cultivating. It was, therefore, left to the women of the household to take out time after their household chores to discover ways to harvest rainwater and conserve it.

The women started from scratch. The agricultural land given to them was uneven and strewn with stones. So they started with weeding the stones out of the farmland. They collected all the stones and arranged it on the border of the farm. They worked in summer, too, along with male members of the family. They dug out the soil and levelled the land. They brought stones and rocks from nearby hillocks for rainwater harvesting and, in the process, worked out a system of conserving rainwater and soil with the use of stones. The role of women was, thus, important in rediscovering this method of harvesting rainwater.

WOMEN'S RECIPE

To put it simply, a stone *bund* (*nullah* plug) is first made and earth is filled in the front. This is followed by cutting and filling valleys between the hills to reclaim land.

A stone *bund* of size 12 metres (m) x 2 m x 2 m between two hills or from the point the stream was flowing was created. This helped in controlling surface flow. To make a stone *bund* they dug out around 0.3 square metres of the area and formed a layer of stones haphazardly to create a wall of about 1.5 m. Once this process was complete, they again created a layer of soil before the stone wall. The undulating topography was made fit for cultivation by building terraces over time across the sloping land by chopping the lower portion of the sides of the hills. The soil collected was spread, thus increasing the area of cultivation.

Significantly, they never used sand, cement, lime or any such material, depending on dry masonry instead. When the rainwater entered the soil-layered wall, it was protected by the stone wall and, as a result, water was confined. This ensured that soil particles entering the stone wall became hard enough to effectively hold the rainwater. Hence, soil and rainwater could not escape through the gaps between the stones. Over a period of

time, dust and soil particles clamped with the stones, making the stone layered wall impregnable.

To protect the stone *bund* and to prevent soil erosion during flooding, two precautions were taken. Another stone layer in front of a stone *bund* was created. On one end of the stone *bund*, an approximately 150 mm outlet for the flow of excess water was created. This helped decrease the pressure permitting the remaining rainwater to flow out without causing any damage to the stone *bund*.

This method of harvesting rains is unique in that normally for harvesting rainwater, one has to start from the upper level. However, these people, with their indigenous knowledge and creative techniques, moved from the lower level to upper level, which helped them expand agricultural land further. After a gap of two to three years they moved to a higher level, from the lower part of the slope to its upper part, where they created a layer of 0.45 m.

There are however limitations to expansion. Given the undulating topography, building big stone plugs is possible only on a limited scale. But the potential for increasing productivity through this kind of moisture-treatment is virtually limitless.

In the present scenario, tribals put in many years of family labour to reclaim 0.13-0.20 hectares. The process starts with sloping land by building a *bund*, cutting it, relocating the soil and levelling the slopes to form terraces. Given the semi-arid agroclimatic character of the region, terraces are built to impound 100 per cent runoff with only a small weir. By using this technique their livelihood has improved, their lands have developed, and water harvesting has expanded.

FRUITS OF LABOUR

The fruits of labour have been many:

a) Previously these communities cultivated maize and pulses only, but now, due to harvested rainwater, they also cultivate paddy. The quality of rice has improved. Wheat is also being cultivated.
b) Groundwater levels have increased and the water level in wells stands at 6.0 m in summer.
c) Horticultural crops like lemon, bamboo and mango as well as different vegetables are being cultivated. They have started using fertilisers, improvised means of farming, animal rearing, diesel pumps for wells, and machines for farming.
d) In protected areas outside the village, the joint forest management programme was implemented under which they planted trees which can be used as fuelwood, and other commercial plantations. In 1977, as much as 26.60 ha of land was under joint forest management in Ravatwada village alone.
e) Women used to wear same clothes even after their bath as they had only one *sari* each. They have now got more clothes and there is an improvement in living standards. Now they own radios, electric fans and other gadgets, an indication of improvement in living standards.
f) They used to eat maize only, but now they have started eating rice and wheat as well. Nutrition levels will thus improve.
g) They are now self-sufficient in food and need not purchase staple food from the market.
h) They had been living in thatched huts. They have now started living in better dwellings.
i) The animal feed quality and quantity has improved.
j) Previously they used to have simple, inexpensive marriage feasts. Spending power has now increased.
k) Frequent interaction among women has enhanced their level of understanding and united them.
l) Participation by women in family and community life has increased.
m) Women have initiated work under joint forest management programme.
n) Women have started saving groups and the whole exercise is handled by women only. Women have become more aware of their rights and they fight unitedly to preserve those rights.
o) Due to their efforts, women were able to install hand-pumps, deepen wells and arrange for bus services.

POLICY POINTS

There are now many instances of people's initiative in developing rainwater harvesting techniques. The Ralegan Siddhi experiment by Anna Hazare in Maharashtra is one such example. The Rameda and Ravatwada effort is of a similar nature. We need more experiments like these. This work can be promoted by formulating policy that works at the grassroots level. The policy could include the following:

- Relatively developed villages could be offered 40 per cent of the required funding by government;
- in case of a backward village, the government could contribute 60 per cent, while people could contribute 40 per cent; and,
- in case of a tribal village, villagers could be asked to contribute 15 per cent and the rest can come from the government.

Ultimately, a strong political will is required and a demonstration of it in the official budget.

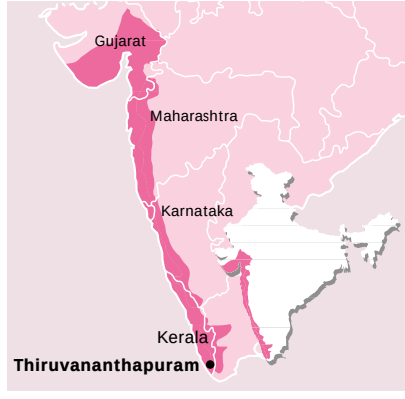
Manav Kalyan Trust (MKT), a non-governmental organisation, based in Sabarkantha since 1985, has been helping to promote this traditional water harvesting system since 1993. To facilitate the process, MKT has conducted exposure tours for water harvesting to Ralegan Siddhi in Maharashtra, organised street meetings, training programmes, provided land-leveling facilities, and partial funding for participatory community action. ■

Community Inventorisation

Kerala has involved the people in a statewide programme to inventorise and assess traditional water harvesting systems

Srikumar Chattopadhyay
Centre for Earth Science Studies, Thiruvananthapuram, Kerala

Kerala, with its rich tradition of water harvesting, is one of the few states where government departments, non-governmental organisations and research institutions are working together to revive traditional water harvesting systems. One of the main obstacles that these efforts face is the lack of sufficient data. A significant effort towards gathering ground-level data has been through the *panchayat*-level resource mapping programme (RPM).



Despite a large amount of rainfall — the average annual rainfall is 3,063 millimetres — and the presence of 50-60 ponds in each *panchayat*, 55 per cent population in Kerala does not have access to potable water. This shortage of water can be met by utilising the numerous ponds and lakes which have traditionally played a significant role in micro-level water management in the state. Efforts have been made by various organisations to assess the potential of traditional water harvesting systems and identify research needs for their revival. The highlight of these efforts has been the involvement of people through the *panchayat* RPM.

The main objective of the *panchayat* RPM launched in 1990 in Kerala was to objectively assess the potential of traditional water harvesting systems. The programme was jointly undertaken by the Thiruvananthapuram-based Centre for Earth Science Studies (CESS) in collaboration with the Kochi-based State Land Use Board and a voluntary organisation called the Kerala Sasthra Sahitya Parishad (KSSP). Initially covering 25 *panchayat*s, this programme has subsequently been taken up for the entire state. By mid-1998, all water harvesting structures such as ponds, wells, lakes, canals, rivers and springs in 168 *panchayat*s had been documented.

COMMUNITY INVOLVEMENT

A water resources inventory has been taken up. The potential of traditional water harvesting systems to meet water demand will be assessed. To do this, the State Planning Board has roped in communities to document traditional water harvesting systems under the People's Campaign for Ninth Plan Preparation. These include ponds, tanks, freshwater lakes and paddy fields / lowlands.

To document the traditional water harvesting systems of Kerala, an ambitious statewide effort called the 'People's campaign for Ninth Plan Preparation' was launched by the state planning board in 1996. This campaign was aimed at inventorisation of water sources. *Gram sabhas* at ward levels were activated and surveys to identify potential water resources initiated. A development report named *Vikasana Rekha* and a plan document, including projects that were available to each *panchayat* and municipality in Kerala, were compiled. Task forces were constituted at *panchayat* level to look after water-related issues. A number of waterbodies in Kerala were surveyed under this programme. The findings of the survey on ponds revealed a rampant decline *(see Table 1: Pond problems)*.

POND POTENTIAL

Ponds have great potential for meeting water demands even today. Even though each district of Kerala has between 50-60 ponds, with some of them even being perennial, ponds have been increasingly neglected over the years *(see Box: Tragedy of Thiruvananthapuram)*. A statewide survey conducted by the Khozikode-based Centre for Water Resource Develop-

Table 1: Pond problems
Status of ponds in some selected *panchayats*

Panchayat	Area in (hectares)	Geographical location	Number of ponds	Perennial ponds	Use	Problems
Myyil	0.48	Midland	27	17	Irrigation	Siltation
Kumarakom	0.52	Lowland	120	120	Domestic use, irrigation	Water quality
Mexhuveli	0.14	Midland-highland	47	27	Domestic use, irrigation	Water quality, siltation
Madakathara	0.25	Midland-highland	26	7	Irrigation	Siltation
Onchiyam	0.09	Coastal	84	39	Domestic use, irrigation	Siltation

Source: Anon 1993, *Panchayat* Resource Mapping Project, Centre for Earth Science Studies, Thiruvanthapuram, *mimeo*

ment and Management (CWRDM) in 1989 had identified 885 large ponds within the state, with a minimum summer storage capacity of 1,500 million cubic metres (mcum). Of these, 287 were public and 137 belonged to temples. Palaghat district alone accounted for more than 50 per cent of the total number of large ponds existing in the state *(see Table 2: Water storehouses)*.

On the basis of origin, ponds can be divided into three categories: natural depressions; excavated or human-made depressions; and, valley-head ponds or *taka kulam*. While the first two types are usually located in low-lying areas, the third type is found at valley heads. Water is impounded in valley-head ponds by constructing a barrier across the valley. These tanks are mainly used for supplementing rainwater for rice cultivation.

Based on ownership, ponds in Kerala can again be divided into three types: owned by religious institutions (temple / mosque / church), privately owned, and *panchayat* / corporation owned. Ownership of ponds is important because it is often difficult to intervene in matters relating to privately owned ponds.

What is now required is a detailed analysis of pond catchment characteristics, mode and intensity of use,

TRAGEDY OF THIRUVANANTHAPURAM

A number of traditional ponds and tanks have either disappeared or are being hopelessly mismanaged

An investigation within Thiruvanathapuram municipal corporation area by a group of students revealed that there are 79 ponds and tanks in various states of disrepair. The existing ponds are still being used for irrigation, domestic use and other activities, like soaking of coconut leaves. However, owing to the growth in population, as many as 12 ponds have already been filled up for construction of housing complexes, playgrounds and markets. Lands have been reclaimed even by the Thiruvananthapuram municipal corporation. Privately-owned ponds are comparatively well managed. There are also a number of ponds which have not been renovated for the last 25-30 years.

The heartening factor about this survey was that it was undertaken by students. To create awareness among people about the importance of such water harvesting systems, Kerala Sasthra Sahitya Parishad supported by Centre for Earth Science Studies and Centre for Water Resource Development and Management organised a programme called 'Welcome to the monsoon'. The programme demonstrated the link between land management, habitation and water resources and worked to prepare a micro-drainage map, all with the participation of volunteers.

Table 2: Water storehouses
Distribution of ponds in Kerala

Districts	Number of ponds	
	Public-owned	Temple-owned
Kannur and Kasargod	14	16
Kozhikode	11	20
Waynad	6	—
Malappuram	12	14
Palaghat	41	26
Trichur	51	26
Ernakulam	31	16
Idukki	3	1
Kottayam	19	—
Alappuzha	36	6
Pathanamthitta	7	1
Quilon	8	8
Thiruvananthapuram	48	3

Note: *Ponds with a summer storage greater than 1500 cubic metres.*

Source: Anon 1989, Tanks and ponds of Kerala, Centre for Water Resource Development and Management, Kozikhode, *mimeo*

HARVESTING MORE THAN PADDY

Paddy fields of Kerala help in capturing water

Paddy fields and lowlands have served as traditional water harvesting systems since ages. Except in the Kuttanad region, narrow valleys receive sediments and water from the surrounding slopes. The loose sediments retain water and help in groundwater recharge. Studies around the Sasthamcotta lake indicate the importance of preserving these fields and lowlands for recharging the lake. During the dry season, the water level in the lake is maintained through seepage water. Wells located near paddy fields in the Vamanapuram river basin experience lower seasonal fluctuations than those located away from it. Wells also help in rainwater harvesting. Kerala has perhaps the highest density of wells in India. In some areas, it is as high as 400 wells per square kilometre or four wells per hectare.

AMIT SHANKER / CSE

Paddy fields facilitate groundwater recharge

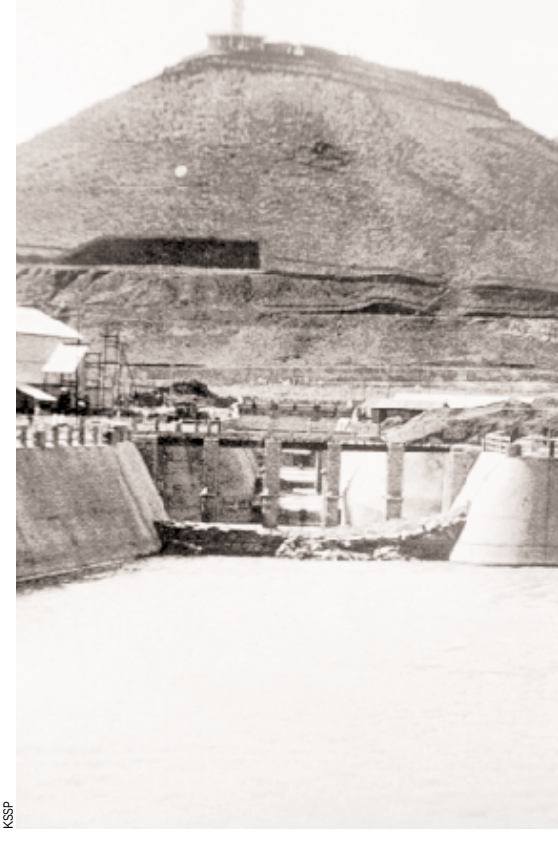
storage capacity and its potential, desiltation requirements, beneficiaries, and scope of extending the use of these water bodies. Sample studies conducted by CESS have already indicated ways to rejuvenate these structures.

FRESHWATER LAKES

The three large freshwater lakes in the state constitute an important source of water. Vellayani lake in Thiruvananthapuram district, Sasthamcotta lake in Kollam district, and Pukot lake in Waynad district are all within the Western Ghats. While Pukot is used for pisciculture and irrigation, Vellayani and Sasthamcotta supply drinking water to adjacent urban areas. Kollam town with a population of 140,000 depends on Sasthamcotta lake for its drinking water. Sasthamcotta is surrounded by shallow depressions that function as natural rainwater harvesting mechanisms during the monsoon months.

To conserve these water bodies for long-term use, the Kerala Water Authority asked the CESS to prepare a conservation plan for Sasthamcotta lake. The study highlighted the fact that apart from direct rainfall, the lake received water from a vast sub-surface catchment inflow. Paleochannels (ancient water channels), with connections to an adjacent river and the riverine alluvial plain used for paddy cultivation, also contributed to the recharge of the lake *(see Box: Harvesting more than paddy)*.

A scientific study showed the water quality to be good and unpolluted, although there were human settlements around the lake. However, water budgeting showed that the present use could not be increased without enhancing the recharge capacity of the lake. The study has highlighted the overriding importance of preserving the surrounding wetlands and having a wider catchment conservation plan to augment water supply to the lake. A similar investigation by CESS for Vellayani lake is in progress. ■



KSSP

A structural barrier made to lock the water at a* taka kulam *in Kerala. A* taka kulam *is a valley head pond where water is impounded by constructing a barrier across the valley

Stepping out of a Paradox

Kerala receives high amounts of rainfall. A regular water shortage is indeed paradoxical. A panchayat level study may be the first step to find a way out of this dilemma

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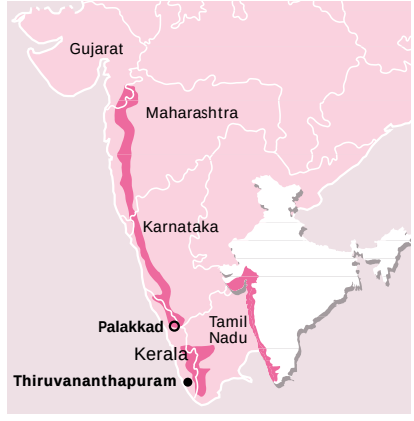
Integrated Rural Technology Centre, Mundoor, Palakkad, Kerala

Kerala suffers from water shortages, despite having a very high percentage of wetlands and high rainfall. Floods also assail the state every year. A *panchayat* area called Akathethara in Palakkad district, possibly having the lowest rainfall in the state, has been chosen to find ways to solve these problems, as part of a larger initiative for local development.



Kerala has an annual average rainfall of 3,085 millmetres (mm) which is almost three times higher than the national average of 1,194 mm. It has a large number of wetlands, but the water quality of most of these waterbodies is so poor that it cannot be used for domestic purposes. The present situation in Kerala has been the result of an almost casual attitude towards water. Compounding this is the high population density, the misuse and abuse of wetlands resulting from encroachment, neglect, pollution, fragmentation and conversion for development purposes, and excessive sand mining from rivers.

Despite a comparatively small land area and a contrasting terrain, floods and drought occur in localised areas. According to government estimates, during 1998, the loss due to drought was around Rs 582 crore, while 82 human lives were lost due to flash floods, landslides and related problems. More than two-thirds of the population of Kerala suffers from water shortage. Since state-level policy decisions are difficult to take, slow to implement and often ineffective to practice, remedial actions at local levels need to be taken. With the increased delegation of powers provided to the *panchayat* by the 73rd Constitutional amendment, such localised action plans have now become easy to execute.

A MODEST BEGINNING

Akathethara panchayat has been selected as a study model, under a water and sanitation project being executed by the Centre for Development Studies (CDS), Thiruvananthapuram. The objective of the study is to prepare a scheme to provide 250 litres per capita per day (lpcd) water to all the 6,000 odd households within a distance of 50 metres (m) and provide fully sanitized toilets.

The *panchayat* has a population of 22,000 spread over 1,950 hectares (ha). It receives an annual average rainfall of 1,920 mm. Some 20 per cent of the *panchayat* area is marked as reserve forest. The study shows that harvesting 60 per cent of the annual rainfall would be enough to meet the water needs of the *panchayat* with an investment of about Rs 50 lakh. For the entire state, impounding the rainfall for 44 days would be enough to supply 250 lpcd to every person in Kerala for an entire year.

There are 16 seasonal channels in the *panchayat*, discharging 0.001-0.609 cubic metres (cum) of water per second for 6-9 months in a year. Impounding water from these sources for a mere 15 days would be enough to meet the annual water requirement of the *panchayat*.

There are a large number of wells also present in the *panchayat*. Some 12 community wells and six tanks are still being used in the *panchayat*. About 40 per cent of households, numbering 2,361, possess their own wells. But one-fifth of these dry up during summer. About eight per cent of households have access to piped water at the rate of 25 lpcd from 140 public taps where water is supplied for one hour in every two days in summer, and for four hours during the remaining months.

N M NAYAR

The Kongappadam water tank in Akathethara panchayat

Currently, all development plans initiated by local bodies and the government are directed towards augmenting piped water supply. There is universal faith in the minds of the people about piped water supply being the ideal arrangement for meeting water demands. There is also this misconception that all piped water supply is safe. This is a major change in the mindset of the people of a state, where, until 50 years ago, various waterbodies — rivers, canals, tanks and wells — were used for drinking, bathing and washing purposes. However, with piped water supply failing to deliver, there is now a trend in rural and urban areas towards tapping wells. Despite rural and urban households still being heavily dependent on wells and tanks, no funds are set apart for either increasing their number or improving their water quality.

A disturbing finding of the study is that as many as 60 per cent or 3,455 households depend on outside sources like piped water, which increases by eight per cent during summer. About 6.5 per cent or 3,453 households have to walk more than 50 m, while 20 families have to walk more than 500 m to fetch water. Since women and girl children are invariably entrusted this chore, it is an additional burden on them. When water has to be carried over long distances, personal hygiene gets adversely affected, as less water is used for bathing and washing clothes.

In the proposed programme, all existing wells and tanks in the *panchayat* are to be improved and additional ones to be built. By ensuring quality of water in such structures, their use for washing and bathing will be encouraged. Where homesteads are small, special efforts will be made to maintain the quality of water in domestic wells, by keeping them far apart from contaminating sources like toilet pits, using locally available technologies. Water users will be charged for the water supply and all facilities will eventually be owned and operated by the local community. ■

N M NAYAR

A* cherad nullah *(seasonal watercourse) in Akathethara panchayat

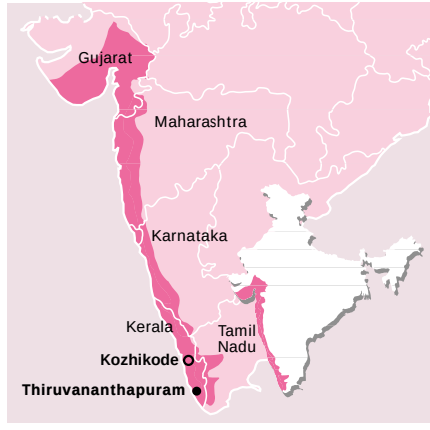
The Kerala Experience

Decentralisation of powers through the 73rd amendment of the Constitution has opened the doors for revival of traditional water harvesting systems in Kerala

K P P Preman
Assistant Development Commissioner, Kozhikode, Kerala

The 73rd amendment of the Constitution is a significant step towards decentralisation. With this decentralisation of power and devolution of funds, Kerala is now involving communities in water harvesting and conservation, through projects such as the Akashganga (Ganga of the skies, or river of the skies) in Kozhikode district *(see Box: Akashganga: Reaching for the skies).*

This project takes care of all traditional water harvesting conservation issues such as harvesting of rainwater, maintenance of ponds, pits, check dams, cleaning of tanks, and construction of river pockets to hold the water which flows into the Arabian Sea within a period of 48 hours. The district *panchayat* of Kozhikode has availed of this opportunity to formulate a plan for conserving traditional water harvesting systems for the whole district.



DECENTRALISATION DETAILS

Through the 73rd amendment, most developmental powers have been given over to the three-tier system of *Panchayati Raj*, namely, the *gram panchayat*, block *panchayat* and district *panchayat*. Further, the role of *gram sabhas*, as the 4th tier of decentralised power structure, has also been recognised. Twenty nine subjects directly connected with common people have been set apart for these *Panchayati Raj* institutions.

This decentralisation of power has opened up new opportunities for rural development, making participation of communities in the developmental process possible. Along with decentralisation of power, there is also the devolution of planning to the lower tiers of governance, indicative of a revival of the peoples' strength to solve their own felt needs.

KERALA: LEADING UPFRONT

While most states have failed to grasp at this opportunity, Kerala has taken the lead by making comprehensive enactments to facilitate decentralisation. With the Kerala Panchayat Raj Act 1994, all major developmental activities have been earmarked as responsibilities of *Panchayati Raj* institutions. A separate provision for the constitution of a panchayati finance commission to make recommendations on resource mobilisation has been made.

The upkeep and maintenance of public tanks, construction and maintenance of open draw wells, and maintenance of canals and other water conservation structures are included in the list of powers vested with the *Panchayati Raj* institutions. It is these areas where *gram panchayats* can actively involve themselves in reviving traditional water conservation structures. The intermediary tier which will implement centrally sponsored schemes like Jawahar Rozgar Yojna will also be able to take up water conservation activities. District *panchayats* are now vested with powers for the construction and maintenance of irrigation channels, water conservation projects and watershed management at a higher level, by which they can also be closely involved in water conservation activities.

Kerala has gone a step further. In addition to the above enactment, the government of Kerala has decided to decentralise the planning process from the first year of the Ninth plan, that is, 1997-98, by devolution of funds to the *Panchayati Raj* institutions, amounting to 35-45 per cent of the plan outlay. Another 30 per cent of the funds have been earmarked for the upgradation of the service sector. About 10-30 per cent

were earmarked for development of infrastructure facilities and 10-12 per cent of funds is set apart for scheduled castes and scheduled tribes. Another 10 per cent has been made available for expenditure. Resources from centrally sponsored schemes, state sponsored schemes, credit facilities, voluntary action and revenue of *Panchayati Raj* institutions are pooled together to form the plan corpus.

Panchayati Raj institutions are provided with funds based upon the following criteria: total population, scheduled caste population and scheduled tribe population. These institutions are now authorised to chalk out plans at their level and implement the same with their machinery. Government machinery available at each *panchayat* level has been put under the control of *Panchayati Raj* institutions to a limited extent.

The primary step of plan formulation starts from the *gram sabha* which is the convention of all the electors of the ward. Such proposals are placed before the task forces constituted for each sector at *gram panchayat* level. Human resources available at *gram panchayat* level, both from governmental and non-governmental sources, are utilised for the functioning of the task forces. Preparatory steps such as rural inventory of natural resources, primary and secondary data collection, resource mapping, and compilation of rural technology are carried out.

The enthusiasm within communities to participate can be gauged from the the fact that more than 30 lakh people actively participated in the first *gram sabha* meetings. *Gram sabha* meetings were also held for formulating the plan for the second year, based on an evaluation of the first year's implementation.

TRAPPING THE SKIES IN THE SOIL

For the last 20-25 years, Kerala, in spite of its annual rainfall of about 3,000 millimetres (mm), has been experiencing acute shortage of drinking water. This has called for massive short-term investments from government and other sources, while the rainfall flows uselessly into the Arabian Sea within 48 hours of falling, when it should really be trapped in surface and sub-surface waterbodies and the soil.

It is for this purpose that the Akashganga project for the district of Kozhikode has been proposed.

Kozhikode district, with an area of 23.45 hectares, has five rivers, namely, Kuttiad, Korapuzha, Kallai, Chaliar and Kadalundy. The combined discharge of all these rivers is 8,761 million cubic metres (mcum). Out of this, the utilisable yield is 3,631 mcum. The groundwater yield is estimated at 27 mcum. The estimated irrigation demand of the district is 351 mcum. If we add drinking water demand and industrial use to

AKASHGANGA: REACHING FOR THE SKIES

Kerala, with all its rainfall, faces water scarcity. The Akashganga project promises to change this

The district *panchayat* of Kozhikode has taken advantage of the opportunities that decentralisation offers to revive traditional water harvesting systems in Kozhikode district.

The Akashganga project in Kozhikode district is a judicious mix of the old and the new. The objectives of the project are two-fold: to reverse the unscientific, eco-hostile, unsustainable attitude of the people by educating them about traditional water conservation methods and to increase the water conservation capacity of the soil by rejuvenating existing structures and constructing new ones.

The scope of the project is the whole district. The project will take are of all traditional water harvesting systems Efforts have been made to merge beneficial 'modern technology' with traditional systems while restoring or constructing water conservation structures. The mere knowledge of calculating the waterholding capacity of a structure itself has led to the construction of more efficient water harvesting structures. There is a change in attitude towards water, from a water-hostile to a water-friendly one.

The district *panchayat* is pulling out all stops. A 200–strong voluntary brigade called the Akashganga Brigade creates awareness amongst people to revive their traditional knowledge of water conservation and involve them in small conservation efforts.

Student power is being awailed off. There are 125 high schools in the district and a school environment club has been organised in each of these. Each club has 30-40 students who help in this endeavour. The 360 *mahila mandals* (women's groups) that exist in the district have also been involved in the project and are active in promoting the Akashganga concept. These groups are promoting small, cheap and low technology-oriented projects which people can understand and undertake.

Efforts are made to make the people understand the scientific basis of traditional water harvesting systems: How these waterholding structures can hold enormous amounts of water? About 150 awareness camps have been undertaken for the rural poor. The people are surprised when they are informed that a small reservoir, 10 cubic metres in size, can hold up to 100,000 litres of water which will percolate into the soil and underground aquifers — the biggest reservoir of the earth.

During the first year of implementation of the Ninth Plan, in this district alone, about 125 freshwater tanks, 100 new conservation structures, and 3,500 rainwater harvesting pits will be constructed. All this will be done to hold the rainwater that flows into the Arabian Sea within 48 hours of falling.

this, the total demand works out to 4,200 mcum. Some 75 per cent of this demand is in summer months. Unfortunately, the flow in the rivers is very lean during this period: only 550 mcum flow is available. Even if we add the groundwater to this, the deficit will be of the order of 2,825 mcum. Reservoir storage in the district is only 113 mcum, negligible in comparison to the demand. There is a need to build at least 25 more dams like Kuttiady to solve the water shortage, which is not a practical solution.

The solution lies in storage in the soil — *in situ* conservation. Any attempt to stop the surface flow or to reduce its speed will allow more water to infiltrate into the soil.

Unfortunately, efforts in the past have been only partially successful because of the lack of a scientific and integrated approach. Under the Akashganga project, efforts have been made to learn from the past. Practices used to conserve the water have been divided into two broad classes: agronomic and mechanical.

Under agronomic practices, preference has been given to social forestry activities. The best land-use for water conservation is forest land. These lands act like a sponge, absorbing water during the rainy season and releasing it during summer. Forestry is the best measure for all highly sloping lands (with a slope of 45 per cent and above) and land having very thin top soil.

Under mechanical methods, tanks, trenches and pits, *bunds*, terraces, check dams and tilling have been proposed. Tanks are excellent water conservation structures. They can be constructed to channelise water from streams or small catchments. Trenches and pits act as excellent *in situ* conservation measures and there is no standard design for these structures. They are custom built to suit the site requirements. *Bunds* can be earthen or earthen with vegetative barriers or stone-cladded. These can be used for slopes less than 10 per cent. Retention terraces also serve as good water conservation structures. However, this should not be practiced on slopes more than eight per cent. Check dams are very effective water conservation structures. These can be built using earth, rubble, brushwood, bamboo, reinforced earth or concrete. For small structures of less than 1.5 metres and width of two metres, there is no need of elaborate design. For larger check dams, detailed designs are needed.

Tilling of land with terraces hardened during the scorching summer is an old practice by farmers to facilitate percolation of water into the soil. This is also being promoted.

The total outlay of the project is Rs 611 lakh, of which Rs 150 lakh will be through voluntary participation. The balance amount of Rs 461 lakh is expected from government resources.

The projected amount of water that will be conserved at the end of three years is phenomenal:

- The water storing capacity of the district will increase by 720 million litres; and,
- the water content of the soil will be increased by 1,155 million litres *(see Table 1: Unfolding promises)*.

Table 1: Unfolding promises

Water storage capacity and resultant increase in soil moisture content possible after implementation of Akashganga project

Type of project	Water storing capacity (million litres)	Increase in water content of soil (million litres)
Public reservoirs	50	150
Private reservoirs	100	300
Tanks		
a) Renewed tanks	100	300
b) New tanks	50	150
c) Tanks owned by religious and charitable institutions	5	15
Rainwater harvesting structures	20	60
Check dams	10	30
River pockets	385	150
Total	**720**	**1,155**

The Akashaganga project will be implemented through people's participation, supervised and monitored by *panchayat*, block and district-level governmental agencies. Technical supervision of the project will be done by engineering personnel attached to block and district *panchayats*. Technical training for the beneficiaries and engineering wing of block *panchayat* will be provided. The beneficiaries will be selected by the *gram sabhas* and eligibility examined by the village extension officers and submitted to the concerned *gram panchayats* for approval. Valuation certificate of the projects completed will be issued by the village officers/extension officers and engineering staff of the blocks based upon the rates approved by the district level committee. Assistance will be provided on the basis of the valuation certificate approved by the *gram panchayat*. The overall supervision of the projects rests upon the district level committee of the Akashaganga project.

Unless implemented, devolution of power will be ornamental only. Traditional water harvesting systems can be revived through strengthening *Panchayati Raj* institutions and *gram sabhas* in plan formulation and implementation, devolution of plan resources to the grassroot level, integration of sustainable modern technology with that of traditional know-how, and the mobilisation of concerted people's action through voluntary organisations. ■

Alleppey's Alternate

Residents of the coastal district of Alleppey survive on the rain that they harvest from their roofs

Fr Yesudas Kattunkathayil
The Alleppey Diocesan Charitable and Social Welfare Society, Alleppey, Kerala

The Alleppey Diocesan Charitable and Social Welfare Society has constructed water harvesting and storage systems for 52 households of Pallithode village in the coastal district of Alleppey, Kerala.

Contrary to popular belief, Kerala suffers from drinking water scarcity. There are 1,164 'problem villages' without adequate water supply. The rainfall in Kerala is high. Though there are 44 rivers flowing through the state, these are small. The total length of 41 west flowing rivers adds up to 3,092 kilometres (km) as compared to the Indus river in north India which alone has a length of 2,735 km.

The coastal areas of Alleppey extend along the narrow strip of land from Ottamassery to Chellanam. There are 2,000 fisherfolk families residing here who experience severe drinking water scarcity. Though rainfall is heavy, salinity intrusion through the estuaries makes the water brackish and hence unsuitable for use. In addition, there are location-specific problems of turbidity, excessive hardness and the presence of high levels of iron and flouride. The region has a high water table — about 1.5-2 meters (m) below the ground, and due to capillary action, during the summer, iron salts get deposited on the surface. Proximity to the

AMIT SHANKER / CSE

There may be enough water in Alleppey but most of it is unfit for drinking

sea results in inundation, which in turn increases the salinity in the water.

Women in this problem area have to walk 1-2 km to fetch water for cooking and domestic purposes. In times of extreme stress, government tankers provide minimal quantities of water. Selling water has become lucrative, a bucket sells for Rs 10, for those who can afford it. For those who cannot, the only option is to drink whatever water is available — brackish or contaminated.

RAY OF HOPE

The Alleppey Diocesan Charitable and Social Welfare Society assessed the viability of providing rooftop rainwater in the coastal belt. Rainfall data over a period of 10 years was collected and peak periods and dry spells analysed. As many as 2,000 households spread over 1,500 hectares were surveyed. Almost all the houses had tile roofs or concrete roofs through which rainwater could be conveniently harvested. On an average, each roof provided an area of about 50 square metres (sq m).

With one square metre of area and one millimetre (mm) of rain, the water that can be harvested is one litre. This means that the roofs have tremendous potential — with 10 mm of rainfall, 500 litres of water can be collected by a 50 sq m roof.

THE PALLITHODE EXPERIENCE

Some 30 km north of Alleppey is a narrow strip of land lying between the Arabian Sea coast and Thuravoor kari land. This is Pallithode, also called *kari* land, inundated with saline water. The peculiarity of *kari* land is that it is highly acidic due to the presence of iron, aluminium and manganese in the form of their phospates during the dry season and their presence in insoluble condition due to water stagnation during monsoon. The use of surface or groundwater is, therefore, ruled out.

Since 1997, the organisation has constructed 52 rooftop rainwater harvesting structures in 52 homesteads. The rainwater is being used by the people successfully at a cost of about Rs 10,000 per household *(see Table 1: Cost of storage)*. The water samples have been tested and the water certified as safe.

The components for rooftop harvesting are:

Catchment: A well-maintained roof of any shape forms the catchment area for rainwater collection. Terraced and tiled roofing proved satisfactory.

Valley gutters: These are made from galvanised iron (GI) sheets of 18 or 20 gauge bent in the shape of a semi-circle of 15-20 centimetres (cm) in diameter and length equal to that of the eaves in the building. Readymade gutters of cement or burnt clay can also be used.

Table 1: Cost of storage

Cost of a five cubic metre capacity storage tank and other associated structures

Material	Approximate cost in rupees
Cement – 53 grade (12 bags)	2,500
River sand (1.5 cum)	1,000
38 mm metal (0.5 cum)	175
19 mm metal (0.5 cum)	175
10 mm diameter mild steel rod (29 kg)	400
6 mm diameter mild steel rod (10 kg)	400
22 guage chicken mesh (45 m)	750
Binding wire (2 kg)	100
17 mm polyvinyl chloride (PVC) pipe (1.5 m) and PVC pipe (51mm guage) (4 m)	250
Brass tap (1)	50
Flange plate (3)	50
Waterproof compound (8 kg)	200
Filter bucket with materials (1)	250
Zinc sheet for making gutters (15 m)	500
Bricks (100)	250
Waste motor oil (2 litres)	25
Transportation and incidentals	375
Labour (Masons-8)	1,300
Labour (Helpers-8)	1,000
Labour (Plumber-1)	250
Total	**10,000**

Notes: *cum: cubic metre; kg: kilogrammes; m: metres*

Mild steel: Mild steel rods are fixed to alternate rafters using channel clips in such a way that their bent end protrudes beyond the eaves. The valley gutters are seated on this bent portion. Gutters should slope gently towards the outlet point to facilitate easy and quick discharge of rainwater to the destination without spillage.

Conduit pipe: The conduit pipe can be of polyvinyl chloride and of about 7.5 cm diameter. The size of this pipe depends on the amount of water that can be carried down at the peak period of rainfall.

Foul-flush separator-cum-strainer bucket: The runoff from any roof surface contains impurities like dust, bird

THE ALLEPPEY DIOCESAN CHARITABLE AND SOCIAL WELFARE SOCIETY

A circular ferrocement tank in Pallithode captures the rain that falls on the roof for domestic consumption

droppings and decayed organic materials. This needs to be discarded to ensure the purity of the rainwater stock at the collection point.

A bucket (about 38 cm height and 30 cm width at its top) with holes at the base is filled with the following materials in layers of about 15 cm in the following order from the base upwards: boulders, palm fibre, river sand, pebbles, palm fibre and charcoal. The bucket is covered with a polythene micronet and is fitted on the top of the storage tank where a bucket hole is provided. The tail end of the conduit pipe is fitted above the strainer bucket so as to get free flow of rainwater collected from the roof top to the valley gutters.

Storage tank: A circular ferrocement storage tank is built on the ground and provided with a tap. The capacity of this tank is five cubic metres (cum).

Moulds: Corrugated thick galvanised iron sheets are fitted on iron bars with nuts and screws. Each curve is reinforced (inside portion) with iron rods and, a week later, two layers of 22 gauge chicken mesh is fitted to make it compact. There are seven segments to a mould to facilitate transportation. The dimensions of the mould are 1.43 m height and 2.2 m diameter. These moulds are used one after another.

Ferrocement tank: Ferrocement tank construction (five cubic metre capacity) starts after a suitable site is located, the land is excavated upto a depth of 64 mm in the form of a circle, 2.4 m in diameter. A 102 mm width concrete foundation in the ratio of 1:2:4 of cement, stone chips and red sand is then laid.

A week later, a mould built with corrugated galvanised iron sheets is placed on the foundation, and wrapped with two layers of 22 gauge chicken mesh. This is roped with binding wire on each curve and pasted over with cement mortar of 1:3 (cement:sand) ratio.

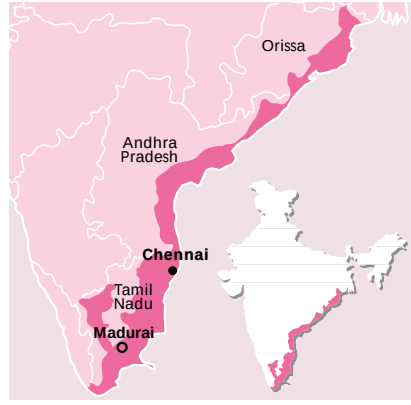
The next day the mould is taken out and pasted inside with cement sand mortar. The bottom of the inside portion of the tank is again given 128 mm thick concrete. The thickness of the tank is now 50 mm. There is a provision of inlet, outlet and overflow. The top is covered with 51 mm thick concrete slabs with a provision for a manhole and bucket hole at the top. The tank is filled with water for curing and is then ready for use. ■

The Rise of a Phoenix

Villagers can breathe a new life into their drylands by regenerating their neglected tanks. Efforts are on to pursue the dream

R Seenivasan, C R Shanmugham and M P Vasimalai
DHAN Foundation, Madurai, Tamil Nadu

Mismanagement and neglect of more than 100,000 traditional tanks (earthen bunded reservoirs constructed across slopes by taking advantage of local depressions and mounds) in the Deccan plateau have led to a severe shortage of water in the region *(see Box: Sad demise)*. Tamil Nadu, Karnataka and Andhra Pradesh together have some 150,000 tanks. To arrest the decline of the tank system, a Madurai-based non-governmental organisation (NGO), Development of Humane Action Foundation (DHAN) has successfully initiated extensive tank regeneration programmes with active community participation.



DHAN'S APPROACH

DHAN's approach for this programme has been to enhance people's awareness of the benefits of tank rehabilitation; organise the community; help it to mobilise resources; share its knowledge in planning and prioritising the works to be undertaken; and, involve people in implementation. The objective is to motivate the people to build their stake and to inspire them into constructive action through self-help, so that they can become self-reliant and not be dependent on the government for every development activity.

Realising that there is an urgent need to revive tanks as a source of irrigation at the grassroot level, the foundation has categorised its approach into the contents of the programme for tank rehabilitation that it wants to undertake and the process that it wants to adopt *(see Table 1: Strategic planning)*.

In order to regenerate tanks, the areas of research, action and study of policy impact include:

- Encroachment;
- usufruct sharing;
- customary water rights;
- institutional development:
  - multi-level people institutions
  - water users' association, water shed association, district federation;
  - legitimate interface with *pan chayat* and other mainstream institutions;
  - farmers, priorities, planning and contribution;
  - self-management;
- technical aspects:
  - tank hydrology estimation;
  - design of least-cost maintenance;
  - conjuctive use of water;
  - groundwater recharge research;
  - desilting;
  - integrated tank management, including catchment treatment;
  - developing a chain of tanks rather than an individual tank;
- tank economics, including renovation and environmental impact analysis; and,
- large-scale demonstration of farmer-managed tank-fed agriculture.

Launched in 1992, the tank rehabilitation programme has now spread to around 150 villages, giving rise to 165 Tank Farmers Associations (TFA) in Madurai, Theni, Thiruvalluvar, Villupuram and Ramanathapuram districts in Tamil Nadu and Chittoor district in Andhra Pradesh. Construction of community wells in 35 tank command areas has also been taken up. Villagers have responded positively by contributing 25-50 per cent of the total cost of the

SAD DEMISE

Alienation of villagers and unnecessary intrusion by government agencies have led to the downfall of a vibrant tank system

Tanks are earthen-bunded reservoirs constructed across the slopes by taking advantage of local depressions and mounds. Tanks are of varying sizes: smaller ones having a few hundred metres of earthen *bund* irrigating 1-2 hectares, while the bigger ones have *bund*s several kilometres long, irrigating several thousand hectares of land. Situated mostly in southern India, there are more than 100,000 tanks, accounting for 30 per cent of the irrigated area. These structures are centuries old and have a place in history.

Tanks are not only irrigation resources but are also the main sources of livelihood for most of the deprived communities of small and marginal farmers who have no access to more dependable canal irrigation projects.

The local village assemblies till the arrival of the British managed these traditional structures. Historically the tanks were well taken care of by the people themselves with financial allocations of four to five per cent of the gross production. Over the last 200 years, the right of ownership of various village assets, including water tanks, has been taken away from villagers who were competently managing a plethora of small traditional tanks dispersed over the Deccan Plateau. The funds for tank maintenance was reduced to as low as one per cent of the gross revenue. The collection of land and water cess from the people resulted in the people disowning these small but valuable water resources.

The village community derived the use of silt, fuel, timber, grass, fodder and fish from the tank. With colonial rule coming into existence, several changes occured in land settlement and these common properties were converted into state properties.

With government departments becoming responsible for the maintenance of these structures, the entire tank system deteriorated due to mismanagement and neglect. While ignorance and lack of resources rendered government agencies ineffective, introduction of a land and water cess impelled villagers to disown small water harvesting structures. Dependence on wells for water steadily increased, increasing the use of groundwater. Marginal farmers who cannot afford pumpsets today but need to lift water from wells, face severe water scarcity.

In order to arrest the steady decline of tanks and tank-fed agriculture in all the southern states, DHAN Foundation has established a Tank Support Group (TSG). It aims at promoting tank rehabilitation through community involvement, and facilitating exchange of ideas, opinions and experiences of tank irrigation systems being developed and restored.

projects. All construction or repair work is executed through TFAs and no contractors are involved. These associations have executed physical work worth about Rs 1 crore so far. Renovation of existing small irrigation systems has turned out to be labour-intensive, easily adaptable, cost-effective and environment-friendly, as well as conducive to groundwater recharge and conjunctive use of surface and groundwater.

Usually, a TFA forms the basic unit of the tank renovation effort in villages, registered under the Societies Registration Act. There is a possibility of recognising the TFA as a sub-unit of a *panchayat* in the future. Once that happens, TFA would draw legally-sanctioned power, resources and governance rights. It is hoped that once these efforts are successful, with greater collaboration with the village *panchayats* and government, a tank rehabilitation movement will finally bring lasting benefits to deprived farmers.

Table 1: Strategic planning

DHAN Foundation has defined the activities that need to be undertaken for participatory tank revival and how this can be achieved

	Stake-building and trust-building	Standardisation	Integrated tank system development	Self-management of tank system
Content	Tank selection	Farmers planning	Catchment treatment	Ongoing operation and maintenance
	Formation of water users association	Farmers implementation	Integration with other tanks	Endowment fund
	Leader(s)	System repairs	Water management	Institution building
	Farmers contribution	Encroachment eviction	Conjunctive use and crop production	Turnover
Process	PRA methods	Sharing of experiences	PRA methods	Review process
	Exposure visits	Specific training	Handholding of TFA	Capacity building training
	Farmer sub-group meeting	System design and implementation	Integration of catchment and command area farmers	Setting up of self renewal mechanism

Note: *PRA: Participatory Rural Appraisal* *TFA: Tank Farmers Association*

DHAN Foundation

Vandagacholam kulam overflowing after the monsoon rains

TANK REHABILITATION CATCHES ON

The newly formed Theni district, carved out of Madurai district, was facing acute groundwater shortage and around 2,000 wells in 10 villages had been dry for the last 10 years. With the help of DHAN, villagers have been able to save five tanks by mechanical desilting and excavating new supply channels. Using water for direct irrigation has been strictly prohibited. The harvested water is used only for groundwater recharge. These efforts should help recharge groundwater aquifers.

Based on this pilot experiment, DHAN proposes to renovate a series of 40 tanks, which have degraded because of siltation and encroachment. The district administration has already allocated funds for renovating eight such tanks during 1998-99.

In Chittoor district of Andhra Pradesh, renovation of tanks has been combined with watershed development and development of dryland farming in the catchment area. Horticultural plantations, bunding and check dams across supply channels along with tank rehabilitation are also planned. Five such watersheds have been identified.

Experience shows that besides developing supply channels for individual tanks, treatment of major channels feeding a series of tanks is quite useful. In Madurai district, a supply channel benefiting 20 tanks has been rehabilitated after several decades. Farmers from four villages participated and contributed to the programme which has shown good results.

A tank comprises the catchment area, supply channel, waterspread area, outlet structures (sluices), flood disposal structure (surplus weir) and the command area. Rehabilitation includes not only bringing these components to their originally designed standard, but more important, facilitating efficient water management and improved cropping practices. A combination of human effort and machines is used for tank rehabilitation. Silt excavated from tanks is transported by tractor-trailers, often brought by farmers on their own. Where the soil is dry and hard, machines are used to excavate the earth. Spreading of soil and sectioning of *bunds* is done by human labour. Combining the use of machines with manual labour is both economical and efficient.

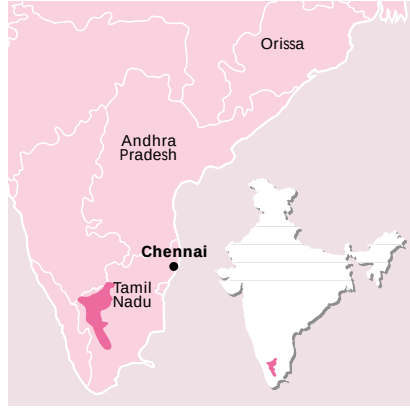
The government has been requested to allow the use of machinery in rural employment generation programmes under the material component of the funds made available. ■

Sweet Success

Centre for Water Resources, Anna University, has been carrying out tank rehabilitation experiments to evolve alternative approaches to groundwater use in Tamil Nadu

N V Pundarikanthan
Anna University, Chennai, Tamil Nadu

Groundwater resources in Tamil Nadu may appear to be extensive. However, regional, seasonal and spatial distribution is uneven. Traditional rainwater harvesting structures like tanks, ponds and percolation ponds are presently in a degraded condition. These systems could go a long way in meeting local needs. However, local communities feel that the state government has not provided sufficient funds for the upkeep of traditional water harvesting structures, while the government blames local communities for lack of participation.



The Chennai-based Centre for Water Resources (CWR), Anna University, has been striving to find solutions to this impasse since 1988 and carrying out experiments to evolve alternative approaches through tank rehabilitation in rural areas with the participation of local communities.

Tamil Nadu covers an area of 13 million hectares (mha), with 384 blocks or *mandals* classified under 29 districts. Some 29 major river basins constitute the major drinking and irrigation sources for the urban and rural areas. According to the status of groundwater report, as of January 1997, out of a total of 384 blocks in the state, there were 97 dark blocks, 88 grey blocks and 199 white blocks. The state groundwater department defines blocks as dark, grey and white according to groundwater development (percentage of water utilised from the available groundwater store) of 85 per cent, 65-85 per cent and less than 65 per cent, respectively.

The number of wells has increased from 0.144 million in 1950-51 to 1.45 million in 1994, making the state second in terms of having energised wells (wells fitted with electrical or diesel pumpsets) in India. Irrigation through groundwater sources grew from about 0.5 mha during 1950–51 to 1.23 mha in 1989–90, while irrigation through surface water sources remained quite static. Increased use of pumpsets and availability of institutional finance, mainly to medium and small farmers, were key to this development. Although this has helped in increasing the area under cultivation, it has endangered groundwater resources through overexploitation. To find an alternative source of water and irrigation, CWR took up tank rehabilitation in rural Tamil Nadu.

EXPERIMENTING WITH TANK REVIVAL

A field-based research scheme called 'Alternative approaches to tank rehabilitation and management — an experiment' was undertaken by CWR in March 1998 with the help of a Ford Foundation research grant and state government support, to be completed in two phases.

In the first phase, four experimental tanks have been selected by CWR for rehabilitation, with involvement of local communities from the initial stages of planning to design, implementation and management. These tanks have been selected in four different agroclimatic regions where water users' associations and farmers' associations (FA) have been formed and encouraged to take part under the guidance of CWR and public works department (PWD). Four control tanks have also been identified to compare the *modus operandi* and results and to evolve a viable model. These tanks are located within a radius of 10 kilometres (km) of the experimental tanks and are being rehabilitated by private contractors under the supervision of the PWD.

The farmers have done commendable work for these tanks. The lessons learnt during the first phase

BINAYAK DAS / CSE

Kaveripakkam tank, in Vellore district of Tamil Nadu, rehabilitated with the participation of users

have been put to use in the next phase. At the completion of the first phase, the government of Tamil Nadu agreed to more flexible project financing terms. It did away with the contract system and awarded contracts to local FAs, extending loan advances of Rs 50,000-80,000 at a nominal 12 per cent interest rate. The government also agreed to compensate for the cost escalation by granting revised rates in genuine cases. Donors like the European Union (EU), supported by the government of Tamil Nadu, agreed to include community wells, catchment treatment and creation of FAs into the programme.

To ensure greater participation by the FAs, the government stipulated in the second phase that only those FAs which put up one lakh rupees as seed money would be entrusted to take up tank rehabilitation work. Out of the nine tanks under consideration, FAs belonging to eight tanks responded positively and were awarded the work.

Nine new tanks have now been chosen for fresh experiments with governmental support in Vengal, Samuthiram, Papadaikulam, Ayanittam, Karuppur, Sennaneri, Thiruppuravasal and Chettikutichi villages. For these tanks, Anna University is providing support only as a community organiser, while the rest is being done by the PWD. The intention is to evolve a working model, according to PWD designs.

The success of these experiments has demonstrated that given proper encouragement and inputs, farmers can establish sustainable and economical models of tank systems. Recommendations based on the research findings have been used in the rehabilitation of some of the 522 tanks in Tamil Nadu.

At least 9,000 percolation ponds have been constructed in the last decade in the state. Studies conducted by CWR indicate that the influence zone of the ponds extend from 1.6 km to 2.8 km in the downstream area in places like Salem and Dharmapuri districts. The studies also indicate that 70-90 per cent of the water conserved in the ponds goes down as groundwater recharge, while the rest evaporates. These ponds have led to an increase of water level in wells by 1.75-3 metres. Recent studies on percolation ponds using tracer technique more or less confirm these findings. This technique determines groundwater movement by using a chemical, fluorescent or radioactive tracer.

So far, water harvesting work in Tamil Nadu has not been undertaken through a scientific process of site selection for maximising benefits. New studies were conducted to do away with this lacuna by the remote sensing centre, Anna University. These studies identified recharge zones and suitable structures for optimal use. Four different kinds of recharge zones, namely, highly favourable, moderately favourable, less favourable and poor zones have been classified. Creation of a digital database which will be available to the user community has been proposed.

High and moderate zones are areas suitable for artificial recharge activity. In the other two zones, low-cost small recharge structures may be contemplated, according to the local need. Percolation ponds are also recommended in favourable recharge zones. Desilting of tanks with recharge pits and check dams are recommended for waterbodies close to energised pump sources.

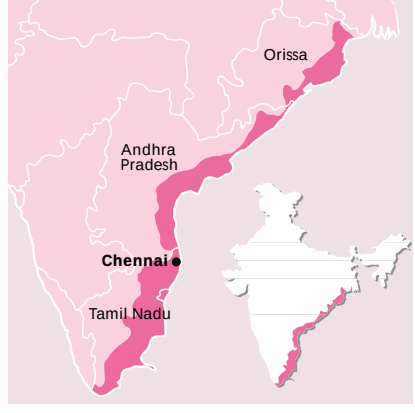
Tamil Nadu has a budget allocation for the desiltation of 200 tanks before the arrival of monsoon every year. This has proved to be a successful and popular programme in which local communities have freely participated. This has caught the attention of agencies like National Bank for Agriculture and Rural Development (NABARD) who are planning to cover more tanks under similar schemes. However, to bring greater responsibility and participation, users must be organised on a partnership basis and trained for achieving near-sustainability of such structures. Water harvesting efforts must be monitored and evaluated so that the lessons learnt can be built into future programmes. ■

Born Again

Members of a youth group in Kovalam village of Tamil Nadu have successfully restored a derelict village pond, making its water potable

T K Ramkumar
Exnora International, Chennai, Tamil Nadu

Despite the existence of three freshwater ponds, Kovalam, a small fishing village in Tamil Nadu, was facing acute water shortage. Pond waters were contaminated by open defecation, polluted runoff from neighbouring settlements, and an experimental prawn culture farm. Hardships faced by the villagers led them to approach Exnora International, a Chennai-based non-governmental organisation (NGO) for help. Subsequently, a youth group called Kovalam Youth Exnora was formed to take remedial action. Exnora helped in spreading awareness about replenishing groundwater and recharge wells with rainwater. They also took up the task of managing the solid waste generated.



Investigations revealed solid waste was an important source of land and water contamination in the village. To address the problem, youth group members were trained in waste management. A local business establishment sponsored a tricycle and a 'street beautifier' was employed to regularly sweep the village streets and undertake door-to-door collection of solid wastes. This ensured that garbage did not contaminate the soil or the pond water. The new concept of solid waste management was well received by the villagers, and the waste disposal situation has improved.

Success at this initial stage motivated the members to take up other aspects related to the problem of safe drinking water with greater confidence. They concentrated on making toilet facilities available to villagers to stop open defecation. A Swiss couple contributed money needed to build a public convenience. The utility of this structure elicited support from local people and the *panchayat* board, resulting in the construction of a few more public toilets.

Restoration of the Kovalam pond was the next logical step. Awareness campaigns were conducted by the members to inform and encourage the villagers to help in cleaning the pond. After the catchment area of the pond was traced and cleaned, half of the pond was taken up for restoration. Floating wastes and vegetation were removed and using suction pumps the pond was emptied for desiltation of the tank bed. To increase water storage capacity, the community collectively erected earthen bunds and planted grass to strengthen them. To avoid contamination of the tank water, a metal bed filter was built along the sides, through which water could flow in from the main catchment area. This ensured that the quality of pond water became potable. Various species of fish were introduced to maintain the cleanliness of the water. The pond was restored as a source of drinking water for the village, and springs and rains replenished the water level.

After the successful restoration of the pond, a neighbouring *durgah* (a holy place dedicated to a saint), which had never before concerned itself with the pond, claimed the right to use the pond water. A settlement was worked out whereas villagers assisted the *durgah* to restore the other half of the pond for its use.

A year after the restoration of the pond, water in the pond was getting contaminated again. The villagers investigated and traced the source of contamination and under the guidance of water experts from Rotary Clubs and Exnora, they are now setting up a filtration plant for treating the pond water.

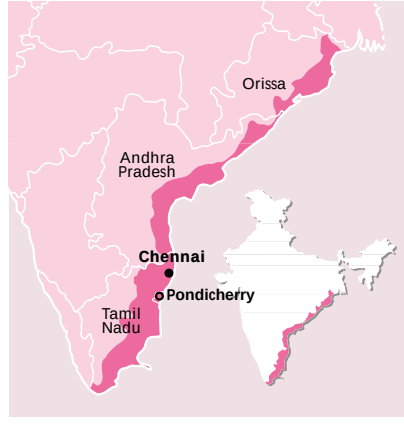
The community is proud of its success. They are striving to keep the pond clean. The people, who once went to its banks to wash and bathe, now use a bucket to take water away from its bank. ■

Healing a Scarred Land

Building bunds *and check dams followed by large-scale tree plantation has helped arrest soil erosion in villages around Auroville in Pondicherry*

Anupama Pai and N Parthasarathy
Palmyra, Auroville, Pondicherry

Wastelands in villages around Auroville in Pondicherry are the result of many factors: topography, rainfall patterns, changes in cropping practices, absentee landlordism and increasing fallow lands. The combination of heavy rainfall concentrated over a small period of time and a steeply sloping terrain causes most of the damage. Palmyra, a Pondicherry-based non-governmental organisation, has treated around 3,000 hectares (ha) of private and community-owned land in eight villages around Auroville by extensive bunding, building over 60 check dams and planting one million seedlings, using a mix of about 70 species of indigenous and exotic trees.



TRICKY TERRAIN

Land in this region slopes abruptly from a plateau 45 metres (m) above mean sea level to the sea within a short distance of about seven kilometres. An annual average rainfall of 1,200 millimetres (mm) comes down usually over a short period of three months and often as a very heavy downpour, within 5-10 days. The result is severe land erosion, with gullies and ravines being a common feature.

Palmyra started watershed restoration in 1990 in lands at the top of the plateau, gradually working down to lands located in lower areas. Without this, any bunding or planting work could easily be undone in a good spell of rain. With the involvement of local communities, *bunds* and check dams were built to conserve water *(see Box: Arresting water, wresting soil)* and trees planted to arrest soil erosion. Since the wastelands were community as well as privately-owned, it was important that communities themselves be convinced to arrest water, plant trees and grasses, and change agricultural practices to suit the soil condition. They could simply not afford to indulge in experiments. But absentee landlordism had also become popular and people were reluctant to put in any input for the improvement of their lands. Plantation of perennial crops such as cashew had become popular, since they allowed landowners to go elsewhere for employment.

One of the reasons for farmers' reservations against undertaking new watershed management measures stemmed from their basic dependence on land for survival. Secondly, despite the success of such efforts at Auroville, they felt that Auroville was able to protect treated lands from grazing and fuelwood collection, something that would not be possible for them. The proximity of the selected project area to Auroville however made it possible for the farmers to visit numerous sites and see for themselves the efficacy of different methods of nursery raising, bunding and building of check dams on a watershed basis. This helped in convincing them to take up similar efforts.

TOWARDS NEW PASTURES

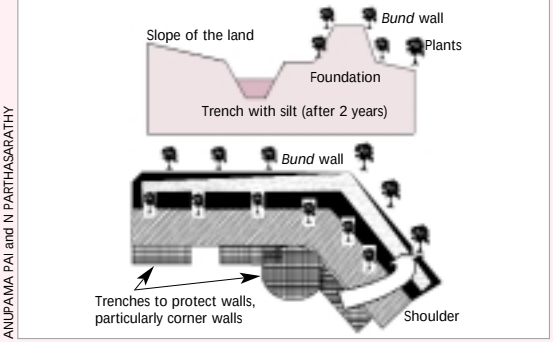
Palmyra aims to restore 1,250 ha of degraded land and plant about two million trees over the next five years. The acceptance of the work is much higher now as farmers see the results in other areas. The water table has already improved in wells in the project villages. With such positive results, farmers are now keen to revive the fertility of their lands.

As part of the new initiative, Palymra has started rapid surveys in 13 new villages to focus on landholding patterns, agricultural base, animal care and natural

ARRESTING WATER, WRESTING SOIL

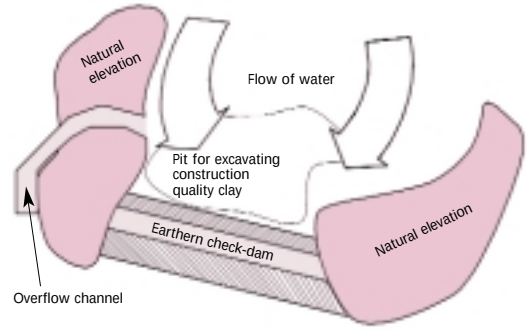
Holding back the flow of water saves soil from being washed away and facilitates groundwater recharge

Fig 1: Field *bund* construction



ANUPAMA PAI and N PARTHASARATHY

Fig 2: Check dam construction



In regions where rainfall is unpredictable and heavy, water and soil conservation becomes essential through building of *bunds* and check dams. *Bunds* are simple and effective structures that reduce the flow of water to stop soil erosion, reclaim unproductive land, and generate groundwater recharge.These are constructed either along the contour lines of large fields or community lands, or along the perimeter of a farmer's field, using soil dug along the line where the *bunds* are situated. The soil is deposited about 30 centimetres away from the trench and built up into a wall. Each layer of soil is compacted by walking over the wall. The height of the *bund* is adjusted so that the centre point remains highest while the edges serve as points of overflow. The trench serves as a percolation device and helps in slowing down the speed of water. The *bund* walls are planted with grass seeds or other plants to strengthen it, especially at the overflow points *(see Fig 1: Field* bund *construction).*

The number and size of *bunds* in an area depends on the slope of the land and the intensity of rainfall. *Bunds* should have overflow arrangements and percolation ponds to deal with surplus water. Work on *bunds* should start from the highest point in the watershed and proceed downwards to ensure that they are not destroyed in a sudden rush of water from upper areas. The lowest point of the *bund* should be reinforced as an additional precaution.

Check dams are constructed in much the same manner as *bunds*, only these are larger in size. These structures are possible only when the available soil is of right quality, being slightly heavy clay with the necessary strength to hold back water and prevent seepage. The natural topography of the land is manipulated to hold back more water or redirect the flow of water, if necessary. Check dams are designed to join two natural high points in a land, with a height that depends on the amount of water needed *(see Fig 2: Check dam construction).*

The soil for the dam wall is dug from the natural depression itself, thereby increasing its water storage capacity. Sometimes it is dug from as deep as three metres (m) to obtain the right kind of soil. The dam wall is compacted by walking on the wall as each headload of soil is deposited. Only the overflow point is constructed in concrete to withstand the constant pressure of flowing water. Trees and soil-binding species such as vetiver grass are planted to strengthen the dam wall. Locally available materials, with a minimum amount of concrete and masonry, are used to lower costs. For example, a 35 m long and 2.75 m high check dam costs only Rs 35,000-40,000.

resource bases like water and biomass. Survey findings indicate that the main occupation in villages is agriculture. Land distribution is highly unequal, with about 10 per cent landholders owning around 60 per cent or more of the agricultural land. It is found that marginal lands are highly prone to erosion and, being dependent primarily on rainfed agriculture, are left fallow for most of the year. Animal care forms another important source of income. The total number of livestock, however, is far in excess of the available biomass in the study area.

The survey details have also revealed the presence of extensive traditional tank irrigation systems (*eris*) which are in a degraded state presently. The upper caste community called Ooru controls most of the community tanks which have traditionally sustained paddy cultivation. The populist measure of providing free electricity to farmers has resulted in a rapid increase in the number of private borewells, leading to a drop in groundwater level and neglect of traditional water harvesting systems. Additionally, most of the tanks are owned by the public works department and remain neglected, as villagers do not feel any sense of ownership towards them.

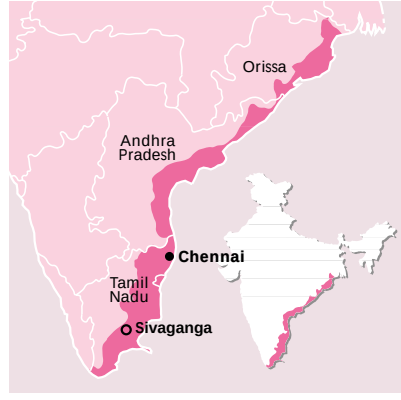
There is a need today to develop the potential of the natural resource base which can help in supporting local communities. The future lies in reviving degraded irrigation tanks through desiltation of tank beds and supply channels and repair of tank *bunds,* sluice gates and waste weirs. Palmyra plans to do just that. ■

Pond Purification

With help from a voluntary organisation the residents of Athakaraipatty village in Tamil Nadu have revived a pond to solve their water problems

A Kalimuthu
WaterAid, Tiruchirapalli, Tamil Nadu

An old pond has been renovated to solve the drinking water problem in Athakaraipatty village of Sivaganga district in Tamil Nadu, through careful planning and active participation of villagers. Some 240 families in the village depend on an openwell, connected with an overhead tank (OHT) and a borewell fitted with a handpump for their drinking water needs. Till a few years back, both sources yielded saline water and the openwell remained operational only during the monsoon months.



Located seven kilometres (km) southeast of Tirupathur, the *taluka* headquarter of the district, 80 per cent of 1,360 people in the village are landless labourers and the rest own less than an acre of land. Most of them depend on lands that are unfit for cultivation due to very high alkalinity. Traditionally, the community used water from a surface pond — locally called *Thamarai oorani* — located on the northern fringe of the village, for drinking and cooking purposes after applying locally available *nirmali* (*Strychnos potatorum*) seeds to remove dissolved sediments from water. Bacterial contamination, however, often led to diseases like diarrhoea. As the pond bed was not desilted for long periods, it gradually filled up and because of its reduced capacity, began to go dry immediately after the rainy season. Villagers had to fetch water from a stream some 2.5 km away, by digging small potholes in its bed.

OPERATION 'CLEAN-UP'

In order to address the problem of drinking water effectively, a non-governmental organisation (NGO) called Tirupathur Rural Upliftment and People's Action (TRUPA), a partner agency of WaterAid, a UK-based NGO, decided to elicit the support of the villagers. As the pond constituted the main source of water in the village, TRUPA decided to rejuvenate it. All the problems associated with the pond such as salinity, silting, presence of germs, seepage loss, and lack of soil conservation were discussed with the villagers before an action plan was prepared.

In early 1995, a series of awareness camps was conducted. About half the villagers realised the need for proper maintenance and improved technology inputs to increase water availability and get rid of diseases. Old, effective systems of maintenance were discussed and plans were made to introduce similar systems for future use.

It was decided that any further work to solve the problem would be taken up only after forming a committee, comprising both men and women. The elected members would undertake the planning needed to improve and maintain the pond. A detailed technical study was conducted to understand the present capacity of the pond and also to design the required size for the future. On the basis of the study, the following action plan was developed:

- Increase the depth of the pond to reduce evaporation loss and also reduce the surface area;
- prevent any plant growth in the pond to avoid growth of germs;
- increase inlet-flow by providing cement concrete pipes, connected to the feeder channel, and also to provide an outlet on the opposite side;
- no cattle or person will be allowed into the pond for watering, washing or bathing;
- fence the pond to prevent entry of cattle and other animals;

TRUPA

Active community participation during the desilting of the Athakaraipatty oorani

TRUPA

The settling tank, horizontal filter and slow sand filter near the Athakaraipatty oorani that cleans the water before supply

- to avoid faecal contamination, introduce filtration systems comprising Horizontal Roughing Filter (HRF) and Slow Sand Filter (SSF);
- to avoid turbidity, a settling or sedimentation pond was to be added;
- while TRUPA will take care of funds required for all the masonry work and one-third of the labour costs, villagers will contribute the major share of funds and provide free labour to upgrade and maintain the pond;
- two elderly persons from the community will be elected to settle the encroachment on the feeder channel by landlords;
- selected members will be delegated the responsibility of raising funds for maintenance from villagers who will contribute a small portion of their wage. Collected funds will be deposited in the local post office in a joint account;
- villagers will be trained in the management of the filter systems; and,
- the local *panchayat* will bear the cost of running the motor for pumping water into the settling pond and the cost of repairs of motor and plumbing works.

With the above agreement and understanding, work started towards the end of 1995. The settling plant with the HRF and SSF was constructed and the *panchayat* changed the motor and renewed the electricity connection needed for it. The *panchayat* also agreed to repair the well inside the pond area and connect it with new pipes, with an expectation of more water being available throughout the year. All these tasks were completed by 1997.

AFTER EFFECTS

Due to the longer duration of water storage in the pond, groundwater recharge has increased and its salinity has decreased considerably. With the increase in availability of water in the wells, more water is available to the community for domestic use.

Water analysis conducted by the Chennai-based King's Institute shows that the water available after treatment is fit for drinking. Turbidity levels have reduced from 120 Nephlometric Turbidity Units to five after the water passes through the HRF. This further decreases to one after the water passes through the SSF. Total coliform units (Most Probable Number or MPN / 100 ml) fall from 11,600 to 240 and 17, respectively, and the faecal coliform count drops from 6,240 to 110 and zero, respectively, after the water passes through the HRF and SSF. As a result, there has been a marked decline in diarrhoea and other water-related diseases. Now people use only the treated pond water for drinking and cooking purposes. The water in the pond gets pumped into the settling pond, and from there it goes to the HRF and SSF by gravity.

Contribution and participation by the villagers has created a sense of ownership in the community. The village community is changing and washing the filter materials in HRF and SSF regularly. The water committee has directed the villagers who have lands in the pond catchment area to adopt good soil conservation measures to prevent silting of the pond bed — a rule which has been duly observed by respective landowners. The villagers have also decided not to go for open defecation in the catchment area and plans are afoot for toilet construction in each house.

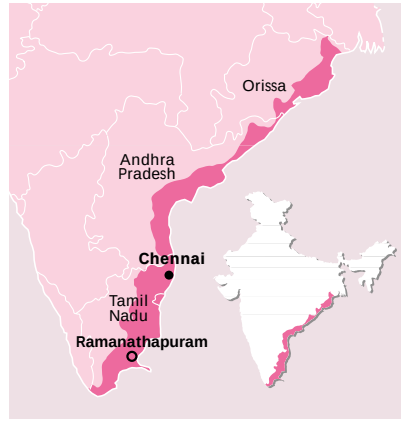
Athakaraipatty's experience presents a classic example of the benefits of judiciously mixing the traditional with the modern. It also shows that there will be popular support and participation for traditional systems, provided people are made to realise their importance. ■

Return to Roots

When modern water supply methods failed to deliver water to villages in Ramanathapuram district, water from renovated ooranis *came to their rescue*

G Vasudeo
Vivekanand Kendra, Kanyakumari, Tamil Nadu

Despite many programmes undertaken under the Rajiv Gandhi Drinking Water Mission by the government, including costly desalination plants, drinking water supply in many pockets, including Mudukulattur block of Ramanathapuram district in Tamil Nadu, is still either inadequate or highly saline. Efforts by government departments to tackle the various problems leading to water scarcity have failed so far. Relief from acute water shortage has finally come from renovating *ooranis* or traditional ponds. Vivekananda Kendra, one of the voluntary organisations working in Ramanathapuram district, convinced villagers in Mudukulattur block to participate in reviving *ooranis* and harvest rainwater using rooftops.



Spread over an area of 3.38 hectares (ha), Mudukulattur block has 36 revenue villages and 155 hamlets under 48 *gram panchayats*, with a population of 85,329 in 1991. There are 61 minor irrigation tanks and 42 tanks belonging to the public works department connected to the Vagai river by a network of supply channels. The annual average rainfall is around 650 millimetres (mm).

Covered by sedimentary rocks, most of the villages have brackish water. Though there are about 25 power pumps and 240 handpumps in the block, these produce only saline water. Many pumping schemes introduced in the sporadic and shallow freshwater pockets have only resulted in rapid upward movement of the underground saline water. The absence of deepseated freshwater aquifers has restricted groundwater use.

FAILED SCHEMES

Government efforts to provide water have proved to be futile. The government implemented a number of piped water schemes with the Vagai river as the source. The Kulandurai and Rajagambiram schemes, for instance, envisaged transporting water from filtration wells to a number of villages spread over a 40 km radius. Despite huge expenditure, these schemes failed miserably due to shortage of water in the main source — the river itself — during summer. As many as 14 desalination plants installed by the government to convert brackish water into potable water also failed due to the lack of feedwater sources, high quality membranes to treat highly saline water, and lack of trained persons in remote villages.

The government, various voluntary organisations and local villagers then realised that the only viable solution to the chronic water scarcity and salinity problem faced in the district was to develop traditional water sources like *ooranis*.

OORANI OPTION

In 1987, K C B Raju and N Varadaraj of the Central Ground Water Board (CGWB) had presented detailed accounts of hydrogeological zones in the area up to a depth of 1,000 metres (m) and also provided a feasibility report for utilising traditional resources to solve water scarcity in villages under the Rajiv Gandhi Technology Mission.

In the face of failure of modern attempts, it was only a question of time before *ooranis* had to be used to meet

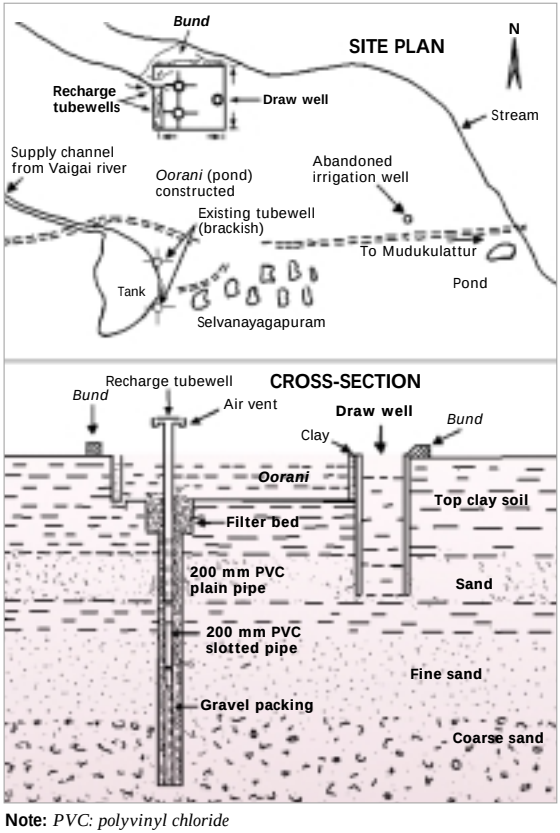
drinking water requirements. These traditional ponds that collect surface runoff, and even sub-soil freshwater at places, had been neglected and fallen into a sad state of disrepair. Storage capacities were greatly reduced due to siltation and encroachment. Absence or choking of proper inlet structures, poor maintenance of side embankments, and contamination due to lack of fencing further led to their decline. Fed by the irrigation supply channel network of the Vagai river, these structures were receiving steadily declining amounts of water due to reduced water supply into the channels.

To rejuvenate *ooranis*, Vivekanand Kendra began close interaction with local communities in Mudukulattur. With help from these communities and the Council for Advancement of People's Action and Rural Technology (CAPART), New Delhi, the Kendra succeeded in remodelling *ooranis* in Thattankudiyiruppu (in 1991), Sambakulam (in 1991), Kottakudi (in 1994), Mattiyerandel (in 1994), Kannicheri (in 1995) and Selvanayagapuram (in 1995).

Villagers were motivated through film shows and weekly group discussions that debated issues related to the work. They actively participated in desilting operation. To increase the storage capacity of existing *ooranis*, the *oorani* beds were widened and deepened taking care that there was no saline water intrusion. Simple inlet and outlet structures were added. Stone pitching work and grass turfing were initiated on the slopes of these structures to prevent soil erosion. To get clean water, filter trenches were connected to draw wells outside the ponds. Once the *ooranis* were successfully desilted and remodeled, a checklist for periodic maintenance of the structures was given to the villagers. Village-level cooperative societies were also formed in some villages, with a corpus fund for maintaining these *ooranis*. Villagers resolved to mobilise funds on a quarterly basis to augment these deposits.

Fig 1: Reconstructing *ooranis*

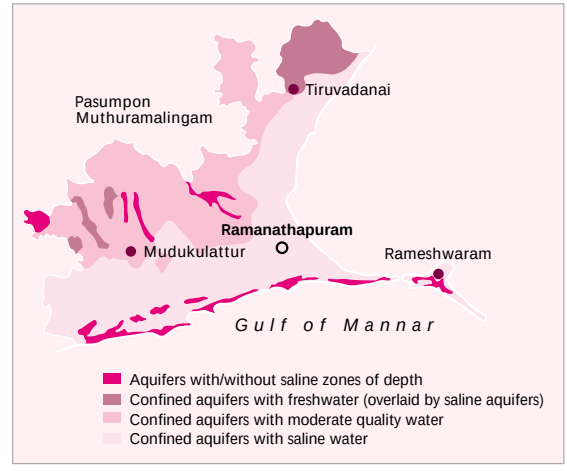
Site plan and cross-section of recharge tubewells in the *oorani* of Selvanayagapuram



G VASUDEO

Note: *PVC: polyvinyl chloride*

Hydrogeological zones of Ramanathapuram district, Tamil Nadu



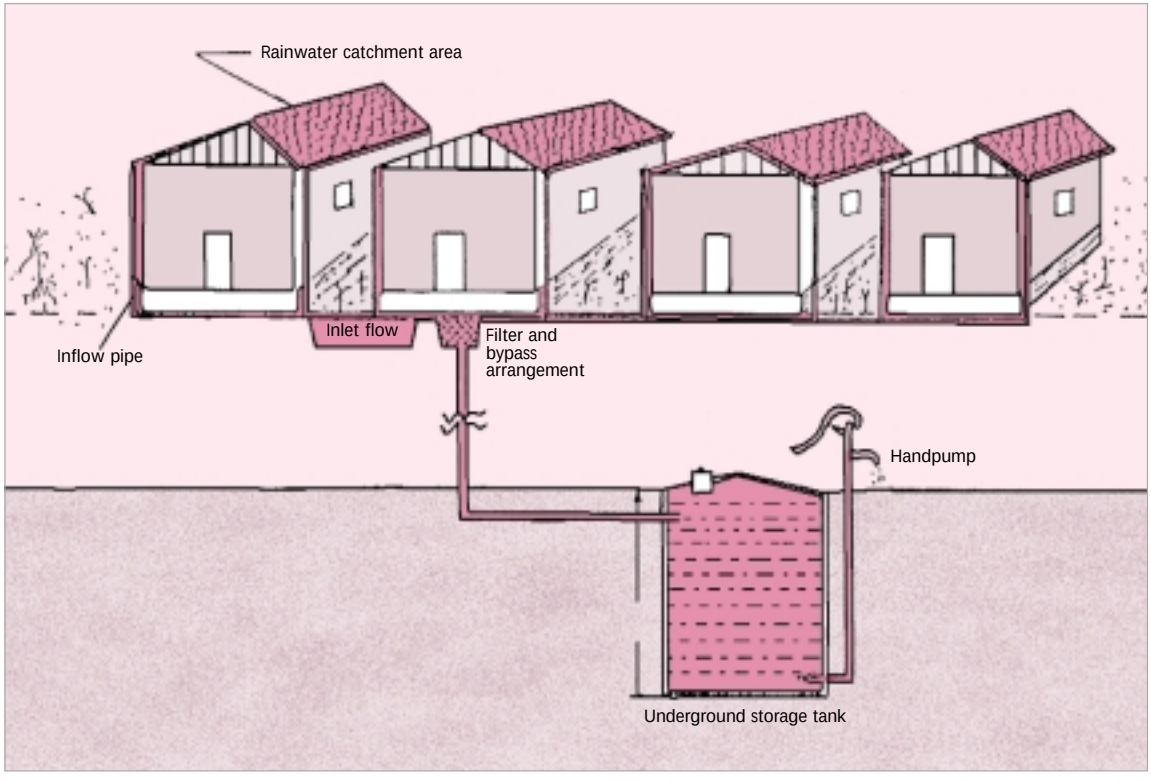
VALUE ADDITION

To augment drinking water supply, Vivekanand Kendra decided to provide *ooranis* with recharge tubewells. The Kendra carried out detailed studies in consultation with the CGWB officials at Chennai and Thiruvananthapuram and selected Selvanayagapuram and Merkukottakudi villages in Mudukulattur panchayat for installing these recharge structures *(see Fig 1: Reconstructing* ooranis*)*.

In spite of the considerable potential of *ooranis*, there are constraints in their repair and maintenance. The sub-soil water level and brackish groundwater does not allow any appreciable deepening of the *oorani* bed, while the high rate of evaporation in summer months necessitates deepening rather than increasing the surface area.

Selvanayagapuram has a number of tubewells and a big irrigation tank, but water here is brackish. To get quality drinking water, villagers purchased

Fig 2: The flow from tiled tops
Layout of rooftop water harvesting in Thattankudiyeruppu



G VASUDEO

0.84 ha of land adjoining a rivulet for the construction of an *oorani*. Each family contributed *shramdan* (voluntary labour) worth Rs. 50,000 which was later reimbursed and put into a fixed deposit for use by the village community.

The pit made by the villagers was deepened using earthmovers to expedite construction before the onset of monsoon in June 1997. The average length and width of the pond was 83 m and 70 m, while its depth was 1.30 m. Two recharge tubewells of 200 mm diameter and 36.37 m depth were constructed inside the pond. Gravel was packed in pits with 1.2 m diameter and two metres depth around the tubewells to facilitate rainwater collected in the pond to recharge the sand layer occurring below five metres.

In addition, a draw well of 1.80 m diameter and 7.90 m depth was constructed using concrete rings to collect water for drinking. The pond was full by September 1997 and inflow into the tubewells could be perceived by the lowering of the water level in the pond.

At Merku Kottakudi village a recharge structure was built to improve the brackish quality of water in the existing tubewell. A small depression on the upstream side of the tubewell was turned into a pond of 50 m length, 30 m width and 1.50 m depth. A tubewell of 200 mm diameter and 45 m depth was constructed and rainwater collected in the pond created effective groundwater recharge into the same aquifer. The water quality of the tubewell improved considerably in the first year itself. Another tubewell constructed about 200 m downstream permitted greater extraction and also induced more recharge in the system.

The work of Vivekanand Kendra in Mudukulattur area of Ramanathapuram district has proved to be successful. The recharge tubewells allow underground storage of rainwater and easy extraction. Increased water availability through traditional methods has impressed nearby villagers who plan to take up water harvesting on similar lines.

The Kendra has also introduced rainwater harvesting using rooftops in areas that have no *ooranis* or the groundwater is saline. For example, in village Thattankudiyeruppu *(see Fig 2: The flow from tiled tops)*, all tiled rooftops that were not flat were connected through an underground network of pipes to a collection tank. Water was then filtered and stored in another underground tank to be lifted by a handpump for use. ■

Bangladesh: Search for New Solutions

Increasing demand for water and the inability to control its source, timing, quality and quantity are becoming critical issues for Bangladesh

Reba Paul
Local Government Engineering Department, Dhaka, Bangladesh

Bangladesh is ravaged by severe floods and droughts regularly. Three mighty rivers — the Ganga, the Brahmaputra and the Meghna — flow through the land. These rivers cause devastating floods during the monsoon and debilitating droughts in summer. An unpredictable rainfall pattern and increased groundwater extraction further aggravates the problem.

Most of Bangladesh falls in the floodplains of these rivers and their tributaries form an extremely complex network of waterways. These rivers drain a total catchment area of about 172 million hectares (mha), of which only about seven per cent lies within Bangladesh. The country has no control over the inflow and outflow of water and sediments, making it vulnerable to both floods and droughts. The minimum flow of water in rivers near the Bay of Bengal is only one-twentieth of their peak monsoon discharge. High water levels in major rivers during the monsoon cause drainage congestion and spillage over their banks which is often exacerbated by high rainfall. In the 1988 flood, almost 60 per cent of the national territory was inundated and, in 1998, flood waters inundated about 50 per cent of the territory. Alarmingly, floodwaters remained for a much longer period in 1998 than in 1988.

ANIL AGARWAL / CSE

Rural habitation by the riverside

Table 1: Mix and match
Irrigation pattern in Bangladesh

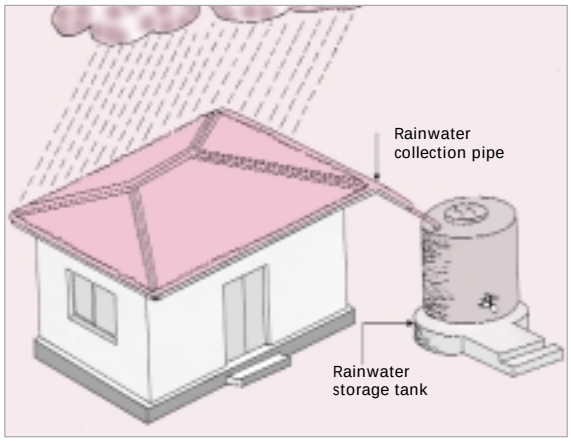
Method of irrigation	Irrigated area (million hectares)
Large irrigation systems	0.20
Shallow tubewells	1.16
Low lift pumps	0.64
Deep tubewells	0.44
Others (traditional)	0.49
Total	**2.93**

Certain parts of Bangladesh, particularly the western half, suffer droughts even during the monsoon, adversely affecting *kharif* crops by as much as 13 per cent. According to the National Water Policy (NWP), the net cultivable area is estimated at 9.04 mha, out of which 7.56 mha is suitable for irrigation and only 2.93 mha is irrigated *(see Table 1: Mix and match).* Upstream withdrawal of water during the dry season forces farmers to use groundwater extensively, lowering the water table in many reaches, often beyond the reach of shallow tubewells. Urban areas too are facing the problem of receding groundwater table due to heavy extraction.

Seepage of agrochemicals into shallow aquifers has further polluted water sources. Salinity intrusion from seawater deep into the southwestern parts of Bangladesh is also making groundwater unusable. High iron content in groundwater in other parts of the country creates similar problems.

Although 99 per cent of the total population in Bangladesh is covered by official drinking water supply, the water it receives is of dubious quality. Surface water supplies are generally polluted and groundwater, which till now has been considered the best source of drinking water, has been found to be contaminated with arsenic in many parts of the country.

Fig 1: Reinforcing the tank
Rooftop rainwater stored in ferrocement tanks



REBA PAUL

THE STATE TAKES A HAND

The government has finally recognised rainwater harvesting as a good alternative for meeting water demand and controlling arsenic poisoning by reducing excessive withdrawal of groundwater. The final draft of the NWP has been approved by the executive committee of the National Water Council and is now awaiting final approval. The policy emphasises preservation of natural depressions and waterbodies in major urban areas for recharge of underground aquifers and rainwater management. Specific plans and contingencies for drought monitoring will be prepared for regions experiencing recurrent shortage of water. The conjunctive use of rainwater, surface water, groundwater and other alternative sources will be explored. Provisions to limit groundwater use will be included in the plan. Local government bodies (*parishads*) will be the principal agencies for coordinating the efforts for water resource planning and management. Community-level self-help groups and non-governmental organisations (NGOs) will be requested to assist in these efforts.

The people in coastal areas and hilly regions of Bangladesh have long been collecting and using rainwater. They used clay pots to collect rainwater. A loan agreement has recently been signed between the World Bank and the government of Bangladesh for Bangladesh Arsenic Mitigation Water Supply project, worth US $32 million. Under the project a total of 215 rainwater collection systems will be constructed by community-based organisations at a cost of Tk 69.8 million (US $1.34 million).

An NGO called Forum for Drinking Water and Sanitation in Bangladesh has already constructed 15 household rainwater harvesting plants in Satkhira district which lies in a saline zone. The harvested water is stored in ferrocement tanks which limit bacterial contamination *(see Fig 1: Reinforcing the tank).* In 1999, it planed to build 15 systems in the same district and five more in Khulna district. Beneficiaries are contributing 25 per cent of the cost of these plants which varies from Tk 3,000-9,000 (about US $58-170), depending on the capacity ranging from 1,000 litres to 3,200 litres.

Local government engineering department, a decentralised and fully privatised organisation under the ministry of local government, rural development and cooperatives is taking a keen interest in utilising rainwater. Its responsibility is to develop infrastructure and strengthen local institutions. The department has already proposed about 650 rainwater harvesting structures in the impact zone of the Sundarban Biodiversity Project. ■

Nepal: Nepal's Nascent Efforts

Attempts to revive rainwater harvesting systems are growing in this mountain kingdom

Dwarika Nath Dhungel
Department of Water Supply, Kathmandu, Nepal

Several government agencies and non-governmental organisations (NGOs) in Nepal are meeting the challenge of providing water through a mix of traditional techniques and innovative, modern methods, both based on water harvesting. Though policies and institutional frameworks need to be developed, the trend is favourable.

Nepal swings between acute water scarcity and abundance. Average annual rainfall in Nepal is 1,500 millimeters (mm). With 80 per cent of the rainfall coming during the period June to September, this rainfall pattern creates a seasonal and uncontrolled fluctuation.[1] The problem is compounded by the fact that within a short distance of 150 kilometres (km), there is a sharp vertical gradient from 150 metres (m) to 8,000 m above mean sea level. The country can be divided into high mountains, hills and the southern flatlands called *tarai*. Most people live in villages and depend on agriculture for their livelihood.

Though the government has opted to provide safe piped drinking water to the entire population, this is difficult as 30 per cent of the rural population lives in remote and isolated areas. More than 40 per cent of the rural population in Nepal does not have access to safe drinking water.[2] About 45,000 children below the age group of 5 years die every year due to waterborne diseases.[3] People in the hills still rely heavily on traditional water sources, often at great distances, and women and children spend hours daily in their quest for water. Pumping up water in hills on a regular basis is a costly affair and often a crop on a farmland barely 30 m above a flowing stream or river may fail due to water scarcity. Innovative methods of water harvesting at a micro-level are thus required to improve the overall water situation. Available traditional sources and systems of water harvesting could assist in finding easy and economic solutions *(see Box: Myriad memories)*.

ROPING IN RAINWATER

Efforts by various organisations are now focussed on water harvesting and watershed management. The International Center for Integrated Mountain Development (ICIMOD), Kathmandu, commissioned a study to find out the possibility of water harvesting in mountainous regions. In order to ascertain the requirement and availability of water and the status of water harvesting systems, ICIMOD has started a regional collaborative programme in countries in the Hindu Kush Himalayan region. Phase I of the project aims to develop a better understanding of technical, organisational and managerial aspects of local water harvesting systems in micro-watershed areas.

Materials like polythene are being used to prevent seepage in water harvesting structures. ICIMOD has constructed a plastic-lined rainwater harvesting pond at Dhaireni in Kavre Palanchowk in 1993-94. The pond has a small silt trap before the water inlet to prevent sediments from entering. The organisation has also built two plastic-lined storage tanks at Godavari trail, a village located 13 km south of Kathmandu district to store spring water. Similar efforts are on in Lalitpur and Kavre Palanchowk districts.

A Kathmandu-based NGO**,** Support Activities for Poor Producers of Nepal (SAPROS), is undertaking construction of polyethylene-lined tanks for very small irrigation projects, mainly for vegetable farming by marginalised farmers. SAPROS provides plastic sheets, sprinklers and pipes. It has already built 13 ponds of 5,000-114,000 litres capacity in four districts of Dhading,

MYRIAD MEMORIES

Traditional water supply systems lie neglected while huge expenditures are made on piped systems

A rich tradition of water harvesting lingers on across Nepal. *Pokharis* (ponds), common in almost all parts of Nepal, are mostly found around stone platforms built on roadsides for travellers to rest. Water collected in *pokharis* from mountain streams and rainfall is used for irrigation and other domestic purposes. The rainwater that collects in the ponds is diverted to the land through canals or by inundating the land and allowing the extra water to pass on to the next terrace. Though the water in *pokharis* does not usually last long due to high evaporation and ground seepage, it also recharges groundwater that sustains streams during dry winter periods.

On hilltops along the *kharkas* or pastureland in Ramechhap district, *pokharis* are still being constructed through community initiatives to harvest rainwater mainly for use of livestock and small-scale irrigation. These structures can typically provide irrigation to 4-5 hectares of land. In the eastern hill district of Bhojpur, mango orchards are being irrigated from similar sources. However, with the introduction of polyethylene pipes in rural water schemes, *pokharis* are now being neglected, leading to siltation and deterioration.

In Kathmandu Valley, *raj kulos* (royal canals) and *dhunge dharas* (stone spouts) had been traditional sources of water for irrigation, drinking and other domestic purposes. The *raj kulo* in the Kathmandu Valley dates back to the 16th century and the Bhimsen kulo built in Gorkha district, to the 19th century. The *raj kulo* in Lalitpur district brings water — mostly rainwater runoff — from Nallu and Lele rivers located in the southern rim of the valley to the city of Patan, to maintain a high water table essential for regular supply of water to the wells, ponds and stone spouts. There are 51 such spouts in Patan.[1]

Dhunge dharas are built near springs to store rainwater that support recharge of aquifers used by stone spouts. Although their water quality is poor, spouts serve 4-6 per cent of the total population of Kathmandu valley. Out of the 115 stone spouts in the Kathmandu valley, more than 50 per cent are non-functional and 80 per cent of the water coming from functional ones, goes waste. About 18 per cent of the population of Patan could benefit if these systems are properly conserved. In Tansen (district Palpa), the district water supply office spends substantial amounts of money in pumping water to a height of 500 metres for water supply while water from stone spouts remains neglected.

V SARAVANAN

A stone spout providing water in medieval Bhaktapur city

ADDRESSING ISSUES

Successful rainwater harvesting depends on people, technology and effective policy

If rainwater harvesting is to be successful on a sustained basis, several issues need to be addressed:

- Development of technologies that are cost-effective, simple, and prevent contamination of water. Rainfall in Nepal is concentrated mainly in the monsoon season, and if this water is to be used during the dry period, large storage space is required. While *pokharis* (ponds) have been traditionally serving this purpose, pressure on limited land resources make large structures unfeasible. China, for example, has solved the problem of space as well as quality by constructing underground cisterns.
  Moreover, in the hills, most of the houses have thatched roofs. In the northern districts, the roofs are made of mud and are usually flat. Besides, the northern region receives mainly snow and so different technologies are needed to tap snowmelts.
- Participation by the user groups is essential to sustain these efforts irrespective of technology. Any strategy that is planned for promoting rainwater harvesting, should therefore involve them right from the start. This job will be better handled by non-governmental organisations rather than government agencies.
- Contribution by user groups towards meeting costs of construction, either in cash/labour is essential for development of a sense of ownership.
- A specific policy that deals with rainwater harvesting does not exist, though there are sectoral policies that deal with drinking water and irrigation. A rainwater harvesting policy should be based on past experiences, both within and outside the country and be prepared in consultation with all the stakeholders, taking into account the ecological regions of the country and issues like subsidy, research and technology.
- Development of an appropriate institutional framework that addresses the various issues relating to water harvesting is also necessary.

Gorkha, Dailekh and Humla. Another NGO, INSAN, also based in Kathmandu, has built some ponds at Banepa in Kavre Palanchowk districts.

Watershed projects are being implemented in the watershed areas of Bagmati river in Lalitpur and Kavre Palanchowk districts by the ministry of forest and soil conservation (MoFSC). Apart from improvement of hilly rural tracks known as trails having an average path of 1-2 m width, terrace improvement and drainage construction programmes, it has undertaken a number of schemes to manage monsoon runoff. MoFSC has constructed catchment ponds to tap monsoon runoff in the Bhardev / Nallu watershed in the district of Lalitpur. A total of 40 ponds have been built under the Bagmati watershed project.

In areas suffering from severe water scarcity, rooftop water harvesting, locally known as *baresiko pani thapne*, has been traditionally practised. NGOs and government agencies are now promoting these efforts. In the hill town of Phulchowki, rooftop rainwater harvesting was initiated in 1970 by the department of civil aviation for its office complex. A tank of 45,000 litre storage capacity was built using stone masonry. It had a catchment area (roof) of approximately 300 square metres (sq m) made of asbestos-cement corrugated sheets and a 200 mm diameter semi-circular plain galvanised iron (GI) sheet, serving as the gutter.

Tansen Hospital, located in the hill district of Palpa, has been successfully maintaining its rainwater harvesting system through storage tanks for the last 25 years. Peace Corps, Nepal has also initiated a community-based rainwater harvesting scheme for its health post in the Ramechhap district and some similar schemes for schools in Kaski district.

Large-scale implementation of rooftop rainwater harvesting faces two hurdles from houses built in the hill regions: houses with thatched roofs or flat roofs, and storage. These roofs need to be replaced by corrugated galvanised iron (CGI) sheets. Ferrocement tanks can be used to store harvested rainwater.

The Rural Water Supply and Sanitation Project, launched by His Majesty's Government (HMG), Nepal, with the support of the Finnish government, has implemented rooftop rainwater harvesting schemes in two hill districts of Gulmi and Palpa. Under this project, two jars were provided to houses with CGI roofs and one jar to houses with thatched roofs. The project had provisions for providing 16.72 sq m of CGI sheets to individual project beneficiaries to replace thatched roofs.

Local communities opted for simple, cheap and durable piped gutter system to transfer the rooftop rainwater to storage jars provided to them. HMG contributed 50 per cent of the cost while the project beneficiaries and the project planners equally shared the rest. User groups were strengthened and trained with support from local NGOs, village development committees and district development committees — the latter two are agencies of local government units and the ministry of local development. By March 1998, about 478 jars had been distributed.

Though the ongoing efforts are encouraging, sustainability in water harvesting will only be achieved if associated issues are appropriately addressed *(see Box: Addressing issues)*. ■

Weak Water becomes a Growing Point

China has been successful in large-scale rainwater harvesting. There is tremendous scope for more

Qiang Zhu, Changming Liu, Haisheng Mou, Huilin Wang, Hsiang-te Kung, Zhang Wanjun, Liu Zhijun and Cao Jiansheng

With population growth and rapid economic development, China is increasingly facing water problems. Some 300 cities out of the total 600 are lacking water. Among them, shortage is very serious in 144. The daily water deficit in urban areas amounts to 16 million cubic metres (mcum), causing an economic loss of US $24 billion each year. Annual water shortage in agriculture reaches 77,000 mcum. Water quality is another serious problem. Some 170 million people drink water polluted by organic matter, 110 million people drink water with high mineral content, and 50 million with high fluoride content. Moreover, about 60 million people cannot get enough potable water, mainly in the loess plateau of northwest China, islands and coastal areas, and the Karst area in southwest China. Water shortages have seriously hindered social and economic development in China. Because of drought, water pollution and growing demand, water shortages will be one of the most serious problems in China in the next century.[1]

RICH BUT STILL POOR IN WATER[1]

China has a huge amount of water resources. Ranked sixth highest in the world, the total precipitation is 6,190,000 mcum, which produces 2,710,000 mcum of river runoff and 130,000 mcum of groundwater. However, the water resources per capita are only 2,300 cubic metres (cum), one-fourth of that in the world. Moreover, the available water resources are unfavourably distributed. South and southwest China have the benefit of 81 per cent of the country's water resources, with only 55 per cent and 36 per cent of the population and cultivated land, respectively. Water resources per capita vary from more than 20,000 cum in southwest China to only 200-300 cum in the north. While there are floods in the south, drought often occurs simultaneously in the north. China is known for its monsoon climate. The distribution of river runoff is very uneven within a year and between years. Some 60-70 per cent of runoff is concentrated in the flood period from July to September. This kind of distribution pattern causes seasonal water shortages even in the semi-humid and humid areas.

There are many ways to solve the water problem. One common measure is to build reservoirs and/or inter-river basin water diversions. However, many of the favourable sites have already been used. Building projects at the remaining sites face increasing difficulties. The construction cost is rising all the time. Besides, many large projects often cause environmental problems: large-scale inundation of settlements and negative impacts on the hydrological and hydrogeological conditions as well as on the ecological system. Overexploitation of groundwater has become a common measure to provide water, which has caused a series of environmental problems. The water table is continuously going down, in some areas by 20-30 metres (m).

On the other hand, utilisation of rainfall is at a low level. When water becomes more and more critical for human existence and development, it is necessary to pay greater attention to the direct use of precipitation, especially in those areas where surface and sub-surface water are short or their abstraction is very difficult and rainwater is the only potential or easy-to-exploit water source available.

AP / PTI

While some regions in China face drought, others, like the Hunan province, have to deal with floods

PRIORITY AREAS[2]

Under these circumstances, rainwater becomes a very important and reliable water source because it is accessible almost everywhere. The Chinese people have realised that the direct collection and utilisation of rainwater is a technique clearly in line with efforts aimed at developing sustainable societies in the future.

Rainwater harvesting has been a popular technique in China for thousands of years. In order to provide sufficient drinking water for people and domestic animals, the roof, courtyard, ground and road were used for harvesting rainwater. For example, in Dongzhi-yuan of Gansu Province and north of the Weihe river, the Shanxi Province, rainwater wells and jars already existed about 2,000 years ago.

There have been no studies focusing on rainwater utilisation and identifying potential rainwater harvesting areas in China using the geographic information systems (GIS) method. Where should rainwater utilisation be applied in China? In areas where no piped water supply is available, a dugwell is not applicable (that is, where there is no aquifer) or where drinking water is urgently needed because potable (treated) water is too expensive. Sometimes, a lake, reservoir, river or stream is not close at hand or the soil is not deep enough to sink a well. In China, the zones where potable water is difficult to cover a vast area, include:

- Agricultural zones (including rural areas) far from rivers;
- semi-arid or semi-humid hilly lands;
- 6,620 islands in the 300 million hectares (mha) territory waters (especially coral islands and volcano islands);
- 100 mha in Karst territory; and,
- territory with high fluoride in groundwater.

In all these cases, rainwater utilisation may be the best source for water supply.

FACTORS AFFECTING RAINWATER HARVESTING[2]

Several factors influence rainwater harvesting potential. Precipitation, number of rainy days, rainfall fluctuation rate and topography are considered as the main factors directly affecting the feasibility of rainwater harvesting.

The amount of rainfall in a region decides other factors of the rainwater harvesting system, for instance, the catchment area and volume of the storage tank needed to harvest water and also costs of the system. Rainfall characteristics will also affect the demand of rainwater harvesting. In China, the maximum annual precipitation is about 6,000 millimetres (mm). But the area with precipitation less than 300 mm covers one-third of the country.

Rainwater is a kind of scattered water with

Table 1: Where rainfall is important-1
Rankings for rainwater harvesting demand according to annual rainfall (Rank 5: Highest priority)

Order	Area with annual rainfall (millimetres)	Rank
1	0-100	1
2	100-200	5
3	200-400	4
4	400-600	3
5	600-1,000	2
6	Greater than 1,000	1

characteristics of low intensity and widely distributed range. This scattered water is very important, especially in those areas that lack *concentrated water sources* (such as rivers and reservoirs).

Annual precipitation

Where precipitation is small, rainwater harvesting is needed. However, according to related studies, if the precipitation is too small (less than 100 mm), there is usually no need to collect rainwater because human activities do not exist. For the areas where the precipitation amount is very large (more than 1,000 mm), there is little demand for rainwater harvesting.

For an annual precipitation between 100 mm and 1000 mm, the water demand, and, hence the need to harvest the rain increases with decreasing rainfall. This is the basis for the ranking according to annual precipitation *(see Table 1: Where rainfall is important-1).*

Rainy days

The number of annual rainy days also influences the need for rainwater harvesting. Fewer annual rainy days or longer the dry period, the more the need for rainwater collection in a region. However, if the dry period is too long, big storage tanks will be needed to store the rainwater and water quality will be at risk by pollution and deterioration. The cost of construction and maintenance will be high. Therefore, the number of rainy days is an important parameter for system design *(see Table 2: Where rainfall is important-2)***.**

Rainfall fluctuation rate

Another precipitation parameter — annual fluctuation rate — also affects the application of rainwater harvesting. China is situated to the west of the Pacific Ocean and on the slant of the Eurasian Continent that slopes to the southeast. Due to impact of the monsoon climate on the terraces, rainfall progressively decreases, from south to north and from east to west. Given this general trend, however, the precipitation shows a great variation rate both within a year and between years. The function of

Table 2: Where rainfall is important-2
Rankings for rainwater harvesting demand according to annual rainy days (Rank 3: Highest priority)

Order	Annual rainy days	Rank
1	0- 60	3
2	60- 120	2
3	Greater than 120	1

rainfall variation acts as the rainy days in influencing rainwater harvesting. Higher the fluctuation rate, more significant becomes the collection and storage of rainwater, and higher the demand for rainwater harvesting *(see Table 3: Where rainfall is important-3)***.**

Topography

Types of topography also influence the application of rainwater harvesting systems. In general, there are concentrated water sources, such as rivers, lakes and groundwater in the low plain areas. In the high mountains, precipitation usually falls as snow. Because few people live there, there is little demand for rainwater harvesting. The people there usually can find springs for water supply. But, overall, hilly and mountainous areas need more rainwater harvesting systems than the plain areas while the arid areas need more rainwater harvesting than the humid areas *(see Table 4: Where rainfall is important-4).*

Other factors

Areas where potable water is difficult to reach are in great need of rainwater harvesting. The areas that are far from rivers and where groundwater is not available also need rainwater harvesting. These include the small islands and Karst area and territories with high fluoride water. Data related to these factors are not available right now.

The four factors were equally weighed in a study carried out by the Beijing Research Application Institute of Water because there is no evidence that one factor is more important than the others. The final ranking is achieved by the addition of the four individual rankings. The final ranks range from five to 14. In order to get a clear idea of which part has a higher priority for rainwater harvesting, the final ranks are re-coded to

Table 3: Where rainfall is important-3
Rankings for rainwater harvesting demand according to annual rainfall fluctuation rate (Rank 3: Highest priority)

Order	Annual rainfall fluctuation rate (per cent)	Rank
1	0-15	1
2	15-30	2
3	Greater than 30	3

four scales (1-4), as shown in *Map: Prioritising national areas for rainwater harvesting).*

The highest priority areas for rainwater harvesting are the north, northwest and southwest of China. The resulting pattern conforms to the tradition and current practice of rainwater harvesting in China. The northwest part of the Yellow soil plateau, for instance, has the longest history of rainwater collection and today it is the most advanced area of rainwater harvesting. The middle and eastern area of Inner Mongolia is China's most important pasture of rainfed grassland. The middle part of Qinghai is also a rainfed pasture. The east of Qinghai, the south of Shanxi and the south of Gansu are also traditional rainwater harvesting areas. The southern oases of the Tian Mountains are advanced agricultural areas using rainwater. North Xinjiang is a rainfed arid pasture.

Rainwater can be used for both domestic consumption and agriculture. In fact, in the Yu-Zhong-Bei hilly land of Gansu province, a project named '121' has been successfully carried out under the lead of the provincial government. There are also three areas of exception among the above regional areas. However, the exceptions indicate some reasonable and rational points of the above divisions. The first exception is located in the middle of Ningxia. Local people

Table 4: Where rainfall is important-4

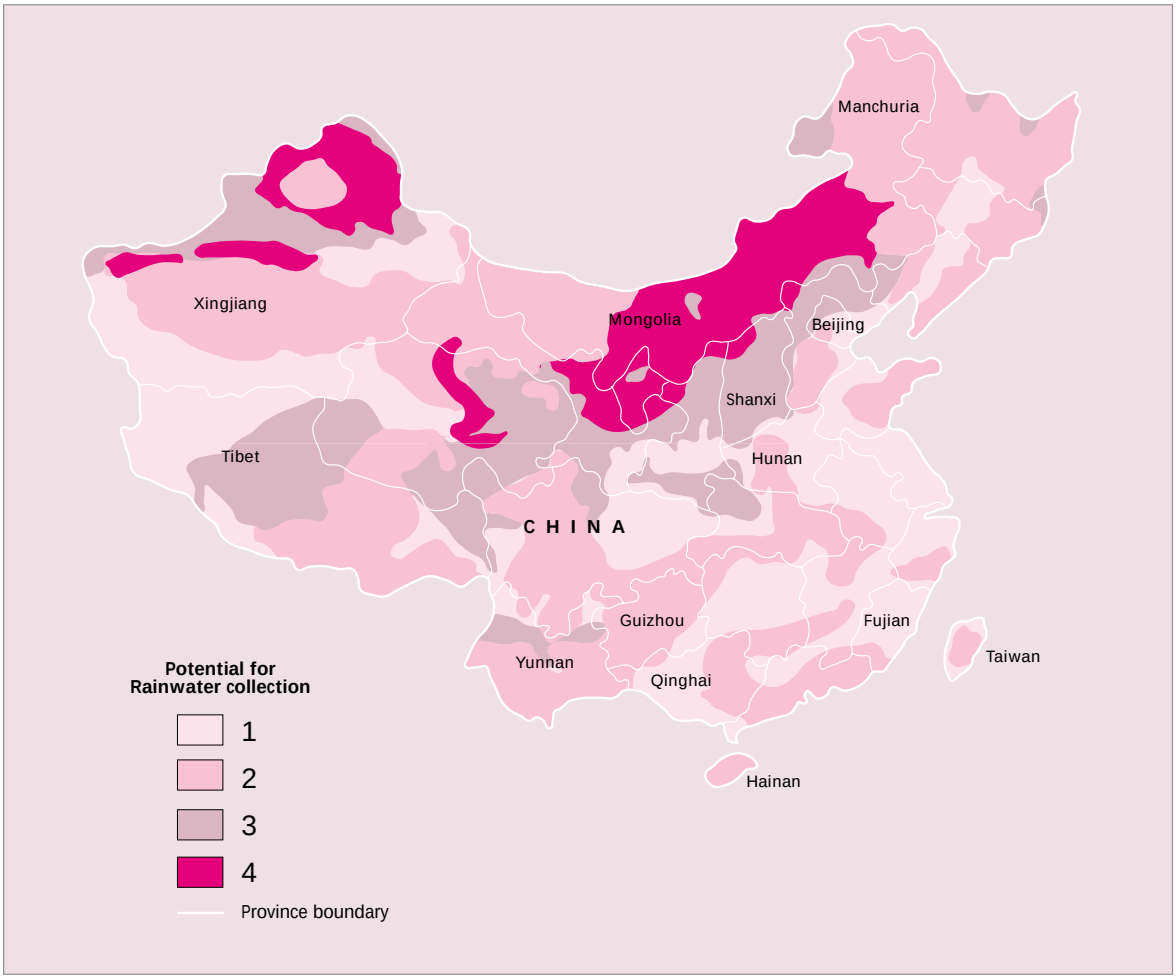
Rankings for rainwater harvesting demand according to topographic type (Rank 4: Highest priority)

Order	Topographic Type	Rank
1	Arid basin	3
2	Arid/Cold hill	3
3	Cold plain	1
4	Cold plateau	2
5	Cold/Humid hill	2
6	Cold/Humid plateau	2
7	Desert/Grassland (Prairie)	4
8	High mountain	1
9	Humid basin	1
10	Humid/Warm hill	2
11	Humid/Warm island	2
12	Humid/Warm mountain	3
13	Low plain	1
14	Semi-arid plateau/Hill	4
15	Semi-humid hill	3
16	Semi-humid prairie	4

ANIL AGARWAL / CSE

The many faces of water: This lake in Xian serves as a popular tourist spot

Map: Prioriting national areas for water harvesting
Potential rainwater collection demand area in China by order of priority (Rank 1: Highest priority)



developed a self-running irrigation system next to the Yellow river, and rain-water harvesting is not necessary for irrigation. The second exception is He-tao irrigation region in the middle of Inner Mongolia. The third exception is the bottom of Zhunger Basin — an arid, thinly populated desert.

The second rank areas of rainwater harvesting are the northern and western parts of Hebei, Shanxi, Ningxia, Gansu, east part of Qinghai, eastern top of Inner Mongolia, areas around Tian Mountains, the middle part of Tibet, part of Yunnan and Guizhou. These areas are either relatively arid or hilly or both. All of these areas are relatively poor and undeveloped. Water resource shortage has been blamed for their underdevelopment. So rainwater harvesting will be an important way for these areas to develop their economy and improve peoples' lives.

The third rank areas are spread over the low humid and semi-humid regions of the country. Parts of these areas also receive heavy rainfall but still face water shortage because of the uneven distribution of precipitation among seasons and the effects of topography. The rich rainfall season may not match with the growing season of grains and the mountains and hilly grounds cannot hold the rainwater efficiently. In these areas rainwater harvesting is still important for a better harvest. These areas cover most of northeastern China, hilly areas of east China and mountain areas of southwest and northwest China. An obvious feature of these areas is that they include the major forest areas of China.

The fourth rank areas are where rainwater use is not encouraged. It only indicates that there is no condition or no need for rainwater harvesting in this area, for example, arid deserts and cold, high mountains. Or,

these are areas where the surface water or groundwater is rich, for example, Sichuan basin, Volley plain and deltas of Liaohe, Hai-luan-he, Yellow, Huaihe, Yangtze and Pearl rivers. The fluvial plain has a low demand potential for rainwater harvesting, especially in South China. These areas are humid and relatively flat and have access to concentrated water sources.

121 PROJECT IN THE LOESS PLATEAU[1]

Since the end of the 1980s, rainwater catchment and utilisation (RWCU) has made rapid developments in the loess plateau — north Shanxi province, Northwest Shanxi province and Tienshui and Dingxi counties of Gansu province — and hilly areas located in northwest and north China. This is one of the driest and poorest areas of China with an area of 62.7 mha. In this area runoff and groundwater is scarce and water resources available per capita are only 540 cum, one–fifth of that in the country. The topography is unfavourable for water diversion from the river to the land. Ravines and gullies and the high altitude of land make water conveyance systems and irrigation networks almost impossible to build. Agriculture in this region is mainly rainfed. Although the annual precipitation reaches 440 mm on an average, its distribution is very uneven and drought occurs frequently. In a dry year, the yield cannot even compensate the seeds. The people lead a poor life. The annual income of a family is as low as US $250-300. Moreover, most of the people in the region have suffered from thirst for centuries. In most years, the government has to despatch trucks to transport drinking water. In the winter and spring time, many animals die because of lack of drinking water. Water shortage is the root of poverty.

The Ninth Five Year plan set up an objective to eradicate poverty before the year 2000 for 65 million people. To realise the above target, the key measure was to change the water condition. The only potential water source in this area is rain. It is estimated that on the total land of the loess plateau, the annual precipitation amounts to 275,700 mcum which is more than eight times the flow of the Yellow river at the Lanzhou section. However, utilisation of rainwater faces very unfavourable conditions. Firstly, rain in this semi-arid area is mostly small rain, which cannot produce runoff on a natural soil. Secondly, the deep layers of loess soil have a high vertical seepage coefficient, so most rain infiltrates into the soil and then evaporates. Finally, a large part of rain cannot be used owing to the uneven temporal distribution patterns. It is estimated that only 5-8 per cent of precipitation can form runoff, about 15-20 per cent is absorbed by the crops, and the remaining 75-80 per cent is lost without any use.

ANIL AGARWAL / CSE

The 121 Project in Gansu: Rain falling on this roof is carried to a tank underneath and a solar heater can be used to improve its quality

Local people here have a tradition to use rainwater as their drinking source, which can be traced to a thousand years ago, but the total water harvesting is so low that the problem has not been solved. Under the support of the local government, the Gansu Research Institute for Water Conservancy has carried out systematic experiments on RWCU and set up numerous demonstration projects since 1988, which aim at supplying water for drinking and courtyard irrigation. Several types of materials for the harvesting catchment were tested to find out the rainwater catchment efficiency (RCE) versus the characteristics of rainfall and the moisture in the material before rain. A new RWCU system composed of a catchment field that is hardened or treated for anti-seepage, water storage, water supply and irrigation facilities and their design procedure has been suggested. A special kind of tile made of cement mortar on the roof and concrete slab in the courtyard as the water harvesting field were found to be the most optimum. Underground water cellar and kiln (similar to a cave dwelling used in northwest China) with cement mortar or concrete lined inside were recommended to replace the old storage. It was proved that RCE of the new system can be increased by 10 times as compared to the old one. Testing and the pilot projects gave successful results in an area with annual precipitation of only 250-400 mm.

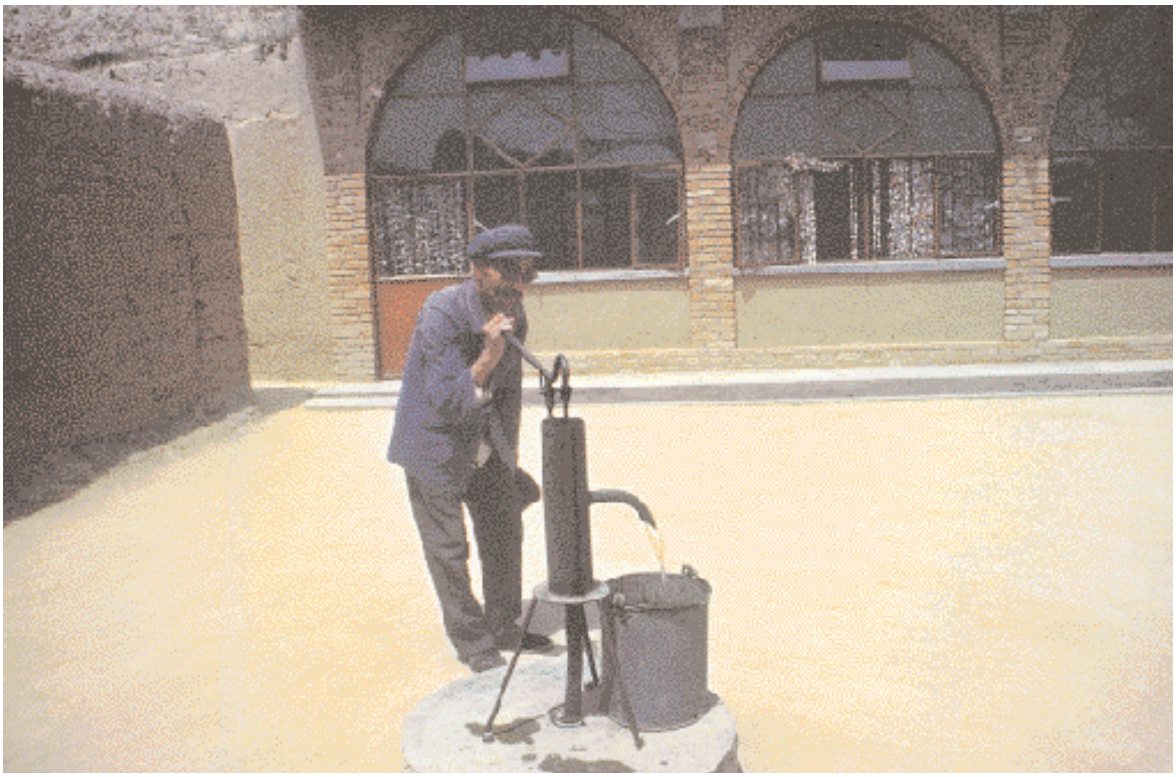
By the end of 1994, in the loess plateau of Gansu province, 40,000 family-based RWCU systems had been built. **In 1995, a once-in-60-years drought year occurred but families having a RWCU system got sufficient water to drink while other families had to rely on government rescue trucks.** On the basis of this successful experiment, the Gansu provincial government decided to carry out the '121' project, namely, to support each family to build one rainwater collection field lined with anti-seepage material, two storages each with a capacity of 15-20 cum, and one piece of land for planting cash crop or fruit trees. From 1995-1996, a total fund of US $12 million was raised, which helped 200,000 families with one million people, build their own RWCU system. The project not only solved the drinking water problem that had puzzled the local inhabitants for generations, but also created a better living environment. Moreover, farmers now can irrigate a cash crop of fruit trees in their courtyard to increase income. Total area of courtyard irrigation using a rainwater catchment system amounted to 10,000 hectares (ha) by 1996 in the loess plateau of Gansu province.

A follow-up project aimed at improving dryland farming by using rainwater has been carried out in neighbouring areas such as Ningxia Hui and Inner Mongolia Autonomous Region. In Ningxia, in the autumn season of 1995, 16,000 water cellars were built to store rainwater for next spring irrigation. In Inner Mongolia, from 1995 to 1996, pilot projects, including 1,584 water cellars, were built to irrigate 386 hectares of land for 1,452 families in 32 villages. In the project, people use highways, country roads, threshing yards and sometimes artificial seepage-controlled fields for water harvesting. The water storage is of the same type but of a larger volume, from 30-50 cum. Owing to the very limited amount that can be harvested by the RWCU system, the water is used in a judicious way. Highly efficient but very cheap irrigation methods have been adopted. For example, during seeding, a water tank installed on the seeding machine supplies water in the seed dibbles. During the growing period, dibble irrigation is also adopted. Plastic film covering is another technique adopted to save water. Furrows or land is covered with plastic film with holes for the plant. Irrigation water flows into the holes and is kept under film to prevent evaporation. Sometimes, water flows in the furrow under the film without holes. If a farmer can get support from the government or a loan from a bank, then a movable pipe system for drip irrigation is also adopted.

Another water saving technique is to adopt the concept of supplemental irrigation and limited irrigation. Usually, from July to September, sufficient rain is available to meet the water demand of the crop. Normally, two or three applications at the critical stage to mitigate water deficit are enough for most crops to get satisfactory yield. For maize, experiments showed that the optimum time for irrigation is at seeding and early earring stage. The RWCU irrigation project has had miraculous results. An experiment carried out in Ningxia during 1984-1995 showed that supplemental irrigation for spring wheat increased the yield by 19-29 per cent. Good results have also been found with maize and melons. By using the RWCU technique, four demonstration families got a yearly income of US $700 on average, doubling the income earned before the project.

Another study reported that in the semi-arid Jingmucha village with a population of 274 in Gansu province, the RWCU project harvested 12,760 cum of rainwater for irrigation in 1995, which increased grain production by 27.25 tonnes valued at US $6,566. This means that each cubic metre of harvested rainwater can produce 2.1 kilogrammes grain, which is very significant for farmers living in such a poor area.

In the semi-humid and humid areas of southern China where a seasonal drought often occurs, RWCU has again made big progress. In Xuzhou, east China, the natural river and artificial channel were widened and deepened and linked with reservoirs and ponds to form a network for retaining rainwater. The controlled rainfall runoff has increased from 348 mcum in the 1980s to 600 mcum by the middle of 1990s to ensure irrigation water. In China, there are 433 islands inhabited by 4.53 million



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The 121 Project in Gansu: Rainwater stored in an underground tank being drawn with a handpump. The courtyard is used together with the roof to collect rainwater

people. Most of the islands and the coastal areas have a yearly precipitation of more than 1,000 mm. However, owing to the steep slope and local geological conditions, the natural water storing capacity is very low. Freshwater supply is a big problem. People have to transport water from the mainland by boats and the water cost is very high. Since the 1980s, people have built water tanks to collect rainwater from roofs for domestic and industrial use and have proved to be successful.

The RWCU System

The RWCU system is one kind of rainwater utilisation (RWU). It is well known that all kinds of water in the earth are derived from precipitation. Any water resource project thus uses water only from rain can be included under RWU. However, an RWU project denotes the use of rainwater in its original form or in the initial stage of transformation from rain to runoff, groundwater and soil water. It may be called as the primitive use of rainwater. There are many types of RWU which can be divided as follows:

- Measures to raise the efficiency of soil water use in rainfed agriculture, such as deep plough, harrowing and raking, soil-surface plastic covering to conserve moisture, inter-ridge ditch cultivation covered with plastic to concentrate runoff, etc.
- Soil and water conservation techniques including terracing, contour line ditching, fish-scale pits and small watershed management.
- RWCU is one kind of micro-water resources project which collects, stores, regulates and uses rainwater under artificial and/or natural conditions. It can be used to solve drinking water problems and to develop courtyard economy and small plot irrigation using water saving techniques.

The RWCU system is usually composed of three parts, namely, rainwater collection sub-system, storage sub-system and water supply and irrigation sub-system and agriculture facility.

Rainwater Collection Sub-system

Rainwater collection fields can be of the following types with different collection efficiencies *(see Table 5: Collection efficiency):*

- ***Roof:*** The roof is the most common water collection field for drinking water. The most commonly used roof is tiled. Recently, in Gansu, a new tile made of cement mortar has been developed. It has the advantages of high rainfall collection efficiency (RCE) and low price.

Table 5: Collection effeciency

The efficiency of rainfall collected using various types of materials in different frequency years in regions with different annual precipitation (unit: percentage of rainfall)

Annual precipitation	Frequency (%)	Concrete	Cement-soil	Buried plastic film	Compacted loess	Cement tiles	Clay tiles machine-made	Clay titles hand-made
400-500 mm	50 75 95	80 79 76	53 51 42	46 45 36	25 23 19	75 74 69	50 48 39	41 38 31
300-400 mm	50 75 95	80 78 75	52 46 40	46 41 44	26 21 17	75 72 67	49 42 37	40 34 29
200-300 mm	50 75 95	78 75 73	47 40 33	41 34 28	20 17 14	71 66 62	41 34 30	34 28 24

- ***Concrete lined surface***: In a semi-arid area, when water collected by the roof is not enough to meet the demand, then concrete slabs in the courtyard with a thickness of 30-40 mm can be used, whose RCE can be between 0.75-0.80.
- ***Cement-soil lined surface***: When gravel and sand is not available locally, cement-soil, a mix of cement, water and soil can be used to replace concrete.
- ***Plastic film***: A plastic film can be used in two ways: exposed or covered with sand or soil. The former has very high RCE but gets easily damaged. The latter protects the film but the efficiency is lower (0.45).
- ***Compacted soil***: This is the cheapest field but with a low efficiency (0.15-0.25) and short life.

Selection of the field should be according to the local condition. For RWCU system aimed at the drinking water problem, roof and concrete surface in the courtyard are recommended. For RWCU irrigation, the existing, less permeable fields such as a paved highway, road, or threshing yard can be used. When irrigation is for a high value crop, then use of plastic film or concrete could be feasible.

The area of the field is determined by the water demand and RCE of material used. For domestic use, in rural areas, a quota of 20-40 litres is adopted for daily consumption of each person. In an extremely dry year and/or arid area, a lower quota could be used. For instance, for the 121 project in Gansu province, a daily quota of 10 litres in a normal year and six litres in an extremely dry year was suggested.

Storage sub-system

The following types of rainwater storage systems exist in China:

- ***Water cellar***: A kind of underground water tank that fully uses the self-sustaining feature of the soil. The soil inside the cellar is drawn out without taking away the top soil. Inside the cellar, to avoid seepage, a thin layer of cement mortar is used on the wall. The cellar capacity ranges between 15-50 cum or even more.
- ***Water kiln***: The shape of a water kiln is similar to a dwelling cave commonly used in northwest China. In most cases, a kiln is usually excavated at a precipice without taking away soil of the upper layer. Inside the kiln, a masonry or concrete wall and arc roof are built to support water and overburden pressure.
- ***Water tank***: One kind of tank is an underground tank whose shape is similar to a water cellar but different in excavation method and the inside structure, for which thick concrete or masonry wall is used. Another type of tank is built in a building which has a capacity of around five cubic metres.
- ***Water jar***: This is made of steel mesh reinforced cement mortar of 20 mm thickness. Water jars are very popular in the coastal areas of south China, especially in Zhejiang province.
- ***Pond and reservoir***: This is the simplest and cheapest system in terms of cost of unit storage. However, it has a high evaporation rate in semi-arid areas.

The accurate way to determine the storage capacity of an RWCU system is to conduct a computer simulation model with a long series of precipitation data and the water use history curve. However, it is not usually necessary to use such a complicated method for a small RWCU project. Some simplified methods have been recommended. The storage capacity can be calculated by multiplying the daily water use with the number of days in a dry period that can be taken as 100 in south China and 180-240 in the north for drinking purposes. Another method is to multiply the yearly water amount by a coefficient that can be roughly taken as 0.5-0.8 for drinking water projects and 0.4-0.6 for irrigation projects.

Water supply and irrigation sub-system

In China, for the water supply sub-system, a handpump is commonly adopted and has proved to be good and affordable by the farmer. For irrigation projects, simple and appropriate methods such as hole irrigation, dibble

irrigation together with irrigation (especially the furrow) under film cover, and other such measures, have been found to be useful. With the support of government, semi-stationary drip and seepage irrigation methods have been widely adopted.

HARVESTING RAIN IN TAIHANG[3]

Rainwater harvesting is a traditional technology around the Taihang mountain. But rainwater utilisation techniques have been further updated and developed here. Measures in the treatment of catchment fields and control of rainwater have been adopted to develop runoff agriculture and runoff reforestation.

The experimental area is located at the juncture of the north China plain and loess plateau. The climate in this area is of two types, namely, semi-arid and semi-humid continental monsoon climate. It is characterised by little snow in the winter and much rain in summer. The annual precipitation ranges from 400-600 mm, 67.8 per cent of which falls in the period from June to September. The yearly potential evaporation reaches 1,934 mm.

Soil thickness ranges from 200-500 mm. Its water holding capability is low while its conductivity is high. Water storages are the main constraint for the development of agricultural production and improvement of people's living conditions. It is estimated that rainfed agricultural land amounts to 0.44 mha, 79.8 per cent of the total cultivated area, and has low yield owing to frequent droughts. Besides, there are 1.05 million people and four million animals lacking drinking water supplies. Rainwater is the only potential water source in the area. Development of the rainwater resources will play a very important role in agricultural production.

Following rainwater utilisation techniques have been adopted in the Taihang Mountain area:

Rainwater harvesting using roof and courtyard: In this system, the roof and courtyard are used to collect rainwater for domestic use. The roof area of a normal household is about 150 square metres (sq m). The average runoff coefficient is about 0.75. In a normal year, it can collect 80 cum rainwater to meet the water demand of 4-6 people and 1-2 big animals.

Rainwater harvesting using natural slope: The natural slope is used to collect rainwater for irrigation of crop and cash plants. The system is composed of natural slope for rainwater catchment, ditches for water collection and a cistern for storage. Sometimes, the slope is treated by compacting the surface, chemical spraying or by covering it with plastic film. The runoff coefficient for the treated surface can be increased from 0.3 on the natural slope to 0.48, 0.65 or 0.67, respectively.

Rainwater harvesting on bare rocks: This type of rainwater harvesting is mainly distributed in areas of calcareous sandstone and slate. Large bare rock is used as a rainwater catchment field. Rainwater is collected in pools or ponds for irrigation use. The pool is cylindrical or cubic in shape with a depth of three metres and storage capacity of 10-1,000 cum. The bottom and sides of the structure are lined with cement mortar in hilly areas and with soil, cement and lime mixtures in the plains. The inlet and outlet are built on the side of the pool.

Rainwater harvesting using road as catchment: The road surface is used to collect rainwater for irrigation of crops and cash plants. It is composed of a collecting ditch and storage pool or cistern. Roughly speaking, 100 sq m of asphalt paved road can collect 40 cum of rainwater while the same area of sand-gravel road can collect 30 cum of rainwater.

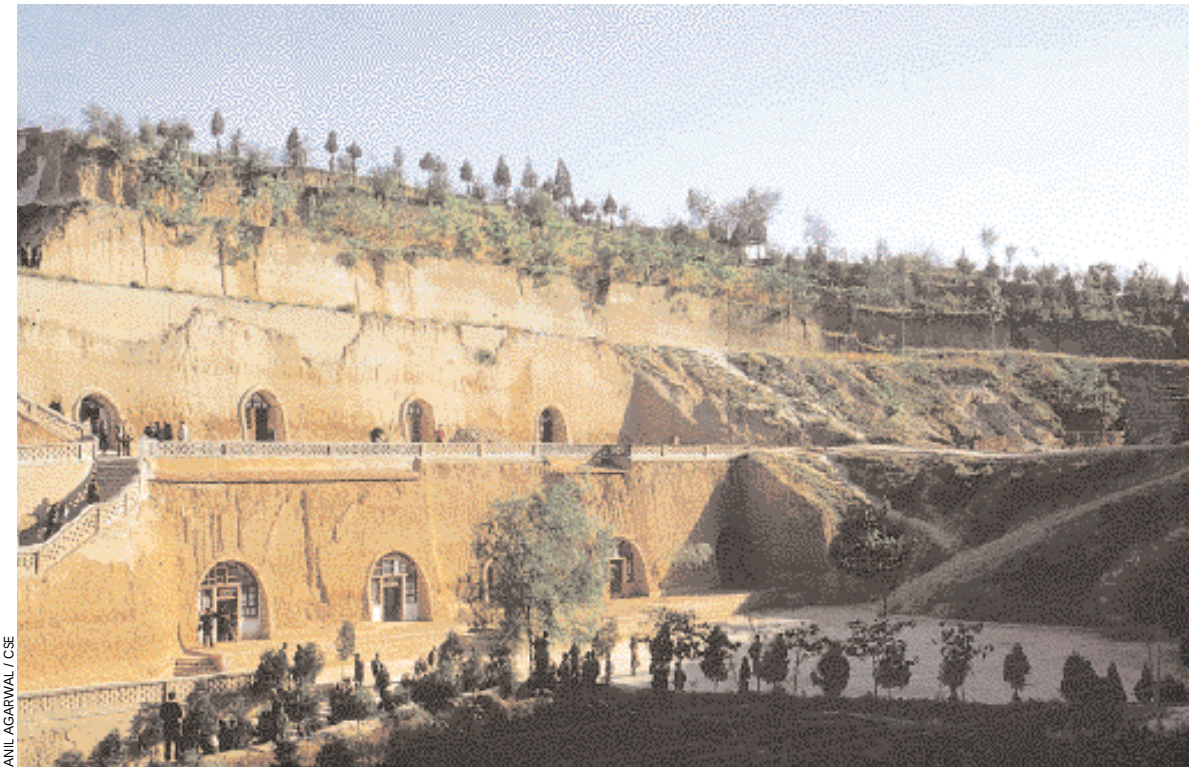
Harvesting of springs and submerged flows: These projects are mainly where many springs and sub-surface flows are widely distributed. Pipelines divert the scattered springs and the submerged flow is retained by concrete underground dams and then directly used for irrigation or stored in pools for irrigation and drinking purpose. Although there is little spring water, averaging a daily output of three cubic metres, it can be stored for irrigation of 0.4-1.2 ha of farmland.

Weir pit and pond: In these systems, runoff is stored for irrigation by weir, pit or pond in a valley or gully. Usually, no complicated seepage control measures are needed. The normal storage capacity is less than 10,000 cum, enough for agriculture, animal care and drinking purposes.

Pits are usually constructed in the granite-gneiss area where the soil has a strong penetrating capability and rich submerged and basic flows are available. Pits in the main gully with round or cubic shape, 3-10 m in diameter and 10 m in depth, are excavated and lined with cement mortar. They are mainly for storing runoff and submerged flows for irrigation and domestic use.

The pond is for retaining flood flows with a capacity of 10-100,000 cum for irrigation. In seasonal rivers with a large flood, both in total amount and peak discharge, the diversion dams and channel systems are constructed to distribute the runoff into many connected cisterns or convey water directly for irrigation.

Rainwater harvesting in a microwatershed: A water collection field with a relatively large area is used to produce water, which is stored in a reservoir or cisterns and then delivered by channels or pipes to meet irrigation and domestic water use. The water collection field is treated according to the economic condition. The



ANIL AGARWAL / CSE

Coping with the inhospitable terrain in northwest China, people sometimes live in caves cut into hill slopes

respective rainwater harvesting systems can also be connected to form a large runoff agricultural system.

Micro-runoff reforestation: The micro-runoff reforestation, also called on-the-spot irrigation system, includes a terrace with slope in between and terrace with an inverted slope, contour planting, and a fish-scale pit and contour ditch. The water collection field is built for a single tree or a tree group without water storage and conveyance facilities in common. Rainwater is stored in the soil by increasing infiltration and improving soil properties. Economic trees are planted along a contour line and their water requirement can be met by concentrating rainwater from a slope.

Impact on the hydrological cycle

The Taihang Mountain, located in the upper reaches of the north China plain, is an important water source for water supply to Beijing, Tianjin, Shijiazhuang and other big cities as well as for agricultural requirements of the plains. Rainwater utilisation for agriculture and forestry development has produced great social and economic benefits. Experiments on the reforestation of the sunny slope of Taihang Mountain by the Shijiazhuang Agriculture Modernisation Institute showed that the production value of each hectare could reach US $3,600. *Large-scale water harvesting, especially seepage control on a large slope, does not reduce the water flow downstream.* Artificial rainwater harvesting is mainly to stop rainwater from evaporating. Evaporation is very intense in north China due to the dry climate.

According to the rainwater catchment experiments conducted in Taihang Mountain, a natural slope usually does not produce runoff in the case of rain with normal intensity. Runoff is only formed on the southern slope when rainfall reaches more than 40 mm and has a certain intensity. For example, rainfall of 20 mm can only moisten 40-60 mm of the upper soil layer, while the daily potential evaporation usually is 6-8 mm, even upto 10 mm. It takes only 3-4 days to exhaust the moisture. It is apparent that small and medium rain will be consumed by evaporation if it is not collected. Secondly, the rainwater catchment area accounts for 20 per cent of the total watershed and the anti-seepage treatment only occupies about 10 per cent of the slope area. So rainwater catchment will not have a significant influence on river runoff. Furthermore, most treated slopes collect water for runoff reforestation, which will, in turn, improve soil moisture and benefit groundwater recharge. Thus, river runoff in the lower reaches will not decrease.

Impact of reforestation on hydrological cycle

Generally speaking, evapotranspiration from a forest is 22 per cent and 30-40 per cent higher than that in a cultivated field and in barren land, respectively. A recent experiment with runoff reforestation showed that although the evapotranspiration from trees increases, the soil evaporation decreases. In an experimental area of *Robina pseudoacacia.* forest with 416 mm of precipitation, a ten year test showed that evapotranspiration by trees increased to 60 per cent after slope treatment as compared to 30-40 per cent in the traditional case while soil evaporation and other losses reduced it to 40 per cent. It is also apparent that the increase of tree consumption comes from the inefficient evaporation.

According to a runoff reforestation experiment in Taihang Mountain, the forest density is determined by the following equation:

$$(D-d)/d = (CM + M-m)/m$$

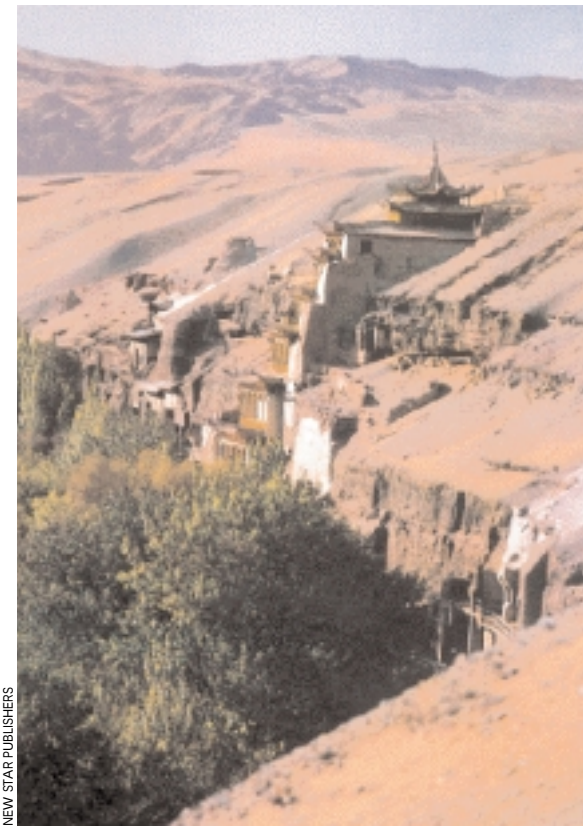
where, D: distance between tree belts (m)
d: width of rainwater catchment area
C: test parameter
m: annual rainfall (mm)
M: forest water requirement (mm)

Based on the above equation, forest density is determined by the water requirement of a vegetation community in a natural distribution. Therefore, evapotranspiration of vegetation will not have a negative influence on downstream water flow. Rational distance between forest belts is 6-7 m according to the above equation. This means that even a dense planting within the belt can only be an open forest, for which evapotranspiration would be small. Besides, the tree belt with higher water consumption is in a small area, only one-sixth of the area between the belts. The soil evaporation from five-sixth of the area will be reduced with evapotranspiration increase in the other one-sixth area. So it can be seen that even if the entire slope is used for reforestation, the total water consumption will not increase. The reduction of water flow in the lower reaches is out of the question.

Problems and prospects

With the rapid increase of population and economy and progress of technology, more and more people will start rainwater harvesting, which means a further control of the hydrological process by human beings. Around Taihang Mountain, rainwater harvesting was mainly concentrated in the area of calcareous sandstone where water shortage is more serious. However, it will be necessary to develop runoff agriculture and runoff afforestation suitable for the whole Taihang Mountain area, given the dry climate and water scarcity in agriculture and forestry as well as for drinking water supply. To ensure that the low annual rainfall of 500-600 mm in the area with uneven distribution meets the water needs during the whole year, further developments in rainwater harvesting systems are required. The problem in popularization of rainwater utilisation techniques is the relatively high cost of construction. It is very critical to have cost-effective designs.

People still pay more attention to the water resources of rivers, lakes and groundwater and less attention to the widely distributed rainwater. In order to meet the increasing water demands of agriculture in the plains and industrial and domestic use in the big cities such as Beijing, Tianjing and Shijiazhuang, 22 big and medium reservoirs with a total capacity of 7,850 mcum and more than 400 small reservoirs and 8,000 ponds with a total capacity of 1,000 mcum were built in the area of Taihang Mountain. These reservoirs and dams already collect most of the surface runoff in a normal year and there is little potential of additional water resources from the rivers. Moreover, the rivers can only supply a certain area and groundwater is not available everywhere while rainwater falls on the whole area.



NEW STAR PUBLISHERS

The Mogao caves at Dunghuang in Gansu province

Therefore, rainwater utilisation is very important for the development of mountainous regions. It is the only way to deal with water scarcity and has a great potential and wide prospect in the Taihang Mountain area.

FUTURE OF RWCU IN CHINA[1]

Based on research and practices of RWCU in China, its future in China will be as follows:

- Progress in RWCU will probably lead to an innovation in the concept of water resources development in China. Though precipitation is the original form of all kinds of water resources, the term 'water resources' is generally regarded as the sum of river runoff and groundwater. These two parts only come from about 44 per cent of precipitation in China's continental landmass. We cannot forget the other 56 per cent. Water resources can be divided into two types. The *concentrated* type which has a high intensity of water flow rate in a short recovery period for replenishment, such as river water and easily recharged shallow groundwater and the *discrete* type which has a low intensity flow rate but covers a large area such as rainwater. The former is the object of large water projects while the latter can meet the decentralized water demand. While the former is always diverted to other places for use, the latter is mainly collected, stored and used on the spot. If the water flow rate of concentrated water resources is measured by unit of one metre per second, then one millimetre per minute can be used for *discrete* water resources like rainwater. It is clear that there is difference of 105 in order of magnitude. So it might be reasonable to call the former *strong* water and the latter *weak* water.

  Although the intensity of *weak* water is very low, it can be intensified by artificial concentration measures, including spatial and temporal aspects. The spatial aspect includes raising rainwater collection efficiency (RCE) and enlargement of the collection field. The temporal aspect includes retention of water during the flood period for use during a drought period, and to store water in the non-use period for the use period. With these measures, rainwater can become *strong* enough to become a necessary supplement to surface and sub-surface water. This is the process to turn rainfall into a usable resource. Many new ideas and methodologies of water resource evaluation and utilisation are needed to turn it into a mature discipline of water science.
- RWCU can bring a new orientation to water resources engineering. Modern water resources techniques are characterized by their large scale, huge capacity in water volume and power generation, etc. However, most of the population living in mountainous areas cannot get a direct benefit fom it because of the long distance, unfavourable topography and the high water cost. On the contrary, rainwater is available everywhere, easy to collect and use with low input. In despite of complicated topographical conditions, RWCU can be built at any place if a certain amount of precipitation is available. RWCU also has very little negative impact on the environment. Exploitation of extensively distributed rainwater is likely to become a new trend, a *growing point* of water resources development in China.
- RWCU can be a breakthrough for the development of dryland farming. In China, more than half of the cultivated land is under rainfed agriculture. In the past half century, scientists, engineers, agronomists and farmers have made great efforts to improve rainfed agricultural production. The key point in dryland agriculture is how to keep the soil moisture from rainfall as much and as long as possible. Measures include land-leveling, deep ploughing, harrowing, fertiliser application, mulching, sand or plastic covering, and soil and water conservation measure like building contour lines, fish scale pits, terracing (level terrace, terrace with inverted slope, terrace and steep slope in between), and small watershed management.

All of these help to retain soil moisture and increase yields. However, when demands on agriculture are increasing, people are finding that the role of traditional rainfed agriculture and soil and water conservation is limited, especially in semi-arid areas, where the rainfall is unevenly distributed and evaporation is high. The concept of RWCU is to reallocate rainwater for moisture supplementation in the critical stage, to concentrate more rainwater to the plant to meet the crop water demand. Progress of RWCU in China shows high yield, high quality and high value agriculture in specific local areas is feasible. ■

This paper is an edited version of the following papers:

1. Qiang Zhu and Changming Liu 1998, Rainwater Utilisation as Sustainable Development of Water Resources in China, paper presented at the workshop on water harvesting, Stockholm Water Symposium, Stockholm, August 10-13, *mimeo*
2. Haisheng Mou, Huilin Wang and Hsiang-te Kung 1999, Division Study of Rainwater Utilisation in China, paper presented at the 9th International Rainwater Catchment System Association Conference, Brazil, June, *mimeo*
3. Zhang Wanjun, Liu Zhijun and Cao Jiansheng 1999, The Prospects of Rainwater Utilisation in the Taihang Mountains, China, paper presented at the 9th International Rainwater Catchment System Association Conference, Brazil, June, *mimeo.*

Glimmers of Hope

While doomsday predictions warn about an impending global water crisis, small yet effective efforts to harvest rain in Southeast Asia offer a glimmer of hope

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In face of dire predictions of global water crises and unaffordable costs of large centralised water supply systems, it is important to look into systems that have been adopted recently to revive the practice of rainwater harvesting, where the emphasis is on simple methods. Efforts with Southeast Asia's poor rural communities have yielded good results. The mode of repayments of loans in some cases have been interesting — in kind — in the form of she-goats.

Water harvesting is as old as civilisation itself *(see Box: Revisiting history)*. Around the 1960s a revival of rainwater harvesting was started on a small scale in some Southeast Asian and other countries. A large number of rainwater collectors were established in Kenya, Tanzania, Botswana, Uganda, Zambia, Zimbabwe and other countries.[1–4] Developing countries in Asia were assisted to a great extent by non-governmental organisations (NGOs). Three countries in Southeast Asia — Thailand, Indonesia and the Philippines — made special attempts with the sole target of supplying drinking water to the people.

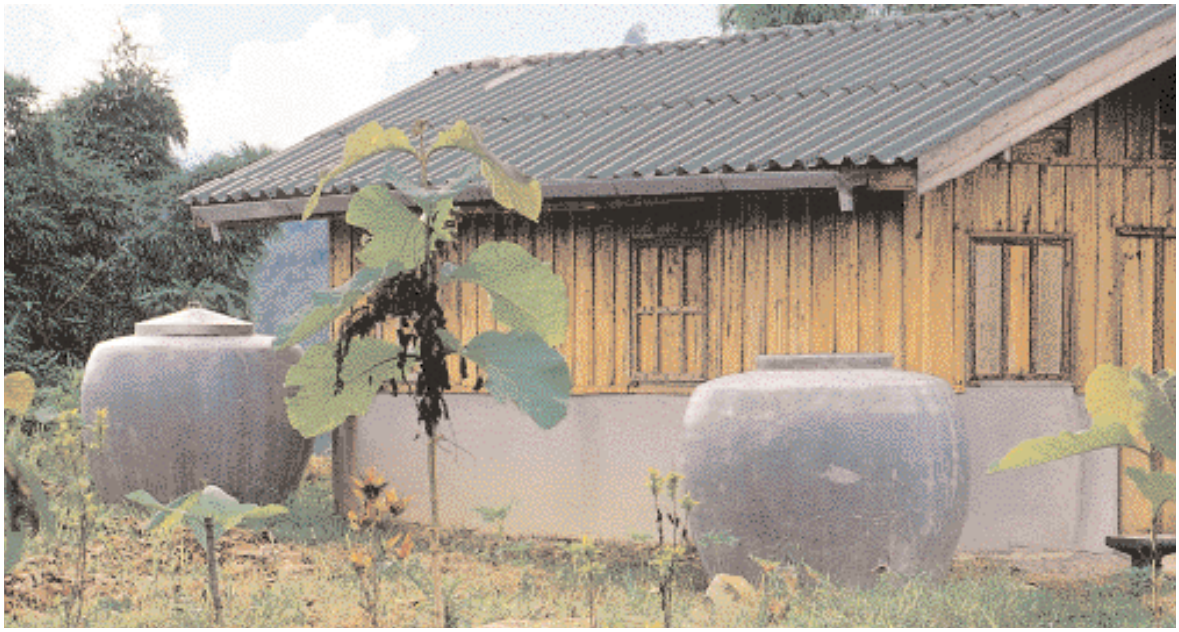
DOWNSIZING IN THAILAND

In the absence of foreign assistance, the Thai government looked at smaller options available for providing water and has not looked back since.

In the early part of the 20th century, planners in Thailand strove for a large-scale impact and resorted to elaborate systems involving big dams and reservoirs. Such systems, however, called for substantial foreign assistance which was not forthcoming. This led to the realisation that rainwater catchment systems, on a smaller scale, could be adopted because they were relatively simple and cheap and did not require imported material or expertise. From 1982, the emphasis shifted to providing clean drinking water for rural areas through shallow and deep wells and rain harvesting programmes. The allocated funds permitted a communal system to be executed either by village councils, foreign agencies, government or private organisations. One programme which was developed and implemented very successfully was by the Population and Community Development Association (PDA), a non-profit development organisation.

The operations carried out by PDA were well-defined.[5] The crux of this method was participation and training. The villagers were trained by PDA to carry out construction work for the whole village. The necessary labour was provided by other villagers. In fact, the willingness of the villagers to participate in such development projects was a crucial factor for successful implementation.

This scheme, with some foreign aid, proved successful and an elaborate construction programme was carried out 1983 onwards. Indigenous material like bamboo reinforced concrete were tried, reducing costs to almost half that of conventional steel reinforced concrete. The success of this scheme and the interest it generated amongst the rural population in dry areas was instrumental in spurring research on building materials, both conventional and unconventional. Building materials like plastic, steel, bamboo, bricks, interlocking mortar and ferrocement were tried out. The construction of cisterns was part of a village development programme. The costs of each of the units and repayments were quite low as indigenous materials were used. Besides, an appropriate fund collection system was worked out.



SUNITA NARAIN / CSE

Rainwater jars in a Thai household — holding the rain

Water quality studies of water harvested from different roofing materials as well as post-storage in different types of tanks revealed that the stored rainwater was clean enough for drinking, provided cisterns were well-maintained.

INDONESIA'S INTEREST

While promoting water harvesting in rural Indonesia in 1979, the prerequisites were simple: there should be no conflict with the way of life, the material used for cistern

REVISITING HISTORY

Ancient civilisations across the world revered rain

Most ancient civilisations evolved in cities that had vast hinterlands where water was available for irrigation and navigation. The use of rainwater collection systems is known to have existed in semi-arid and arid regions in the Negev desert in Israel 4,000 years ago, an area with less than 150 millimetres annual rainfall. Hillsides were cleared to increase runoff and contour ditches collected water for crop irrigation.[1] Underground storage volumes of upto 300 cubic metres (cum), enough for 10 families and their flock for a year, have been reported.[2]

In the Mediterranean area, rainwater collected from roofs and stored in cisterns was the principal source of water during the Phoenician, Carthaginian and early Roman times from the sixth century onwards.[3] Upto the 16th century, rooftop collection and storage was practised in Venice, and there is evidence to show that 177 public and 1,900 private cisterns held 665,000 cum of water to supply about 16 litres per capita per day.[4,5] In Iran, rain harvesting has been gaining considerable prominence and high levels of technology have been attained in the spreading of flood waters.[6]

In India, in the early Buddhist era, monks living in mountainous terrain like Elephanta Caves in the Bombay area and Udayagiri and Candagiri caves in Orissa had laboriously hewn intricate series of gutters and water cisterns in rock faces to provide domestic water supply throughout the year. Besides, the Chola and Pandya kings in the 7thand 8th century AD had constructed rainwater catchment tanks at many foothills.

In Thailand, the existence of rainwater harvesting and storage systems extend to more than 2,000 years, and there is evidence of an elaborate system of dykes built and utilised about 800 years ago.[7] In Indonesia, because surface waters and groundwater are brackish in the Kalimantan area, rainwater has been collected for several centuries.[8] In the Philippines, the use of rainwater is still being practised in the provinces as it is traditionally believed that it is safer than river water for household and human consumption.[9]

In Africa, rainwater catchment systems have been used for at least 2,000 years wherein rainwater was collected from thatched roofs in open jars.[10] In China, there are isolated instances of use of roofwater catchment systems in action but, largely, rainwater is used for irrigation purposes.

In Japan, the use of rainwater has always been a way of life. In most urban areas, rainwater is collected and stored in the basements and subjected to some form of treatment. In cities which are prone to earthquakes, rainwater is collected and stored for firefighting when normal supplies are disrupted.[11]

construction should be locally available, and the design should be within the villagers' technical capability.[6] Bamboo reinforced concrete and ferrocement cisterns were standardised and a method of most effective construction using community participation was developed.

The general *modus operandi* of implementing roofwater collection systems by getting the villagers to be involved was similar to that in Thailand. A non-governmental organisation called Dian Desa was involved in the project. Realising the great importance placed by villagers in Indonesia on the value of working together, Dian Desa got involved in the Gunung Kidul area ensuring local community participation to develop technical skills. They took into consideration local lifestyle, tradition and opinion on water consumption and ensured that project schedules matched local time constraints. They also ensured that technical skills and maintenance know-how was transferred to the community.

Great emphasis was placed on the interaction of Dian Desa's field officers with the villagers. The village head and government officials were normally requested to take part in the activities. Surveys were carried out and discussions held to determine the type of technological changes that were feasible and most appropriate for each village. A very important element in this model is that the recipients were chosen by identifying the 'poorest of the poor' in the region.

In the method adopted to build the tanks, initially an indigenous material (instead of sand), stone and cement were used. Skilled labour and cement were supplied and local people participated fully by providing labour. Following this, in 1978, ferrocement tanks were constructed but finding them cost-prohibitive, bamboo reinforced concrete tanks were introduced in 1979.

In the implementation stage, the field workers trained the villagers to build their tanks. The villagers with the right ability and aptitude were given extra training and recruited as local cadres. When the next set of tanks were being constructed, these cadres trained other villagers and, thus, the core of cadres was enlarged.

The financing aspect of the schemes was quite unique due to the limited funding from external sources and the very low economic status of the borrower. Two she-goats were loaned to the family. When these bore (normally) four young ones, two of these were returned to the owner and the other two belonged to the borrower. The borrower then looked after the two young ones and when they had grown up used them as payment for the water tanks.[7]

THE PHILIPPINES ADVANTAGE

Water harvesting in the Philippines was promoted with the backing of the experience gained from Thailand and Indonesia. The proposed method was a 'total approach' — to build technically sound roofwater collection systems taking into consideration socioeconomic and cultural considerations.[8,9] The primary step taken was to select the most appropriate location. The province of Capiz, which is in Panay island and lies in the southern half of the Philippines, was selected as only brackish water was available there. The average rainfall was 1,700 millimetres and the area of the province was 0.26 million hectares, having a population of 0.49 million.

Three pilot locations were selected based on earlier investigations each having different topographical conditions, together representing 30 per cent of the province. In each of these locations, 10 ferrocement tanks were installed and the rainfall, water-use pattern and quality of rainwater monitored.

Before implementing the scheme, two officers from the proposed project team were sent to Thailand and Indonesia to study their methods and check on the extensive use of ferrocement which was not only cheap but also easy to handle by non-technical personnel. Local officials and influential people were contacted at *barangay* (village) level. Meetings were held with residents to solicit their support and participation. A household survey was done to get baseline information on demographic characteristics, annual income and expenses, water consumption per day and general water use habits. This was done with the sole objective of ensuring that village groups involved would acquire the skills for constructing, installing and, subsequently, maintaining their own tanks.

The tremendous potential for establishing such collection tanks in Capiz warranted a design that would be easy to construct using locally available or trained skills and, preferably, using local building materials. Accordingly, only two sizes (five cubic metres (cum) and 16 cum) were selected, analysed, constructed and tested. The relevant methods of construction and details were made available to the potential user and, to ensure proper transfer of technology, two of the project officers obtained the necessary training from the designers.[10]

Installation of the tanks was completed in early 1988. Following the completion of the 30 tanks, constant monitoring was carried out with respect to rainfall pattern and water quality. Health education was imparted to ensure that water use was not mismanaged and that the quality was not affected by poor collection methods.

Since the villagers were poor and had obtained the basic material for construction, they were asked to get their suggestions on the most suitable repayment method. They were in favour of engaging in hog-raising where the project authority provided the piglets and basic training on how to care for them. This proposal was very much akin to the Indonesian 'two she-goat' system policy which had given excellent results.

During the period of construction of these 30 tanks, many villagers constructed their own tanks. A total of 600 additional tanks were built. ■

Redeeming Negev's Heritage

Israeli scientists have revived agriculture in the Negev desert using ancient water harvesting practices after a gap of 1,300 years

Anant Gogte
Gram Vardhini, Pune, Maharashtra

The Negev desert in Israel lay uncultivated for 1,300 years from the 7th century AD onwards, until Israeli scientists reconstructed the ancient agricultural farms during the 1950s harvesting the area's meagre annual average rainfall of 100 millimetres (mm). Trees and plants that used to be raised in the Negev in the past were once again raised successfully.

The Negev is situated in the south of the country and covers an area of 1.25 million hectares (mha). Summers are hot and dry, extending over 7-8 months from March to October, while the winters are cool. Rainfall is sporadic and irregular, varying from 25 mm in a drought year to over 200 mm in a good year.

The Negev was densely settled by the Israelites under Solomon and the Judean kings in 1000 BC, marking the beginning of a period when desert agriculture flourished. It came to an end in the 6th century BC. The Negev was deserted until the 3rd century BC when the semi-nomadic Nabateans came from southern Arabia and settled there. They brought merchandise from India to the east of Damascus, Athens and Rome and built fortresses and cities at Avdat, Shivta and other places in the Negev to protect their trade routes. They practised agriculture around these cities to supply food to passing caravans, reusing the remains of old Israelite farms. In 106 AD, the Romans occupied the Nabatean empire, but agriculture in Negev continued to flourish.

MAXIMISING MEAGRE RESOURCES

Farmers in ancient times used a technique called runoff farming which made it possible for them to cultivate the desert with only 100 mm of rainfall. The soil of the Negev has the property of clogging and forming a thin crust on the surface as soon as it gets wet, turning impermeable to water almost immediately. As a result, the initial infiltration rate of 17-18 millimetres/hour (mm/hr) soon drops to 2-3 mm/hr. When the precipitation is more than three millimetres per hour, the excess water flows over the soil surface as runoff, which is then used for irrigating the crops.

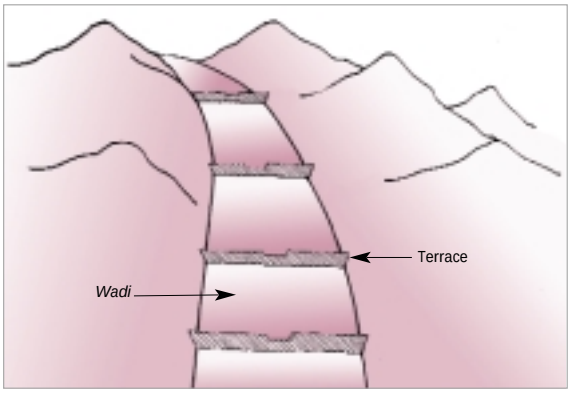
The intensity of rain is more important than the amount of rain to create a runoff. A cultivated plot needs a catchment area 20-30 times its own size to get enough runoff for growing one crop. For example, consider the annual rainfall to be 100 mm and the catchment 20 times larger than the cultivated plot. If 75 per cent rainfall is lost due to infiltration and evaporation and only 25 per cent runoff is actually generated, then the plot receives 20 x 25 = 500 mm of runoff, in addition to 100 mm of direct rain. This quantity of water is enough for one cropping season.

Depending upon prevailing conditions, three different water harvesting systems were constructed on dry river beds known as *wadis.* In its simplest form, the *wadi* was divided into a series of terraces by building horizontal stone walls across it. These terraces retained part of the floodwater and the excess amount flowed into successive fields below *(see Fig 1: Terraced harvest).*

In the second system, where terraces were unable to withstand the strong river currents, diversion dams were built across the river bed to raise the water level high enough to enter adjoining channels, leading to terraced fields built on adjacent floodplains**.**

The third and the most common method of rainwater harvesting was the conduit channel system, linking a group of terraced, cultivated fields to their catchment areas located on the slopes of surrounding hills. The terraced fields were normally located on the beds of

Fig 1: Terraced harvest
Terraces were built across *wadis* (river beds) to retain water and allow the excess water to flow to the next field



small tributaries, dispersions or floodplains. The slopes had channels which ran diagonally along the hillsides and emptied the runoff into the fields *(see Fig 2: Terraced network)*.

Terrace walls were 300-500 mm high and built with 2-3 rows of stones. The distance of one wall from another was about 15 metres (m), which also defined the size of the terrace. The stone walls had spillways to give way to excess water. The spillways had stone staircases which led the water to the lower terraces without causing erosion.

The depth of soil in the fields was 2-3 m. When the fields were flooded, water stood at 300 mm over the surface and then infiltrated the soil within 2-3 days. Experiments have shown that one millimetre of water is able to wet up to 8-10 mm depth of soil. Thus, a 300 mm of water column would suffice to saturate 2-3 m of soil in terraced fields which is sufficient to grow crops.

Traces of the old agricultural practices can still be seen in the Negev. The hills here are covered with stones and prevent the formation of a complete crust when it rains. Besides, the stones retain some water which then infiltrates the soil. These stones were deliberately collected together to either strengthen the channels or heap them into mounds which are still visible in some areas. This also helped to increase the runoff once the catchment area was cleared of stones.

Inhabitants of the Negev built several cisterns to store drinking water for themselves and their livestock. One or more channels from the neighbouring hills would lead the runoff water into each cistern. Before entering a cistern the channels would open into a basin which collected part of the silt and dirt carried by the water. The cisterns were covered to protect them from pollution and evaporation. These cisterns are still recognizable in the desert, identified by the high mounds with loose white silt along their sides that give evidence of past cleaning operations of the cisterns.

RESTORING A SHATTERED VISAGE

Israeli scientists, led by Michael Evenari, botanist and desert ecologist at the Hebrew University in Jerusalem, reconstructed two ancient farms at Shivta and Avdat in 1960, to understand the ancient systems of agriculture and how these could be adapted to suit present needs.

The farm at Shivta was reconstructed using the layout and water distribution system of the original Nabatean farm. Only those trees were planted which were grown by farmers in ancient times, as mentioned in the documents dated between 7th century AD and 8th century AD. These included almonds, pistachios, figs, grapes, carobs, apricots, peaches and plums.

Avdat, on the other hand, was an experimental farm with the objective of testing new crops, increasing yield and widening the application of runoff farming. As the water entering the fields was to be accurately measured and controlled, a modern floodwater distribution system was superimposed over the ancient system. In Avdat, trees were selected on the basis of their resistance to drought. Besides the trees grown at Shivta, cherries, apples and loganberries were also cultivated. The trees grown in the 7th and 8th centuries in the area fared better. The field crops that were tested in Avdat included wheat, barley, peas for seed production, sunflower and onion bulbs. Among the fodder plants, best results were obtained from alfalfa (*Medicago sativa*), Harding grass (*Phalaris tuberosa*) and Smilo grass (*Oryzopsis miliacea*). The perennial salt bush (*Atriplex halimus*) was also found to be well suited to runoff farming.

SMALL IS BETTER

During the experiments at Avdat, it was discovered that smaller the catchment area, larger the runoff collected per square metre (sq m) of catchment area. During one

Fig 2: Terraced network
Conduit channel systems bring water from different watersheds to terraced fields

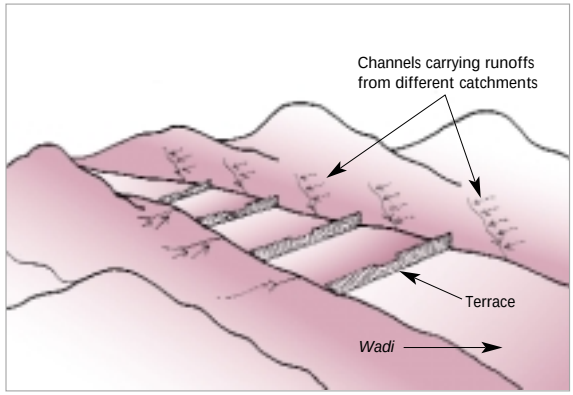
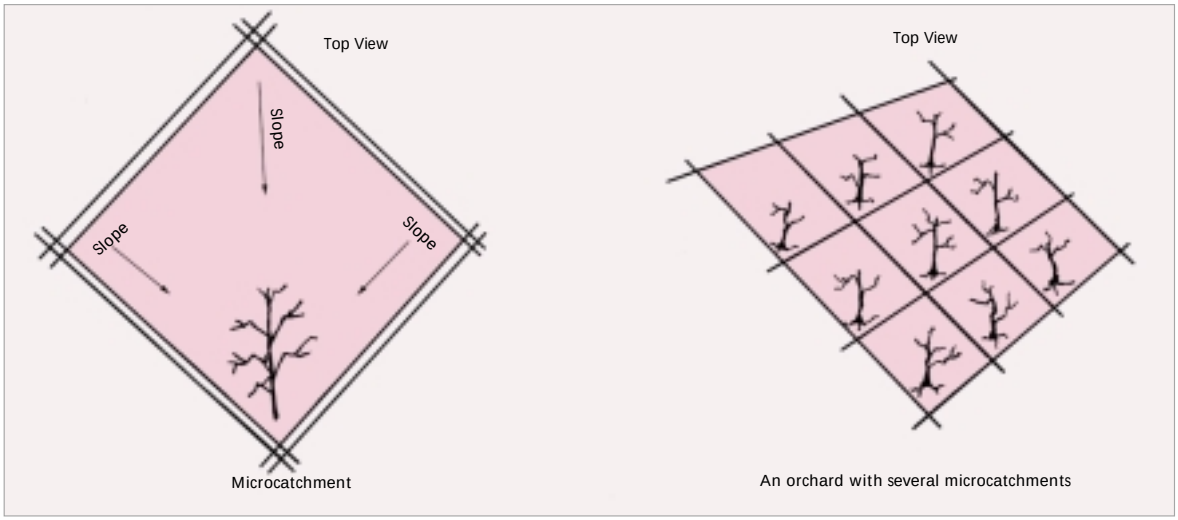


Fig 3: Microcatchments for macro-yields

Israeli scientists found that as smaller catchments provide more water per unit of catchment area, it was good to create microcatchments for each tree to plant an orchard in the desert



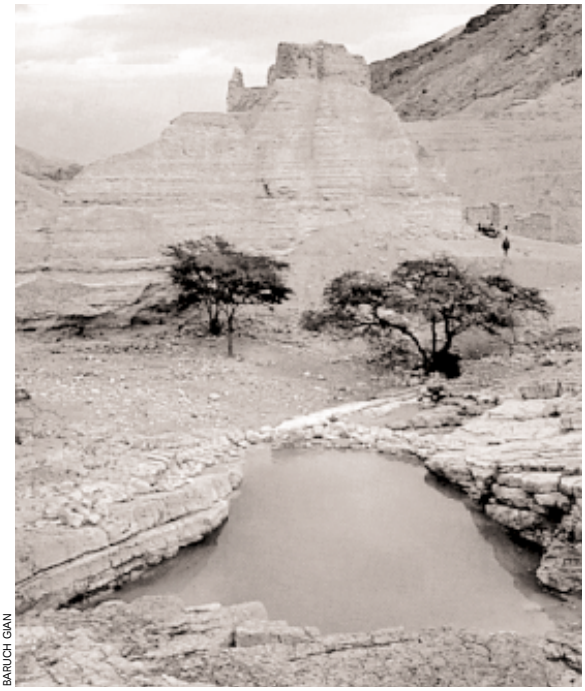
of the floods, measurements showed that a catchment of 340 ha produced 1,238 cubic metre (cum) of runoff or 3.6 cum / ha, whereas a three hectare catchment produced 156 cum of runoff or 52 cum / ha.

This is because in a large area where the runoff has to travel over long distances, more water was lost due to depressions, stones and other irregularities, resulting in infiltration and evaporation. This gave the scientists the idea that each tree or bush could have its own independent catchment called microcatchment *(see Fig 3: Microcatchment for macro-yields).*

Microcatchments between 15.6-1,000 sq m in size were constructed with an earthen border 200 mm in height. A square basin was dug at the lowermost point to collect the runoff from the microcatchment where a tree or a bush was planted. The basin had to be dug up after every flood for aeration. The optimal microcatchment size for fruit trees was 250 sq m, for grape vines 62 sq m, and the salt bush 32 sq m.

Microcatchments offer many advantages. Being small in size, they do not suffer from water loss due to evaporation and uncontrolled percolation that larger catchments witness. The amount of water collected in microcatchments can account for upto 62 per cent of the total rainfall. Even low intensity rains generate runoff in microcatchments and while large catchments have only one runoff, these can generate upto eight runoffs. The cost of installing and maintaining a microcatchment is also very low as no channels, terraces or stone fences are required. Even flat areas can have microcatchments. These can also help to bring saline soil under cultivation, as runoffs are large enough to leach the soil in 1-2 years.

Though the microcatchment technique was developed independently in Israel, it was a surprise for Israeli scientists to discover later that farmers in southern Tunisia were traditionally growing olives in microcatchments, a technique probably introduced there by Phoenicians who had built Carthage in 814 BC. ■



BARUCH GIAN

A water source in the Negev desert

A Way Out

For Sub-Saharan Africa, reeling under abject poverty and arid conditions, there is an urgent need to devise water harvesting structures suitable to the arid environment

John Mbugua Kiongo
Land Use Consultant, Nakuru, Kenya

Sub-Saharan Africa is lagging behind the rest of the world for a number of reasons, most prominent among them being poor economic performance and lack of fiscal discipline. A huge foreign debt has worsened the situation. Sand deserts appear to be enlarging and droughts are further contributing to the economic devastation of these countries. While the population continues to increase, poverty is abject. Under such conditions it is important that the meagre water resources available be captured and used for poverty alleviation.

Given the fragile ecosystems of Africa, water practices developed for temperate climates may not work well in this continent. New approaches to water technologies, particularly those designed to meet the needs of arid regions, are required. While the technologies should be such that they supply low-cost, high-quality water to meet domestic and agricultural needs, practices should be such that there is an increase in the supply of usable water like rainwater and reduction in the demand. Some examples of rainwater harvesting that are in use in Africa include rooftop catchments with tanks and cisterns, rock catchments, sub-surface dams, sand dams, and ground and road catchments.

In Sudan, the traditional use of baobab or *tebeldi* trees (*Adansonia digitata*) for storage is reported. When hollowed out, these five metre diameter trunks are fed by water collected from the tree branches or buckets from ground collectors. There is extensive use of rainwater harvesting in Kenya, Uganda, Malawi, Mali, Zimbabwe, Nigeria and Ghana.

Other methods which make use of land alterations to meet the challenge of water scarcity are also being tried. These include clearing of rocks and vegetation, compacting of soil surface physically, and the use of chemicals such as paraffin wax to seal soil pores. Polythene sheets to increase runoff are being used by a few well-off horticultural farmers.

Runoff farming is another option being adopted by farmers to meet agricultural needs. This involves the use of rainwater directly into agricultural systems specifically designed for the purpose. These include triangular microcatchments, semi-circular *bunds* and trapezoidal *bunds*. Hand-dug or hand-augured wells are also being put to use. For effective and maximal use of the limited water available; efforts are directed towards reducing evaporation loss from water surfaces; reducing seepage loss; reducing evaporation from soil surface; reducing cropland percolation losses; reducing transpiration; cultivating crops that use water more efficiently; and, the use of drip irrigation.

The World Health Organisation's (WHO) guidelines for drinking water quality have often been used by government officials to discourage use of rainwater. While drinking water standards are important, these should take into account prevailing environmental, social, economic and cultural conditions. This may lead to the formulation of national standards that differ appreciably from WHO. Technology should be suitable to the ecologically fragile region, be affordable and acceptable, and encourage participation. Poverty can be eliminated only when approaches are sensitive to social justice and environmental limits.

To improve water availability and alleviate poverty, the Anglican Church of Kenya started a project in Laikipia. Ten years later, the results have been dramatic. Crop production has increased and the economic status improved. A valuable lesson has been learnt: Poverty alleviation will succeed only if technical and environmental issues are balanced with equity and justice.

THE LAIKIPIA EXPERIENCE

Water supply coverage in Kenya is about 42 per cent only. This leaves a large number of people without this important basic need. This has serious social and economic consequences for people particularly living in rural areas, situated away from rivers and nearly always underdeveloped with regard to water. It is common that every time there is some money available to be used for water supply development, drilling of boreholes and piped water are usually given preference.

Inspite of its potential, rainwater harvesting has not received adequate attention amongst policy makers, planners and water projects managers in Kenya and the continent as a whole. Low-cost options which people can afford and use for improving their standards of living are often overlooked. But, over the last ten years, individuals and institutions who are committed to increasing water supply coverage through utilisation of rainwater have increased rapidly. Some individuals and groups have also organised themselves into organisations to coordinate their activities. One of them is the Kenya Rainwater Association (KRA).

Hardly any figures are available on poverty in Kenya. The minister of finance recently gave a figure of 13 million, about 50 per cent of the population, living below the poverty line. For these people, access to food, clean water, education and health care is a daily struggle.

To mobilise these people to overcome this dehumanising state and start a journey towards self-reliance, ten years ago, the Laikipia water project was started by the Anglican Church of Kenya. The experience gained in Laikipia has shown that increasing water supply for drinking and for food and livestock production are successful mobilisation strategies for poverty alleviation. This is because coventional water sources like ground and surface water are not available in many places unlike rainwater. This is why the KRA was formed and today several small consulting firms have been set up and registered with the government and affiliated to it. Such private sector groups include Land Use Consultants who use rainwater harvesting as a catalyst to mobilise and build the capacity of target communities to move towards self-reliance, self-determination and confidence.

Laikipia district, on the leeward side of Mount Kenya, has an annual average rainfall of approximately 700 millimetres. Rain falls in two seasons, the long and the short rains. This area is categorised as semi-arid. Local communities consist of subsistence farmers growing crops (mainly maize and beans) and keeping livestock (cattle, sheep and goats). There are frequent droughts, resulting in crop failure and decimation of livestock.

Participatory rural appraisal (PRA) was used as a tool to take stock of the circumstances prevailing in the target area. Both social and physical environmental circumstances were investigated. The PRA results

JOHN MBUGUA KIONGO

As the success of rooftop water harvesting spread, the size of storage tanks increased

JOHN MBUGUA KIONGO

Communities enjoy the asset that they have created. Capturing water has reduced drudgery and increased yields

revealed that the existing landuse and farming methods were not suitable and, therefore, not sustainable.

Catalytic role

Rooftop rainwater harvesting played a catalytic role in promoting rainwater harvesting. A programme was introduced starting with an ordinary oil drum of 200 litres and a few 1 metre (m) x 3 m galvanised iron sheets. Then 2.5 cubic metre (cum) water jars were introduced. As awareness and, therefore, willingness to pay for increased water access improved, other tank sizes were introduced. Finally, huge 50-100 cum underground tanks were introduced. All the above provided water for the most needed domestic and livestock requirements and for some limited vegetable growing.

As the result of this, rainwater harvesting continued to impress local communities, and runoff farming was introduced as part of a watershed management approach.

Ten years later, the maize yield has increased from eight bags of 90 kilogrammes each to 20 bags — a 150 per cent increase. Crop failure rate declined because of the additional water harvested through a number of approaches like terracing, composting, afforestation, and generally suitable land use and good farming practices. This has become possible for the fact that five hours lost earlier on average in fetching water now go to farming. In addition, lost labour due to frequent diseases related to use of unsafe water is now available. There is extra income from the excess farm produce sold and, in general, living standard has become better and poverty greatly reduced.

Experience gained in this project have helped build capacities of many rural and scattered communities in Uganda, Tanzania, Zimbabwe and Ethopia. Community-based institutions have been formed. This institutional arrangement provides the vehicle needed for development at the grassroots level in many developing countries. This has proved useful particularly in Kenya, where increased costs of living, collapse of several public services due to mismanagement of the meagre resources available and inequitable distribution of the resources and opportunities available are rampant.

The Laikipia experience offers many lessons to be learnt. Rainwater harvesting technology has high initial capital costs but negligible recurrent costs. However, the choice of technology is the singlemost important decision that determines cost of the service chosen. Communities, which produce food or livestock products for sale, face financial problems as they try to leap out of poverty due to lack of markets and marketing skills. Among many groups which have done rainwater harvesting, resources are being better managed using local skills. Community knowledge has enhanced as has community solidarity. ■

CHAPTER 4

Urban Water Harvesting Programmes

- Urban areas face peculiar water problems the world over. Urban wastewaters pollute rivers and aquifers. Even as high demand deplete aquifers and rivers, downpours leave the city waterlogged. As natural drainage channels get clogged up and the urban catchments degrade, urban tanks and lakes dry up. With heavy concretisation of urban areas, urban floods become common. Thus, the urban citizen has to deal with water scarcity on one hand and flooded streets on the other. Urban water management is in a total mess in India. But what is heartening is that in many places civil society is playing an important role, approaching courts where necessary.

- Water harvesting is increasingly being practised in urban areas to deal with this twin menace of scarcity and floods. Indian examples range from Aizawl (Mizoram) in the Northeast to Chennai (Tamil Nadu) in the south. In Chennai, rainwater harvesting is also being used to prevent salinity ingress into coastal freshwater aquifers.

- Rooftops are popular catchment areas that are used to harvest the rain. The rainwater harvested is reasonably clean and can be used either directly or for recharging groundwater aquifers. But urban runoff can be highly polluting because of industries and vehicular traffic.

- Urban waterbodies are today no more than dumping grounds in India. They are not only heavily polluted but also uncared for. They steadily decline in size and soon get taken over by land sharks. In Udaipur as well as in Hyderabad, both cities abounding with tanks, a vigilant and persistent civil society has played a major role in stemming their decline. In both cases, the courts have had to intervene.

- Waterbodies in small towns are no different. In Khandwa, for example, the destruction of the urban waterbody followed by its attempted takeover by the land mafia in connivance with the local bureaucracy was prevented only by court direction.

- Necessity has motivated rainwater harvesting in several countries the world over. Problems of sewage, urban flooding and depleting groundwater reserves have combined to catalyse action. Policy measures include subsidies as well as taxation. In Japan, for example, subsidies are given to people to install systems. In Bonn, households pay a special tax depending upon the amount of stormwater they let into the stormwater drains. The increasing rates of both, water supply as well as sewage treatment in Germany, has facilitated the installation of rainwater harvesting systems.

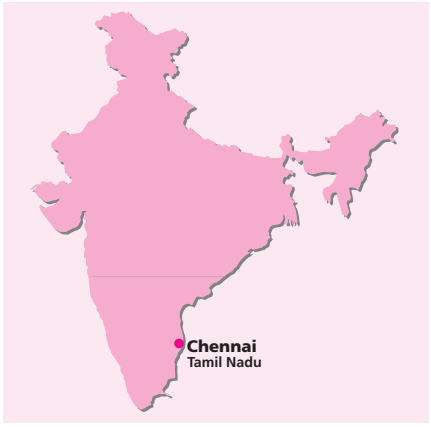
- Singapore has a high population density and hence a high water demand. But it has no rivers and limited groundwater. Almost 50 per cent of its total land area is today used as a catchment area, which includes highrise buildings and the international airport. Extensive research and coordination between various departments has been undertaken to ensure the quality of the urban runoff captured.

The Chennai Experience

The water supply crisis in Chennai is leading to innovations in water management. Now the city leads the country in urban water harvesting

Shanta Sheela Nair
Government of Tamil Nadu, Chennai, Tamil Nadu

The city of Chennai faced a serious crisis in water supply in the late 1980s. Exploding demands coupled with failed monsoons and salinity intrusion from the sea forced the authorities to make efforts to capture rain, recharge groundwater aquifers, and prevent their overextraction. Ten years later, in 1998, the changes have been significant. Salinity has been kept at bay and groundwater tables have risen. All this has been possible with legislation for controlling groundwater extraction and installing rainwater harvesting and groundwater recharging structures.



Like other ancient urban centres in Tamil Nadu, the cities of Madurai, Thanjavur and Tiruchirapalli flourished on the banks of rivers like Vaigai and Cauvery. Chennai, however, was a fishing hamlet where the East India Company set up trade, developing later into the major metropolis it is today, without the benefit of any major natural river or lake system to meet the growing water needs.

The earliest organised water supply for Chennai was based on extraction of groundwater and supply to the White town — the town where the whites resided. Other residents made their own arrangements.

Development of reservoirs for meeting the city's drinking water needs was taken up with the diversion of the flood waters of Koratalaiyar river to the Redhills Lake in the later part of the 19th century. The artificial reservoir at Poondi was created in 1948. Together with the Cholavaram reservoir, these three lakes form a major rainwater collection system for supply of drinking water to Chennai city. This system made available 240 million litres per day (mlpd) of water, for providing a population of 4.5 million a per capita supply of 70 litres per capita per day (lpcd) up to the year 1996.

In 1998, the demand for domestic water supply was about 630 mlpd at 140 lpcd for a present population of 4.5 million. Up to 1996, only 280 mlpd was available and, from September 1996, the total water supplied has fluctuated between 300-440 mlpd. Additional requirements of water were met from:

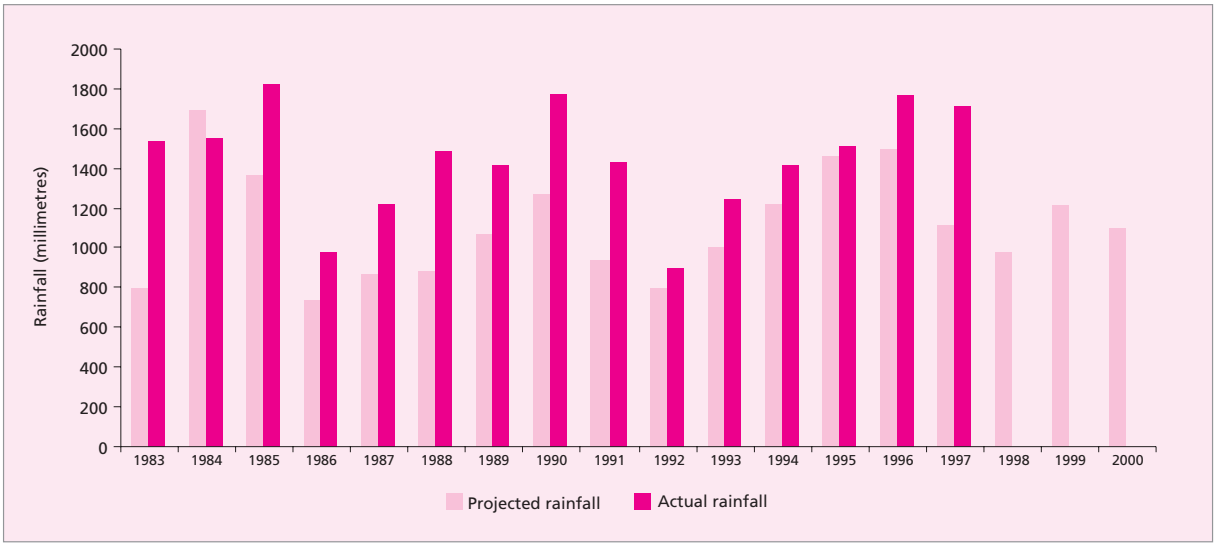
- Domestic groundwater dugwells and borewells;
- commercial groundwater supply services by private vendors charging exorbitant rates from Rs 25 to Rs 40 per kilolitre as against the flat rate of Rs 40 per month charged by the public water authority; and,
- from September 1996, some additional water was received under the Krishna Water Project.

The future looked bleak. It was estimated that the domestic water demand in 2011 would reach 1,570 mlpd, a growth of 25 per cent. Given the already precarious situation, even a marginal deficit in rainfall would become a cause of serious concern. Another alarming factor is the usual discrepancy between predicted and actual rainfall. These differences are obvious from the rainfall projection for the years 1983-2000, based on a model prepared from records for 1901-1982, and the actual rainfall *(see Graph 1: The ground reality)*.

NEED FOR ACTION

The city faced a serious challenge. Demand was increasing and supply dwindling. Continued and excessive withdrawal of groundwater started ringing alarm bells when groundwater in the northwestern coastal belt indicated that there was a rapid ingress of seawater

Graph 1: The ground reality
Differences between prediction and reality: predicted and actual rainfall in Chennai



from three kilometres inshore in 1969 to seven kilometres in 1983, and nine kilometres in 1987.

An immediate fallout was the movement of private water vendors to the southern coastal aquifer in 1983. Large-scale groundwater mining reached menacing proportions with the ever-increasing demand from the growing metropolis. Groundwater levels within the city also fell and brackish water began to appear even in localities which earlier had good quality groundwater sources.

The need for effective groundwater management along with the management of surface runoff became a necessity. In 1986, a major drought hit Chennai city. Rainfall recorded was only 979.7 millimetres (mm). The total available water in the three lakes of the city was only 35.4 million cubic metres (mcum). The cycle of floods followed by acute drought and its impact on water scarcity in Chennai was most severe in 1987 and 1993. In 1992-93, the rainfall was again abysmal, recording only 900 mm. Lake storage levels touched a new low of 28.3 mcum. A third drought seemed almost impossible to bear.

Realising the 'near precarious situation', the Chennai Metropolitan Water Supply and Sewerage Board or Metrowater has over a period of time evolved a strategy for conjunctive use of surface and groundwater. These measures include harvesting floodwaters along the course of the river bordering the city, building check dams, constructing injection wells and enacting legislation to regulate groundwater use and install rainwater harvesting systems in new constructions.

The need to invest wisely and heavily in Chennai city's water management was brought home in a World Health Organisation/United Nations Development Programme study. As a prerequisite for pursuing such a plan, a separate board, Metrowater, was set up as a statutory board in 1978. Over the years, Metrowater evolved a strategy for the conjunctive use of surface and groundwater. In 1993, the use of treated sewage was added.

CONCERTED ACTION

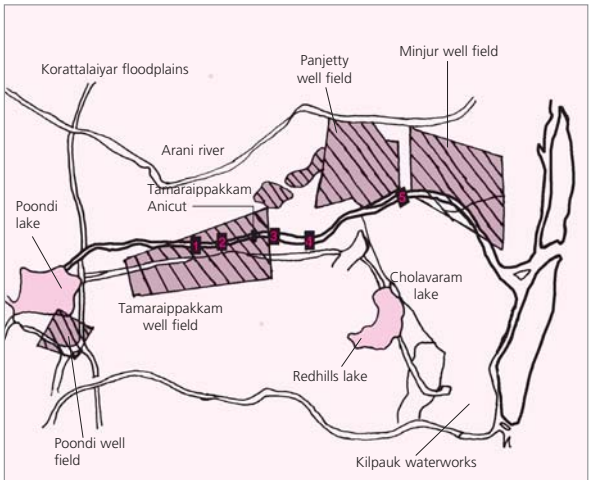
A series of investments were made by Chennai Metrowater from 1991 onwards to harvest floodwaters along the course of the rivers bordering the city. This belt called the Araniyar-Koratalaiyar well fields has as many as 76 major borewells, which constitute 20 per cent of the city's water supply.

Check dams were constructed in 1991, 1992 and 1995 at Valliyur, Jaganathapuram, Melsembedu and two more at Athangi Kavanur and Alnjivakkam are to be taken up *(see Fig 1: Recharging the river).* These check dams have had a significant impact in improving the groundwater availability.

In order to facilitate groundwater management, the Chennai Metropolitan Area Groundwater (Regulation) Act 27 was enacted in 1987. In addition, a number of other projects were undertaken:

- The Veeranam and Krishna Water Schemes to convey water from long distances which were initiated earlier were pursued as priority projects;
- an experiment was taken up for creating an artificial barrier against saline incursion by injection of groundwater along the city's northern coast;
- individual house-to-house rainwater harvesting

Fig 1: Recharging the river
Check dams across Korattalaiyar river



S S NAIR

Check dams at: 1. Melsembedu, 2. Velliyur, 3. Athangi Kavanur, 4. Alinjivakkam, and 5. Jaganathapuram

systems were promoted as a critical need for the year 1994; and,

- desalination of brackish water on a localised basis was taken up as pilot projects.

Injecting life

Continued mining of groundwater along the coast drew saline water into the Minjur aquifer *(see Fig 2: The saline invasion)*. Direct injection of freshwater into this aquifer was required to keep the advancing intrusion of sea water at bay. Heavy pumping over many years for irrigation and city water supply had created a large and deep cone of depression. Flow towards the depression resulted in sea water intrusion up to an alarming nine kilometres inland.

The alluvial aquifer in the Minjur well field is of a channel type and is replenished mainly by precipitation. The lithological logs of the boreholes drilled in the Minjur aquifer indicate four prominent channels and two from the Minjur aquifer. Detailed investigations carried out by the UNDP and Metrowater brought to light the movement of sea water towards land.

An injection experiment was conducted to establish the intake capacity of the recharge well (where the aquifer has already been affected by sea water intrusion). The studies carried out gave scope for creation of an artificial recharge freshwater barrier east of Minjur well-field area.

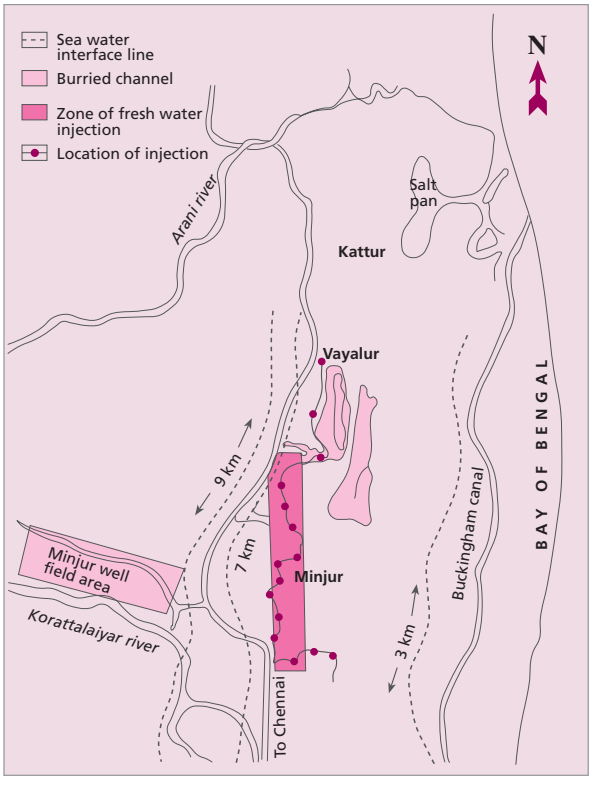
To create an artificial barrier, 15 injection wells of 350 mm diameter and 45 metres (m) depth were constructed with necessary facilities for injection of water. Cast iron mains of 300 mm and 150 mm diameter were laid for a length of about 10 kilometres (km) and two kilometres, respectively, for conveying the water to each injection well. In addition, 10 observation wells of 150 mm diameter for a depth of 45 m were also erected for monitoring the quality of groundwater periodically.

The injection of water into the wells showed improvement in groundwater quality. The wells, which had electric conductance (EC) values of more than 65,000 micromhos/cm came down to 34,000 micromhos/cm. The wells having EC values of 2,000-3,000 micromhos/cm came down to 1,400-1,600 micromhos/cm. The EC value of the water used for test purposes was around 650 micromhos/cm. Studies are under progress and will be continued as long as necessary.

Desalinisation of brackish water

The Chennai Metrowater also treated the locally available poor quality surface and groundwater for use in two projects. An effort to use poor quality surface brackish water was made in Okiyam area. In this project, brackish water was mixed with good quality groundwater and after basic treatment of filtration/chlorination, the improved water was added to drinking water supplies. Approximately, one million litres per day was added to city water supply.

Fig 2: The saline invasion
Sea water intrusion slowly extended from three kilometres inland from the shore in 1969 to nine kilometres inland in 1987



The fishing community living in the Nochikkupam area (located in the heart of the Chennai city along the Marina beach) was supplied water through tankers. As tanker supplies were not reliable and led to frequent law and order situations, a desalinisation plant of 0.15 million litre capacity was set up in 1996 to convert brackish groundwater to potable standards. The plant has been functioning for over two years.

Community involvement in rainwater harvesting

After the devastating drought of 1993, a need was felt for community participation in the collection and use of rainwater. During that time we had to bring in water by train from other parts of the country. The crisis led to considerable involvement of non-governmental organisations (NGOs) followed by residents' associations. This was a great support to our efforts because public agencies are often not considered good agencies. Metrowater took a policy initiative that required all new constructions in the city to have rainwater harvesting structures designed to recharge groundwater and alleviate flooding in low-lying areas to some extent. The Chennai Metrowater proposed to the Chennai Metropolitan Development Authority (CMDA) that provision of rainwater harvesting must form a necessary part of building plans before they are submitted to Metrowater for approval. The request was accepted by the CMDA and approved.

Metrowater was identified as the enforcing authority for multistoreyed buildings/special buildings and the concerned local bodies for ordinary buildings. This provision came into effect from January 1, 1994. This move was followed in 1995 with a request to the Chennai Municipal Corporation to extend the requirement to smaller and ordinary buildings, which too was accepted.

In the initial stages, the response was lukewarm. Builders were not really keen to provide rainwater harvesting systems. Chennai Metrowater then issued instructions that no new water connection be given unless rainwater harvesting structures provided in the approved plan were implemented. Builders and others then began to take rainwater harvesting structures seriously. Some representations were also made to Metrowater suggesting alternative methods and systems of rainwater harvesting structures.

Metrowater launched a major campaign in 1996 involving builders, water management institutions, NGOs and others for suggesting innovative methods for provision of rainwater harvesting structures in individual buildings in the city. In July 1997, Chennai Metrowater wrote to the member-secretary, CMDA, suggesting several alternatives to the initially proposed rainwater harvesting structures. It was also stated that in case builders or others had their own suggestions for rainwater harvesting, Metrowater would have no objection in accepting the same, provided such systems served the purpose of collecting rainwater and recharging groundwater sources.

Instructions were sent to the Chennai city authorities and also to the municipal board to cover all buildings. However, Metrowater soon found that government buildings were lagging behind. After receiving complaints that government structures were not good, Metrowater found that implementation was possible by private agencies. So it gathered all the relevant agencies and made sure that the law was implemented.

It took a while for the message to sink in that Metrowater was serious, but finally it did. The progress in implementing the directives to Metrowater can be seen from the decline in number of applications rejected. In 1994, 40 per cent of all planning permission applications were rejected; in 1995, 30 per cent; in 1996, six per cent; and, by 1997 only two per cent.

This was followed up in 1996 by the enforcement of instruction on grant of water/sewer connections based on provision of rainwater harvesting structures as per approved plans. No building that had failed to provide rainwater harvesting systems was allowed water/sewer connections. The twin measures contributed to a sense of compulsion in promoting house-to-house rainwater harvesting systems.

A public education programme was mounted through the media for carrying the message on the need for rainwater harvesting in all buildings, old and new. A series of pamphlets and brochures on rainwater harvesting were brought out. Rainwater harvesting was adopted as a theme by Chennai Metrowater while participating in all exhibitions, trade fairs and other government-sponsored functions such as Republic Day celebrations. Stakeholders and their roles were effectively spelt out. These included city agencies, NGOs, press and media, educational institutions, religious and charitable endowments, builders, construction companies involved in residential/commercial complexes, and specialised institutions. These initiatives included selection of pilot project sites and door-to-door campaigns. Through students in educational institutions, parks and playgrounds of the municipal corporation were also identified as possible areas for rainwater harvesting.

SWEET SUCCESS

Concerted efforts by Metrowater began in 1988. Ten years down the line, these efforts have borne fruit. Some of the highlights include:

- The groundwater level in 1988 was around eight metres in the southern coastal aquifer area. A gain of 4-5 m was established in the 20 km stretch along the

Graph 2: Rising groundwater levels

The groundwater level in the southern coastal aquifer rose from about eight metres depth in 1988 to about four metres in 1998 after groundwater recharge efforts

southern coast *(see Graph 2: Rising groundwater levels).* In Anna Nagar, a significant difference was observed between areas where rainwater harvesting had been undertaken and where there were no such efforts *(see Graph 3: Making a difference)*. For the city a a whole, the average water level has increased from 6.8 m in 1987, to 4.55 m in 1998 *(see Graph 4: The metro miracle).*

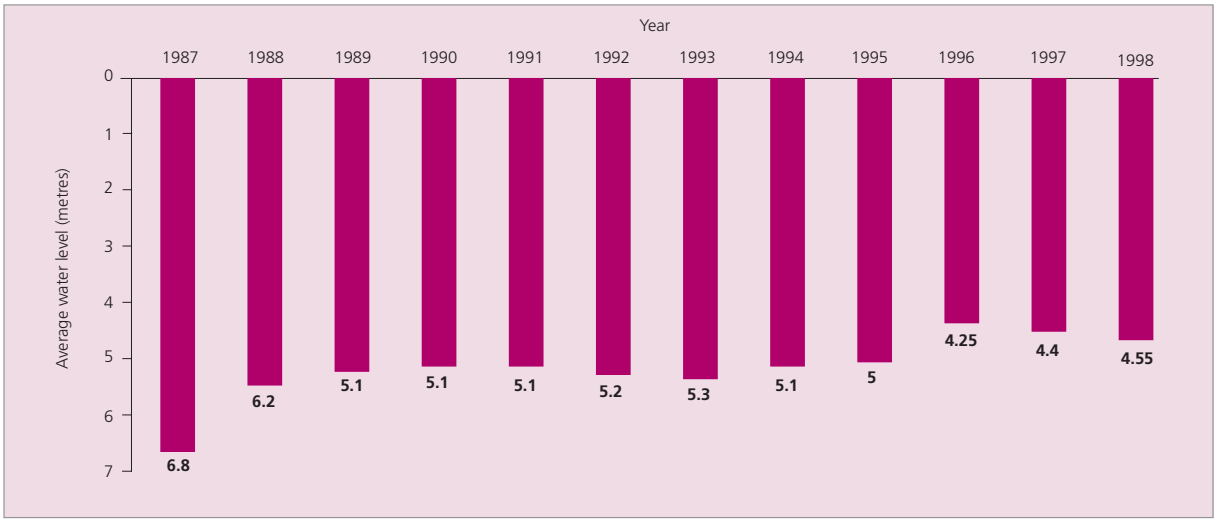
- A mega-project for supply of only treated sewage for non-domestic industrial purposes was taken up in 1996.
- In 1988, as many as 96 licences were issued for extraction and 260 for transportation of groundwater. In 1996, only 10 licences for extraction and 11 for transportation were issued. During 1997-98 and 1998-99, no licence was issued either for extraction or transportation of groundwater.
- During the 10 year period 1988-98, the number of vehicles used for the transportation of water seized annually rose from 15 in 1988 to 65 in 1998.
- The number of villages covered under the groundwater regulation act increased from 229 to 243.
- Some 20 writ petitions were filed against Metrowater by major water suppliers in the city of Chennai. Out of these, 11 cases were disposed of in favour of Metrowater.
- After the severe drought of 1993, active participation by the people increased. NGOs, consumer action groups and local residents' associations assisted in

Graph 3: Making a difference

Water levels in Anna Nagar with and without rainwater harvesting systems

Graph 4: The metro miracle

Groundwater levels in Chennai after implementation of the Groundwater Act and rainwater harvesting systems



providing information on violations, undertook direct action to prevent illegal extraction and transportation of groundwater from the notified villages, all contributing to better enforcement of the groundwater act.

- An independent study on seawater intrusion in the southern coastal area was made in 1996 by Rail India Technical and Economic Survey Limited (RITES) to obtain a second opinion on the status of water quality and quantity in the southern coastal aquifer. The report submitted in February 1997 confirmed the effectiveness of regulating the extraction of water from the project area and opined that saline water occurs at 15 m below ground. The present level of extraction was considered optimum and sub-surface flow of water to the sea could be avoided by maintaining an optimum water level at six metres below ground.

ROTARY CLUB / CHENNAI

Tank restoration in Chennai

LEARNING FROM EXPERIENCE

Too much water for two months, too little for 10 months has been the bane of Chennai city. The major agency involved in the provision of drinking water to the city, Metrowater, has, therefore, had to consider all possible means to stablise the situation.

In the introduction and implementation of house-to-house rainwater harvesting systems, the important lesson learnt was the need to follow up the directives of the Metropolitan Development Authority with the provision or denial of water/sewerage services as an effective tool to ensure implementation. Though rainwater harvesting was introduced immediately after the drought of 1993, good monsoon years in 1995-96 and 1997 have somewhat dimmed public responses.

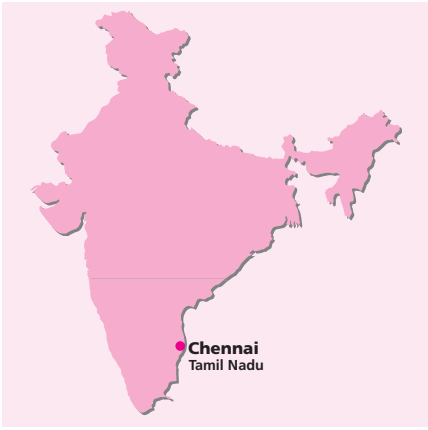
There is now a need to work further at collecting rainwater in ponds, riverways, canals and low-lying areas in urban localities as part of a future master plan for city water supply. The potential for collection of rainwater for direct consumption in individual houses and building complexes has to be worked out in terms of technical feasibility and cost-effectiveness given present day urban land costs. ■

Chennai's Concrete Coffin

Spreading concrete pavements are sealing the surface of Chennai, letting rainwater run freely to the sea, denying groundwater recharge and creating water scarcity despite high rainfall

Sekhar Raghavan
Centre for Policy Studies, Chennai, Tamil Nadu

Chennai faces a problem that is unique to coastal towns. The town suffers from scarcity amongst plenty: water tankers zip across the city supplying water, doing business even when there is urban flooding due to heavy downpower. While water scarcity in a state like Rajasthan where the rainfall is meagre is understandable, in a city that gets 1,100 millimetres of rainfall annually, it speaks of gross mismanagement of water resources.



With the construction of multistorey residential and commercial complexes in Chennai, all open areas around them are being paved. Individual houses are also following this practice, resulting in heavy, uncontrolled runoff flowing directly into the sea through stormwater drains, without generating any groundwater recharge. In streets where there are no stormwater drains or where they are blocked, the rainwater is let into sub-surface drains by puncturing manholes. When these pipes get choked, rainwater mixed with sewage overflows onto the streets, posing serious health hazards. Waterlogged streets and long lines of empty buckets in front of non-functional tubewells are two sides of the same coin. Almost all major cities in India face the twin problems of flooding during the monsoon and water shortage during the rest of the year.

MISMANAGING NATURAL ASSETS

Located near the tip of the Indian peninsula, Chennai receives particularly heavy rainfall and its management is a serious challenge for the city today. Due to increasing urbanisation, traditional waterbodies have been shrinking in the same way as open spaces in Chennai. Lakes have already been converted into dwelling places.

Chennai is endowed with natural wetlands and traditional tanks built by local communities which are now endangered by modern construction and real estate activities. Even state bodies, often funded by external agencies such as the World Bank, are reclaiming such water harvesting structures. Citizens action groups had to approach the Chennai High Court on two recent instances to stop the government from filling up natural wetlands.

The only waterbodies remaining are 39 temple tanks that continue to act as important aquifer recharge sources.

A SUBURBAN DILEMMA

In Chennai, the construction of multistorey residential and commercial complexes are on the increase. The courtyards all around such complexes are being completely paved. This tendency to concretise has spread to persons living in independent residences with the result that almost all the rainwater runs off into the streets. As there is no open space in the streets, this rainwater either stagnates or flows into the sea. Great pride is taken in the efficiency of the drainage system, scarcely realising the mismanagement of rainwater as a source of water that is taking place.

Suburbs of a coastal city often develop within 1,000 metres (m) of the sea. Groundwater extraction makes these areas quite vulnerable to saline seawater ingress. Besides, in such areas, excessive groundwater withdrawal results in salinity intrusion into fresh groundwater aquifers, rendering them unusable. Excessive groundwater withdrawal from coastal aquifers in some areas in north Chennai has already led to receding groundwater tables and a landward (mostly inland, and

to some extent upward) movement of seawater/freshwater interface. In Besant Nagar, there is a noticeable decline in groundwater quality. In such areas rainwater harvesting needs to be immediately undertaken to stop seawater intrusion which can do irreversible damage to freshwater aquifers.

To make better use of rainwater, users, advocacy institutions and the state must come together and play a meaningful role. Members of the user group, consisting of ordinary citizens, industries, offices, hotels, educational institutions, hospitals and other such institutions, exhibit an unhealthy dependence on the state for the supply of freshwater.

The author has been involved in a door-to-door campaign in the coastal suburbs of Chennai, trying to create awareness about rainwater harvesting. During the four monsoon months, the author would visit 10-15 houses per day on public holidays, spending some time going around the complex and distributing printed leaflets containing information about rainwater harvesting. In more than 50 per cent of the houses, particularly flat complexes, the entire quantity of rooftop water was let into the sewers. In the other 50 per cent, barring a few exceptions, the rooftop water was led onto the pavement and into the streets.

The experiences of the author speak for themselves. About 20 per cent of the residents would be unavailable. Of the remaining 80 per cent, 20 per cent were not convinced about the potential of rainwater harvesting and had no faith in their ability to solve their water problems on their own. They would rather surrender their civic rights to the state in return for some assurances. The remaining 60 per cent would give a patient ear, praise my efforts and then express an inability to make a sincere attempt.

Advocacy institutions such as the print and electronic media, industrial and business bodies like the Confederation of Indian Industries, various other chambers of commerce like the Federation of Indian Chamber of Commerce and Industries, clubs like Rotary Clubs and Lions Clubs, non-governmental organisations and consumer action groups can play an important role in promoting the concept and acceptance of rainwater harvesting. The Rotary Club of Chennai has already spent Rs 1.5 lakh to clean up four traditional temple tanks and their catchment areas to ensure that a sufficient amount of runoff is generated from the neighbourhood.

ROLE OF GOVERNMENT

About 25 years ago, the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) was formed to look after the supply of freshwater in Chennai. Water supplied by the board, popularly known as Metrowater, is supplied to people who have obtained official

ANIL AGARWAL / CSE

Recapturing rain in concrete: A pipe carries rainwater from the pavement around an apartment complex to a recharge well

connections and to residential colonies promoted by the state, and to individuals living in slums through tankers.

Till about 20 years back, three reservoirs located at the outskirts of the city constituted the only source of freshwater supply to the city. But with the growth of population and demand, only about 80 per cent of the water supplied to the city comes from these sources. The other 20 per cent is extracted from underground aquifers in coastal suburbs. So far, the state has neither taken any serious steps to replenish these underground aquifers through water harvesting nor augment the capacity of the three surface water sources that it exploits.

The Chennai Metropolitan Development Authority, in charge of approving all building plans in Chennai, through a notification made rainwater harvesting mandatory in all residential and commercial complexes having ground plus three floors since January 1, 1994. In 1996, CMWSSB strengthened the above notification by issuing a fresh order that such complexes would be sanctioned Metrowater connections only if they fulfiled the requirement of rainwater harvesting. Though laws have been in place, enforcement still leaves a lot to be desired.

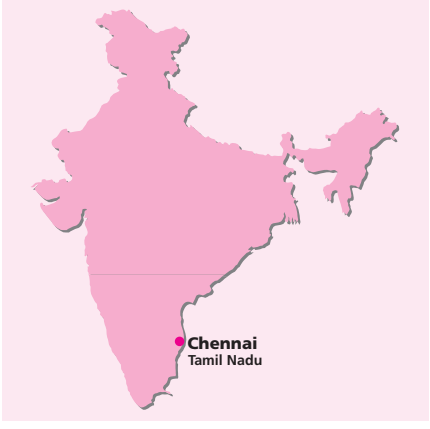
On the occasion of World Water Day on March 22, 1998, the board also launched a year long action plan to create awareness about rainwater harvesting. A water conservation committee had also been constituted to monitor the activities of the plan. Public institutions like schools, ladies clubs and residents' welfare associations have also been approached in this regard. ■

Quenching Chennai's Thirst

Builders in Chennai provide low cost solutions to augment water supply and reduce problems associated with urban waterlogging

R Jeyakumar
Rajparis Civil Constructions Ltd, Chennai, Tamil Nadu

Cities face peculiar problems. There is water scarcity on one hand and localised flooding due to downpours on the other. Water tankers do brisk business zipping across the city even on days of heavy downpour. Builders in Chennai have now devised water harvesting systems that deal with this twin menace. These builders even assure their clients that they will provide more water to the occupants because of the installation of these systems. Rooftops for instance, can serve as good catchment surfaces (see *Fig 1: Rain on the roof).*



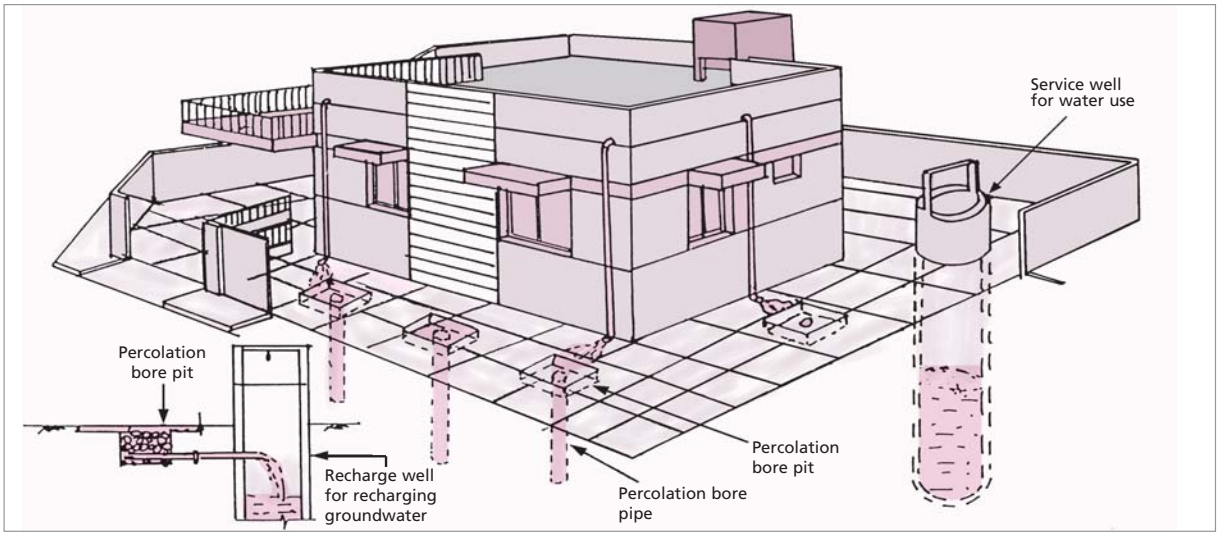
In order to promote this concept, papers were invited for assessing and for awarding prizes. The competition evoked a good response. Thirty people who had implemented rainwater harvesting systems participated.

BASIC NECESSITIES

Implementation of rainwater harvesting requires some background preparation.

- For cities, rainwater harvesting should be considered a necessity. Awareness about the advantages of rainwater harvesting should be created.
- Information regarding various options of rainwater

Fig 1: Rain on the roof
Blueprint for rooftop water harvesting in an individual house. Gutters from the roof carry rainwater to percolation bore pits around the house. These pits are in turn connected to a recharge well



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harvesting, the costs involved and suitable locations should be easily accessible. Ideally, a person must be able to know the suitable methods, cost and people who can implement, just by making a telephone call.

- Simple methods and techniques to ascertain the quality of the stored water should be popularised. The amount of chlorine and alum for sedimentation should be specified for various quantities of water and should be easily available.
- Banks should come forward and give loans for executing rainwater harvesting and collect the dues in installments.
- Simple systems of rainwater harvesting should be made compulsory in all buildings. Public buildings and educational institutions should implement them in their buildings and set up an example.
- All stormwater drainpipes should have percolation bore pits in the base. But then stormwater and seawage must not get mixed.

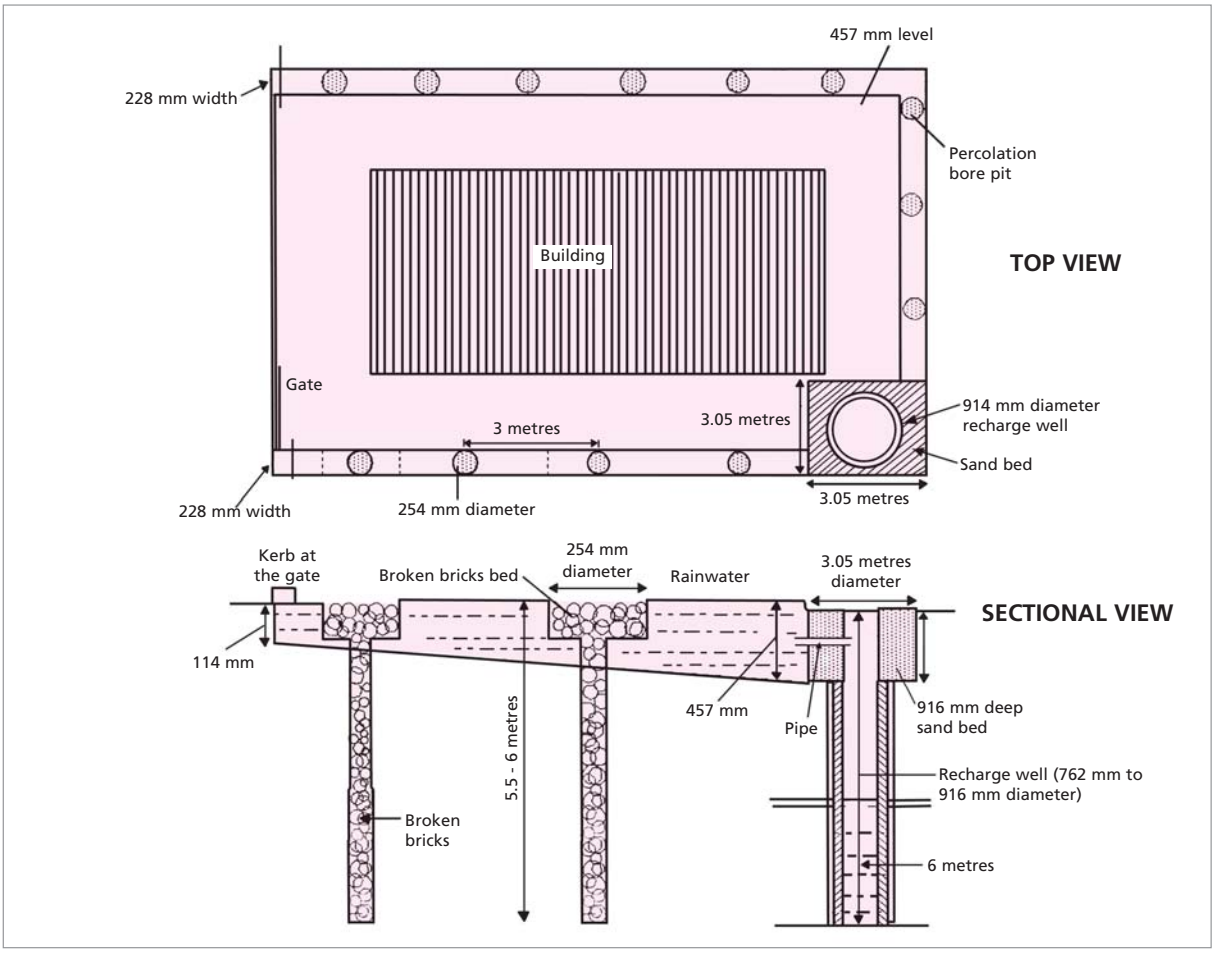
TECHNOLOGIES FOR CEMENTED AREAS

It is possible to ensure that rainwater reaches the aquifer even when the open land around the dwelling is covered by concrete flooring or roads which is impervious. This method is comparable to the natural draining of water into the sub-soil in the absence of concrete flooring.

- Normally, a building is constructed in the centre of the plot and the open area is paved with concrete and the slope is towards the gate which allows the rainwater from the plot to flow into the road. To prevent this, a kerb of 51 millimetres (mm) to 76 mm height is made at the gate which diverts the water into a trench within the plot.
- A trench of 229 mm width around the periphery of the plot is made which is 114 mm deep near the gate and 457 mm in the rear of the plot, which helps the water flow back into the plot *(see Fig 2: A trench to capture the flood).*

Fig 2: A trench to capture the flood

Trench percolation pit method — top view and sectional view of the base



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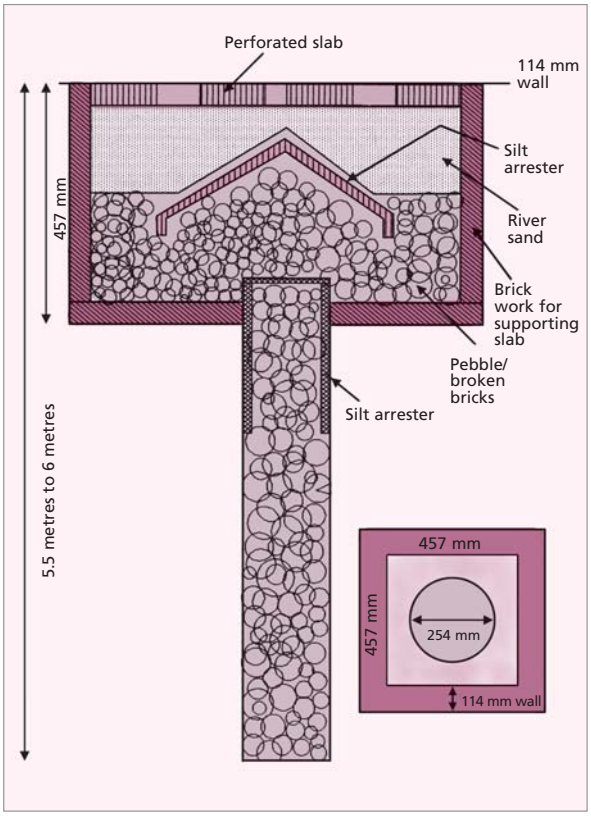
- To enable the water collected to percolate and disperse back into the sub-soil, percolation bore pits of 254 mm diameter and 5.56 metre depth are made at three metre intervals with collection chambers. The bore is drilled with an auger (tool for drilling borewells) and is filled with broken bricks and sand. A collection chamber of size 457 mm x 457 mm x 457 mm size is provided on top which is filled with broken bricks and a silt arrester. The top of the percolation bore pit is provided with a rainwater collecting grid which is shaped like a rotary symbol to enable silt free flow of water into the collection chamber. This collection chamber is provided to create a pressure head for the water to easily percolate through the bore pits into the sub-soil and subsequently to the aquifer. Water, when it fills the percolation bore pits at a deeper level, finds its way to the well *(see Fig 3: Rainwater pits)*.
- A 3.05 m x 3.05 m sand bed of 916 mm depth with a 762 mm to 914 mm size open well in the middle of the sand bed is built. Irrespective of any slope around the building, the water that gets out of the building is diverted by the kerb to a trench. As the trench is sloped towards the rear of the plot the water gets filled in the trench. The rainwater collected reaches the percolation bore pit by the pipe provided and the rainwater percolates into deeper strata of the soil. As the trench is filled with the water there will be a constant water head for the percolation bore pit. Any excess water from the trench overflows into the sandy bed at the corner of the building and percolates into the well.

The main problem in rainwater harvesting is silt formation. To arrest this, the percolation pit lid is provided with undulation which will arrest the silt. In the percolation pit a cover is provided and a polyvinyl chloride (PVC) pipe is placed in such a way that the water percolates after a fall, hence the silt gets arrested in the pit itself.

For recharging the well, the rainwater pipe can be connected to the open well to divert the rainwater from the terrace into the well through rainwater downtake pipes. The rainwater falling around the open space surrounding the building can be diverted to the front gate where a gutter is provided for a depth of 457.2 mm and a width of 609 mm with perforated slabs. The rainwater collected in the gutter in front of the entrance is discharged into another recharge well of 914.4 mm diameter and 6.9 m depth, provided nearby through necessary piping arrangements.

This system helps in augmenting the groundwater to the maximum by dispersion into the plot which will in turn charge the well or wells present in the plot by underground water movement. As and when the water from the well is pumped out, the retained water from the surrounding sub-soil will percolate into the well, thus maintaining the water level in the well. This also generates active underground water movement.

Fig 3: Rainwater pits
Cross-section of percolation bore pit



This slow induction and dispersion of water ensures that no damage is caused to the structure on the plot. In plots where a compound wall exists, a small trench is made along the compound wall which collects the water and through a 101 mm PVC pipe, conveys the water to the bore pits which are around 76 mm away from the compound wall *(see Fig 2: A trench to capture the flood)*.

Water harvesting has been successfully used to augment water supply and reduce localised water stagnation caused by rainfall in a factory in Chennai *(see Box: Industrial harvest)*.

ADVANTAGES OF THIS SYSTEM

- Cost effective *(see Tables 1A, 1B and 1C: Cost of construction)*;
- driveway not affected;
- water is taken to deeper strata;
- withdrawal of water is facilitated;
- the entire water falling within the compound will

Table 1A: Cost of construction
Percolation bore pit

Description of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Drilling 250 mm diameter pile to a depth of 6 m* and filling it with broken brick and sand	9 metres	running	50	450
Supplying and filling pile and chamber with broken bricks and river sand on top	0.50	cubic metres	425	215
Construction of a brick chamber of size 450 mm x 450 mm with cement:mortar 1:4 mix and 115 mm thick wall	1	nos.	350	350
Providing a stoneware pipe bit in the percolation bore pit as silt arrester	0.60	running metres	115	70
Rainwater chamber reinforced cement concrete cover	1	nos.	200	200
Transport and sundry expenses	Lump sum	–	115	115
Total				**1,400**

Note: ** The depth of the percolation bore pit should preferably be up to the sandy strata*

Table 1B: Cost of construction
A gutter in the gateway (600 mm X 450 mm)

Description of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Earthwork excavation for channel 3.65 m x 0.91 m x 0.91 m	3.05	cum	70	215
Plain cement concrete (1:4:8) mix 40 mm metal for100 mm thick base	3.34	sq m	108	360
Brick work in cement:mortar (1:5) mix	1.16	cum	1590	1845
Plastering gutter inside	7.15	sq m	65	463
Providing perforated reinforced cement concrete slab cover for closing the gutter	Lump sum	–	617	617
Total				**3,500**

Table 1C: Cost of construction
Rainwater collecting well

Description of work	Quantity	Unit	Rate (Rs)	Amount (Rs)
Digging 0.92 m diameter open well for 6.1 m depth and sinking nattu well rings	6.1	running metres	656	4000
Diesel motor for dewatering well for earthwork	1	day	250	250
Providing reinforced cement concrete cover slab for the well	1	nos.	350	350
Transport charges for the material	1	trip	450	450
Forming channels to well and incidental charges	Lump sum	–	250	250
Constructing a brick chamber size 450 mm x 450 mm with cement:mortar of (1:4) mix and 115 mm thick wall and pipeline	Lump sum	–	700	700
Total				**6,000**

Note: *mm: millimetres m: metres sq m: square metres*

INDUSTRIAL HARVEST

Water harvesting plan for Kone elevators factory, Chennai

The site has great potential for harvesting rainwater in the campus. The basic problems in the campus included stagnation of rainwater around the campus and lack of potable water. Potable water was being purchased through lorries (one lorry load of water is bought every alternate day for Rs 500 per load or approximately Rs 7,500 per month).

The rainwater harvesting system proposed will take care of both problems.

At the car park, water stagnates during rain. Four rainwater harvesting percolation bore pits were suggested around the area to drain the stagnation early.

A major rainwater pipe leads the rainwater from the roof to a gutter on both sides of the building. As the water comes through the roof, it is collected in a proposed storage well and the same can be diverted to the existing service sump (of approximately 7,000 litre capacity). To handle the overflow, two percolation bore pits were provided. The greatest advantage is that this can be cleaned easily.

On the other side of the building is a pipe near the toilet water tank. At present the water is only used for the toilets. The rainwater pipe is diverted to the tanks and the overflow to two percolation bore pits.

There are two main rainwater pipes in the canteen building. The water from the pipe facing the factory is diverted to the existing well and the pipe at the corner is connected to a open well storage sump (as second stage) of about 7,000 litres.

Expectations

During rainy season the storage sumps get water and no purchase is required, since good potable water can be made available by adding alum and a small dosage of chlorine.

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Kone elevator factory – arrow indicating rainwater collection pipe

At present the entire water through the gutter accumulates in one corner of the campus. To start with, around 20,000 litres are expected to be stored which can be used for drinking purposes.

The percolation bore pits and wells will enhance drainage during heavy rains when the water level is high and the bore will be functional for 1.52 metre (m) to 2.13 m only. But during short spells the draining will be very fast.

Table 1: Cost estimate for the rainwater harvesting system

Details of work	Cost (Rs)
Conveying the rainwater collected in the northwest corner of factory building roof to a 1.23 m diameter open well with country well rings, 152.4 mm diameter polyvinyl chloride pipes and a brickbat filter chamber	10,000
Conveying the rainwater collected in the southwest corner of factory building roof to a 1.23 m diameter open well with country well rings, 152.4 mm diameter PVC pipes about 21.33 m below ground level and brickbat filter chamber.	16,000
Connecting the rainwater pipe near the toilet in eastern side to the toilet water tank with 152.4 mm diameter PVC pipes	3,500
Conveying the rainwater collected in the northeast corner of factory building roof to a 1.23 m diameter open well with country well rings, 152.4 mm diameter PVC pipes of 12.19 m long and a brickbat filter chamber	13,000
Connecting the rainwater pipe at the centre of the canteen building to the existing well with 152.4 mm diameter PVC pipes and brickbat filter chambers	7,500
Conveying the rainwater collected at one end of canteen building to a 1.23 m diameter open well with country well rings, PVC pipe and the filter chamber	10,000
Providing rainwater harvesting percolation bore pits and filling them with brickbats and cover slab (10 numbers in the campus)	15,000
Total	**75,000**

Note: *PVC: Polyvinyl Chloride m: metres mm: millimetres*

flow towards trench and then to the sand bed, and if rainfall is more than the load it can harvest, it will automatically flow out of the gate;
- the system can be built in existing buildings without much hindrance;
- the structure does not get affected as there is dispersion and relatively slow induction of rainwater; and,
- a war against the Bay of Bengal, which prevents the sea water from filling the aquifers generated in the absence of good water in the soil.

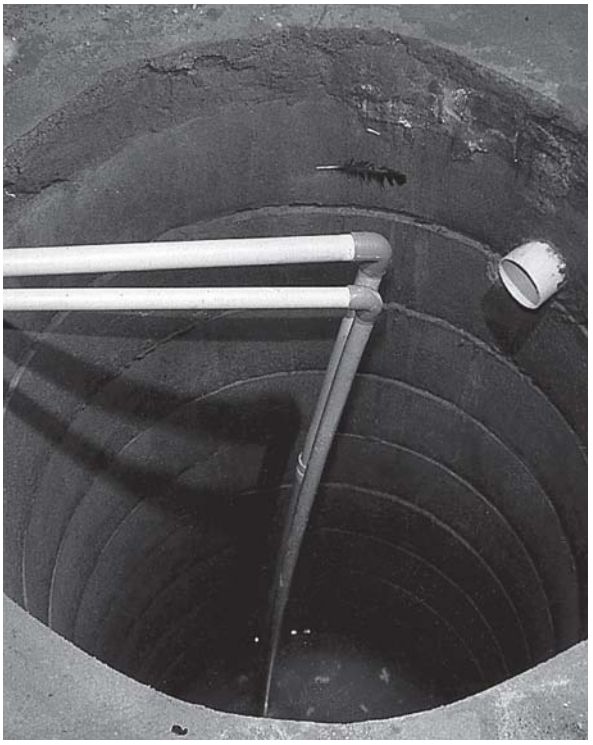
A rough estimate of water that can be harvested by percolation bore pits is as follows:

Capacity of one bore pit = 40 buckets of water
Volume of one bucket = 15 litres (l)
Therefore, capacity of one bore pit =15 x 40 = 600 l
Capacity of 24 bore pits = 600 x 24 = 14,400 l
Therefore, water harvested during a monsoon of 60 days = 14,400 x 60 = 864,000 l

This is apart from the water harvested through the well.

METROPOLITAN MERITS

All is not lost in urban areas, which have a vast potential for rainwater harvesting:
- Development is concentrated. Rain can meet the domestic demands of people residing in multistoried buildings.
- Land is sub-divided and owned by many people. Hence, it can be implemented in large areas as cost of execution is shared. Besides, the person who undertakes rainwater harvesting reaps the benefits.
- There is a tendency in urban areas to cement every bit of land and so water runs off rapidly. To capture this water, harvesting offers a solution.
- Due to stagnation of rainwater, roads deteriorate. This water, if harvested by vertical stormwater drains, will help to augment aquifers, reducing the load on drains.
- Buildings in clayey soils crack up due to differential settlement. In order to minimise settlement, moisture content must be retained in the soil. Rainwater normally flows on roads and through the drains, reaches the waterways and mixes with seawater. If rainwater harvesting is effective, it fills the aquifers and prevents seawater intrusion.
- Large numbers of factories are situated in and around the urban areas and due to water scarcity, water is bought for drinking and other purposes. With rainwater harvesting, costs will reduce substantially.
- Stormwater drains are a part of urban planning and, if properly diverted, significant rainwater harvesting can be achieved.
- Major problems encountered in buildings is the formation of rust on pipelines due to the use of salty water. Rainwater harvesting can reduce the load of saltwater. ■



JITENDRA VERMA

Recharge dugwell

RAJPARIS CIVIL CONSTRUCTION LTD

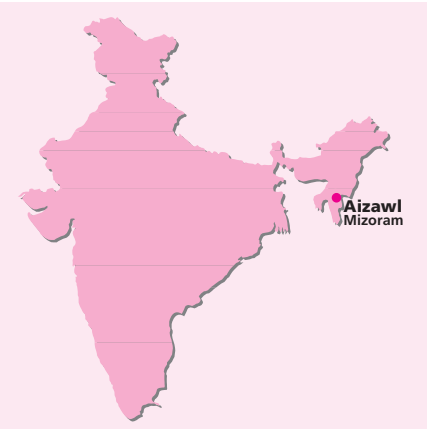
Rainwater flowing down the gutter pipe towards a recharge trench

Rainwater Retains Relevance

The city of Aizawl depends heavily on rainfall to meet its drinking water requirement but the government continues to give higher priority to piped water supply

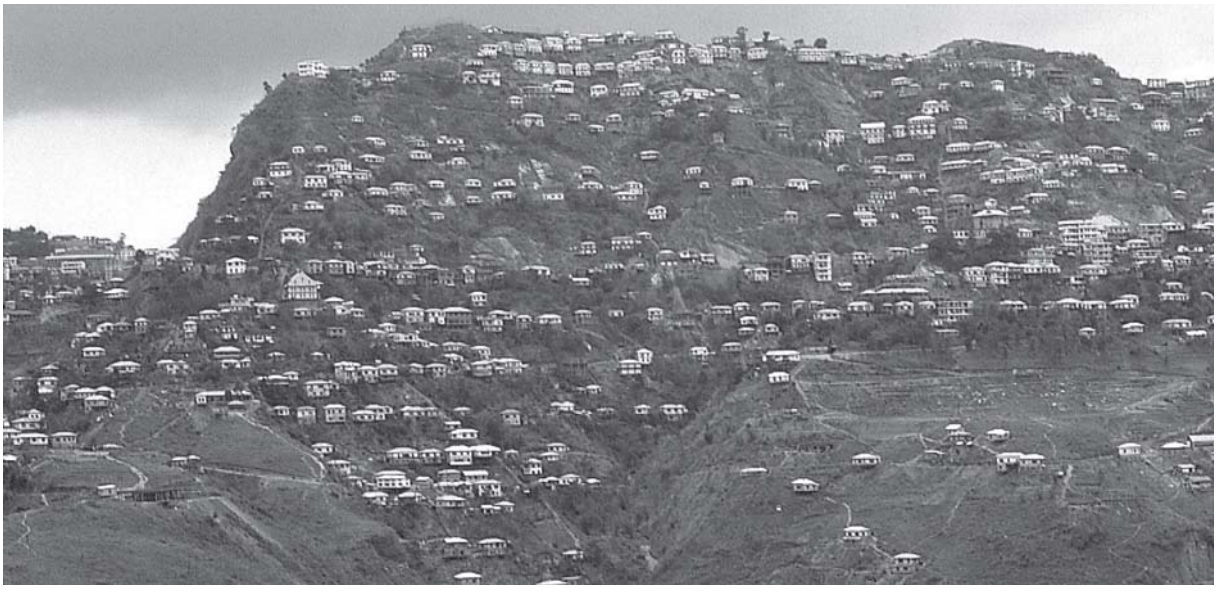
Dunglena
Retired Secretary, Government of Mizoram, Aizawl, Mizoram

Originally designed in 1988 for 80,000 people, the water supply system in the capital of Mizoram, Aizawl, has now been stretched to meet the requirements of over 150,000 residents, making it grossly inadequate. The public water supply system sources water from a perennial river, Tlawng, located some eight kilometres away and was meant to supply water at the rate of 135 litres per capita per day (lpcd). It involves pumping through a static head of 1,040 metres using an eight kilometres long and 305 millimetres (mm) diameter pipeline.



In localities where piped water is available today, the supply is insufficient and rainwater plays a very important role in augmenting the water supply. Many localities in Aizawl are not even connected to the pipeline and their sole source of drinking water is rainwater. To suit the local climate, most houses are built with sloping roofs with galvanised iron sheets which are conducive to rainwater harvesting. At present, Aizawl has more than 10,000 rainwater harvesting tanks in individual houses which have been constructed by the residents at their own expense *(see Box: Rainwater harvesting at domestic level)*.

Located at the extreme northeast corner of India, Mizoram has an area of 2.1 million hectares and



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Aizawl is a hill town with most of the population residing on the hilltops. This makes pipeline water supply from centralised sources impractical and prohibitively expensive

RAINWATER HARVESTING AT DOMESTIC LEVEL

Sufficient amounts of rainwater can be harvested in individual houses by using simple techniques

The catchment areas for rainwater harvesting are generally of three types — hard surfaces like roofs and rocks that generate 100 per cent runoff, semi-hard surfaces like roads and house premises that allow 50 per cent runoff, and loose catchment areas in the countryside that permit only 25 per cent runoff. To arrive at the quantity of rainwater available from these surfaces, the following simple formula may be applied:

Catchment area x Runoff factor x Rainfall = Quantity of water available for harvesting.

For example, if a roof area is 10 metres (m) long and 5 m wide and the rainfall is 2,500 millimetres, rainwater available will be:

10 x 5 x 2500 x 1000 = 125,000 litres

For a family of eight persons, this amount of water can provide a daily supply of 42 litres per person per day (lpcd):

$$\frac{125000}{8 \times 365} = 42 \text{ lpcd (approximately)}$$

The minimum domestic water consumption by an average family, living off a water reservoir and without internal piped water connection, is assumed to be 10 lpcd only. The longest period of dry days without rain or very little rainfall is assumed as 120 days. Thus, the quantity of rainwater required by an average family of eight persons to last the dry season can be calculated as 8 x 10 x 120 = 9,600 litres, or say, 10,000 litres, which can be easily met by rainwater harvesting on a small

receives an annual average rainfall of about 2,500 mm *(see Table 1: A lot of rain)*. The state is thinly populate, with a population of seven lakh, one-fourth of which lives in the state capital of Aizawl. The rest of the population is scattered in 800 small towns and villages, most of who reside on hilltops.

The history of rainwater harvesting is as old as the city of Aizawl itself. It dates back to 1894 when the British established their first administrative unit here. Water was supplied to the British post from an underground rainwater reservoir constructed with stone masonry that had a storage capacity of about 5,000 cubic metres (cum). A sloping roof was constructed with corrugated galvanised iron sheet (CGI) to catch rainwater for the reservoir. Rooftop rainwater harvesting was adopted as the most convenient and economical water supply system. Even today, most buildings in Aizawl are constructed with sloping roofs that use CGI sheets and cylindrical storage tanks with galvanised iron semi-circular rain gutters to catch rainwater. Gradually, reinforced cement concrete (RCC), ferrocement and plastic tanks are being introduced.

In a pollution-free state like Mizoram where major industries are yet to come, rainwater is free from undesirable chemicals and is of potable quality. A study conducted by Industrial Toxicology Research Centre, Lucknow, on water quality of different sources of water revealed that rainwater stored for a long period of time

Table 1: A lot of rain
Rainfall and its monthly distribution in Aizawl (millimetres)

Year	1988	1990	1991	1992	1993	1994	1995	1996
January	0.6	1.6	1.1	5	18	3	4	8
February	28	24	30	68	129	16	10	37
March	64	177	28	7	99	233	37	169
April	137	260	137	50	108	160	40	107
May	333	398	202	161	482	159	367	298
June	497	317	402	277	641	302	449	347
July	552	416	711	374	709	417	405	367
August	444	552	453	382	462	434	474	351
September	327	422	346	316	339	210	349	436
October	231	98	302	256	217	110	171	205
November	41	124	1.3	39	24	26	195	34
December	1	37	1	10	—	0.2	0.5	4
Total	**2,656**	**2,827**	**2,614**	**1,945**	**3,228**	**2,070**	**2,501**	**2,363**

ANIL AGARWAL / CSE

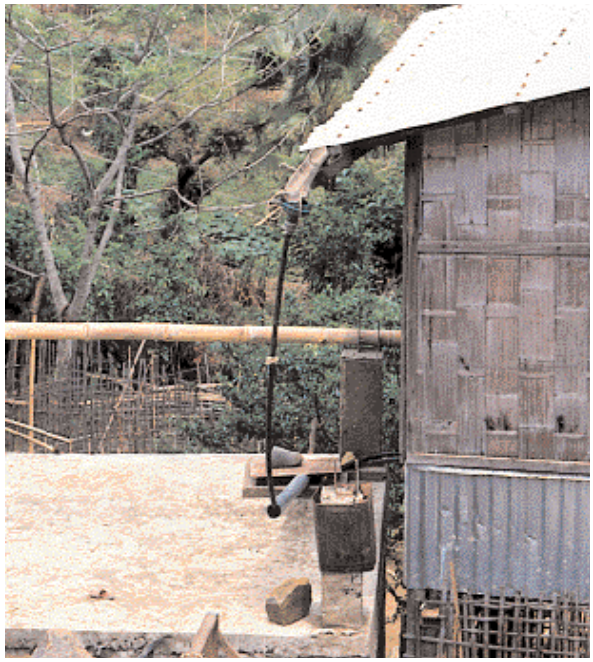
Water needs in Aizawl are partly met through tankers that capture the water from these streams at high cost

without treatment developed bacterial growth but still remained free of undesirable chemicals. However, bacteria can be removed by simple chlorination. An occasional dose of chlorine or bleaching powder once in a month is considered sufficient.

WARPED REASONING

Contrary to existing practices and ground realities, the government is encouraging piped water supply in urban areas. Multi-storied buildings with piped water supply are being built with RCC flat roofs. Use of rainwater is on the decline in urban areas. What makes the piped water option attractive to users is its ability to allow better facilities in houses at a nominal cost. But, in reality, the high cost incurred to provide piped water is not passed on to the actual users. The cost of subsidy, borne by the government, is eventually collected through various other taxes from the population.

It is true that rainwater cannot be conveniently used in modern kitchens and toilets unless individual families resort to pumping it to overhead tanks, which can be costly. But it is equally true that if a consumer is to pay the full cost of receiving piped water



ANIL AGARWAL / CSE

But the wise do not depend on others. They capture the rain that falls on their rooftop through simple, inexpensive means and direct the rainwater into storage tanks

ANIL AGARWAL / CSE

Gutters channelising rooftop rainwater into a storage tank in Aizawl. The quality of the rainwater collected is relatively good since sources of pollution are few. However, it is important that contamination from biological sources be controlled

supply, use of rainwater will prove to be much more economical. Complete dependence on the government for the heavily subsidised water supply is adversely affecting traditional rainwater harvesting systems in the state.

The state government of Mizoram has not yet clearly decided about its approach to water supply. While, on the one hand, it continues to assign the pipeline option the top priority, it has plans to take up rainwater harvesting from rooftops and springs in both urban and rural areas.

In rural areas rainwater percolating through the soil on the hill slopes comes out as springs at outcrops of rock layers during the rainy season and many weeks after rainfall. Small catchment tanks are constructed with stone masonry or concrete masonry at convenient locations. The tanks are provided with roof protection. Water collected in such spring catchment tanks serve a very useful purpose. In some locations water is available the whole year round. But water from spring sources normally has chemicals and bacterial contamination rendering it unfit for drinking. Spring water is used for washing and cooking. It has to be boiled if used for direct consumption.

Under the Accelerated Rural Water Supply Programme and Technology Mission, launched under the Rajiv Gandhi National Drinking Water Mission, as many as 5,993 individual domestic rainwater tanks have been built at a cost of Rs 6 crore in 198 villages. Built with government grants, these structures are to be maintained by individual families at their own expense. This programme has been found to be encouraging in solving the drinking water problems in the rural areas.

The maximum use of freshwater in the world is for food production. While conventional irrigation practices involve the construction of dams and groundwater exploitation, for cultivation on hill slopes, this approach is highly impractical. The best solution for irrigating hill slopes is to collect and store the rainwater on the hill slopes itself, by constructing different reservoirs. This includes ground reservoirs on hilltops, contour reservoirs (long, narrow reservoirs along the contours around the hills), check dams, underground dams (where the sub-surface water is trapped and can be exploited through wells) and spring water collection tanks. ■

Capital Hope

Substantial storage of rainwater through various land forms can augment water supply in Delhi

Ashish Bannerjee and Manu Bhatnagar
Indian National Trust for Art and Cultural Heritage, New Delhi

Even for a highly urbanised city like Delhi with its burgeoning population and limited geographical area, rainwater harvesting offers sustainable water supply solutions. According to the 'Blueprint for Water Augmentation' prepared by Indian National Trust for Art and Cultural Heritage (INTACH) for the National Capital Territory (NCT) of Delhi, about 216 million cubic metres (mcum) of rainwater can be retained *(see Table 1: Reserved for future)* in surface and sub-surface reservoirs. In addition, water can also be stored in aquifers through paleochannels (fossil streams and river beds), an amount which is difficult to assess.

This blueprint commissioned by the department of flood control of the government of Delhi details water augmentation in Delhi through urban and regional water harvesting. Delhi, with an annual average rainfall of 611 millimetres and a confined landmass of some 0.149 million hectares, 50 per cent of which has been urbanised, presents a complex challenge. With realisation dawning that rainwater runoff and flood discharges during the monsoon constitute a major resource to be conserved, this could greatly augment water supply in a water-starved Delhi *(see Box: Priorities for a wet Delhi)*.

Table 1: Reserved for future
Estimated rainwater storage capacity in Delhi

Water harvesting structure	Capacity (mcum)
On-channel	100
Off-channel	30
Quarries and historical reservoirs	19.8
Lakes	44
Village ponds	6.68
Floodplains	12.15
Rooftop	4.31
Recycled water	175
Total	**391.94**

Note: *mcum: million cubic metres*

FOR A WET DELHI

Information gathered from satellite imagery, field surveys, historical data, Survey of India maps dating back to 1906, and hydrological mapping carried out by the Central Ground Water Authority (CGWA) were used to locate several sites for water harvesting in Delhi. To augment water supply, various options such as on-channel storage, off-channel storage, floodplain reservoirs, quarries, historical waterbodies, check dams, paleochannels, lakes, village ponds, rooftop water harvesting and economic sewage recycling techniques were considered *(see Map: Water potential)*.

On-channel storage and recharge

Several seasonal streams, such as Najafgarh, Mungeshpur, Bawana and others, come alive during the monsoon, providing an outlet to floodwaters and local runoff. With careful planning, water from these sources can be stored in the channels themselves or can be diverted through strategically located regulators. The storage capacity of these channels can be enhanced by deepening and widening their courses. These channels can act as sources of surface water and also for groundwater recharge. For demonstration purposes, a technical feasibility study for on-channel recharge on the Najafgarh drain has been submitted to the department of irrigation and flood control which has been accepted

INTACH

Abandoned quarries in and around urban areas can double up as catchment areas to capture and store rainwater after suitable modification so that water flows into them. These quarries can also be linked to existing canals and drains

for implementation with a budget of Rs 35 crore for an estimated supply of about 11.36 million litres per day (mlpd) *(see Box: Najafgarh's potential)*.

Off-channel storage for floodwaters

Seasonal channels are unable to store more than 20 per cent of the water received due to insufficient storage capacities. Therefore, the creation of off-channel reservoirs in places where suitable depressions exist in the neighbourhood is recommended. These depressions can be modified by deepening, expanding and embanking. Another way to accomplish off-channel

PRIORITIES FOR A WET DELHI

Immediate action is necessary to meet Delhi's water demand

INTACH's blueprint to augment water supply in Delhi includes:

- Storing part of Delhi's monsoon allocation of Yamuna waters in floodplains, especially by creating a groundwater sanctuary in the 'Water Quadrilateral' in northeast Delhi;
- storing a part of Delhi's monsoon season allocation of Yamuna waters in the modified Jehangirpuri marshes for use as a groundwater sanctuary;
- developing the Najafgarh Jheel (reservoir) as a groundwater basin;
- storing part of Delhi's monsoon allocation of Yamuna waters in on-channel and off-channel structures in north, northwest, and west Delhi, routing the waters through western Yamuna canal through the various irrigation minors;
- ensuring round the year recharge of groundwater through dispersed hydrological landforms; and,
- recycling domestic sewage through economic and biological treatment.

Though the blueprint has been accepted by the government, the response is marred by indifference of the administration as they seem to have more faith in Himalayan dams. Thus, while there is no water in the reservoirs, the rate of groundwater exploitation is rampant and there is a massive gap between supply and demand of water provided by these dams.

A cluster of localised water harvesting schemes help to bridge a major gap while avoiding interstate politics and can be implemented easily, providing benefits in the form of increased soil moisture and biomass, recharged water table and diluting the contamination in aquifers. Realising this, some administrators are pushing to implement several aspects of the blueprint such as dispersed and localised small-scale water supply systems based on village ponds, rooftop water harvesting, byelaws for government and private buildings, creating a groundwater sanctuary (urban wetland) in North Delhi (Jehangirpuri marshes) and extraction of floodwaters in an abandoned stormwater channel (Old Bawana escape).

storage is to simply widen the channel wherever conditions permit. Twelve such sites have been identified in Delhi.

Storage in lakes and depression

Lakes in urban areas have often been misused for solid waste dumping and sewage disposal. The storage capacity of these structures needs to be increased through desilting and widening. Low-lying areas can be used to store monsoon waters for recharge as well as creating urban wetlands. By introducing aquatic plants and fish, a very low cost treatment technique, it can be ensured that only clean water enters underlying aquifers from where water can be extracted by shallow tubewells for a long duration. Eighteen such lakes and depressions have been identified for further action.

Floodplains reservoirs for conjunctive extraction

Usually, urban areas have no topographical relief to store floodwaters. Reservoirs can be created on the floodplains that are generally marked by large underground freshwater aquifers, to retain water through the main channel from urban areas. These reservoirs can enhance recharge, which can be extracted later by shallow tubewells during the lean season. Six such sites covering 760 hectares on the floodplains have been identified.

Quarries

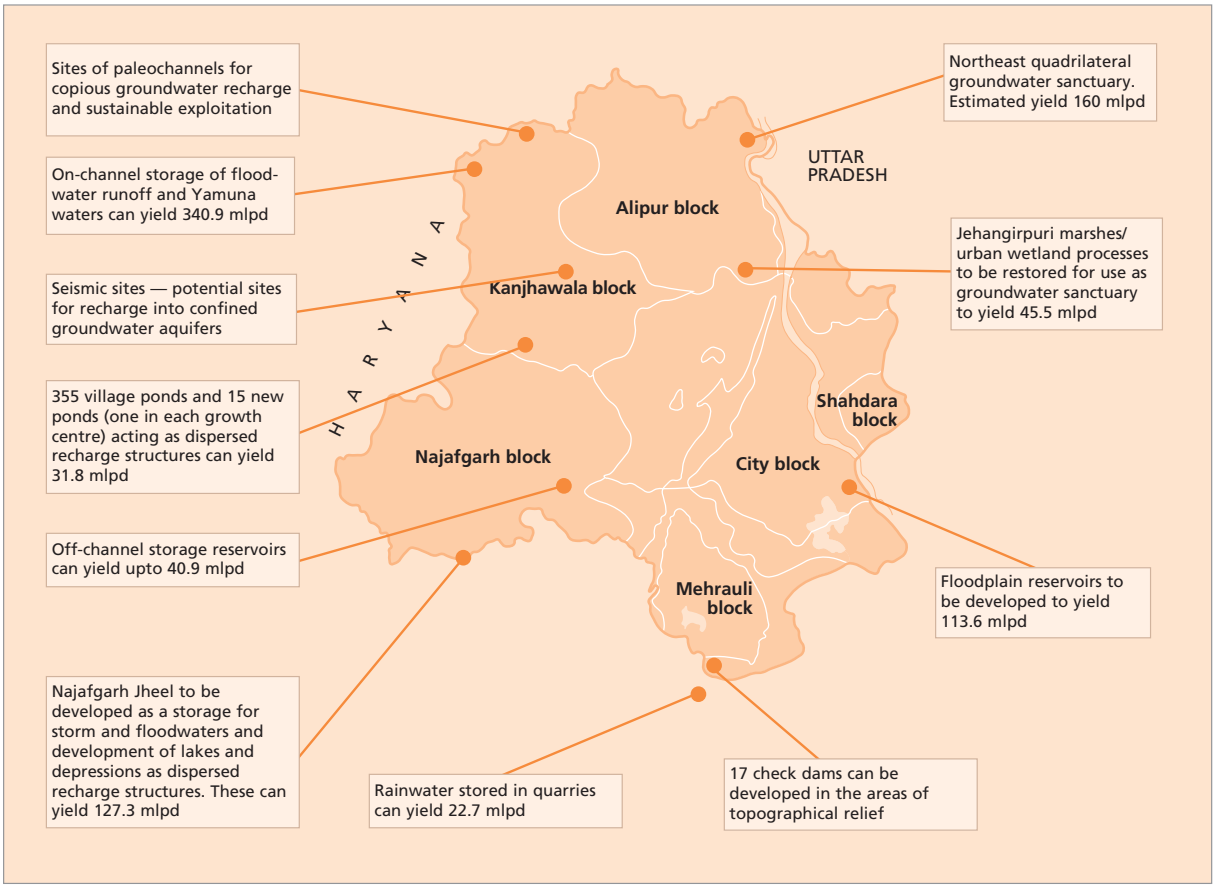
Often abandoned quarries are available in the vicinity of urban areas, which can be used to store water after modelling their catchment areas or linking them with nearby channels or canals during the monsoon. Twelve major quarries have been identified.

Historical water bodies

In many urban areas, large historical reservoirs have fallen into disuse either due to change of catchment characteristics or by destruction of feeder channels, which can be restored.

Water potential

Map indicating potential for generating water in the various 'water blocks' of Delhi



Note: *mlpd: million litres per day*

NAJAFGARH'S POTENTIAL

The Najafgarh drain has a tremendous potential to store water

Using the Najafgarh drain for on-channel recharge involves storing a substantial fraction of the local runoff as well as flood discharge in the drain itself. It is proposed to carry out this exercise on the 30 km of relatively unpolluted stretch of the drain from Dhansa to Kakraula *(see Map below)* by closing the Kakraula regulator. At a 75 per cent level of dependability, the water available for storage should amount to 58.22 million cubic metres (mcum) and is far in excess of the storage capacity available on the channel. Therefore, it has been proposed to enhance the storage capacity of the drain by desilting and deepening it by one metre. Considering various scenarios, including the submergence of the *jheel* stretch, the volume of water stored would range from 10-25 mcum. The work on desilting the drain is in progress and test boreholes will be executed for finalising sites of shallow tubewells.

Noting the large difference between the availability of water and the storage capacity on the channel, Delhi Development Authority (DDA) has commissioned an exercise for storage of the excess water in an off-channel reservoir in Dwarka area. This could lead to the formation of a 150 hectare reservoir, capable of storing six mcum of floodwaters, and delivering up to 11.36 million litres per day to Dwarka. However, this will be taken up subsequent to the successful completion of the Najafgarh drain project.

These concepts in various combinations can be applied to most urban and regional situations. INTACH has proposed the extension of the blueprint exercise for Delhi to the entire National Capital Region (NCR), which could lead to sustainable water supply in the region. The NCR Planning Board has been approached in this regard which is trying to incorporate urban and regional water harvesting features into its future plans.

On channel recharge
Najafgarh block showing the proposed waterbodies

Check dams

In areas with undulating topography, check dams can be created to recharge groundwater tables. As many as 17 such check dams are feasible in the ridge area of NCT Delhi.

Paleochannels

These landforms — abandoned courses of rivers or streams — are excellent recharge sites. Located through satellite imagery, these paleochannels can be recharged through monsoon waters for subsequent extraction during the lean season. Several paleochannels, such as Drain No 6, which is the oldest course of the river Yamuna, have been identified.

Village ponds

As villages get absorbed into urban areas, tubewell use is increasing and ponds are becoming cesspools or being reclaimed for development purposes. These are to be desilted and their water quality and storage capacity improved. Some 300 ponds have been identified.

Rooftop water harvesting

Institutional establishments can capture rainwater from rooftops and help to infiltrate it into the ground through injection wells to impart a measure of sustainability to groundwater extraction. Byelaws to make rooftop water harvesting mandatory at all new construction sites are on the anvil.

Ecoparks

Ecoparks, using aquatic root zone system (oxygen fixing and pollutant consuming plants and fish) to treat sewage waters upto tertiary levels (bathing quality water) for non-potable purposes such as horticultural irrigation and possible use in some industrial estates, is an established technique. Capital and operational costs are low.

Estimated cost

The estimated cost for creating these structures is Rs 1,000 crore (the major expenditure being on land acquisition for off-channel reservoirs) which works out to be Rs 2.5 crore for four mlpd of capital cost, as compared to an average of Rs 4 crore of capital cost for water obtained from upstream Himalayan reservoirs and approximately Rs 3 crore for canal water, subject to availability of surplus water elsewhere. The construction exercise can be phased out over 7-10 years and the identified sites and catchments integrated in the proposed master plan for Delhi. Combined with demand management and control of on-line losses, this could bring about a degree of water self-sufficiency in Delhi. The water table could be stabilised in the city area, ensuring a minimum acceptable flow in the river Yamuna. ■

Protection of Urban Tanks: Khandwa

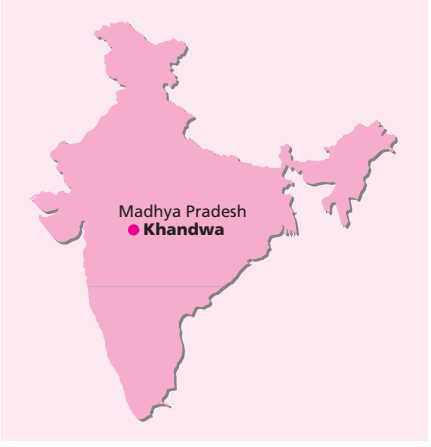
Khandwa's Water Mafia

A vigilant society prevents a land mafia from taking over the catchment of a waterbody

Jai Nagda
Nai Duniya, Khandwa, Madhya Pradesh

The decline in urban waterbodies and their catchments offer an excellent opportunity for the land to be taken over by land sharks, usually with the connivance of the government. The *modus operandi* is simple: neglect the waterbody, declare the land as useless, and then sell it off to a private party.

There are several types of mafiosi functioning in India: land mafia, jungle mafia and drug mafia, amongst others. What is less known is the water mafia, which in urban areas, has set its eyes on both water and watersheds of big *talaos* (lakes). In Khandwa, a vigilant and active society prevented private ownership of the land surrounding the Nagchun talao, its catchment neglected by the administration and then declared useless land by the municipality.



HISTORICAL ROOTS

Khandwa, divisional headquarters of Nimar, in Madhya Pradesh is steeped in history. So are its water resources. Khandav van, figuring in *Ramayana* and *Mahabharata,* is identified as the present day Khandwa. Four *kunds* (ponds/tanks) surround the *van* (forest) and have their own historical significance. To the east of the town lies Surajkund, to the west Padamkund, to the north Rameshwarkund, and to the south Bhimkund. The common belief is that when Lord Rama's wife, Sita, felt thirsty travelling through the desert during their exile, Lord Rama shot an arrow into the ground which sent forth gushing water. This place then became Rameshwarkund. Even today, this *kund* supplies water to the town. Whenever this area was hit by a severe drought and all sources of water went dry, this *kund* remained a reliable source of water. The other three *kunds,* too, have sufficient water in them, though they are no longer used as sources of water supply. Bhimkund is a picture of neglect, Surajkund has been encroached upon and turned into private property. The utility of Padamkund has been reduced to the immersion of Durga and Ganesh idols.

After the *kunds* came the age of *taals* and *talaiyas* (lakes) during British rule. The major *talao* was Nagchun, and among the smaller ones, Bhairontalao, Doodhtalai, Singadtalai and Shakartalao. A valuable source of water for the town at one time, these are now defunct due to continued neglect. Doodhtalai, Singadtalai, and Shakartalai, right in the middle of the town, came under heavy encroachment. The continued neglect had a price: it ultimately led to a fall in the water tables of the wells nearby. Gradually, the entire town became dependent on Nagchun talao alone for its drinking water needs. Till 1968, Nagchun was the only source of drinking water for this town whose population at the time was 60,000.

THE NAGCHUN TALAO SAGA

This *talao* is located in Nagchun village, about three kilometres (km) away from Khandwa. It was constructed in 1897 to supply water to the town. This saucer-shaped structure was built by constructing a 1,500 metres (m) long and 12 m high earthen embankment. This site was chosen specifically because it was at a higher altitude than the town, so that water could be supplied to the town by gravity alone. The 2,330 hectares (ha) watershed of this *talao* is as significant as the structure itself.

The main source of water for this *talao* is rainwater

which comes from the extensive watershed as well as from the 6.4 km long Ajanti canal. The municipality used to supply two million litres per day (mlpd) of water every day from this *talao* to the town without the help of any mechanical device. Drinking water was available up to the first floor of buildings with great force.

With the growth in population, new sources of water were required. In 1968, a dam was built on the Sukta river to create another source of supply, with a capacity to cater to a population of 1,00,000 in 1991. However, by 1991, the population had reached 140,000. In 1998, the population was 240,000. The Sukta structure was estimated to supply 13.6 mlpd, but in actual practice, it never supplied more than 6.3 mlpd.

The commissioning of the Sukta water supply system was the beginning of the decline of Nagchun talao. First, the station pumping water to the Ajanti canal from Badur Nullah was closed. The pipeline was removed and the municipality stopped desilting and cleaning the Ajanti canal. This stopped the water flow from the canal to the *talao*. The water table in the *talao* began to decline. The filter plant stopped working. The municipality concentrated on beautifying the *talao*, turning it into a picnic spot, neglecting the *talao* proper. After the formation of the municipal council in 1995 the situation took a turn for the worse.

Coveted watershed

The land mafia was covetous of the watershed and 1,011 ha of fertile land around it. A nexus soon developed between the mafia and the civic administration. They first created an alibi that this *talao* no longer had enough water. As it dried up in May and June, there should now be a system to bring water from the Narmada, they argued.

Next, they declared that the 1,011 ha of land around the *talao* was lying idle and under threat of encroachment. As it was impossible for the municipality to look after the land, it was better to lease it off to some company or individual, the mafia-officialdom nexus pleaded. Not only would this supposedly protect the land, but also generate revenue for the municipality.

Meanwhile, Nepa Paper Mills, a public limited company, placed a proposal before the municipality to take the land on lease at a rate decided by the civic body. The company would also give 10 per cent of the profits earned from the proposed tree plantation on the leased land to the municipality.

This proposal was turned down. In July 1995, the municipality invited tenders for a tree plantation lease on the land. Three offers were received. The maximum lease offer of Rs 7.11 lakh a year came from a private firm, Nepa Farms. Later on, it became known that all the three offers were from the same company, under different names.

Enter the public

This scandalous bid of the municipality to sell off valuable public property for a mere pittance was highlighted by the local newspaper. Mounting public pressure forced the municipality to cancel the deal and call for new tenders.

In the next round came an offer of Rs 21 lakh per year, which was hiked to Rs 39.5 lakh per year. In the meanwhile, following a public interest petition in the Jabalpur High Court, the government ordered the municipality to call fresh tenders. This time, the highest bid came for Rs 55 lakh per year, which exposed the malafide intent of municipal officials who were out to lease this public property for a mere Rs 7 lakh per year.

Though this appears to be primarily a case of corruption, allotment of this land for agroforestry purposes had serious environmental implications. The land would need to be levelled and the catchment would be eroded. Water from the *talao* would be used to irrigate the trees. Chemicals would be used to facilitate growth. Another concern was that once the lease expired, the land would be handed over back to the corporation, wasted and depleted. Not only would this land be difficult to reclaim, but would seriously affect the *talao* itself. Environmentally, this was, therefore, not a sound strategy.

When these issues came into limelight, the administration claimed that the Environment Planning and Coordination Organisation (EPCO) of the Madhya Pradesh government had prepared an environment assessment report on the implications of leasing land for agroforestry purposes. The report was produced in the High Court, which finally allowed the municipality to lease the land. EPCO had put certain conditions for the lease: no water should be taken from the *talao* for irrigation, no tubewells should be sunk anywhere in the watershed, no chemical fertilisers or pesticides should be used, and each stage of the plantation should be monitored for its environment impact. It also asked for a larger, more comprehensive study.

LEGAL LACUNAE

This episode has highlighted a major loophole in the present legal system: there is no law against the misappropriation of public waterbodies like the Nagchuntalao. Such incidents can be repeated anywhere in the country. The pertinent question to be asked is: Is it possible for a *talao* to function if its watershed is taken away from it? Is it proper to declare a watershed as 'useless' land? Unless these questions are answered, water sources cannot be protected from land grabbers. ■

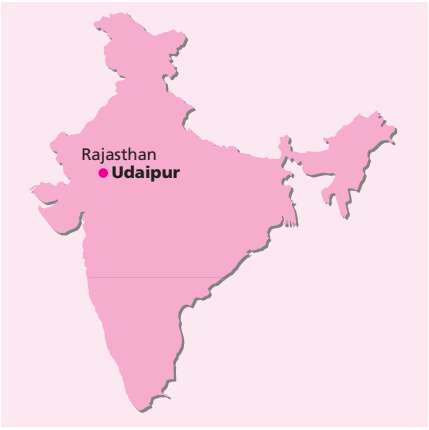
Protection of Urban Tanks: Udaipur

A Languishing Legacy

Concerned citizens have come together in Udaipur to protect the legendary lakes of Udaipur, systematically being turned into the city's waste disposal bins

Tej Razdan
Jheel Sanrakshan Samiti, Udaipur, Rajasthan

Appalled at the rapid deterioration of the lakes of Udaipur, concerned citizens have come together to form a forum, the Jheel Sanrakshan Samiti (JSS) or Lake Conservation Committee. Formed to counter the dismal situation of the city's lakes, the primary objective of this body is to identify the problems and threats faced by these lakes and try to solve them. Through various programmes and fora, JSS has been striving to bring together local people, experts and decision-makers to arrive at workable solutions to save the lakes.



Udaipur owes its existence to the foresight of Maharana Udai Singh, who established this city as the capital of Mewar in 1559, primarily because of its natural fortification provided by the surrounding hills. Realising that the city would face water scarcity, the rulers of Udaipur ensured that the capital did not go without water, by constructing artificial lakes.

In sharp contrast, the present day leaders have no qualms about turning these lifelines into disposal units. About 6,000 cubic metres of sewage and 40-50 tonnes of solid waste material find their way daily into the famous lakes of Udaipur *(see Table 1: Wasted waters)*. As many as 2,000-odd people defecate daily on their shores and about 100 latrines drop faecal matter directly into the lake waters. All open drains and sewer lines of localities in the vicinity of the lakes, housing about one lakh residents, terminate directly into the lakes. Yet, the government had no second thoughts about turning these lakes into an exclusive source of drinking water for the city of Udaipur in 1985, discontinuing their traditional use for irrigation *(see Box: Udaipur's utopia)*.

Table 1: Wasted waters
Amount of sewage and solid waste daily entering the lakes of Udaipur

Name of lake	Number of drains	Effluent volume (cubic metres per day)	Solid waste (tonnes per day)
Pichchola	25	3,580	4
Rangsagar	8	1,250	5
Kunwariyatalab (part of Pichchola)	1	830	2
Swaroopsagar	4	340	6
Fatehsagar	Not available	Not available	4
Total	**38**	**6,000**	**21**

BEYOND LIMITS

As if serving as a disposal bin of the Udaipur residents was not enough, the city's lakes also have to contend with the floating tourist population which also does its bit to pollute these lakes. Out of the 10 lakh tourists visiting the lakes annually, about 100,000 are foreigners who bring in considerable foreign exchange. As a result, many entrepreneurs and hotel groups want to put up hotels around the lakes, if possible, within the lakes themselves. Many small shops have come up in the vicinity of these lakes to cater to the tourists. Tourists throw plastic and polythene packets into the lake waters, endangering aquatic life. Ill-maintained boats spill oil into the lake waters. Tourists-in-transit add to the threat, coming by busloads, and, who defecate,

UDAIPUR'S UTOPIA

Designed for self-cleansing, the lakes of Udaipur form an intricate network to maximise water utilisation

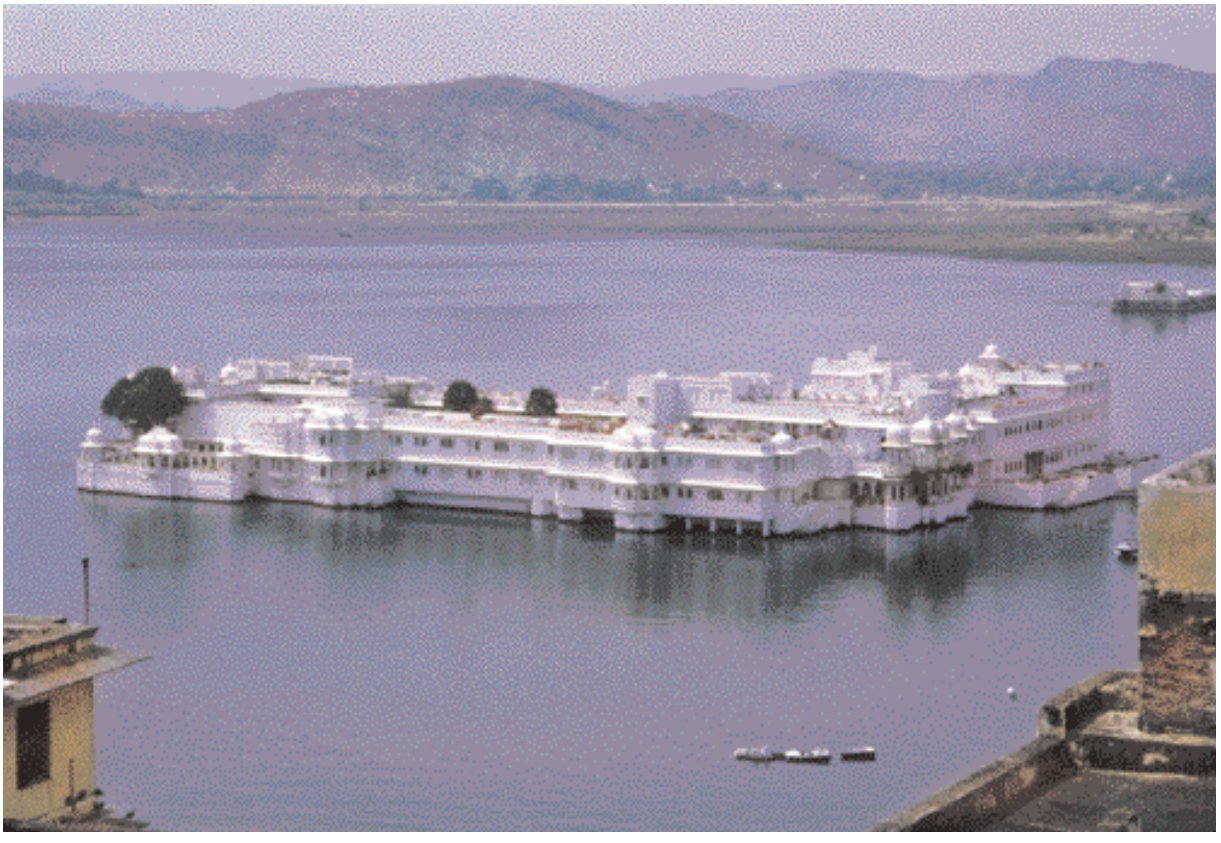
Maharaja Udai Singh established Udaipur as the capital of Mewar in 1559. Because of its geographical situation, Udaipur faced a scarcity of water from its very inception. Hence, it became a priority for the erstwhile rulers to construct artificial lakes to have assured water supply. Most of the lakes around Udaipur like Chota Madar, Bada Madar, Kumahariya Ka Talab (1668), Rangsagar (1668), Swaroopsagar (1844), Fatehsagar (1678, renovated in 1889), Govardhan Vilas and Udaisagar were constructed by the rulers of Mewar. These lakes were not primarily meant to provide drinking water to the citizens because they depended on *baoris* (stepwells), openwells and *kundis* (tanks) for drinking purposes.

These lakes are interconnected, diverting water overflow of one lake into another, ensuring optimum utilisation of water and natural cleansing of the lakes. The Aayad and Sisarma rivers are the primary sources of water for these lakes. These lakes finally discharge their overflow into the Bedach river, which is a part of the Ganga river system. Thus, the lakes of Udaipur are a vital part of the national water system.

wash clothes and vehicles on the lake shores.

Considering the total amount of human excreta and solid/liquid pollutants released into the lakes daily and the fact that just one gram of human excreta contains one million bacteria or organisms, one shudders to think of these lakes as sources of drinking water. The quality of the water in the lakes is abysmal. Studies show that levels of dissolved oxygen, biological and chemical oxygen demand, total and faecal coliform, all are way above permissible levels. Nutrient-loading and boosting of nitrogen and phosphorus in the lakes are a direct consequence of sewage and solid waste coming into the lakes. Carp fishes like *rohu* (*Labeo rohita*), *katla* (*Catla catla*) and *mrigal (Cirrhina mrigala)* have disappeared and only hardy air-breathers like *sanwal (Opheocephalus), singada (Mystus seenghala)* and *singi (Heteropneutes fossilis)* are found now. The lakes are experiencing an alarming growth in sedimentation, water hyacinth, blooming algae and submerged weeds that hamper not only the quality of water, but also the very tourism because of which they have proliferated.

So bad is the pollution that in the case of Swaroopsagar, the filtration plant just cannot deal with the load. The filters get clogged. To deal with this, the



AMIT SHANKER / CSE

Interconnected, Udaipur's lakes ensured optimal water storage and great beauty

TEJ RAZDAN

Concerned citizens participated in a voluntary programme to remove water hyacinth from Swaroopsagar

public health and engineering department is pumping water from this lake into the relatively cleaner Fatehsagar and then passing this mix through the filtration plant. The result? Pollution of Fatehsagar.

Deforestation in the catchment areas is another major factor responsible for the plight of the lakes. Systematic denuding of forests has caused heavy siltation, reducing their water storage capacity by one per cent every year. The groundwater table has declined. The sudden spurt in the number of industries in the catchment areas of these lakes has also resulted in considerable amounts of chemical pollutants entering the lakes.

The most pathetic aspect of the problem is the multiplicity of government departments involved in the so-called conservation of the lakes, all of them unconcerned about actual conservation. There are no less than 12 such different government agencies: the irrigation department, public health and engineering department, forest department, tourism department, the municipality, Urban Improvement Trust, revenue department, public works department, soil and conservation department, pollution control board, fisheries department and the town planning department. This makes passing the buck all the more easy.

RAY OF HOPE

The people of Udaipur are, since 1969, actively participating in programmes to clean up the lakes. In 1980, for instance, the citizens, operating like a conveyor belt, removed the water hyacinth which had totally covered two lakes. In 1995, when again the citizens were participating in cleaning up the lakes, they requested the municipality to arrange for trucks for weed disposal. The municipality refused. A heap of water hyacinth was left piled up on the road, causing traffic jams. The police came into the picture and chargesheeted the people involved in the cleaning operations. The case is still going on.

The JSS is determined to save the lakes and is trying to communicate with and coordinate between these various agencies, attempting to drive home the point that these lakes are vital for the city. To make sense out of this confusion and chaos, JSS has regular dialogues and correspondence with central and state governments and other scientific bodies. Through rallies, public meetings, pamphlet distribution programmes and lecture sessions at various schools and colleges in Udaipur, JSS is striving to build up support for saving the lakes. By bringing together a conglomeration of professors, engineers, doctors, architects, planners, advocates,

BETTER LAKE THAN NEVER

It all started with a case filed by Balwant Singh Mehta in 1982 demanding his right to clean water. Some 18 years later, the state government has been pulled up by a High Court bench. Mehta turns 101 this year

The city of Udaipur gets its water supply from its lakes. In 1982, concerned by the rampant pollution of these waterbodies, Balwant Mehta filed a public interest litigation in court, demanding his right to clean water. This marked the beginning of a long struggle which took several petitions in the court. In May 2000, the High Court bench of Justice D N Joshi and Justice N N Mathur held the chief secretary responsible for implementation of the court's orders.

The chronology of events was as follows:

1982 – Balwant Singh Mehta approached the Rajasthan High Court because the Udaipur lakes were polluted.

1992 – Jheel Sanrakshan Samiti, a non-governmental organisation, came into existence and started a crusade to save the lakes of Udaipur.

1994 – In January, Mehta's case was decided and the Udaipur administration was directed to constitute a committee to examine causes of water pollution in the lakes and to supply clean water to the residents within six months. While the government claimed to have taken action, in reality, nothing was further from the truth.

1997 – Jheel Sanrakshan Samiti (JSS) initiated a public interest litigation (PIL) in the Supreme Court for pollution of the Udaipur lakes and to inform the court that in spite of court directions, the water quality had only deteriorated.

1997 – The Supreme Court directed the PIL to the Rajasthan High Court, which admitted the case.

1998 – As this PIL had reference to the PIL filed by Mehta, the Court took a *suo moto* decision of contempt of court against the district administration (collector) for non-compliance of the High Court order of 1994. The High Court appointed the district judge of Udaipur to enquire and submit a factual report of the condition of Udaipur lakes to the High Court.

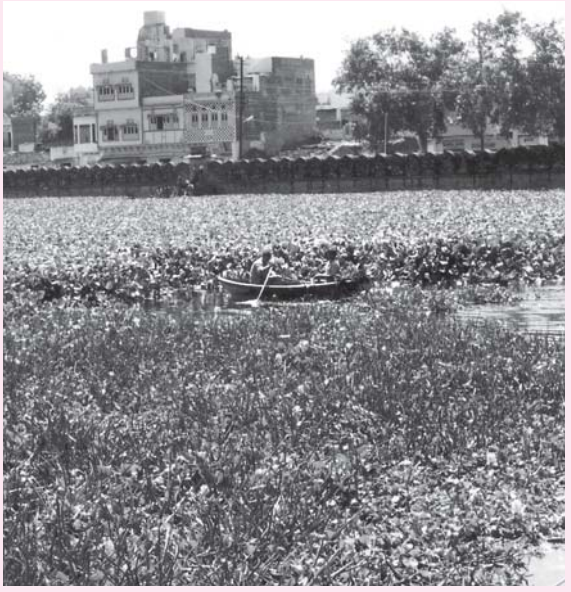
1998 – The district judge O P Bishnoi submitted his report to the High Court, exposing the true state of the lakes of Udaipur, the role of government departments in polluting these lakes, and the lack of action taken by them. He noted the tendency of state departments to shift the blame from one to the other. He also declared that the lakes of Udaipur were, beyond doubt, more polluted now than when Mehta had first filed his petition in 1982.

1999 – JSS initiated another PIL for the same cause in the Rajasthan High Court. The other pending PILs and the contempt case were clubbed together.

1999 – The Jheel Vikas Society is formed with the divisional commissioner of Udaipur as the president and the district collector as vice-president.

2000 – The case is now being heard by the High Court Double Bench headed by Justice N N Mathur and Justice D N Joshi. These judges heard the case on a fortnightly, even weekly basis, holding the concerned officials strictly responsible for implementation and issuing them a stern warning.

The directions of the court left nothing to chance. There was action at last. The lakes were desilted before the onset of monsoon to capture the rains. Drying up of the lakes had lowered the groundwater table considerably. Desiltation will enhance groundwater recharge. An action plan was prepared and submitted by the Jheel Vikas Society.



TEJ RAZDAN

Water hyacinth, so tall that the boat and occupant are hidden

hydrogeologists and experts from different fields, JSS acts as an expert body. It has submitted many projects like a domestic sewerage system for the city, treatment and disposal of sewage, and a preliminary feasibility report on environmental improvement of Udaisagar lake to the state government and other financial bodies for approval and endorsement. The JSS does not get into implementation of the projects, leaving that to government departments.

Through constant dialogue and reminders, the government has been compelled to define and declare a 'no construction zone' around the lakes. Attempts to dilute the order were thwarted when the JSS moved the court for strict implementation of the order (*see Box: Better lake than never).*

JSS has also ensured that the government initiate acquisition of all lands coming under the high flood level area of the lakes. JSS is now fighting for diversion and treatment of sewage that enters the lake waters, effective treatment of catchment areas, execution of Mansi Wakal project for augmenting water supply to Udaipur lakes, the creation of a Lake Authority, and an early implementation of the National Lake Conservation Plan. ■

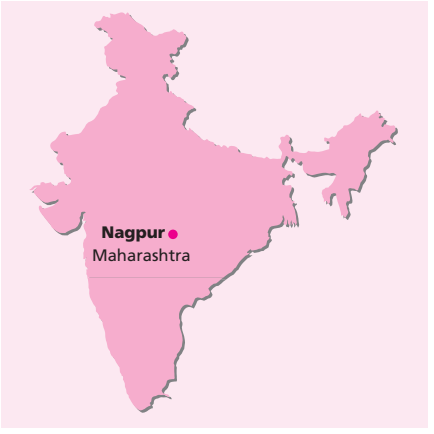
Protection of Urban Tanks: Nagpur

Towards a Model Ecocity

Efforts are on to stop the degradation of traditional waterbodies in Nagpur and to maintain it as a model ecocity by striking a balance between economic and ecological development

Pradyumna Sahasrabhojanee
Vidarbha Nature and Human Science Centre, Nagpur, Maharashtra

Up to the beginning of the 20th century, Nagpur could have been categorised as an eco-city *(see Box: How green was the city then…)*. According to the Japanese architect Koichi Nagashima, an eco-city is one which aims at a degree of self–sustainability within its own ecological system. Nagpur, with its vast forests and wetlands, was once a good contender.



The decline of waterbodies around Nagpur began after Independence. Ambazari dam, one of the most important traditional sources of water to the city, was overlooked as a drinking water source and used to dump sewage and garbage, while distant river sources were preferred.

The Ecocity Foundation of the Vidarbha Nature and Human Science (VNHS) Centre is working towards developing Nagpur as a model ecocity by striking a balance between economic and ecological development. Its immediate concerns are to stop the degradation of ecological resources and biodiversity. VNHS is working towards motivating people to promote the principles of an ecocity and to persuade authorities not to ignore ecodevelopment issues while drafting land use, town development and other management plans.

AMBAZARI THEN…

Ambazari dam not only feeds the main river Nag but also plays a key role in maintaining the natural pattern of the water drainage system in the area. It was originally a small natural waterbody that was gradually converted into a large lake. Its importance was first discovered by the Kohlis, a community of water experts. The water of the Nag river was stopped by building a dam, using simple yet foolproof techniques. The pace of construction had deliberately been slow and each year, a new layer was constructed on the embankment after carefully studying the effect of last year's construction. Black cotton soil, considered troublesome even in modern construction sites, was effectively used for constructing the dam by ensuring that the soil always remained wet.

Water from Ambazari was used to irrigate areas which presently fall in the centre of the city, namely, Punjabrao Krishi Vidyapeeth (PKV) lands, Ramdaspeth and Dhantoli. According to the original design, the dam was 777 metres (m) long with a tank area of 96 hectares and storage capacity of 0.3 million cubic metres (mcum). The average water depth was 3.7 m.

In 1770, the then rulers, Bhonsales, added stone pitching to strengthen its embankment. For regulating the flow of water, a large well was dug adjacent to the embankment. During this period water was provided through 228.6 millimetre (mm) diameter stone aqueducts to the *mahal* (palace) and to some of the *wadas* (residencies) of *sardars* (landlords). The natural west to east gradient was ingeniously used to achieve this.

In 1869, when a severe drought dried up the lake completely, a British engineer discovered several underground springs in the lake bed. After this drought, the height of the embankment was raised to about 12.5 m to increase the capacity of the dam to 0.9 mcum from the existing 0.3 mcum. Since then, the lake has never completely dried up. The British then used this lake for supplying water to the newly developing southwestern parts of the city. With the help of pipes brought from England, supply of tap water began from the Ambazari lake in 1871. Subsequently, on the advice of the

HOW GREEN WAS THE CITY THEN...

Nagpur could have been categorised as an ecocity till the beginning of the 20th century

Nagpur had a high degree of self-sustainability within its own urban ecological system, which has been considerably degraded in recent decades through thoughtless planning. However, signs of that great heritage still linger in the city.

During successive regimes of the Gonds, the Bhonsales and the British, Nagpur was a city with vast green zones and rich wetlands, perennial rivers like the Nag and Pili, and ten strategically located lakes. The British used to call this city the 'Gateway to the central Indian forests'. Signs of this natural heritage are in existence even today. Nagpur still has the best land-to-population ratio in India. It has hills, healthy wetland systems, vast green belts and open land areas like the Seminary hill, abounding in rich biodiversity.

The Nag and Pili flow through the city of Nagpur. The Nag originates from the Ambazari lake and Telangkhedi tank, while the Pili's source lies in the Gorewada lake. Interestingly, the main catchment area of both the rivers lies within the municipal area of the city itself. There are two streams of the Nag river which flow through the city and meet at the *sangam* near the city. The *sangam* is called Nag Nalla because the sewer lines are drained into this. The Nag river basin is more important as it flows through the centre of the city itself. There are other smaller lakes that are quite important to the city. Constructed during the Bhonsale period, most of these tanks are constructed with black basalt rock and are located at old military camp sites.

The overall water drainage system around Nagpur is divided roughly into three valleys sloping from the west (Mahadagarh hills) towards the east (towards the Wainganga river basin). Numerous waterbodies like the Ambazari, Telangkhedi, Pandharabodi (Bhide), Gorewada, Sonegaon and Dahegaon form a necklace on the western rim above the city.

With increasing population and urbanisation, all these waterbodies today are endangered by pollution and encroachment. Some of the tanks such as Shukrawari in the centre of the town have shrunk in size while others like Gandhi Bag tank and Pandharabodi tank have disappeared altogether.

This has had an adverse impact on groundwater levels. The construction of every house begins with the sinking of a borewell. For further growth of the town, it is important for town planners not to permit housing colonies upland of these tanks. Other water-related planning items include the need to prevent urban flooding, pollution prevention in existing waterbodies, and recognition of the role of wetlands in water management.

PRADYUMNA SAHASRABHOJANEE

Nagpur had a series of thoughtful rulers, who took care to maintain and respect the natural drainage of the area and preserve their sanctity. The Bhonsales, for instance, constructed several tanks with temples on the banks

PRADYUMNA SAHASRABHOJANEE

The wetlands of Nagpur are home to a rich biodiversity. If this ecosystem has to be maintained, there is a need to plan the city as an ecocity where these resources are not overburdened

renowned engineer, Sir M Visvevaraya, a stone wall was constructed at the southern end of the dam to control the flow of water.

...AMBAZARI NOW

After a heavy rainfall in 1994, the city authorities breached the stone wall instead of strengthening it, to let out excess water. To add to the problems of the dam, a large industrial estate had been allowed to operate in its catchment area and the streams feeding the lake were allowed to carry industrial effluents. The university campus located on the edge of the dam disposed wastes from its laboratories and staff quarters situated close by, which eventually found their way into the dam. In addition, politicians actively contributed to create slums on the edge of the dam from where night soil got carried into the lake directly, especially during rains. A boating centre has also been developed from where visitors dumped garbage into the dam.

Until some years back, illegal *murrum* (red sand gravel) quarrying was being carried out on the edge of the dam that did not allow any kind of vegetation to grow in the catchment area. But now, in lieu of the submergence area in Gosikhurd project on the Wainganga river, the catchment area of Ambazari has been declared as a 'compensatory forest' which has been fenced off for protection. Since then, a natural grassland has developed in the area, bringing back a large amount of biodiversity, including rare birds. As the area is less populated and the number of chemical producing industries is limited, pollution levels are also within manageable limits. There are areas on the outskirts of the city where water from Ambazari is regularly supplied. Therefore there is a strong likelihood that water users, including industrialists, will support plans for cleaning the lake.

The Ecocity Foundation has set itself the following targets:

- to restore the original capacity of the Ambazari dam by strengthening its embankments;
- to create recognition that this lake, together with Telangkhedi, is the prime source of water for the Nag river (from which the city derives its name), and that it can still serve as an important source of water supply;
- quantify and monitor the biodiversity in the catchment areas of the lakes and monitor effluent treatment at various points in the municipality area as well as in the university campus; and,
- to create a smaller waterbody between Ambazari and municipality area where the quality of water can be monitored and only then allowed into the main lake. ■

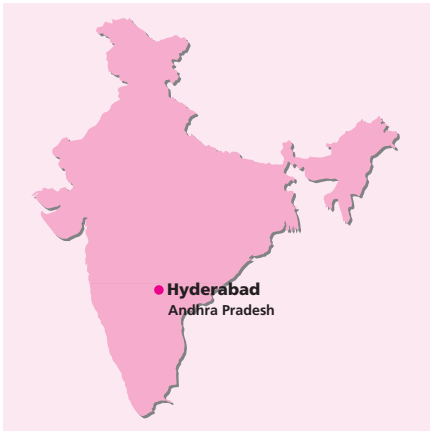
Protection of Urban Tanks: Hyderabad

People's Power

A concerted campaign to save the lakes of Hyderabad yields results with the court on its side

K L Vyas
Save the Lakes Campaign, Hyderabad, Andhra Pradesh

A struggle to protect the lakes around Hyderabad started on September 19, 1993 by PRAKRITI, a group of environmentalists. Termed as the 'Save the Lakes' Campaign, this sustained struggle has yielded positive results. Organised action by communities has succeeded where no amount of intellectual pursuit to highlight the ecological implications of destroying lakes achieved anything.



Hyderabad has been a city of lakes and gardens. Within a radius of 35 kilometres, there were about 532 tanks and *kuntas* (percolation tanks). The Qutub Shahis (1564-1724 AD) and Asafzahi rulers (1724-1948 AD) built many small and big lakes in and around the city to ensure water for their various activities. The undulating terrain of the Telangana region makes it easy to construct check dams against a small *vagu* (rivulet) to collect the rainwater. Hence, the science of harvesting rainwater by way of constructing waterbodies is ancient in this region.

These urban lakes play an important role in groundwater recharge in addition to influencing the microclimate and are special ecosystems by themselves. Lakes like the Osmansagar and Himayatsagar still supply drinking water to the city. The value of these lakes can be gauged from the action of officials towards them: they are being converted into residential colonies with their consent. Even urban planning bodies like the Hyderabad Urban Development Authority (HUDA) have given layouts in tank beds, destroying them completely.

In 1994, out of the 170 lakes that were identified by HUDA to be above 10 hectares (ha) in size, only 23 were perennial. A slum has sprung up at Mir Jumla tank, and a colony for the affluent in the lake bed of Maasaabcheruvu. Yosufgada Lake and Batakammakunta have become garbage dumping grounds for the municipalities of Hyderabad, resulting in the filling up of the lake beds. Ramathpurcheruvu has become a residential colony. Sahebnagarcheruvu in Hayathnagar Mandal is totally occupied by influential politicians and layouts for the housing colony have been given by HUDA. Gopicheruvu at Gacchi Bowli near old Bombay road is converted into a township by Dyon Company. Kanchanbagcheruvu is filled and a hospital is being built in half of the lake bed. Some lakes like the Patancheruvu and Jeedimetlacheruvu have been highly polluted by industrial effluents.

The *modus operandi* for destroying the lake is simple and systematic. The municipality starts with dumping garbage into the lake. Domestic and industrial effluents are let into the lake. Grass, weeds and water hyacinth are never removed. The lake gradually dies and slums, colonies or other 'development projects' spring up near it. The nexus between politicians, government agencies, land grabbers and criminals is strong and powerful, with adequate muscle and money power.

FLASH POINT

The genesis of 'Save the Lakes Campaign' in Hyderabad goes back to 1993 with Saroornagar lake as the flash point. Impounded in the year 1626 AD, more than 300 years ago, the lake is at the tail end of a series of eight waterbodies impounded in the region. The lake acts as a 'shock absorber', containing the sudden gush of flooding rainwater during heavy rainy days. Originally spread over an area of 65 ha the lake is at present reduced to only 25.41 ha.

Both the catchment and command areas were converted into non-agricultural residential zones. In October 1984, the state government issued a government order for the 'abandonment of the lake' by depleting the full tank level from 31 metres (m) to 29 m, to facilitate development of residential colonies in the illegally occupied peripheral areas of the waterbody. This move would affect the livelihood of 300 fisherfolk families who depended on the lake for their livelihood.

The lake would have vanished but for the concern of the then chairperson of the municipal corporation and the corporators of the city, who, in October 1988, unanimously resolved to save the lake at any cost.

There were, thus, a series of disturbing events concerning the lake that spurred the people into action. In addition, there were two major fish kills in October 1993. The Madannapet fishermen's cooperative society reported the matter to the Andhra Pradesh Pollution Control Board (APPCB), who, after water analysis, assigned the cause of the fish kills to eutrophication caused by a drain entering the lake and directed its diversion. The municipality was directed to divert the drainage.

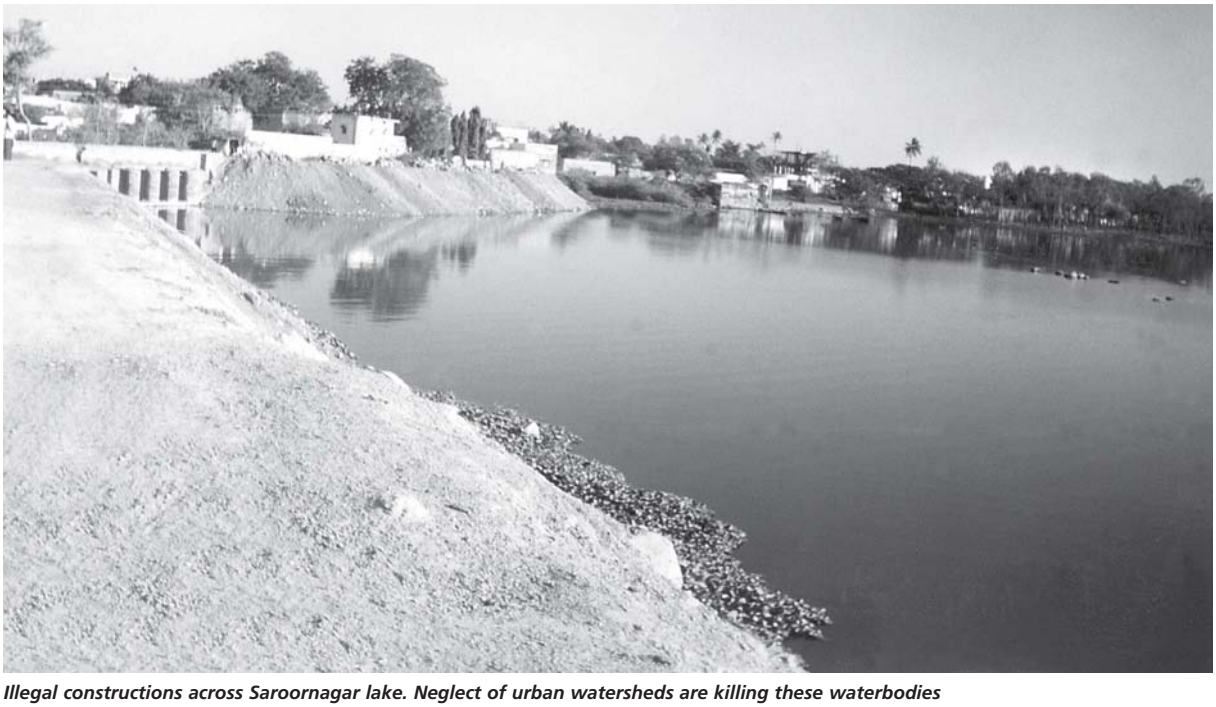
SUCCESS FORMULA

The success of this campaign lies in its membership and its ability in creating awareness and getting communities from all walks of life to get involved. The campaign drew its members from all sections of society, which could be broadly divided into three categories: fisherfolk community and local residents at the grassroots level, scientists (limnologists, biologists and others), environmental activists, teachers, non-governmental organisations, students, womenfolk and others.

With the aim of protecting and saving 170 lakes of Hyderabad, Saroornagar lake was taken as the pilot project. To highlight the problem, the activities included involving interested groups in creating awareness, organising rallies and *shramdan* (voluntary labour) to clean the lake area, lectures, demonstrations and distribution of pamphlets, mass contact, approaching concerned officials, effective use of media, and finally approaching the court for directions.

The public awareness drive soon swelled into a tidal wave. Mass rallies of schoolchildren, students of the National Social Service and National Cadet Corps were taken out, and pamphlets distributed. A postcard campaign was launched. Soon people from all corners of the city started to write about lakes in their respective areas in newspapers and formed groups to represent lake problems.

The stormwater drains in the upper catchment areas of Saroornagar lake are filled with silt and occupied by people, endangering the lives of people residing in the low-lying areas. All these facts were presented before the municipal authorities with a request to prevent the lake being used as a garbage dumpyard; divert the sewage drains entering the lake; demarcate the lake boundaries; remove encroachments; and, undertake plantation on the periphery.



K L VYAS

Illegal constructions across Saroornagar lake. Neglect of urban watersheds are killing these waterbodies

ANJU SHARMA / CSE

The lakes of Hyderabad are no different than lakes across the country. These too serve as receptacles of the city's waste

Meanwhile, as disturbing events concerning the lake continued to occur, the people continued to act. On numerous occasions, irrigation officials, with the help of the local police, attempted to open the *bund* and reduce the lake waters. Each time these moves were stalled by the fisherfolk or the activists of the movement. With the chipping in of students from schools and colleges, who helped in cleaning up the lake, support for the movement swelled. Coverage by the media aided in creating awareness and generating public opinion in favour of the campaign. Similar protests were initiated in other places like Gopicheruvu, Gacchibowli and Kuntacheruvu.

However, explaining issues to the then chief minister and the minister for environment and forests drew a blank. Finally, out of despair, in August 1995, a public interest litigation was filed in the Andhra Pradesh High Court, seeking direction to ensure the protection of the 170 city lakes.

Justice C V N Shastry then directed government departments to protect all waterbodies around the city. On the same petition, Justice M N Rao and Justice Rajgopal Rao directed the state government to appoint the Environment Protection Training and Research Institute to prepare an action plan for the protection of Saroornagar lake. With the aim of protecting and saving 170 lakes of Hyderabad, Saroornagar lake was taken as a pilot project.

The movement has requested the government to declare all lakes as reserved and to constitute a Lake Protection Cell. Since the economy of rural regions like Telangana depends upon thousands of small tanks, neglected by successive governments, the movement is now spreading to rural areas.

LESSONS LEARNT

1. One of the major setbacks faced by the public movement was the lack of proper legislation and legal lacunae to counter encroachment. Some laws were framed before independence, which accorded ownership of lakes to private people. The Nizam of Hyderabad permitted farmers to raise crops in the lake bed periphery (called *sikambhoomi*) during the months when the lake water recedes, to increase food production. In due course, the cultivators became the owners of these areas. They got *pattas* — documents of land ownership — which were soon used to convert these lands into residential areas that gradually encroached into the whole lake bed, destroying it systematically. Hence, there is an urgent need to prevent any conversion of the lake bed or peripheral areas, by cancelling all private *pattas* in these areas. Urban and rural lake ownership needs to be reviewed. Perhaps, in the interest of conservation, these may be taken over under government control ensuring their conservation.
2. There should be stringent enforceable laws to punish those who destroy lakes by pouring in untreated sewage, defecating, dumping garbage and engaging

URBAN NIGHTMARE

After the unprecedented urban floods in Hyderabad in 2000, Andhra Pradesh chief minister N Chandrababu Naidu finally acknowledged that these were due to gross neglect of the city's waterbodies

In early 2000, Andhra Pradesh was in the news for the drought that the state faced:. the monsoon was below normal, and water scarcity loomed large over the state.

In August, the state was again in the news — for precisely the opposite reason. Hyderabad experienced heavy rainfall resulting in unexpected and unprecedented urban flooding. While allegations flew thick and fast, and the buck was furiously passed around — the fact remains that this is another state that does not know how to manage water.

For years now, concerned citizens have been campaigning for saving the lakes in Hyderabad. Citizens Against Pollution and Centre for Resource Education are just two Hyderabad-based non-governmental organisations who put the blame squarely on human mismanagement and the government. Years of skewed developmental policies; changes in the floor space index; siltation of tanks reducing their water storage capacity; encroachment of *nullahs* and waterbodies; and, choking of streams and stormwater drains have taken their toll. The chain link between waterbodies stands destroyed and the transfer channels between the catchment of one tank and the catchment of another tank decimated. Concretisation of the ground prevents seepage of water into the ground with the result that the water build-up into the waterbodies is fast even as their waterholding capacity stands reduced. The urban watershed area has been wrecked, destroying the natural channels of water flow and flood control infrastructure.[1] The chief minister finally realised the effect of haphazard urban development. "All the damage was caused by the construction of huge residential complexes along the flood flow channel of Hussainsagar," he said.[2]

Urban flooding is not a novel experience. Increasingly, more and more Indian cities and towns face waterlogged streets. The frequency of this flooding is also increasing, even when the monsoon is normal or less than normal. Calcutta for instance experienced flooding in 1970, 1978, 1984, 1986 and 1999.[3] Silting up of the Bagjola canal and deliberate filling up of ponds in the city are partially responsible.[4] And as years go by, even relatively small downpours are enough to clog up drains, fill up

REUTERS

Recurring urban floods: An indicator of human mismanagement of water harvesting structures

in other polluting activities. The impact of urban waterbody destruction was made visible by the floods that hit Hyderabad this year (*see Box: Urban nightmare).*

3. The concerned municipalities should be made responsible for conservation and upkeep of the lakes falling under their jurisdiction.
4. Filled up lakes should be developed as green parks — these should not be converted into colonies or put to any other use.
5. Legislators from the area should be made responsible and accountable for the protection of waterbodies. Scientists should translate their research into action.
6. Universities and colleges should be involved to study these waterbodies, suggest solutions and help in the execution of these suggestions. ■

Learning the Value of the Raindrop

Despite initial hiccups, with river waters industrially polluted and groundwater aquifers heavily exploited, rainwater harvesting has finally arrived in Germany

Hannah Büttner
Heidelberg University, Heidelberg, Germany

Water scarcity as well as water disposal problems have forced the Germans to harvest rain. The rising costs of both, and ecological concerns, have resulted in rainwater being accepted as a solution to solve water-related problems. New approaches in rainwater harvesting take into account the interconnections between drinking water needs, sewage control, flooding and groundwater accumulation, which till recently, used to be treated separately. An estimate in 1998 indicated that about 50,000 rainwater harvesting systems were being installed every year. The stumbling blocks have been the competing investments made in augmenting water supply infrastructure and the scepticism of various government organisations.

Water consumption of Germany in comparison to other regions of the world indicate that Germany uses maximum water for industrial purposes *(see Table 1: Water consumption)*. In 1997, only 5 per cent of the household consumption of potable water was actually used for drinking and cooking purposes *(see Table 2: Domestic consumption)*.

The strategy in Germany to meet rising water demand has been to look deeper (into groundwater aquifers) and look further. Sixty five per cent of public drinking water in Germany comes from groundwater. In the early 1970s, people became aware of the contamination of rivers through industrial pollution. Therefore, increasing amount of water had to be sourced from groundwater aquifers for drinking purposes. Another strategy has been to meet increasing demands by sourcing further and further away from urban centres.

The federal state of Hessen was jolted into action when, in the summers of 1992 and 1993, the state had to apply emergency laws to curtail the use of groundwater. Hessen was not alone in facing acute groundwater shortage. Urban centres like Frankfurt, Stuttgart and Hamburg, dependent on limited groundwater resources, have had to export water from far off places. On the other hand, there were rising expenses due to increased flooding and dealing with large sewage volumes since the rainwaters were emptying into

Table 1: Water consumption
A comparison of water use by various sectors

Location	Total consumption	Consumption per person		Consumption by consumer (per cent)		
	units (billion cubic metres/year)	Annual (cubic metres/person)	Daily (cubic metres/person)	Household	Industry	Agriculture
Global	3,240	644	18	8	23	69
Europe	359	713	20	13	54	33
Germany	47	595	16	14	83	3

Source: H Lehn, M Steiner and H Mohr 1996, Wasser-die elementare Ressource, *Lettlinien eine nachhaltigen Nutzung*, Akademie fur Technikfolgenabschatzung, Stuttgart Springer Verlag, Berlin, Heidelberg, New York

Table 2: Domestic consumption
Use of drinking water in Germany, including cottage industry, in 1997

Purpose of water use	Litres/ person/ day	Share (per cent)
Shower, personal hygiene	46	36
Toilet flushing	35	27
Laundry	16	12
Dishwashing	8	6
Room cleaning, car washing, garden	8	6
Drinking, cooking and cleaning of cooking utensils	5	4
Cottage industry	12	9
Total	**130**	

Source: BGW Bundesverband der deutschen Gas — UND Wasserwirtschaft 1998, *Entwicklung der Umweltpolitik*. Wasserversorgung 1990-1997, Bonn

sewage drains. Sewage disposal and flood control have thus also contributed to making rainwater management a crucial issue. This resulted in a revolutionary approach of rainwater management during the 1990s *(see Box: Hessen's rules)*.

WATER SUPPLY SYSTEM

Municipalities are responsible for water supply and sewage disposal in Germany. They are empowered to draw up their own statutes. Municipalities are also responsible for the supply of high standard drinking water quality, parameters of which are legally fixed. The role of the states and the central government is only to provide certain policies or general outlines of laws as guidelines for specific elaboration. In addition, the European Commission passes guidelines for its member-states concerning management of natural resources and environmental protection. For more than two decades, the commission has been passing guidelines relating to groundwater and drinking water quality and sewage treatment plants.

About 99 per cent of the population in Germany is supplied with public drinking water while 89 per cent is linked to the public sewerage system. These services are provided from the fees collected from the consumers. To enable the public waterworks to cover the costs that they incur in providing these services, every citizen is obliged to take drinking water and get connected to the public water works. With a constant rise in the cost of these services and implied mismanagement, this has become a political issue. In sparsely populated rural areas for instance, increasingly communities prefer to delink themselves from the main public water supply system and want local, decentralised solutions.

GERMANY'S WATER WOES

Though massive efforts have cleaned up industrially polluted rivers, they still do not meet drinking quality standards with the result that attention is diverted to groundwater. Even huge chemical factories in the Rhine Valley are now using groundwater. As groundwater

HESSEN'S RULES

Efforts at regulating groundwater use and charging for it have borne fruit

The federal state of Hessen was jolted into action when, in the summers of 1992 and 1993, the state had to apply emergency laws to curtail the use of groundwater. The subsequent five-point programme of the state has yielded results.

In Hessen, 95 per cent of drinking water is supplied from groundwater sources, while the national average is approximately 65 per cent. In recent decades, the state experienced some very dry summers, with water scarcity and depletion in groundwater levels. To combat these problems, the government introduced a five-point programme and initiated appropriate legal steps. In July 1992, Hessen introduced high charges for drawing groundwater to support sustainable groundwater management. Other action points included a groundwater management plan for critical regions where the groundwater levels were sinking; changes in the permission system of groundwater withdrawal to one where the amount of groundwater that could be withdrawn would be calculated on certain groundwater measure-points; the use of legal instruments to reduce water consumption coercively; and, construction of filter systems for river water.

Another important step was to install rainwater harvesting systems, especially in the southern part of Hessen with the help of the money raised by the groundwater extraction fees.

The programme has yielded results. With high pricing and the introduction of water saving devices, the withdrawal of groundwater declined from 483 million cubic metres (mcum) to 432 mcum between 1993 to 1996. With the money raised from the use of groundwater, a number of rainwater harvesting projects have been supported. Private houseowners and associations have invested more than 40 million DM (about US $17 million) in rainwater harvesting. The state chipped in with 14.3 million DM (about US $6 million). More than 7,000 water harvesting structures were installed and 82 projects for water protection in the industrial sector initiated and supported. A groundwater management plan for the critical region has been worked out.

extraction gets into deeper and deeper aquifers, pressures on this limited supply increase. Deep aquifers take very long to replenish. Heavy extraction leads to subsidence of the surface soil and ecosystem changes.

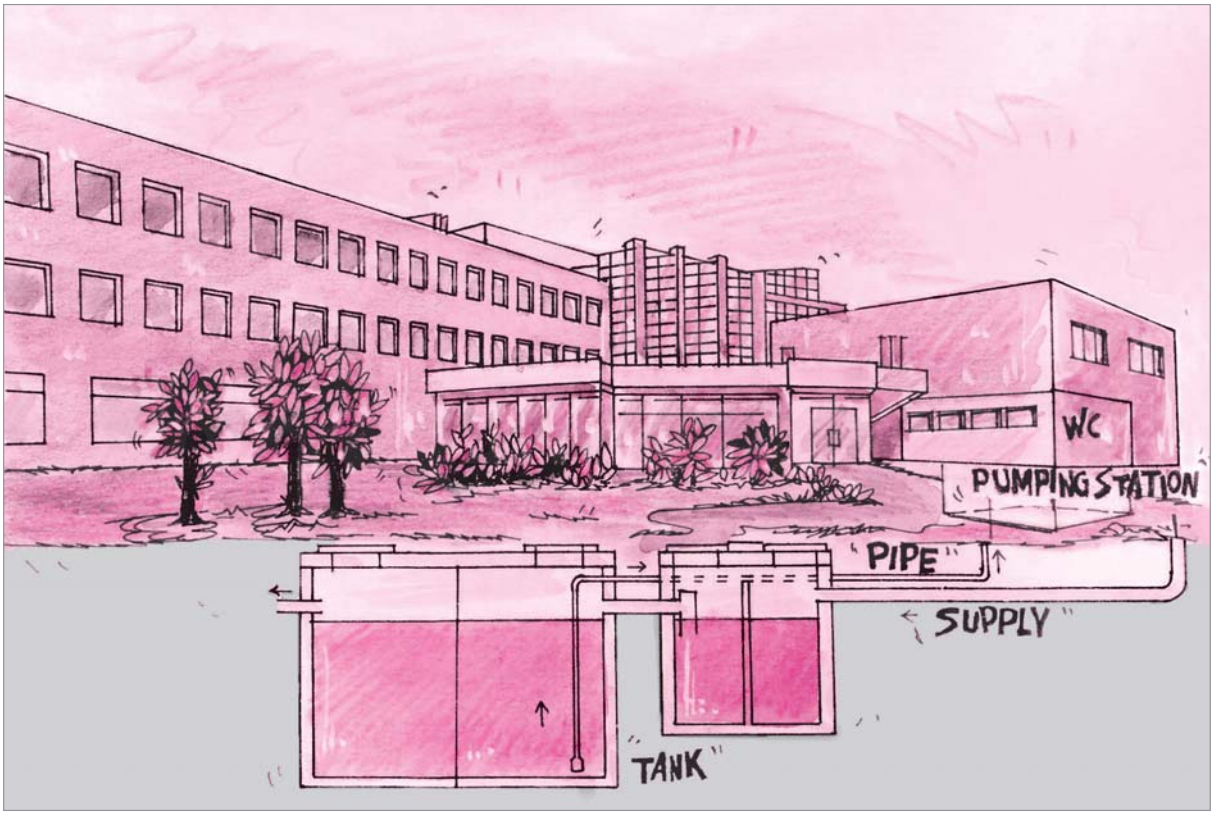
Groundwater extraction from deep aquifers also increases the risk of pollution. In Mannheim, the chemical industry has withdrawn water from a deep aquifer and exposed it to contamination. In regions where the quantity of groundwater is sufficient, its deteriorating quality is causing problems. Pollution sources are diffuse and usually due to agriculture and traffic. In the southern state of Baden-Wurttemberg, more than 500 (out of 2,000) drinking water wells have had to be closed since 1986. In 44 per cent of these closed wells, the concentration of nitrates or pesticides was considered to be too high.

The strategy of bringing in water from less densely populated regions, like the city of Stuttgart which draws water from the Bodensee lake, located some 200 kilometres away has created problems for both the supplying and the supplied regions. Negative impacts like sinking of groundwater level, change in vegetation, disturbance in ecosystems, and damage to houses have been observed.

Pollution treatment, however, is big business. Rather than pollution source control, technological innovations are directed towards producing potable water from this contaminated water. In Germany, only 23 per cent of the public water can be directly used as drinking water: the other 77 per cent has to first be treated. This not only involves high costs, but also high energy and chemical use.

This cost of treatment is reflected in the cost of water supplied. Between 1985 and 1992, the price for water in Germany increased 2.5 times faster than the general cost of living. The average price for one cubic metre water in West Germany in 1995 was three deutsche marks (DM) or US $1.27. Calculations reveal that in the future necessary investments in the supply will lead to much higher costs for consumers.

Not only water supply, but also the costs of sewage treatment and disposal have become difficult and expensive. In some regions, the rising costs for sewage disposal in some regions have overtaken the cost of drinking water — in the federal state of Baden-Wurttemberg, for instance. Another brewing crisis is the growing movements by citizen groups in sparsely populated rural areas for delinking from the public system, demanding decentralised solutions. This is because of the rising sewage quantities. The German sewerage



HANNAH BUTTNER

The German way — rainwater from rooftops is taken to underground tanks via pipes. From here, it is pumped to the toilets

system is more than 100 years old. This system collects waste from toilets and other sewage in the same sewer, which is then drained into the sewage treatment plant. Rainwater from rooftops and streets also run into the same sewer. With the increase of sealed surface area this has led to rising amounts of rainwater in the sewer which causes two problems. Firstly, it waters down the sewage and increases the amount of water to be cleaned, making sewage treatment more difficult and expensive. Secondly, during periods of heavy rainfall, the retention capacity of the sewage system is exceeded and the surplus uncleaned water has to be released untreated into the rivers. This not only disturbs river ecology but can also lead to floods downstream. The city of Cologne has been subjected to floods precisely because of this.

Many municipalities have developed two different strategies for using surplus rainwater to control sewage disposal and flood control. The first is to invest in a separate sewer system which collects rainwater from roofs and streets and drains it directly to rivers. Only sewage from households and industries is led to the treatment plant. The other strategy is to construct municipal retention tanks, where surplus rainwater can be retained and its release to the sewerage can be controlled. Both solutions are expensive and ecologically problematic.

The other area of concern is the quick runoff of rainwater which reduces the amount of seepage and groundwater recharge. Special facilities need to be constructed to support and control seepage in environments where a lot of area is covered. Professor Friedhelm Sieker of the University of Hannover has developed a system to tackle this problem using two structures — a hollow and a trench. The hollow collects and retains the rainwater from where water seeps into a drainage trench to finally seep into the groundwater level. When the trench is constructed, the surrounding natural soil is replaced with gravel or other water permeable materials, which perform important filtering functions.

GROWING UP

Since water problems became obvious the state of Germany reacted by adding the aspect of protecting water resources to the water-budget law in 1986. The law now recognises 'water as an element of the nature-balance which has to be managed in a way that any avoidable disturbance will have to cease,' and, 'everybody has the duty to use water sparingly out of consideration for the water balance'. In its reports the national ministry of environment writes: 'each withdrawal of water, especially of groundwater, is an intervention in an ecosystem with more or less detrimental effect. Withdrawal of groundwater always causes lowering of the groundwater table.'

With realisation followed action. In areas where the contamination of water is due to intensive agriculture, like in southern Germany, the farmers are being educated on the need to reduce pesticide and other agrochemical usage in the catchment area. In places where quantitative problems have occurred, two strategies have been developed: the first is to reduce water consumption by creating awareness and promoting the use of water-saving devices and technologies, and, the second is to substitute the use of drinking water with rainwater. Large-scale rainwater harvesting efforts can be found at Frankfurt airport and the Technical University at Darmstadt *(see Box: German models for emulation).*

Rainwater harvesting in Germany has gradually grown into a big market. In the beginning, when rainwater harvesting was newly discovered in Germany, these systems were installed only in private houses. The field of rainwater harvesting has now become professional — special products like self-cleaning filters and concrete tanks are available.

In 1998, it was estimated that 50,000 rainwater harvesting systems are being built every year. This scale-up in implementation has been possible through the efforts of Fachvereiningung fur Betriebs und Regenwassernutzung eV (FBR), which is an association of rainwater experts. The association was formed in 1995, when even the discussion about rainwater harvesting was controversial. The aim of this association is to promote rainwater harvesting systems and to provide a forum for like-minded individuals and professionals. There are more than 350 members in this organisation, who have organised themselves into working groups to deal with various issues relating to rainwater harvesting. The FBR establishes contact with universities, supports young scientists working on rainwater, disseminates information and conducts training.

A growing number of local governments today are supporting rainwater harvesting to save drinking water and for promoting decentralised seepage. Municipalities have developed different strategies to extend direct or indirect support to rainwater harvesting. The city of Hamburg, for example, initially gave money directly to houseowners for constructing rainwater harvesting systems. Gradually, it stopped this direct support and gave indirect help by way of providing consultation, planning and change in the water fees system. The city of Bonn has also changed its system of water fees in order to support decentralised rainwater retention and seepage. It has split the sewage charges into fees for waste water and fees for rainwater. The latter is calculated in accordance with the area of sealed surface per household. If a household has taken measures for decentralised rainwater retention or seepage by building grass-covered roof, seepage facilities or rainwater

GERMAN MODELS FOR EMULATION

From rainwater barrels in gardens to Terminal 2 at Frankfurt Airport, Germany, the development of rainwater harvesting in Germany has come a long way

Rainwater is being harvested at two huge complexes in Germany: Frankfurt Airport and the Technical University of Darmstadt. The combination of huge catchment areas and simple technology have worked wonders.

The Frankfurt Airport is the biggest airport in the European continent. The city of Frankfurt is situated in the middle of Germany, where adequate quantities of water have been a problem. Most buildings in the airport have water saving installations.

In 1993, when a new terminal building was being constructed, a system for rainwater harvesting was installed. With an expectation of handling 13 million people every year, detailed studies were made on the future demands of water. For instance, toilet flushings were estimated at 20,000 litres per day. The rainwater system collects water from the roof of the new terminal which has an area of 26,800 square metres. The water is collected in the basement of the airport where six tanks have been put up, each with a storage capacity of 100 cubic metres (cum). This water is used mainly used for flushing the toilets, watering the plants, and cleaning the air conditioning system with refined river water. In case of scarcity, this refined river water is also fed into the rainwater system. The rainwater harvesting system is one of the biggest in Germany and helps save approximately 100,000 cum of water per year. The costs of the system was 1.5 million DM (US $63,000). Some 50 per cent of the project was financed by the federal state of Hessen. The remaining investments will pay for themselves in approximately four years by reduction in the costs of water supply.

The Technical University of Darmstadt has another colossal rainwater harvesting system. Since 1993, a combination of rainwater harvesting and used-water is being supplied to the university. The water is used for flushing the toilets and is also supplied to the laboratories of the university for cooling and cleaning purposes, for which the water is cleaned prior to use. Ever since this system has been installed, only 20 per cent of the water demand is covered by drinking water, amounting to a saving of 80,000 cum of drinking water per year.

harvesting system, the rainwater fee is reduced.

Another very important instrument to support rainwater management is through proper planning. To empower municipalities to take appropriate steps, national statutes concerning the construction of buildings have been changed and now municipalities can lay down their own decentralised rainwater management plans.

RAINWATER HARVESTING: CONTESTED TERRAIN

Though rainwater management is being supported at the state level in the case of the federal state of Hessen *(see Box: Hessen's rules)*, there are many institutions that challenge the benefits of rainwater harvesting. Although there is a consensus for the growing need for rainwater use, some areas of concern still remain. On a national level, the environment department is sceptical. The arguments against the use of rainwater are basically grounded in concerns for quality and the high cost needed to make it available in modern houses. Use of rainwater for purposes like gardening, cleaning and decentralised seepage is generally accepted. There is also opposition to rainwater harvesting from organisations like waterworks and supplying agencies who have invested heavily in building up water supply infrastructure which amounts to 80 per cent of the total cost. Any reduction in drinking water demand would not only mean less income, but in the long run would also increase the cost of per litre water to the users.

It is often ignored that the increase in cost per litre in supply are matched by a decrease in costs for sewage. However, as long as these services are different, municipal enterprises with separate budgets and thinking, the positive effects of rainwater harvesting cannot come fully to fruition.

QUALITY CONCERNS

For private rooftop harvesting, the quality of rainwater falling on the roof may be affected by the roofing material. Roof material made of bitumen, for instance, adds unwanted organic chemicals to the water. The water from the roof passes through a filter to remove leaves and other particulate dirt before entering the tank. Now self-cleaning whirl-filters which avoid blocking of the gutter are routinely used for this. The tank for rainwater storage can be installed inside the house or underground outside. Experience has resulted in a small innovation: the feeding pipe into the tank is now installed in such a way that the water in the tank is not disturbed. This means that the sediment that settles at the base is not disturbed and mixed with the water affecting quality. Each tank now also has an overflow system: the tank is connected with a sewer or with a decentralised seepage facility. The level of the tank must also be carefully decided so as to prevent the backwaters of the sewer entering into the tank.

The supply of rainwater into the house requires a special system of pipes so that this water is not mixed up or connected with the pipes for drinking water. Technical regulations are in place to ensure that no rainwater mixes with the drinking water: a certain distance of the pipes has to be maintained. ■

Urban Water Harvesting: Japan

Rainwater Utilisation in Tokyo

Sumida Ward of Tokyo sets the example for cities world over

Makato Murase
Environmental Protection Department, Sumida Ward, Tokyo, Japan

The average yearly precipitation in Tokyo is about 1,400 millimetres. This is about twice the German average. However, residents in Tokyo have not appreciated rainwater as a resource for a long time. They have overlooked rainwater flowing into drains and consider that more dams are needed to be built upstream when they run short of city water supply. They have felt that rain falling in reservoir areas is a 'must' whereas rain falling in their communities is a 'nuisance'.

Cities can and must obtain the water they consume on their own as far as possible, and thus rainwater falling in cities should not be wasted. Numerous 'mini-dams' collecting and storing rainwater should be built in cities themselves. The stored water contributes to decreasing the city water demand, provides drinking and non-drinking water in emergencies like earthquakes, and helps prevent disasters like fires.

Tokyo has been inflicted with water shortages and floods alternately every few years. It is, therefore, necessary to appreciate the fact that more than two billion cubic metres of rain falls in Tokyo every year and about the same amount of water is consumed every year. Almost 60 per cent of Tokyo's ground is covered — a city robed in asphalt and concrete. So when the rain falls, the city becomes prone to floods.

Some 16 years ago, a serious flood inflicted heavy financial and health losses in Sumida Ward, also called Sumida City, one of the most densely populated wards in Tokyo. Floodwaters inundated many of the ward's buildings with sewage-contaminated water. For weeks people had no drinking water, as the city's drinking water tanks are installed underground.

I was then working in the public health centre of the local municipality and began to find ways to utilise rainwater. Rain is an incredibly impotant resource. It is essential rto city planning and to mitigate water shortages, control floods and disasters. Yet modern urban society simply throws it away.

Sumida City has since been actively promoting rainwater utilisation policies with three aims:

- Developing water resources in communities;
- restoring the regional natural water cycle; and,
- securing water supply for emergencies.

Sumida City asked the Japan Sumo Association to introduce rainwater utilisation concepts into its new Sumo wrestling arena, Kokugikan, in 1982. Currently, 70 per cent of its facilities, including the air-conditioning system and toilets, use rainwater collected from the roof. Rainfall is collected from a 8,400 square metre (sq m) roof and collected in a 1,000 cubic metres storage tank. Since then the city has initiated rainwater utilisation in its different facilities and constructed Rojison, a simple rainwater utilisation system, in many communities of the city, hand in hand with its residents. The Sumida City ward's own office boasts of a rainwater utilisation system that covers half of the building's water needs and saves ¥1.8 million (US $13,500 at present rates).

Following the example of Kokugikan, nearly 500 buildings in Tokyo have introduced rainwater utilisation systems. The number of houses adopting full-scale rainwater utilisation systems is gradually increasing too.

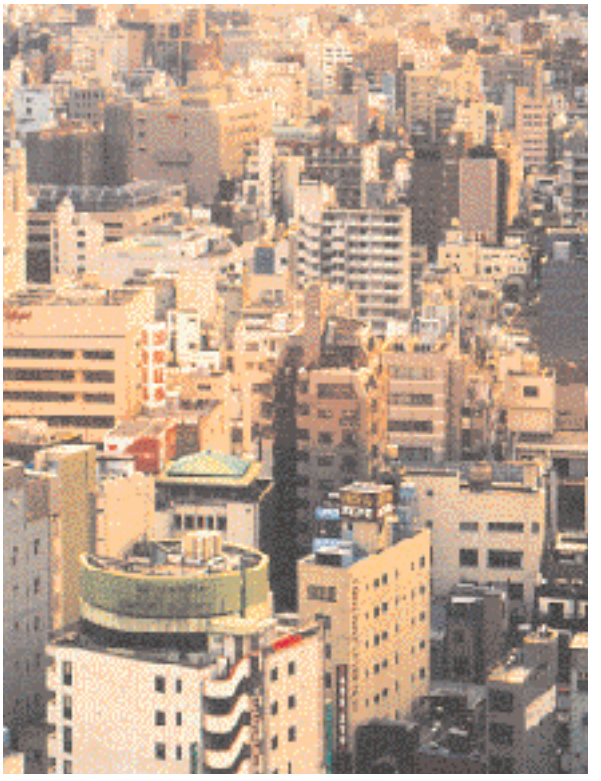
News of the efforts made by Sumida City and its residents has travelled far. The Tokyo International Rainwater Utilisation Conference was held in August 1994 in Sumida City. The conference was unique from three points. First, it was large in scale and was supported by a variety groups. Over 800 people participated in the sessions, including 26 participants from Botswana,

Kenya, Tanzania, China, Indonesia, Singapore, Sri Lanka, Thailand, Denmark, France, Germany, the Netherlands and the United States. Secondly, the conference was the first one to focus on the role of rainwater utilisation from the urban perspective, particularly from that of a mega-city. The primary advantage of collecting and storing rainwater in urban areas is not only producing additional water but also controlling storm runoff and preventing urban floods as a result. Thirdly, the conference was organised and supported by citizens and was funded through the efforts and enthusiasm of people in Sumida city and its neighbouring areas.

The following points were confirmed at the conference:

- Populations in Asia, Africa and Latin America will continue to move into large cities and, as a result, cities there will confront the problem of 'urban drought and urban flood' which Tokyo faces now;
- Tokyo's newly acquired wisdom on rainwater use techniques will undoubtedly contribute to resolving the 'urban drought and urban flood' problem;
- rainwater utilisation is an internationally shared responsibility considering the concept of 'sustainable development' of cities;
- rainwater utilisation is directly related to acid rain and air pollution; and,
- a new rainwater culture has to be created in which cities can live more harmoniously with their rainfall endowment.

This conference changed people's way of thinking about rain. The most important result was networking to disseminate rainwater utilisation information on a global scale.



ANIL AGARWAL / CSE

Lack of space has made Tokyo a concrete jungle. With no place for the rainwater to go, urban flooding is a common occurrence. The city also suffers from water scarcity

SUBSIDIES FOR RAINWATER UTILISATION

Sumida City has closely examined the potential of rainwater utilisation as part of its policies between 1992 and 1994, based on its achievements over the previous ten years. The results showed that increasing the number of city facilities using rainwater will resolve water shortage and urban flooding, and will also help in emergencies. Thus, Sumida City compiled its 'Guidelines for rainwater utilisation' in March 1996. The guidelines feature three principles:

- The city will install rainwater utilisation systems in all its new facilities;
- the city will guide or advise its residents and companies planning to construct houses or buildings in a tract of land more than 1,000 sq m, to install rainwater utilisation systems; and,
- the city will subsidise residents and companies planning to install rainwater utilisation systems.

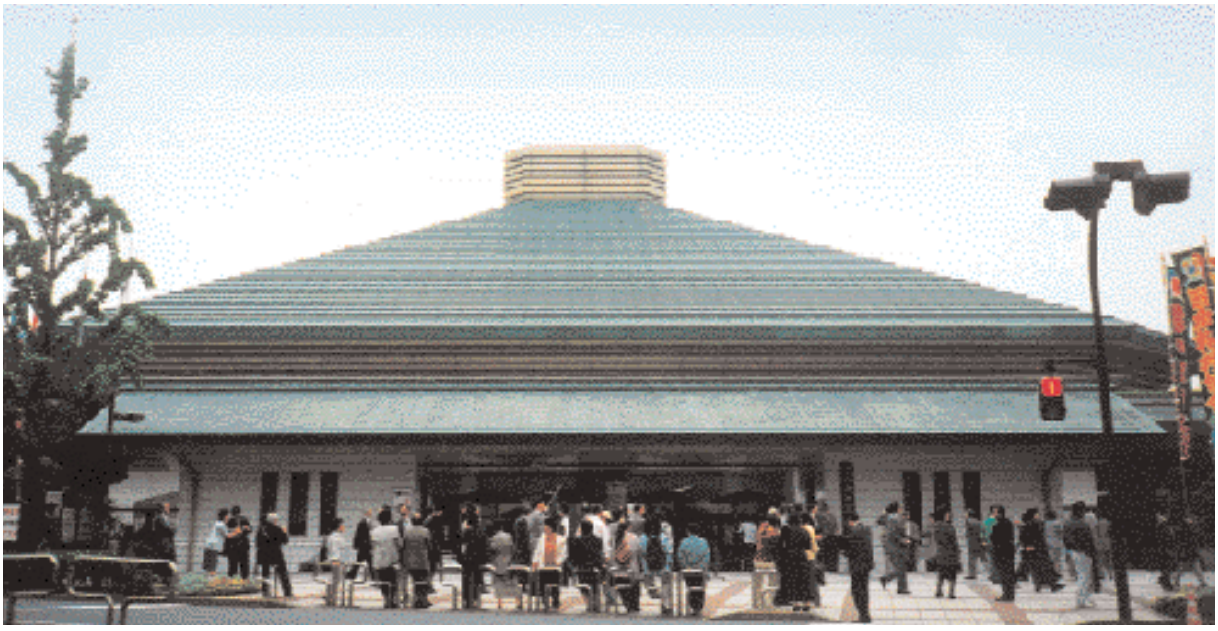
In October 1996, the city launched its subsidies programme for encouraging rainwater utilisation. Sumida City now offers subsidies up to ¥1 million (US $7,500) per rainwater utilisation project. Increasingly, local governments, including Okinawa Prefecture, Takamatsu City, Toyota City, Kamakura City and Kawaguchi City have begun subsidising or loaning funds for installing rainwater systems. About 500 public facilities in Tokyo have already introduced these. The Tokyo dome, a gigantic multipurpose hall which hosts baseball games and concerts, already uses rainwater. This movement is spreading nationwide and driving companies to develop rainwater utilisation devices.

The government is planning water conservation policies for promoting rainwater utilisation and restricting groundwater use *(see Box: Government gears up).*

LOCAL GOVERNMENT COUNCIL

The Tokyo Conference was held in 1994 when many cities in Japan were suffering from serious water shortages in the wake of a long dry spell. This spurred local governments to come up with rainwater utilisation policies.

In July 1996, municipal and prefectural governments established a council proposed by Sumida City, which had already been actively promoting rainwater utilisation. Sumida City is now serving as the council's organ-



NOBUA KUROKAWA

Rainwater harvesting is gathering momentum in Japan as a solution to deal with flooding and water shortage. At Ryogoku Kokugikan, Tokyo's famous Sumo wrestling arena, 70 per cent of the facilities, including the air conditioning system and toilets, use rainwater collected from its roof

iser. The council has two aims. The first is discussing how to utilise rainwater to deal with water shortage and urban flooding problems, for emergencies; and, how to improve the regional and global environment through measures such as the restoration of the regional natural water cycle. The second aim is exchanging information on policies, networking with local governments nationwide, and spreading the network worldwide. Some 77 municipalities and six prefectures in Japan have so far joined this council. An annual forum (Rainwater Fair) organised by citizens and local governments was held in August 1997 in Okinawa Prefecture, an island in the southernmost part of Japan, that has been afflicted with chronic water shortage. A rainwater utilisation forum for local government and citizens was also held in 1998 in Sumida City.

GOVERNMENT GEARS UP

Several ministries are working together to formulate water conservation policies

In the last week of August 1998, six government ministries and agencies of Japan announced that they will jointly draw up water conservation policies. These will include restrictions on the use of groundwater and promotion of rainwater use. The policies are to be approved by the cabinet in 2000. The administration wants to curb construction of industrial plants in upstream areas, prevent deforestation and urban development, and discourage the use of groundwater during a period of water shortage.

The six government outfits involved are the environment agency, construction ministry, national land agency, health and welfare ministry, ministry of international trade and industry, and the ministry of agriculture, forestry and fisheries. They will coordinate policymaking to prevent floods and water shortages in urban areas, among other things. The plans will also promote afforestation and the use of rainwater recycling facilities.[1]

PEOPLE'S ACTIVITIES

The organising committee for the 1994 Tokyo Conference was reborn in April 1995 as 'People for Promoting Rainwater Utilisation', a non-governmental organisation based in Sumida City. Its aim is to spread rainwater utilisation worldwide. This NGO has been engaged in many activities such as consultations, technology development, fact-finding inquiries, cultural research and environmental education. Some members of the group have visited China, Germany and Iran to spread its network overseas.

In March 1995, after the Great Hanshin Earthquake, the Organising Committee for the 1994 Tokyo Conference presented 200 rainwater tanks for storing drinking water supplied by water wagons to communities in earthquake-devastated Kobe City. The city's water supply system was destroyed and people were supplied water through water wagons. If the people of Kobe City had harvested their rainwater, they would not have had to face the acute water scarcity they had to. ■

The Singapore System

Singapore is way ahead of most countries when it comes to harvesting rain. The lack of space available is compensated by utilising available rooftops, paved and non-paved areas

Adhityan Appan
Nanyang Technology University, Republic of Singapore

Singapore is sparing no efforts in capturing its abundant rainfall of 2,400 millimetres. All possible measures are being taken to maximise the use of rainfall given the limited land availability and competing water demands. Some innovative schemes have been introduced. This capitalisation of rainfall has been possible after considerable research and adoption of strict pollution and quality control.

The Republic of Singapore has a land area of 61,000 hectares (ha). Water availability is poor *(see Table 1: Water resources of Singapore, 1995).* In spite of 50 per cent of the land area being used as a water catchment, almost 40-50 per cent of its water requirements are imported.

A fair amount of research and development work has been done in Singapore for maximising the abstraction of rainwater. Schemes have included the utilisation of the roofs of high-rise buildings, the use of runoff from airports for non-potable uses, and integrated systems using the combined runoff from industrial complexes, aquaculture farms and educational institutions.

CAPTURING RAIN

Rooftop water collection systems in high-rise buildings

High-rise buildings in urban areas currently house 86 per cent of the population in Singapore.[1] The potential for using these rooftops as catchments is high. In all cases involving roofwater collection, a simple input/output model has been used to determine the available quantity of rainwater.[2] The systems developed have been the result of intensive research *(see Box: Research to the rescue).*

Use of rainwater in aquaculture and industrial lots

Aquaculture farms have large tracts of land and can utilise rainwater as the quality is acceptable. In a case study involving an aquaculture farm, there was extensive cultivation of ornamental and edible fish and aquatic plants.[3] The rainwater collected helped largely to dilute the water within the other waterbodies that were subjected to high nutrient loads.

Harnessing of runoff in an airport

Catchment areas in airports are much larger than roof areas and involve harnessing of both surface runoff and roof water. A typical case outlining such a system is the Singapore Changi Airport, established in 1986. The runoff is largely collected from runways, the associated area of which is turfed, and the roof of buildings.

In a catchment area of 530 ha as in the case of this airport, two impoundments were necessary, one of which retains most of the runoff.[4] Raw water from this main reservoir is pumped to a pre-treatment plant and the treated water is used for firefighting and toilet flushing. As the airport is close to the sea, the second reservoir is used for storm relief when the time of incoming tide and the storm discharges coincide. Annual savings in water usage amounted to about 390,000 Singapore dollars (S$) (US $243,750). The main finding in this case study was that the existing storage volume of 3,888 cubic metres (cum) was grossly under-designed as a result of which only 13 per cent of potable water could be used. By increasing the storage volume to 80,000 cum, all current demands could be met.

As more data was obtained, this system was further studied in depth and another model developed, which took into consideration tidal effects.[5] The required storage should be not more than 100,000 cum and the buffer reservoir needs to have a volume of only 68,000 cum against the current 100,000 cum. In addition, if rain

RESEARCH TO THE RESCUE

Capturing of rainwater from the rooftops has involved intensive research

In one study by the author, a simple computer programme was developed and a nomogram prepared relating the roof area, tank size and roofwater available.[1] In a system implemented in a 15 storey building, the collected roof water was diverted to two rainwater tanks and the water was used only for toilet flushing. The water quality was acceptable in terms of colour, turbidity and bacteriological content though the total solids and chloride levels were marginally higher. A major issue, particularly in tanks at ground level, was the abundance of mosquitoes. A fine-mesh screen was then incorporated at the inlet, more to prevent mosquitoes from flying out of the tank rather than curbing the ingress of eggs through the input. This problem was overcome by dousing the stored water with paraffin oil.

Next, a more detailed study was carried out and a computer programme developed.[2] In this case, a simple dual-mode system (DMS) was incorporated in the collection tanks which were placed on the roof of the building. The programme also catered for a varying demand, overflows and the amount utilised. An economic appraisal established that there was an effective saving of 13.7 per cent of water. The cost of the rainwater was S$0.395 (US $0.25) per cubic metre (cum) as against the cost of potable water which was S$0.535 (US $0.33).

Another study involved high-rise buildings in an urban residential area of about 742 hectares having a total of 49,000 flats.[3] Using a further modified programme, it was possible to compute the volume of potable water to be pumped when there was no stored rainwater and also determine the frequency of such pumping. In this DMS, it was shown that tanks placed on the roof resulted in lower water costs – S$0.96 (US $0.6) per cum — against tanks placed on the highest floor S$3.95 (US $2.46) per cum.

water is pumped at a rate of 164 cubic metres per hour (cum/hr) against the current 128 cum/hr, there will be no need to use any potable water for non-potable uses.

Utilisation of teaching institutions for collection of runoff

Most institutions like polytechnics or universities are bound to have some land and rooftop areas which can be used to harvest the rain for potable uses. In one of the teaching institutions in Singapore where the total land area is 30 ha and the roof area 1.5 ha, a rainwater collection system has been successfully implemented. The surface and rooftop waters are directed to a collection chamber where the water is subjected to some chemical treatment followed by sedimentation and chlorination. The treated water is being used for watering of sports fields while the untreated water is being used for irrigation. The annual saving in water at current costs amounts to S$74,000 (US $46,250) per annum.

UTILISATION OF URBAN CATCHMENTS

The location of impounding reservoirs is normally far away from highly inhabited areas. Consequently, catchment areas are relatively clean as a result of which most raw waters are of good quality. In Singapore, specific locations have been gazetted as areas wherein pollution-contributing activities are prohibited. However, with cities growing at rapid rates and beginning to encroach on the hinterland, pollution levels in runoffs tend to increase. Suitable measures have to be taken to curb such pollution levels so as to minimise the impact on the quality of raw water which is actually urban runoff.

Water use in Singapore has been steadily increasing. But with a land area of only 61.000 ha, catchment utilisation in terms of total land area has increased from about three per cent before 1969 to about 44 per cent in 1986. Limited land and competing demands for its use from an ever increasing industrial sector has led to the maximisation of land utilisation in Singapore. This includes some urbanised areas with a high intensity of high-rise buildings, light industries and paved areas.

Before 1969, legislation ensured that 'protected' catchments were demarcated only for the development of water resources. Immediately after this, the remaining two per cent of the protected area was used along with

Table 1: Water resources of Singapore, 1995

Given its high population density, water availability in Singapore is extremely poor

	Singapore	India	Bangladesh
Total land area (million hectares)	0.061	297.314	13.017
Total population (million)	2.848	935.744	120.433
Population density (persons/ha)	46.69	3.15	9.25
Water resources per capita (cum)	211	2,228	19,571
Domestic annual withdrawal (%)	45	3	3
Industry annual withdrawal (%)	51	4	1
Agriculture annual withdrawal (%)	4	93	96

Source: Robert T Watson *et al* (ed.) 1998, *The Regional Impacts of Climate Change: An Assessment of Vulnerability — A special report of the Intergovernmental Panel on Climate Change Working Group 2*, Cambridge University Press, Cambridge

ADHITYAN APPAN

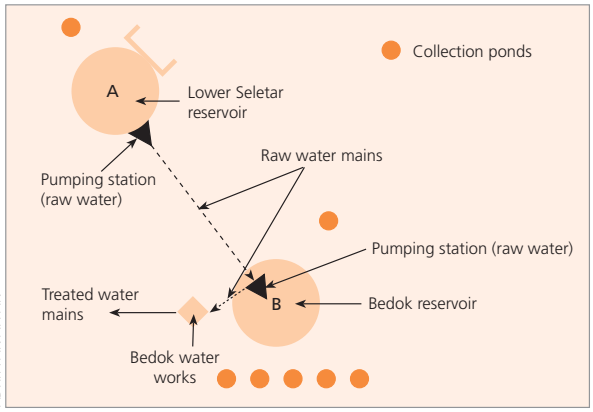
The Sungei Seletar reservoir formed by the construction of a dam with a protected sluice across the Sungei estuary

an additional four per cent of unprotected area in the Seletar Scheme. This unprotected area was strife with pollution from the farming sector and hence the combined area was considered to be 'partly protected'. By 1981, a large tract of almost 26 per cent of the total land was used to establish two major schemes. These areas were totally unprotected and led to the establishment of a number of laws to ensure an overall improvement in water pollution control activities. By 1986, the growing need for water led to the establishment of the Lower Seletar-Bedok Water Scheme (*see Fig. 1: Capturing urban runoff*), where almost nine per cent of the total land area was used. The most important feature of this scheme is that almost one-quarter of this catchment is in an urban area having high-rise buildings and industries and surface runoffs were subject to a wide variety of contaminants. Hence, control of water pollution and relevant technology were the main priorities in the scheme.

Control of water pollution required great inter-departmental coordination. Not less than six government and quasi-government groups met frequently and chalked out programmes for strict pollution control. Such action was essential in this project as its success depended on the effectiveness of pollution control. Activity within the catchment has to be controlled and it should preferably be biodegradable. As a number of departments are associated with the infrastructure, terms of reference must be set up for the catchment in terms of allowable pollution, including the appropriate design of suitable storm diversion and collection methods. Where pollution is inevitable it has to be curbed and where there is potential to avoid it, necessary action has to be taken. In the case of the Lower Seletar-Bedok Water Scheme, various departments involved in planning, public housing, sewerage and drainage systems, pollution control, and others liased and made sure that sufficient restrictions were set to exclude some industries, and also that the drainage system was designed to channel water to suitable collection points.

One of the most important aspects of the utilisation of urban catchments is the need to take an integrated approach towards planning. This will involve a number

Fig 1: Capturing urban runoff
Schematic diagram of the Lower Seletar-Bedok water scheme



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of government, quasi-government and even private organisations and they should bear in mind the need to get together and ensure that water pollution should be avoided and minimised. All such activity should be preferably spearheaded by the water authority of the region.

Lower Seletar-Bedok Water Scheme

The Lower Seletar-Bedok Water Scheme involved the damming of the Sungei Seletar estuary which has a catchment area of 3,200 ha and forming of the Lower Seletar Reservoir. The rest of the catchment of 2,625 ha was primarily urban and both the runoffs are directed to the Bedok Reservoir which was previously a hole dug in the ground for collecting sand. The reservoirs are interconnected and raw water from Bedok Reservoir is treated to potable levels before distribution. The reliable yield of this scheme is 14,000 cubic metres per day.

Following the inter-departmental action to control runoff quality, there are now facilities to divert all flows which have high pollution loads into collection ponds. Runoff is mainly stored in these collection ponds. They selectively collect the urban stormwater runoff which is them pumped or allowed to flow by gravity to the impounding reservoirs which also receive surface runoff from less urbanised areas. An important feature of these collection ponds is the facility to remove debris from the first flush of stormwater flows. These ponds also function as sedimentation tanks. Quantity and quality are continuously monitored. The waters entering these ponds are closely monitored and sensors ensure that only quality levels that are acceptable are directed to the ponds followed be selective onward transmission. These collection systems, which have been in existence since 1985, are operating quite successfully. Special systems are designed to prevent the ingress of rubbish and to accentuate sedimentation. The water quality levels from such ponds are now comparable with those from catchments from protected areas. Thus, with proper management, including improved water quality monitoring systems, urban storm runoff can be successfully collected and stored as raw water that can be transferred to an impounding reservoir to augment the storage volume.

INTEGRATED PLANNING

Apart from inter-departmental planning for controlling water pollution, some of the other important factors to be considered in the overall planning of such systems are as follows:

Hydrological simulation

Appropriate designs of suitable storm diversions and collection methods were determined using two specific computer models. It was found that about 60 per cent of the rainfall ended as surface runoff and relevant pumping schemes were designed from the collection ponds to the Bedok reservoir.

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Skyscrapers catching water from the sky in Singapore. Almost 50 per cent of the land serves as a catchment area

Water quality

Since water quality is of prime importance, systems had to be designed to ensure that only acceptable quality water was pumped to the reservoir. To ensure that good quality water was collected and pumped, appropriate systems were designed to ensure that only better quality water was trapped and monitoring of water quality was carried out on a regular basis.

Trapping urban runoff

In urban areas, studies have shown that dry weather flows are of poor quality and hence such flows are not collected. These dry weather flows normally flow through rectangular channels. During storms flows often exceed the capacity of the channels and, hence, there is a need to remove any debris before diverting the stormwater to detention ponds where there will be some settlement. These functions are carried out as follows:

a) Removal of debris

During a downpour, storm runoff collected in the drain will increase the normal water level and overflow into the gratings which serve as a debris preventer. The stormwater is then collected in a pond and then pumped or allowed to flow by gravity into the Bedok Reservoir.

b) Diversion of stormwaters

Tropical storms tend to attain peak values very early and first flushes tend to carry a lot of debris, particularly when the antecedent period has been quite dry. But when storms follow one after another during the wet season, the debris levels are considerably reduced.

During the event of a storm, a particular system is adopted to collect the stormwater. A level sensor in the monsoon drain at the diversion point will sense the rise in stormwater level and thereby initiate the full closure of the barrage gate. A second sensor in the diversion channel downstream of the sluice gate indicates whether there is any raw water in the channel. A level differential computer will then compare the two level signals and if it finds that the water level is more than 50 mm above the diversion channel water level, the sluice gate will open to divert all the flow into the diversion channel which leads to the reservoir. This system prevents the reservoir water from flowing out into the monsoon drain when the reservoir water levels are high. When the stormwater in the monsoon drain finally recedes, the level differential computer will cause the sluice gate to close the moment the levels in the monsoon drain and the diversion channel are the same. In the event of a power failure, the barrage gate will automatically remain open and the sluice gate closed.

c) Sediment Removal

In spite of the precautions taken, wet weather flows can be full of sediments and they are largely trapped in the detention ponds. Therefore, the first one metre of water which accumulates in ponds during small rainfall events is also pumped out. As suspended solid contents as high as 110 milligrammes per litre (mg/l) were encountered, detailed settling column analyses were carried out and a nomogram prepared. Using these values and adjusting the rate of pumping, achieving higher rates of suspended solid removals is possible.

Quality of water in stormwater ponds

The average raw water quality in all the stormwater detention ponds is shown in *Table 2: Raw water*. The conductivity is on the high side primarily, in some cases, due to the chloride content because of the proximity of the sea. The other values are comparable to the other water sources in Singapore. The raw water in the Bedok reservoir will actually be a mix of urban runoff and of runoff from semi-urban areas. When compared to raw water from a 'protected' catchment, most of the parameters are comparable except for the tendency of the Bedok waters to be more alkaline and have a higher total solid content due to the higher chloride content that is prevalent *(see Table 3: Good in comparison)*. Metallic contents of the urban runoff are also very similar to that of the upland sources and, most important of all, bacteriological contamination levels are also identical.

PREVENTING POLLUTION

Dry weather flows are generally of poor quality and should be allowed to flow to waste. However, as catchment areas are better looked after, such flow quality can improve and can then be utilised. Flow qualities should thus be monitored over a period of time.

When there are tropical storms which tend to peak early, there is the need to have some form of treatment to ensure that the debris in such flows is removed. The stormwater flows are progressively diverted. In effect they are diverted based primarily on water levels or, when close to the sea, chloride sensors. Perhaps, diversions could be arranged to occur based on other sensors

Table 2: Raw water
Quality of water in stormwater ponds

Parameter	Average value
Conductivity	275 micromhos/cm
Total Organic Content	7.8 mg/l
Nitrogen from Ammonia	0.33 mg/l
Nitrogen from Nitrates	0.37 mg/l

Note: *micromhos/cm: micromhos per centimetres; mg/l: milligrammes per litre*

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Highrise buildings serve two purposes. While these allow for increased population density, the roofs are used to capture rain

and the diversions should not be gradual.

Ultimately, it is both the quantity and quality of water that is diverted that is of prime importance. Hence, waters that are diverted to the detention ponds should attain a quality that is acceptable, or at least comparable with, other raw water sources.

Table 3: Good in comparison

Average raw water quality of Bedok reservoir versus water from protected catchment

Parameter	Bedok reservoir	Protected catchment
Colour (Hazen)	12	20
Turbidity (NTU)	2	2.9
pH	7.4	6.3
Total Alkalinity ($CaCO_3$)	43	7
Total Organic Content	2.9	3.1
Total solids	205	25
Chlorides	56	4
Ammonia Nitrate	< 0.02	< 0.03
Phosphorus	< 0.03	< 0.03
Iron	0.04	0.52
Cadmium	< 0.0005	< 0.0005
Chromium	< 0.005	< 0.005
Lead	< 0.001	< 0.001
Coliform/100ml	18	14

Note: *All parameters, except pH, in milligrammes per litre (mg/l) unless mentioned otherwise;*
ml: millilitre; NTU: nephlometric turbidity units; Hazens: unit of colour

On the whole, it has been established in Singapore that the utilisation of urban catchments is a reality that can be highly efficient if the system is well planned, maintained and monitored. Additional research and development will help to optimise the reliable yield from such catchments and make the multiple use of such catchments a truly working proposition.

LESSONS LEARNT

- In terms of the innovative measures taken to harness roofwater in high-rise buildings, industrial lots, institutions, etc., the projects have been shown to be workable and economically viable. Thus, the concept of utilising small catchments has to be accepted.
- In the case of the Singapore Changi Airport, harnessing of runoff has been in operation for more than a decade. Since it has been successful even when the airport is very close to the sea, such projects should, as far as possible, be adopted in all airports.
- For the utilisation of urban catchments, there is a need for excellent control and coordination between many departments. The success of the utilisation of urban runoff largely hinges on the ability of the water authority to closely monitor the quantitative and qualitative characteristics of the raw water.
- By monitoring runoff into impoundments and recalculating the potential of abstraction schemes, there is potential for an increase in the reliable yield. Analyses must become a regular feature for any water authority. Improving operational strategy and optimising output could be far less expensive than embarking on new schemes. ■

CHAPTER 5

Water Harvesting Technology

- Several water harvesting technologies are now available for use in rural and urban areas. These include technologies for capturing rain, recharging groundwater, cleaning surface water and recycling wastewater.

- Information technology has a lot to offer for optimising the results of water harvesting implementation. Using geographical information systems, it is possible to identify potential water harvesting and storage sites. The structure ideal for the region can be selected. Using computers and software it is possible to optimise the size of the water structure being built, taking into account the rainfall, catchment area and water demand. Past data can be used to predict future trends. Computerised databases, available on the internet, offer a mine of information.

- A number of groundwater recharge designs for structures like individual recharge wells, percolation pits and sub-surface dykes are now available to harvest rainfall. Simple measures like preventing the rainwater from leaving the premises can prevent flooding of the streets. The water can be directed for recharge. Dual purpose wells, for withdrawal as well as for transfer of surface water into aquifers, can be constructed.

- Water harvesting can supplement wastewater recycling. Using soil-aquifer treatment systems it is possible to clean up wastewater for recharging and other purposes.

- Urban lakes are in a deplorable condition in almost all urban towns and cities. To restore them to their past glory biological remediation can be availed of.

- Using a combination of physical and biological filters, drinking water can be made safe.

- In rainfed agricultural areas in semi-arid regions, production can be boosted by simple technologies that capture the rain and retain it in the soil. Even one supplementary irrigation makes a significant difference in yields.

- It is important to study traditional systems. A scientific analysis of traditional water harvesting structures around Ramtek township in Maharashtra revealed how a whole system for capturing water, based on local topography and soil type had been developed.

- Traditional technologies, ideal for the time in which they were devised, can be augmented by modern science. For example, runoff from catchments can be increased. Recharging efforts can be made more efficient. In fact, traditional technologies can also be used to deal with the present-day water quality problems that we face like fluoride and arsenic in groundwater. Modern science can also be used to explain how groundwater recharge, through the construction of traditional water harvesting systems, has revived rivers.

A Suitable Site

Remote Sensing and Geographical Information Systems identify 18 suitable sites for rainwater harvesting structures in a watershed of the Song river at Bandal, Uttaranchal

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Indian Institute of Remote Sensing, Dehra Dun, Uttaranchal

Remote sensing coupled with the use of Geographical Information Systems (GIS) can be used to identify runoff potential zones and location of suitable sites for water harvesting. These systems can also be used to identify sites in watersheds that have not been gauged, and where, due to very steep slopes, the runoff drains out fast. This approach has been used to identify suitable sites in the Bandal subwatershed of the Song river, a tributary of the Ganga, located in the Doon valley.

A large part of cultivation is still under rainfed conditions. In areas where slopes are steep, runoff is drained out quickly, resulting in non-availability of water in peak demand periods, even though average rainfall remains quite high. A small increment in water availability by harvesting this rainwater can dramatically increase crop yields and reduce risks of crop failure. For this, excess rainwater must be conserved or stored in different storage structures which can be available later as groundwater recharge. Sometimes, this can make a difference between a crop and no crop in drought areas.

There are a number of water harvesting options such as farm ponds, groundwater recharge, check dams, percolation tanks and *bundhies* (which confine water in fields) to choose from. However, with the objectives and technologies of rainwater harvesting being highly location-specific, based on physiographic, environmental technical and socioeconomic conditions, an appropriate technology developed for a particular region cannot simply be replicated in other areas, and this is where remote sensing can play a vital role.

Integration of remote sensing and GIS techniques provides reliable, accurate and an updated database on land and water resources, a prerequisite for an integrated approach for identifying runoff potential zones and suitable sites for water harvesting. GIS is a software used for presenting and interpreting the attributes of a particular land area such as topography, soil type and vegetation.

THE BANDAL WATERSHED

Suitable sites for water harvesting were identified using the GIS approach described above. The methodology consisted of preparing various resource maps such as landuse/land cover by using IRS-1C, LISS III data by digital image processing techniques, coupled with ground truth data. Digital elevation model, slope map, aspect map, classified map, soil map, drainage and buffer maps for village and agriculture areas were created in a GIS environment. Input parameters deduced from the basic thematic maps were then integrated with field data to generate runoff potential zoning. The Thornthwaite and Mather model was used for calculating the water balance and surface runoff potential. This model uses rainfall data, temperature data, soils, landuse and rooting depth of different types of vegetation for calculating the soil moisture deficit, soil moisture surplus, evapotranspiration, surface runoff and other parameters.

Basic guidelines provided in the Integrated Mission for Sustainable Development (IMSD) and technical guidelines and methodology suggested by the Indian National Committee on Hydrology (INCOH) were used for site suitability analysis. All the thematic maps described above were analysed and suitable sites identified for different scenarios. In all, 18 different sites were identified for different water harvesting structures such as farm ponds and percolation tanks for groundwater recharge.

The aerial extent (area) of the watershed is 8,202 hectares. Geologically, the area comprises of phyllites, shales and alluvium. The drainage pattern is dendritic (branching tributaries from the main drain) with local variations at some places. Physiographically, the area is composed of mountains (steep to very steep slopes), hills, piedmont plains, river terraces and floodplains. The average slope of the watershed is approximately 52.7 per cent. The watershed comprises of soils falling in the order of entisols, inceptisols, alfisols and mollisols

Fig 1: Helping harvesting
GIS helps in identifying ideal sites for water harvesting structures

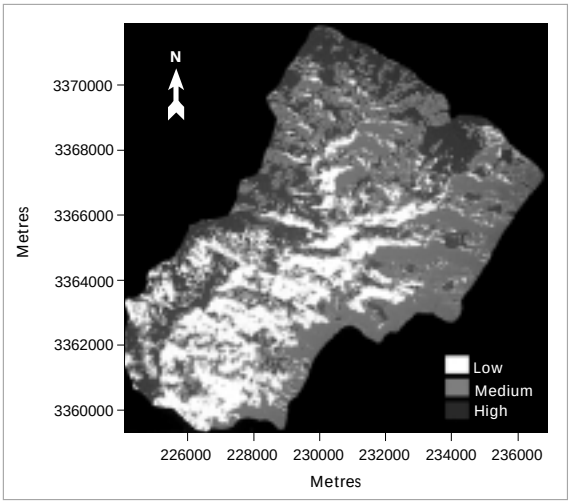
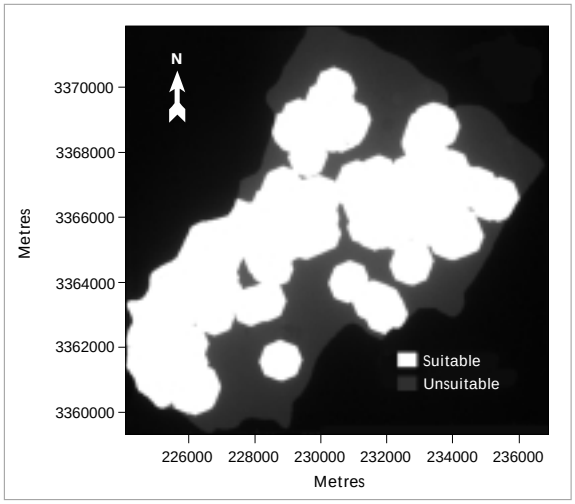


Fig 2: Buffer boundaries
This map indicates the proximity of the water harvesting structure to the user



and are well drained. In most cases, the depth of soils varies from deep to very deep underlain by stones, boulders, sand and silty strata. Average annual rainfall of the study area is 2,500 millimetres (mm), but most of the time the river remains dry due to the steep slope.

The following data were used in the study:

- IRS-1C, LISS III digital data dated October 9, 1997 and February 11, 1997;
- survey of India topographic maps (53J/3 and 53J/7);
- daily rainfall and temperature data for the year 1997; and,
- ground truth data for landuse/land cover and soil classification.

The GIS software used in the study is Integrated Land and Water Information System (ILWIS 2.1) developed at the computer centre of the International Institute of Aerospace Survey and Earth Science (ITC, 1997), the Netherlands, in which the conventional GIS operations can be performed. ERDAS IMAGINE- 8.2 was used for digital image processing and classification.

Using landuse information interpreted from remote sensing imageries and the remaining inputs of the model from available records and ground studies, a digital elevation model was prepared by interpolating the contour map from which the slope map was derived. The slope map was reclassified into seven classes according to IMSD guidelines and slopes of more than 10 per cent were not considered in the further investigations.

A soil texture map was prepared and further reclassified into four classes according to its infiltration characteristics.

The water balance of the watershed was computed using Thornthwaite and Mather's model in GIS environment. The runoff potential map was created and reclassified into three zones, that is, low runoff, medium runoff and high runoff *(see Fig 1: Helping harvesting* and *Table 1: Rainfall generated runoff).*

A buffer map for agriculture and village was created with an assumed distance of 500 metres (m) to do the proximity analysis to supply harvested water for agriculture and villages *(see Fig 2: Buffer boundaries).*

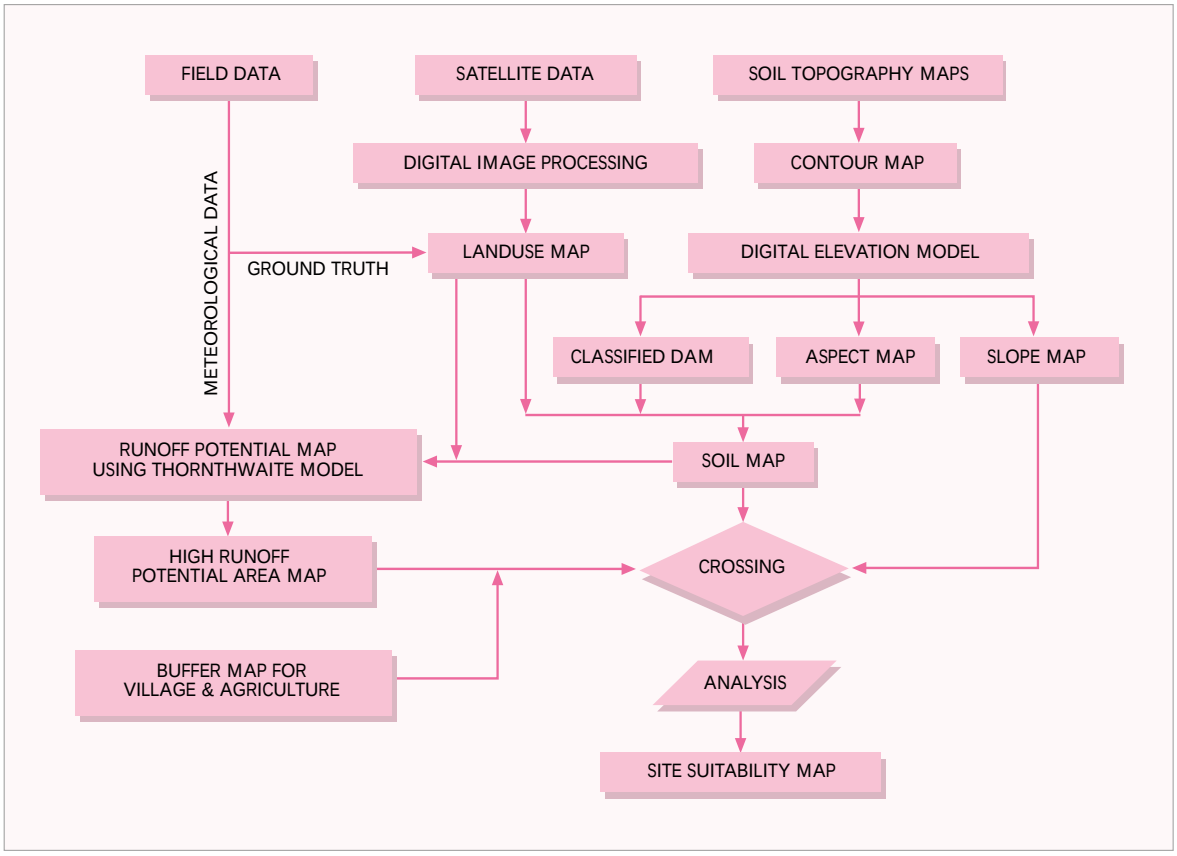
Table 1: Rainfall generated runoff
The actual monthly runoff generated from rainfall

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	34	18	65	98	109	406	873	572	412	162	44	107	**2,900**
PET*	24	35	115	307	379	543	352	346	185	127	76	39	**2,528**
AET**	24	34	104	188	154	417	352	346	185	127	74	39	**2,044**
Runoff	29	14	7	3	2	1	212	166	196	116	58***	48	**852**

Note: **PET- potential evapotranspiration **AET- actual evapotranspiration All units are in millimetres (mm)*
****In the Thornthwaite and Mather model, the basic assumption is that 50 per cent of the total available runoff (surplus) in a month will be contributed as direct runoff in the succeeding month, as a baseflow. Due to this, in some months runoff will be more than rainfall due to the effect of previous month.*

Flow chart 1: Zeroing down

GIS approach for locating water harvesting structures



This map will show an area around villages. In this case, the map shows an area around villages within 500 m distance.

All the maps were overlayed and the derived map was analysed for different conditions. Some suitable sites were identified for different alternatives for the construction of water harvesting structures *(see Flow chart 1: Zeroing down)*.

The output map obtained from overlaying soil, landuse, slope and buffer map were analysed with different decision rules mentioned in IMSD technical report and the INCOH publication. Some suitable sites were identified for the construction of water harvesting structures**.** The drainage map was displayed over the site suitability map to assess the accuracy of the analysis.

RESULTS

Some of the water harvesting structures and the criteria for their selection are:

a) Farm ponds, which require flat topography and low soil permeability.

b) Check dams, which require a medium slope, low permeability of the soil and an available ground area of more than 25 hectares. Check dams should be preferably constructed on lower order streams, up to third order. Rivers can be considered to possess a higher order than the tributaries that branch off them. Similarly the tributary of a river can be considered to possess a higher order than smaller streams. The lower the order is, the lesser is the available water potential.

c) Percolation tanks, requiring flat topography and pervious strata. The available area should be more than 40 hectares.

e) *Bundhies*, requiring medium permeable soils and adequate area, preferably constructed close to cultivated land.

Based on an analysis of the data generated, some of the rainwater harvesting structures that could be constructed in this subwatershed include 14 farm ponds, three groundwater recharge structures and one percolation tank. ■

Technology: Computer Modelling

Simulating a Solution

The Monte-Carlo model uses past rainfall data to optimise storage capacities

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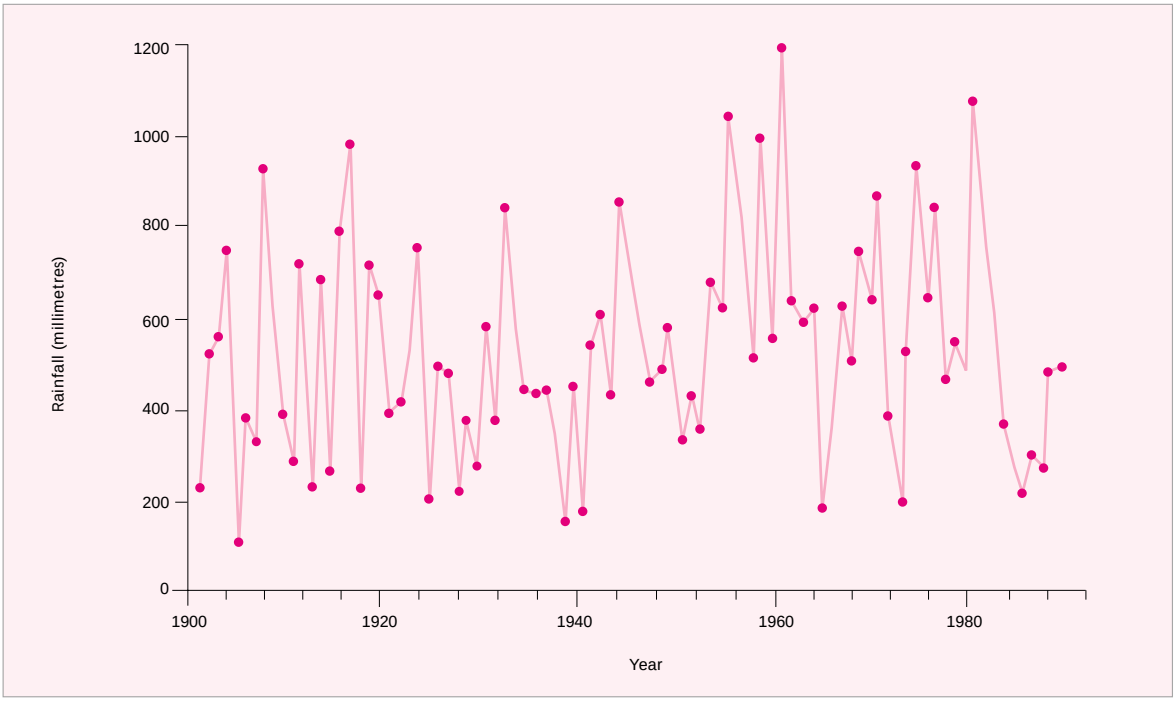
It is being increasingly realised that a growing fraction of the human population will face water scarcity in the coming decades and this will be more acute in the rural areas of the arid and semi-arid (ASA) regions of the world. In this context, the role of rainwater harvesting systems (RWHS), by which we mean the collection, concentration and storage of rainwater that runs off a natural or human-made surface, has greatly increased.[1,2] In the ASA regions, RWHS offers unique advantages over the alternative means of meeting the water needs of rural communities.

These advantages stem from the fact that rainwater harvesting makes use of the natural water cycle in a sustainable way. By bringing water closer to the users, it minimises the amount of energy needed to transport it.

In contrast to these advantages of RWHS is its unreliability, since its depends on meagre and erratic rainfall, particularly in ASA regions. An example of the extreme fluctuations encountered in the rainfall is shown in *Fig 1: Variable rainfall* for the village of Chaksu in a semi-arid region of the state of Rajasthan. Thus, one is faced with the task of designing a RWHS that can meet, in spite of erratic rainfall, the water demands of a community with a desired degree of reliability.

The task of designing such a RWHS will be greatly facilitated if one has access to a computer model for

Fig 1: Variable rainfall
Time series of recorded rainfall at Chaksu, Rajasthan (1901-1990)



GANESH PANGARE / CSE

Tankas *store rainwater in the Rajasthan desert. The challenge lies in optimising the size of the* tanka *and the catchment area, based on water demand and rainfall*

simulating RWHS that explicitly takes into account rainfall fluctuations. The model used described here is the Monte-Carlo simulation model to simulate the effects of fluctuating rainfall on the performance of a given RWHS.

Monte-Carlo simulations of RWHS allow us to make optimum use of an important source of water available to communities living in ASA regions. As implemented in a package like Sim Tanka, particularly when converted to a stand alone application for personal computers (PCs), the method can be a useful tool for designing RWHS *(see Box: Simulating structures)*. It can also provide information to planners and technocrats about what fraction of a community's water demand can be reliably met by RWHS.

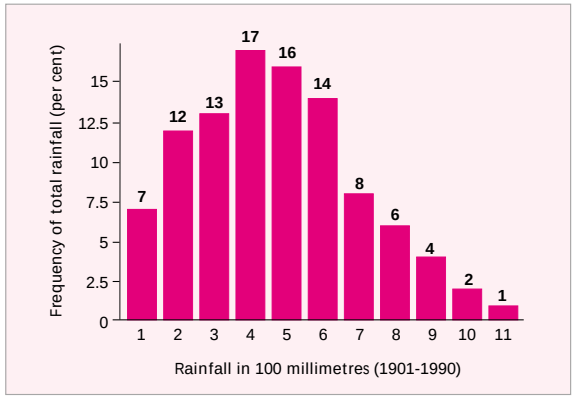
RWHS, especially those in the ASA regions, depend on erratic and meagre rainfall. Furthermore, rainfall fluctuation is generally characterised by the simultaneous presence of many time scales, and thus cannot be easily characterised by means of statistical indicators like the average value or the moments about the average value.[3] Therefore, a realistic simulation of RWHS must explicitly take into account all possible fluctuations in the rainfall pattern. One way of simulating the RWHS under such conditions is to assume that the rainfall pattern of a place is given by some probability distribution and then use the method of Monte-Carlo simulation to simulate this probability distribution.[4,5]

The difficult and delicate question that one faces then is: what is this probability distribution? The probability distribution of the future rainfall pattern at a given place can be approximated by the known past rainfall record. There are two reasons for the assumption. Firstly, lacking a truly dynamic understanding of the rainfall pattern, our best guide to the future is the past. Secondly, this assumption allows for possible changes in the weather pattern, say, due to global warming, but only assumes that the rate at which this may be occurring, that is, the time scale of the change of the entire probability distribution is more than the order of a few decades. As our dynamic understanding of weather increases, we will have a more precise measure of this time scale. For the moment, according to our assumption, we can use the rainfall data of the last few decades to simulate the behaviour of a given RWHS over the next few decades.

With this assumption in mind, the pattern of rainfall can be simulated by the flowing procedure. Let Y_i to Y_f be the time period for which the monthly rainfall data is available, and use this rainfall data to to define a probability distribution of future rainfall. Then generate a random integer (pseudo) with uniform probability, lying in the closed interval (Y_i, Y_f). If the integer is, say, Y, then in the simulation the rainfall experienced is taken to be that which was recorded in the y^{th} year. By repeating this procedure a sufficiently large number of times, one can simulate the entire probability distribution. This procedure of simulating a stochastic variable, in our case rainfall, according to a given probability distribution is called Monte-Carlo simulation.[4,5] It is important to note that while this procedure does simulate the probability distribution *(see Fig 2: Rainfall distribution)*, it does not simulate possible correlations in the rainfall of successive years.

Fig 2: Rainfall distribution

Histogram of time series of recorded monsoon rainfall at Chaksu, Rajasthan (1901-1990)



Note: *This graph indicates the number of times (in per cent), within a specified period, the area receive a given amount of rainfall.*

SIMULATING STRUCTURES

Mathematical models can now be simulated on personal computers to create ideal water harvesting structures to suit varying local conditions and needs

New opportunities are emerging to test even small water harvesting structures by using carefully built mathematical models and computer simulation. Mathematical modelling, complemented by the power of computing, provides a powerful tool for making the right decisions for sustainable development.

For a mathematical description to be useful for rural development, it has to be based on a few parameters that can be easily measured or obtained. For example, to measure the evaporation loss of water in a pond, a mathematical model is required that predicts evaporation loss based only on the average temperature, pressure and wind speed. Such a model in general will however be less accurate than a model that takes into account the temperature of water, temperature of surrounding air, the atmospheric pressure over the pond, and the wind velocity over different points of the pond. While using such a simplified model, its approximation must be validated in order to rely on its predictions with certain measured amount of accuracy. Once this is ascertained, the model becomes a useful tool, allowing us to estimate evaporation losses with a known degree of reliability. Such simplified mathematical descriptions are often called effective or phenomenological models. Their relationship to the fundamental description is many a time incomplete and their validity is based more on comparing their predictions with actual observations.

For such a mathematical model to become useful, it should also be easily implemented on a personal computer (PC), using a simple software. With the increasing power of PCs, this is becoming less restrictive. Once a mathematical model is created, it can be converted into a set of instructions that can be repeated by a computer, allowing different scenarios to be tested. Thus, a mathematical model of a pond that takes into account fluctuations in rainfall, runoff generated, evaporation losses, and percolation losses would allow us to know the amount of water available in a given pond during the entire course of the year, without actually having to build the pond. It helps in deciding whether to build a pond or not, and also what should be its size and catchment area.

Sim Tanka is a software that helps to simulate a mathematical model of rainwater harvesting systems with covered storage tanks on a PC. Such water harvesting structures have been in use for more than a thousand years in various parts of the world. In western Rajasthan, these are called *tanka*. The efficiency and use of a *tanka* is measured by its ability to meet the given water demand. Sim Tanka helps to determine the extent to which a given *tanka* would meet the demand made on it and with a reasonable amount of certainty.

A number of variables like location, rainfall pattern, water demand, catchment area and its coefficient, and the volume and size of the tank need to be measured and fed into the computer by the user to get the right kind of simulation. Some of these variables are specific to geography and some others are chosen by the user.

For example, if the chosen area for creating a Sim Tanka simulation is Bikaner, the rainfall data for the last 15 years would be required to simulate future probabilities of rainfall in the area. Sim Tanka takes into account the possibilities of future droughts as well. The user can choose the degree of reliability that he expects Sim Tanka to perform at, despite fluctuations in rainfall. Higher the reliability factor, larger would be the catchment area and the size of the tank.

Sim Tanka does not make any assumptions about water demand which is decided by the user or a community. Sim Tanka needs one more parameter to create an optimum *tanka*, namely, runoff coefficient. It is the fraction of rainfall that goes into the storage tank after evaporation and loss due to uncontrolled percolation, which depends largely on the type and size of the catchment area. Usually, an indicative, conservative value of the runoff coefficient, which approximates the complexities of the catchment area in one single number is used. The reason for using an indicative value instead of detailed modelling of a catchment area using actual information, is that the reliability of a *tanka* is affected by uncertainty in rainfall, and not by the runoff coefficient.

Now the Sim Tanka has all the information it needs for calculating the size of the catchment area and the size of the storage tank with the desired reliability. It can try various combinations of catchment area and tank size. For each combination it considers whether the demand will be met or not for each rainfall record available. In a certain situation, a catchment area of 400 square metres (sq m) and tank size of 35 cubic metres (cum) are required for a *tanka* to meet the demand made on it with 95 per cent reliability (that is, 95 per cent of times it can meet the water demand). In case a community cannot provide 400 sq m of land as catchment area and, say, the area available is only 200 sq m, Sim Tanka will try to optimise tank size to meet the water demand reliably, which in this case is not possible with such reduced size of the catchment area.

Another software, Jal Chitra, is being developed by the Jaipur-based Ajit Foundation in collaboration with the Social Work and Research Centre, a Tilonia-based voluntary organisation. It aims to provide an integrated view of all the water sources available to a rural community. It also helps a rural community to prepare for future eventualities based on past records. For example, in a given village with many handpumps, it would be useful to know which ones had gone dry in the past summer and with what likelihood. Jal Chitra shows this information on a village map. It is also possible to develop a mathematical model for a handpump which allows the prediction of the amount of water available, based on various parametres.

There are a number of commercial tools such as spreadsheet and Lotus 1-2-3 and database access programmes like Access which can be used for simulating a large number of situations. There are more specific tools freely available on the Internet.

SIM TANKA: A MODEL FOR MONTE-CARLO SIMULATION OF RWHS WITH COVERED STORAGE TANK

RWHS can be divided into two broad categories: one in which the water is stored in a covered tank and another in which water is stored in a reservoir. The method for simulating rainfall is the same for both systems but in the case of those where the water is stored in an open reservoir, one has to take into account water loss due to percolation and evaporation, while in the case of water stored in a covered tank, these losses are negligible.

After having defined the alogorithm for simulating the rainfall, the next step in modelling the rainwater harvesting system is to calculate the amount of rainwater collected by the system which is a function of the catchment area and the nature of the collecting surface. In the present model, the nature of the collecting surface, like the type of roof or the treated ground, is characterised by the parameter called runoff coefficient.[1,2] This is defined as the fraction of the rainfall falling on the catchment area that is available for harvesting, hence its value ranges between one and zero. The amount of water collected by the system in the i^{th} simulation is given by:

$$\text{Rainwater [i]} = \langle r_i \rangle * K * A,$$

Where $\langle r_i \rangle$ is the amount of rainfall in the i^{th} month simulated by the above mentioned procedure, K is the runoff coefficient and A is the catchment area. The angular bracket around a quantity reflects its stochastic nature. The past rainfall data, the runoff coefficient (K) and the catchment area (A), appearing in the above equation are the parameters that the user of the model has to supply. The user has to supply two other pieces of information: the volume of the storage tank, and the monthly water demand made on the RWHS.

The RWHS is simulated by the following the monthly water balance which for the i^{th} month is given by:

Water tank [i] = Rainwater [i] + Water in tank [i-1] – Water demand [i].

As noted above, the water balance equation does not include losses due to evaporation or percolation in a covered storage tank. If one simulates a RWHS where water is stored in an open reservoir, then evaporative losses have to be calculated and included in the water balance equation. For the purpose of the simulation, the year is regarded as starting in the first month of the rainy season at the given place. The volume of the tank (V) appears in the model as a constraint that the amount of water in tank is always less than or equal to V. At the end of each month, the model checks if the water demands were met or not, and if the amount of water collected in that month exceeded the volume of the tank. The results of the simulation are presented as the probability of meeting monthly demand.

ILLUSTRATIVE EXAMPLE

The model described above is implemented as a mathematical package. To illustrate one possible use, consider a hypothetical RWHS built in a place whose rainfall record is given in *Fig 1: Variable rainfall*. Assume that a family wants to use a RWHS to meet its water demands during the dry months, March to June, when its main source of water, a well, fails to meet its demands. Assume also that its daily water need is 300 litres *(see Fig 3: Water demand)*, and that the planned RWHS will use a catchment surface made of compacted and smooth soil, characterised by a runoff coefficient value of 0.6. We will use the Sim Tanka to find the size of the catchment area and the volume of the storage tank.

To test our assumptions, in particular, for disregarding possible correlations in the rainfall record, we do simulations using monthly rainfall data for 1901-1959 and compare with the RWHS performance under the known rainfall record for 1960-1990. We maintain any possible correlations existing in the rainfall pattern and imitate a situation in which a user builds a RWHS in the year 1960 with the help of Sim Tanka and the past rainfall record for the years 1901-1959. We observe how this RWHS performs in the next three decades.

The parameters of the desired RWHS are obtained by doing a coarse search in a two-parameter space of the catchment area and the tank size using the average annual rainfall value. The results are shown in *Table 1: Recording the past, predicting the future*, while the results of the performance of the RWHS under the time series of the rainfall for the period 1960-1990 are presented in *Table 2: Performance on record***.** The simulations clearly show that a RWHS designed on the basis of the average rainfall generally fails to meet its objective (though in this case, the simulation underestimates its performance

Fig 3: Water demand

Monthly demand from a rainwater harvesting system used as a supplementary source of water during dry months

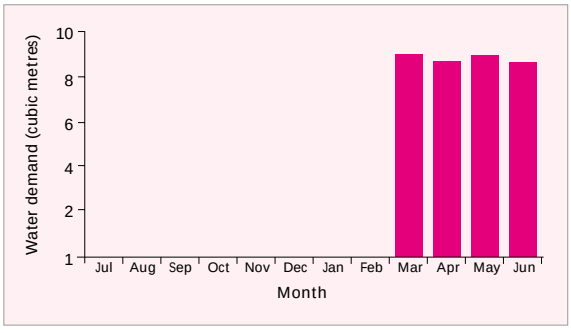


Table 1: Recording the past, predicting the future

Simulations of a rainwater harvesting structure (RWHS) located at Chaksu, Rajasthan. As a comparison between Tables 1 and 2 indicates, it is possible to use past rainfall data to predict future rainfall patterns. This allows optimisation of tank size and catchment area

Using the rainfall record from 1901-59. Runoff coefficient = 0.6

Based on average value of rainfall, simulation was done for 200 cycles, each cycle consisting of five years.

Catchment area (square metres)	Volume of tank (cubic metres)	Probability of meeting the demand (per cent)			
		March	April	May	June
128	37	96	79	65	–
220	60	100	99	97	91
250	60	100	99	98	94
280	60	100	99	98	96
310	60	100	100	100	99
280	40	100	98	94	89
280	70	100	99	98	96

Table 2: Performance on record

The performance of rainwater harvesting structures over the period 1960-90: The table shows the reliability with which a family would have met its water needs during the dry months of March to June with a certain size of the tank and catchment area

Catchment area (square metres)	Volume of tank (cubic metres)	Probability of meeting the water demand (per cent)			
		March	April	May	June
128	37	100	87	70	60
220	60	100	100	90	83
250	60	100	100	97	90
280	60	100	100	100	97
310	60	100	100	100	97
280	40	100	100	100	94
280	70	100	100	100	97

as compared to the time series). We have already remarked that the past rainfall patterns (and hence probable future patterns) are characterised by the simultaneous presence of fluctuations with many time scales. They cannot be adequately characterised by the average value. Comparing *Tables 1* and *2*, we see that the optimum tank size and the catchment area, as obtained by our simulation using rainfall data for the period 1901-1959, performs with the desired degree of reliability in the years 1960-1990.

The above use of Sim Tanka is not its only use. Instead of optimising the space of two parameters, the tank size and catchment area, we can restrict ourselves to one parameter, say, the tank size while keeping the other parameter, the catchment area, constant. We can also use Sim Tanka to find out the fraction of the total water demand, a RWHS of a given tank size and catchment area can reliably meet.

What makes Monte-Carlo simulation useful is the existence of fluctuations with many time scales in the time series data of rainfall. There are other problems of interest to environmental scientists where one needs to model both temporal fluctuations and spatial heterogeneity. Similar problems of different physical origins are encountered in modelling statistical systems and quantum field theories. It is hoped that the interactions between environmental scientists and computational physicists will bring new insights and techniques to the modelling of such complex systems. ■

Innovating Recharge Designs

When demand exceeds supply, augmentation becomes necessary and innovations are born

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Augmentation of groundwater becomes necessary when in a given area or basin, the annual extraction of groundwater exceeds annual replenishment. As water levels decline below the phreatic (unconfined aquifer) aquifer, recharge of the deep aquifers becomes necessary. Deep aquifers can be recharged by surface techniques as well as sub-surface techniques. Surface techniques include technologies to conserve runoff like gully plugs, bench terracing, contour bunds, *nullah bunds,* percolation tanks, spreading basins and individual well recharge. Sub-surface techniques include sub-surface dykes and recharge tubewells.

Conventional recharge structures require maintenance and energy costs, making their widespread application unviable. To overcome this, innovative methods to harvest floodwaters have been developed.

RECHARGE TUBEWELL

In a recharge tubewell, depleted aquifers are directly fed with surface water so that recharge is fast and evaporation and transit losses are zero.

A typical recharge tubewell is designed as follows:

- A borehole of 50 centimetres (cm) diameter is drilled to the desired depth.
- A 20 cm diameter casing (outer pipe of the borewell) is designed by providing slotted (perforated) sections against aquifers.
- The depth of the recharge tubewell should be about 30 metres (m) below the water table in the area.
- The annular space between the borehole and the pipe is filled with good gravel and developed with a compressor till it gives clear water. To stop the suspended solids from entering the recharge tubewell, a filter mechanism is provided at the top.
- A pit of dimensions 6 m x 6 m x 6 m is dug with the tubewell at the centre.
- This pit is filled with small, rounded boulders, stone chips and sand in layers with boulders at the bottom and sand at the top.
- The top one metre of the casing assembly in this pit is filled with sand. The top of the casing pipe is provided with a cap which is about 600 millimetres (mm) below the sand bed to prevent suspended material from entering the well.
- In order to release the air present in the casing assembly during the percolation process of floodwater, the air vent is provided through a 75 mm diameter pipe connected to the recharging tubewell within the top 600 mm through a reducer Tee of dimensions 200 mm x 75 mm. The air releasing pipe is then extended to one of the banks where the air vent is constructed *(see Fig 1: Recharging tubewell).*

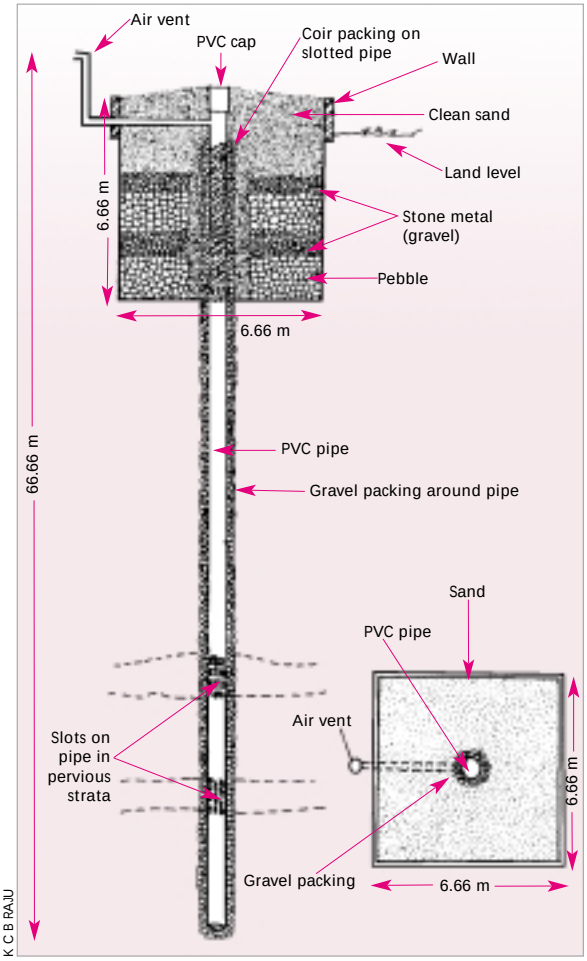
When floodwater filters through the sand, most of the suspended materials are filtered out. The second sand filter surrounding the slotted section of the well at the top prevents the remaining suspended material entering the well. Beyond this is a coir wrapping as a final protective filter before water enters the well. The rate gradually decreases due to settling of silt at the top. Every year, after the rainy season, about one metre of the sand of the filter bed has to be replaced. Every year, the well is developed with a compressor, once immediately after the storage structure becomes empty because the water level is shallow immediately after the monsoon and development is effective.

During pumping, when the water is clear, it may be allowed on the filtered bed so that it takes down the silt accumulated in the filter bed into the well which is being developed. Through this method, the entire filter bed also gets cleared of the silt during the time of infiltration.

SUB-SURFACE DYKE

Sub-surface dykes are often built in riverbeds where base flows are common for sometime during the dry season. Riverbeds generally constitute highly permeable aquifers with good storage potential. In wide streams with high flow levels, the sub-surface dykes are more effective.

Fig 1: Recharging tubewell
A design for rapid recharge



K C B RAJU

Note: *PVC: Polyvinyl Chloride; m: metres*

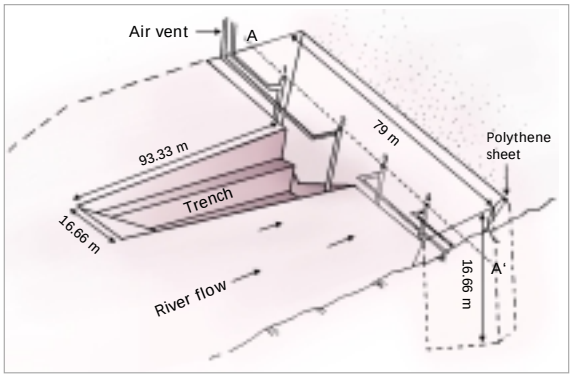
- Generally, the entire width of the river is excavated down to the water table or to a minimum of 15 m when the water table is deep.
- The downstream side of excavation is sealed with a good polythene sheet.
- A trench of dimensions 16.66 m x 16.66 m x 33.33-66.66 m is dug in the centre of the riverbed before the sub-surface dyke in a step design and is filled with sand.
- Where groundwater levels are far below the base of the sub-surface dam, the recharge tubewells are constructed within the sub-surface dam. The depth of the recharge well depends on the existing depth of the borewells in the area and the number of wells depends on the volume of water expected and the size of the impounding structure.
- The entire excavated structure is filled with pervious material in order to harvest the runoff of the river through the sub-surface dam. A check dam is constructed downstream about 100 m away from the sub-surface structure to impound floodwater and to prevent heavy siltation on the sub-surface structure as the silt accumulates near the dam.

Surface dams of this type serve to capture flood flows and also recharge aquifers by capturing the base flows in streambeds. This latter element can be quite considerable depending on the length and width of the river and the thickness of the previous material in the riverbeds *(see Fig 2: Underground action and Fig 3: Inside view).*

INDIVIDUAL WELL RECHARGE

Methods to recharge individual farm wells should ensure that the runoff passes through a filter bed to prevent silting of the well in operation. The finer particles are removed from the earth surrounding the borewell to improve percolation into the well. The following points should be kept in mind:

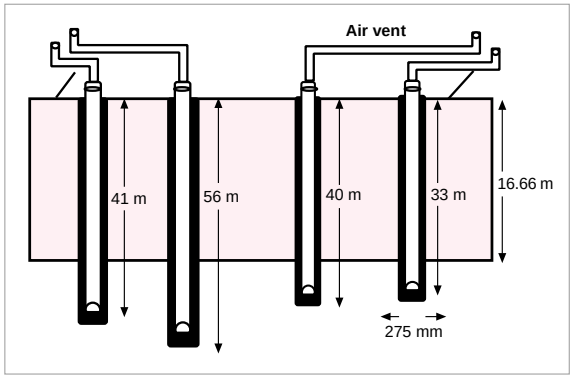
Fig 2: Underground action
Top view of sub-surface dyke with recharge tubewells



K C B RAJU

Note: *1,2,3,4 are recharge tubewells; m: metres*

Fig 3: Inside view
Cross-section of sub-surface dyke



Note: *m: metres; mm: millimetres*

SITE MATTERS

Recharge wells offer great irrigation potential, provided constructed appropriately and cared for

With irrigation being heavily dependent on groundwater and use of energised pumps leading to heavy overextraction and lowering of groundwater tables, recharge wells can provide a solution.

Well irrigation has a lot of advantages, specially if efforts are taken to recharge them. Dual purpose wells can be constructed so that water can be used when required and wells can be recharged when water is available.

Several points need to be considered while constructing a recharge well. The selection of the site is important. If the site is not appropriate, the recharge may not be successful. The well should be planned at a site where the rainwater can be led to the well. In addition, there should be a water reservoir present below the well for recharge.

There are traditional water diviners who can, based on their experience, select an appropriate site for the well. In order to hone their skills there is a need to convince them about the need and the advantages of using simple geological investigation instruments.

No *pucca* (permanent) construction is made on the lower portion of the well. The upper level needs to be constructed with bricks and stones. After this construction, *pucca* pitching should be done on the outer portion of the well. A small window should be made on the direction of entry side of water. The water should enter the well after passing through a tank.

It is important that a small nick be made to lead the rainwater towards the well. This nick takes care during the monsoon, so that it is not washed out. If it fails it should be repaired so that water continues to be led into the well. Constant supervision may be required during the monsoon.

The recharge well requires no special care. However, the well should not be neglected or else it will not give desired results. The nick needs special care. The silt collected should be removed and can be used on the fields.

A precaution that is necessary is that the water should not enter the well directly. If this happens, soil, manure, sand and waste will enter the well along with water, leading to eventual blockage of the well. The runoff generated from rain may also contain fertilisers and pesticides as pollutants in addition to organic and microbial contamination, in which case this water should not be used for domestic purposes.

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- Priority should be given to utilise an abandoned well. If the abandoned well has a borewell, casing can be extended upto the ground level and the open well filled with good sand and gravel around the slotted casing extended into the open well.
- Coir is provided around the slotted section. The floodwater is then directed into the open well filled with sand. The suspended materials get settled on top of the sand and filtered water enters into the borehole. Since there is a good head available, recharge is fast.
- Every year, one metre of sand needs to be replaced.
- In case no abandoned well is available, a filter bed of three square metre is dug up to 2-3 m adjoining the pumping well and filled with filter material. This is connected to the pumping well through a 300 mm diameter perforated pipe laid at the bottom of the filter to prevent silt and other material entering into the pumping well.

The first flood should not be captured if the catchment is an agricultural field as it may carry residual fertilisers and pesticides or pathogenic organisms where organic manure is used *(see Box: Site matters)*.

PERCOLATION PONDS

Located where the surrounding area is flat or gently sloping, percolation ponds are shallow tanks constructed at appropriate places in natural or diverted streamcourses and provided with a waste weir to allow excess water to continue its course. The bottom of the tanks and the soils around should be permeable to allow quick percolation with minimum evaporation losses. If the structure is located where the water table shows a downward slope, recharged water moves away from recharged site, thus constantly providing space for additional recharge.

CHECK DAMS

A check dam is a low weir without a waste weir. It is generally constructed on small streams and long gullies formed by the erosive activity of water. The ideal location for a check dam is in a narrow stream with high banks. A check dam serves many purposes. It cuts off the runoff velocity and reduces erosive activity. The water stored improves the soil moisture of the adjoining areas and allows percolation to recharge the aquifers. When constructing a series of check dams on a long streamcourse, the spacing between two check dams should be beyond their waterspread. The height of the check dam depends on the bank height so that even during the highest flood, it should not spill over the bank as most of the check dams are likely to be located in the proximity of irrigation wells in the surrounding agricultural fields.

Areas where streams have wide drainage courses with high embankments and there is a scope for diverting the excess water after storage through a waste weir to rejoin the same stream further downstream, earthen dams should be preferred with a masonry waste weir. ■

Unravelling Secrets — the Ramtek Model

A scientific analysis of water harvesting structures around Ramtek township in Maharashtra reveals an intricate network of groundwater and surface waterbodies, termed as the Ramtek model. This system is disintegrating due to sheer neglect and ignorance

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A topographical sheet of the Survey of India reveals a fascinating example of water harvesting structures around the township of Ramtek in Maharashtra: a series of ponds and tanks designed to harvest the seasonal rainwater available, based on the unique geographical, geological and climatic conditions. An analysis of these structures proved that there was some method in the ways in which these structures were traditionally designed in terms of location, choice of structure and utility. Unfortunately, this outstanding water harvesting system, termed as the Ramtek model, is gradually disappearing, due to apathy, ignorance and maintenance.

Ramtek taluka in Nagpur district is spread over an area of 41,000 hectares and is marked by narrow hills interrupted by plain country. The hills follow a northwest to southeast trend and descend suddenly down into the plains. The area is underlain by metamorphic rock that is very hard, does not primarily possess any porosity, however, on weathering, develops secondary porosity, and acts as a water-bearing horizon. The thickness of such zones varies from only a few meters (m) to 20-30 m below the ground and is the major source of groundwater. Drainage is characterised by a dendritic pattern. *Nullahs* (drains) of various sizes originate at higher grounds to flow down the slopes in numerous branches. This pattern develops typically in areas with rocks of uniform resistance and implies a noticeable lack of structural control.

The soil in the study area varies in thickness from 250-500 millimetres (mm), implying a shallow depth. The soil is excessively drained and has a sandy loam to sandy clay loam texture. Water availability varies from 140-170 mm of water per metre (mm/m) of soil and the water holding capacity of the soils falls under the medium category of 110-150 mm/m.

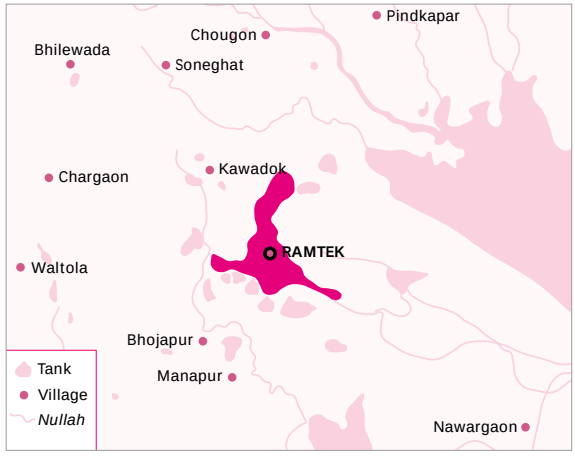
There are 88 villages and Ramtek township within the *taluka*. The landuse breakup of the study area shows 30 per cent land with forest covering on the northern hilly area. The rest comprises 42 per cent cultivated land, 11.5 per cent culturable wasteland and 16.6 per cent uncultivable land.

MODEL MOVES

In order to understand, revive and maintain this heritage, 15 tanks were selected for a model study. The study included actual examination of the tank sites, interacting with elders in the local community, land topography and landuse patterns, the local microclimate, factors which control water flow and a scientific analysis of the region.

The climate and physiography of the area led to building of numerous tanks of various dimensions, mostly on wastelands. While superficial examination of the model depicted simply an array of tanks, a detailed examination on the site and interacting with the local communities revealed that there was much more to these tanks. The Ramtek model in reality represents an intricate network of groundwater and surface waterbodies, intrinsically connected through surface and

Base map of Ramtek taluka, Maharashtra



IN SUPPORT

Variety of traditional water harvesting structures abound in the Ramtek model

The Ramtek model is a system of tanks, *baoris* (stepwells), wells and *kundis* (stone tanks) designed to capture every drop of precious rain.

Supporting the tanks, these *baoris,* resembling the *vavs* (richly ornamented well) or *bavadis* of Gujarat and Rajasthan, are constructed by digging a central mouth extending to a depth of 20 metres (m) to 25 m, accessed by steps to the centrally located waterbody. The presence of sculptures and inscriptions on the walls of the *baoris* demonstrates the importance they commanded in the traditional social and cultural lives of people. It was common among farmers to make offerings to the *baori*, for higher crop production and to eradicate disease.

Almost every *baori* had an inbuilt temple at a depth of 5-10 m from the surface which not only provided platforms for religious and social gatherings but avoided misuse of the premise or the water and helped maintain water purity. A few religious festivals are still performed around some of these *baoris*, but most of these water structures have been destroyed or are in extremely dirty condition.

The wells in the area demonstrate an ideal example of underground water storage structures. Varying in size and depth, these wells constitute a steady source of water. Wells near the hills produce water at 1.2-1.5 m depth and are built with only 800 millimetres diameter to save energy and money. Groundwater on the plains is found at depths of about 7-9 m. The direct relationship between the groundwater level and surface water storage bodies is exemplified by the public interest litigation filed by villagers residing in the command area of Khindsi lake. This suit highlights the fact that water level in wells in the command area drops by 1.5-3 m overnight, after water is released from the lake.

The Jinda Kua in Ramtek maintains high quality water throughout the year and according to the residents of the area, has the potential to supply water to the whole township.

At many places, villagers simply dig a depression — 'water holes'— close to a tank and channelise this water through the depression to meet requirements at a desired place. While a few of these wells are community-owned and can be accessed by any villager, others are owned and used privately.

Kundis, water harvesting structures carved out in hard rocks and arranged in perfect dimensions, were used for bathing before entering temples, many of which are still used to cure chronic skin ailments. Though, some of these *kundis* are now in a state of complete ruin, their presence reflects the ideology of separating waterbodies for bathing and drinking purposes.

underground canals. A fully evolved system, this model harvested runoff through tanks, supported by high yielding wells and structures like *baoris* (stepwells), *kundis* (stone tanks) and waterholes, representing intelligent efforts to utilise every raindrop falling in the watershed area *(see Box: In support)*.

Constructed and maintained mostly by *malguzars* (landowners), these tanks form a kind of a chain, extending from foothills down to the plains, conserving about 60-70 per cent of the total runoff. Once tanks located in the upper reaches close to the hills were filled to capacity, the water flowed down to fill successive tanks, generally through interconnecting channels. This sequential arrangement generally ended in a small waterhole to store whatever water remained unstored.

Absence of algal growth in all the tanks in the study area indicates absence of organic matter and high dissolved oxygen content necessary for healthy aquatic life, possible by regular inflow and outflow of water, and no stagnation.

Today, many of these tanks are facing extinction due to neglect and encroachment *(see Table 1: Ramtek tanks)*. The main reason for deterioration of these tanks is a breakdown in the traditions of community management. Tanks are now under the administrative control of the government which pays little attention to either desilting the tank beds or clearing the choked channels in the catchment areas. This has led to a decline in both quality and quantity of water. Most of the remaining tanks are now utilised only for pisciculture and bathing cattle.

According to an old resident of Ramtek, "What was once everybody's business has now become nobody's business." Most of the current generation residing at Ramtek is not even aware of these tanks *(see Table 2: Declining awareness)***.**

SCIENTIFIC PROOF

The ground observations were supplemented by analysis to 'scientifically' explain the logic of the Ramtek model. A morphometric analysis of these water conserving structures was carried out, using Survey of India (SOI) toposheets. Morphometric analysis is a function of drainage length, stream frequency, drainage density and other parameters, all studied in relation to the drainage texture, which helps to categorise the area into zones of broad water regime.

Table 1: Ramtek tanks

Status of tanks in the Ramtek model

Total no. of tanks	Total no. of selected tanks	Status		Status of inter-connecting channels
		Silted	Non-existing	
144	15	8	3	7 channels choked by siltation

MINENVIRONS

Like other places,* baories *in Ramtek were also associated with religious and cultural values. This ensured against their misuse

Drainage texture is an important criterion in morphometric analysis, and is a function of drainage density and stream frequency. Drainage density is calculated by dividing the total length of drainage streams with the area of the basin, whereas stream frequency is calculated by dividing the number of streams by the area of the basin. The product of drainage density and stream frequency is the drainage texture. Infiltration capacity or permeability of bed rock is the dominant factor influencing the drainage texture. Drainage texture is inversely proportional to infiltration capacity, which means that more is the drainage texture, less is the permeability, and vice versa. Based on these calculations, the area was categorised into surface runoff, recharge and storage zones.

To perform the analysis, a grid of 400 hectares area was overlaid on the drainage map prepared from the SOI toposheet. For each of the individual blocks (drainage basins), various parameters like total drainage length, total number of streams and the area of drainage basins were calculated and ranked accordingly *(see Table 3: According a rank)*.

Table 2: **Declining awareness**
General awareness about the Ramtek model

Number of respondents	Age group (years)	Awareness of existing system (percentage)	Inclination towards revival (percentage)
18	Below 25	15	12
18	25-50	40	50
24	Above 50	88	94

The drainage texture values thus obtained were plotted on the drainage maps. Isolines were drawn (using interpolation method) for drainage texture values, to separate the entire area into three zones having values less than 2, 2-8, and greater than 8, respectively. Based on the values so obtained, the area was divided into three ranks of high, moderate and low *(see Table 4: Value system)*.

Based on this analysis, the study area can be divided into four broad physiographic divisions:

- The northern stretch consisting of hill ranges of the Chorbauli hills and forest;
- middle plain country, extending from the northern foothills to Ramtek-Mansar ridge;
- the abruptly rising Ramtek / Mansar ridge; and,
- the southern portions which lie at the foothills of the Ramtek hills and the plains further south.

THE TWAIN MEET: TRADITIONAL KNOWLEDGE AND MODERN SCIENCE

The superimposition of the field observations on the scientific analysis explains why different water harvesting structures were designed on specific locations.

The abruptly rising Ramtek and Mansar ridges divides the study area into two distinct physiographic plains, with each plain having a different water harvesting system, and water and landuse application. Because of the presence of Chorbauli Hill ranges on the extreme northern part and the intermediate Ramtek ridge in the south, the middle plains constitute an ideal site for catching surface water from the two hill ranges and it

Table 3: **According a rank**
Parameters of morphometric analysis

Area of basin (hectares)	Drainage length (metres)	No of streams	Drainage density	Stream frequency	Drainage texture	Rank
400	5,650	4	1.41	1.00	1.41	C
400	7,650	10	1.91	2.50	4.77	B
400	12,900	23	3.22	5.75	18.51	A

Table 4: **Value system**
Drainage texture values in Ramtek model region

Rank	Drainage texture	Characteristics
High-A	Less than 2	Runoff zone: hill topography, thin soil cover, hard rock and higher slope
Moderate-B	Between 2 and 8	Recharge zone: plain country, moderate to deep soil, moderate slope
Low-C	More than 8	Storage and discharge zone: plain country, thin soil, hard rock

Note: *(i) Drainage structure is the product of drainage density and stream frequency*
(ii) Drainage texture is inversely proportional to infiltration capacity-more the drainage texture, less is the permeability and vice versa

was here that the Khindsi lake was constructed. The entire study area gently slopes towards south, forcing the water (both surface and groundwater) to move along the gradient towards south. Poorly developed water harvesting structures in the middle plains suggest that this area was well served by slopes and streams. The area forms the catchment for Khindsi lake. Various streams and tributaries originating from the northern hills cross this area and add water to the Khindsi lake. A few attempts have been made to trap the runoff into small lakes in this area, before the water finally flows into the Khindsi lake, but the amount of water has not been sufficient to meet the needs of the growing population and increased irrigation. People in this area have to depend on groundwater resources for most of the time, which in turn is controlled by the presence of water in the Khindsi lake.

The presence of the Ramtek ridge in the middle, having a steep slope on both sides, results in quick runoffs and little percolation. This might have led the residents of the southern plains of the Ramtek hills to construct different types of water conservation structures (like tanks) where they could trap the maximum amount of runoff. ■

MINENVIRONS

Carvings and inscriptions on stones used in* bunds *indicate the importance associated with these structures

Technology: Size Selection

Best of Both Worlds

Large and small-scale irrigation systems must be combined judiciously to solve the chronic water shortage in Gujarat

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To solve the chronic water shortage of Gujarat, both macro and micro-scale planning is needed to achieve long and short-term benefits. Macro-scale planning in Gujarat considers the Sardar Sarovar Narmada Project (SSNP) reservoir and Narmada canal as the backbone for transfer of surplus water from south Gujarat to north and northwest Gujarat.

Micro-scale planning envisages conservation and augmentation of water by induced and artificial recharge through minor schemes and small structures such as check dams, percolation tanks, village ponds, riverbed recharge and wastewater reuse. These efforts can immediately begin and be combined with the proposed state water system (SWS) at a later stage. The concept of SWS includes interconnection of various basins to take advantage of the surplus water available during the monsoon season in certain areas, conjunctive use of groundwater and surface water, arresting water quality deterioration caused by overdraft, and erection of new reservoirs. The state water system also envisages using surplus water from the neighbouring states situated upstream. The concept of the Narmada canal serving as the backbone of the proposed state water system, rather than having a restricted command area, can be developed gradually. The Narmada canal can carry considerably more water than its original designed capacity through proper management. Small-scale local connections will be necessary between various schemes and basins and the Narmada canal. In many cases, the connection will be indirect and the same command area would be served by both local schemes and the Narmada canal.

It is also proposed to gradually link new regions to the Narmada canal, including the southern basins of Gujarat, western Saurashtra and some areas in northern Gujarat. Several link systems for southern Gujarat have been proposed, such as Par-Tapi link and Ukai Narmada link. As connecting areas in western Saurashtra or northern Gujarat to the Narmada canal will call for pumping, detailed plans need to be formulated before work can commence. Due to the scale of such operations, this alternative should be considered and implemented on a long-term basis.

Par-Tapi link includes, in its first phase, a canal link between the Ukai dam on the Tapi river to convey surplus water from this river to the southern part of the Narmada command area, thus allowing more Narmada water to flow north. The second phase includes building seven new dams on rivers south of the Tapi river — between Tapi and Par — and a canal linking it to the first phase canal.

Ukai-Narmada link comprises a conduit to convey surplus Tapi water directly to the head reaches of the Narmada canal *(see Fig 1: Ukai-Narmada canal)*. The 220 kilometre (km) long conduit includes numerous closed segments such as tunnels, siphons and pressure pipelines stretching for about 18 km.

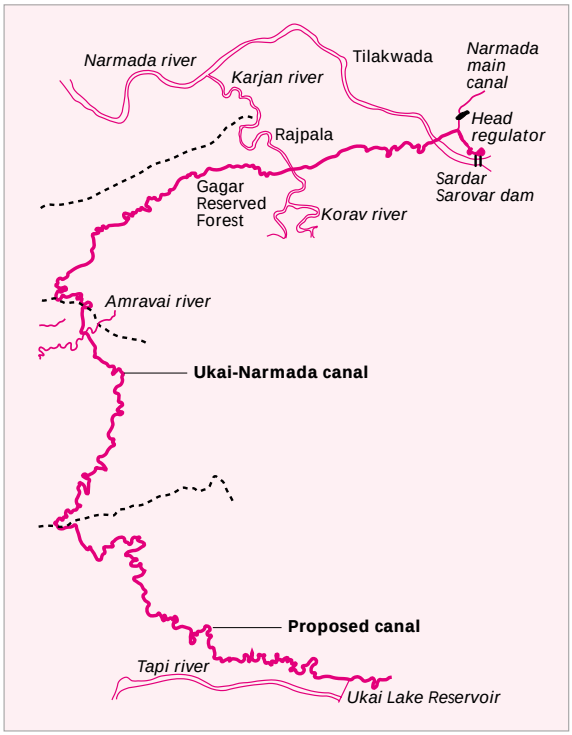
ARTIFICIAL AND INDUCED RECHARGE

Artificial recharge

In most cases, recharge by direct injection is not feasible or economically viable. The area covering Mehsana and parts of Banaskantha, Gandhinagar and Ahmedabad districts, spread over more than one million hectares, has been considered for artificial recharge experiments. These experiments ensured that they would not interfere with other water projects, population and its regular occupation, industrial plots and saline areas where total dissolved solids (TDS) are greater than 5,000 ppm (parts per million). Four types of recharge projects have been suggested for this area.

It has been proposed to direct the monsoon season spillage of Dharoi and Dantiwada reservoirs and direct it to spreading (infiltration) fields through irrigation project canals. The infiltrating water will reach the relatively thin phreatic (shallow) aquifer. Dual-purpose wells, connected to both the phreatic and confined, deep aquifers, allow moderation of water in the phreatic aquifers and then inject it into the confined aquifer.

Fig 1: Ukai-Narmada canal
This is a conduit to convey surplus Tapi water to the Narmada canal



Dual-purpose wells are used both as recharge and pumping wells *(see Fig 2: Meeting two ends)*. These wells have filter sections both in the phreatic and confined aquifers. Dual-purpose wells receive water from the phreatic one and inject it into the confined aquifer. They function by gravity, since the piezometric (water) level of the confined aquifer is below the phreatic level. The flow of water through soil layers and the phreatic aquifer provides for a degree of purification, favourable for injection into the deep aquifer.

Under the riverbed recharge scheme, the wide and deep sandy beds of Saraswati and Banas rivers are considered as separate elongated aquifers. Sills — impervious layers across the bottom of the riverbed, similar to a sub-surface dam — will increase the wetted area and enhance infiltration into them. The infiltrated water will be collected by longitudinal drains and injected by wells into confined aquifers.

It has also been suggested that detention reservoirs of 3-4 million cubic metres (mcum) capacity are to be built on the Rupen river tributaries, from where water can be led to spreading fields through an earthen canal. Canals from each diversion will be effectuated by low 2-3 metre (m) weirs on the river. Water infiltrated into the phreatic aquifer will be injected into a confined aquifer by dual-purpose wells. The surface drainage canals in the southern parts of the zone would be intercepted by some eight *bunds* with dual-purpose wells to recharge deep aquifers. *Bunds* near the Narmada main canal could also be fed directly during the monsoon season.

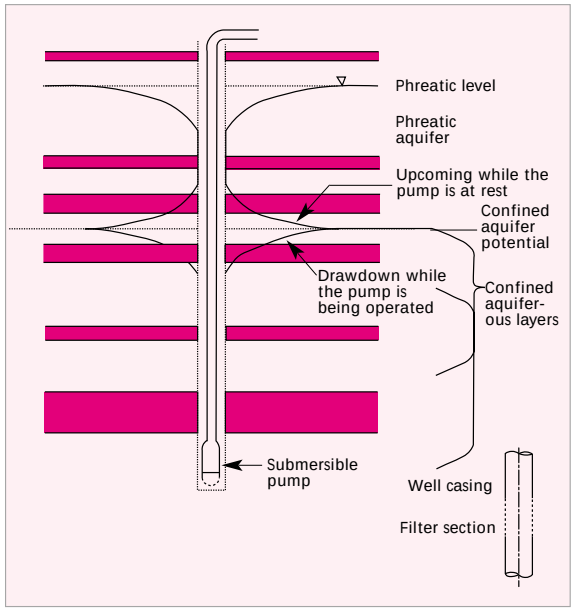
A qualitative appraisal of the projects, based on advantages, drawbacks and costs, indicate the following order of preference for augmenting water in the area: riverbed recharge; reservoir spillage; *bunds;* Narmada recharge; and, Rupen tributaries.

Induced recharge

Induced recharge needs building of check dams and percolation tanks to check water flow in streams or rivers, leading to natural infiltration. In Gujarat, streams are the principal source of freshwater. But due to the typical characteristics of streams which make harnessing water difficult, runoff in large quantities continues to flow unutilised to the sea despite several thousand water harnessing schemes in the state.

There are a number of reasons for this dilemma. These streams witness a large fluctuation in water flow, with large volumes during the relatively short monsoon season. Most streams flow as powerful and sporadic flood waves with peak discharge of hundreds and even thousands of cubic metres per second (cum/sec) that constitute about 70-80 per cent of the annual water flow. This makes it difficult to harness water in small

Fig 2: Meeting two ends
Dual purpose wells (recharge and pumping) transfer water from confined deep aquifers to upper unconfined aquifers. During monsoon, the transfer of water from the unconfined aquifer is directed into the confined aquifer for recharging



schemes. Small discharge flows of less than 4-5 cum/sec that last comparatively long durations constitute only 20-30 per cent of the total flow. Large amounts of sediments that settle in reservoir beds reduce the water storage capacity of these structures and increase water loss due to overflow, evaporation and seepage.

The total effective storage capacity of the major schemes is some 9,636 mcum and of ongoing schemes is 3,106 mcum in addition to 5,800 mcum of the SSNP. The total effective storage of existing and ongoing medium schemes is about 2,300 mcum.

MINOR SCHEMES

There are two types of check dams: check dams on big rivers that stop the flow of water only after the rainy season, and check dams on small rivers that arrest the entire amount of water flow by having permanent closures. Check dams on big rivers utilise less than 1-2 per cent of the total water flow, since no water is captured during the rainy season. Relatively large flooded areas in river channels upstream of the check dams results in high evaporation losses of about 30 per cent. The infiltration rate also gets reduced due to clogging of the stream bed from suspended matter carried in by the water. Check dams on small rivers suffer similar problems of sediment accumulation, clogging, low infiltration rate and evaporation. Percolation tanks also face clogging and reduced infiltration rate, and increased evaporation when these structures are flooded for long.

It is estimated that over the next 25 years, the water retention capacity and surface runoff utilisation of all existing major and medium schemes will be reduced by about 15 per cent which is equivalent to a volume of over 1,800 mcum of water. In minor irrigation systems, the reduction in water retention capacity will be around 500 mcum. These problems can be tackled by creating larger storage capacities to accommodate larger volumes of water and compensate for sediment accumulation.

To enhance induced recharge, replenish riverbed aquifers and reduce evaporation losses, clear water needs to be conveyed from upstream to check dams to generate a much higher infiltration rate of about 100-150 mm/day. If the hydrological conditions at the site are not suitable for recharge of ground aquifers then the water should be diverted to nearby percolation tanks or storage sites.

Check dams on small rivers should be used as operational reservoirs only. After each flood, stored water should be diverted to downstream areas for recharge or to another regulating reservoir. This will ensure that the first reservoir remains free to arrest more water, while the second reservoir allows percolation. Groundwater recharge may be improved by simply transferring the runoff to the downstream side of the weir to be stored mostly in small earthen dams and percolation tanks. A few new designs *(see Fig 3: Improved check dam)* have been suggested for check dams and percolation tanks.

For check dams on small rivers, flushing out sediments settling in the river channel upstream of the weir is suggested. The channel can be divided to have an overflow segment and another for diversion of water at a small rate of about 1-3 cum/sec only. Under new percolation tank schemes, the reservoir formed upstream of the weir is proposed to serve only as an operational reservoir. Following each flood, sediments are to be allowed to settle down for a day or two, and then clear water can be sent to spreading fields downstream of the weir.

The existing development programmes propose the construction of 158 new minor schemes, 1,363 check dams and 961 percolation tanks. On an average, a minor scheme has 206 hectares (ha) of irrigated land as its command area which requires 1,030 mcum/year of water. A percolation tank has 19.9 ha of irrigated command area which needs 0.1 mcum/year of water, while a check dam has an average command area of 9.6 ha of irrigated land with a demand for 0.048 mcum/year, assuming a gross requirement of 5,000 cum of water per ha per year. It is assumed that new schemes will be able to supply higher amounts of water at an average of 0.2 mcum/year from a percolation tank and 0.1 mcum/year from a check dam. For a minor scheme, the storage volume will be 1.3 mcum on average. Despite the fact that the implementation costs are likely to be higher than the current estimates, the cost of water will still be lower. Before final planning and implementation, each scheme needs to be subjected to a field study to determine its actual size, design criteria and local factors like hydrology, topography and water demand.

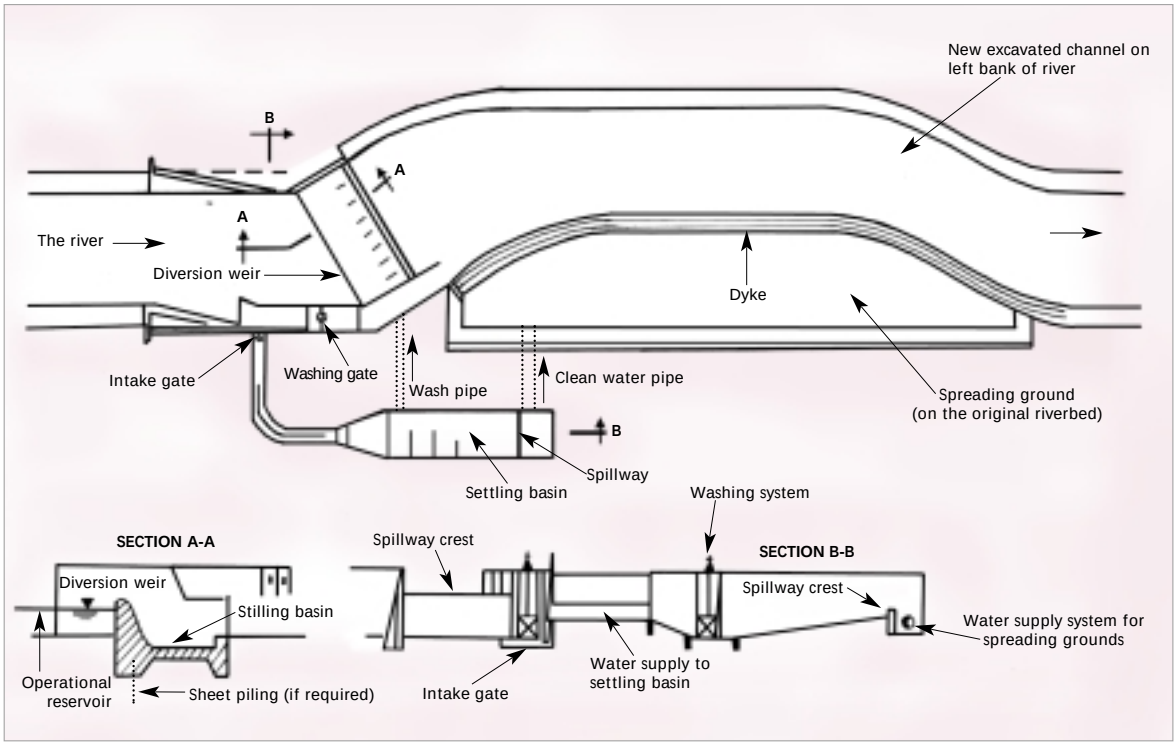
MEDIUM AND MAJOR SCHEMES

In order to increase stream flow utilisation, existing structures need to be improved and new schemes assessed. In places, they need to be integrated to get the best solution. Since new sites for large on-river reservoirs are not available, alternative engineering solutions such as cut-and-fill side reservoirs, connected through diversion channels, need to be found despite the fact that they are likely to be less effective and more expensive.

Raising the height of dams, spillways and dykes can increase the retention capacity of on-river structures. Structures with regular spillways without gates above the crest can be achieved easily and at a low cost. But major schemes necessitate addition of long sections of new spillways in order to maintain safety levels.

Fig 3: Improved check dam

Proposed check dam design on small rivers for increased efficiency: spreading ground downstream of the check dam. After each flood, the water is diverted to a percolating reservoir so that the riverbed is free to hold more water



GSFC SCIENCE FOUNDATION RECHARGE EXPERIMENTS

The GSFC Science Foundation has taken up two recharge wells in Ahmedabad and Bhavnagar districts for experimentation. The well designs have been selected keeping in mind the hydrogeology of the areas.

The recharge well at Ahmedabad has a large diameter, which is actually a modified soak pit, with sides of the well covered with sand and gravel. Apart from generating groundwater recharge using stormwater, the well is also meant to offer adequate aerobic and anaerobic biological treatment to domestic greywater (non-sanitary domestic wastewater). Efforts to monitor the amount and quality of recharge water and its area of influence are in progress. The well at Bhavnagar is designed to recharge deep aquifers by filtering stormwater in upper section and then injecting it through a deep, small-diameter bore. Based on the findings of these experiments, well designs will be modified later.

In order to assess future irrigation water demand, various model irrigation types (ITs) were formulated. An IT represents a typical irrigated agricultural production system, including properties such as crop composition and cropping intensity, irrigation methods and their efficiency and water supply dependability. Three types of ITs for each agroclimatic zone have been considered.

Irrigation type 1 (IT-1) represents traditional irrigation practices using gravity flow, water supply conditions and efficiencies. Crop composition and cropping intensity are similar to those used at present. Irrigation type 2 (IT-2) represents improved reliability in water supply. Although crop composition and cropping intensity are similar to those used at present, their water requirement is better ensured. IT-2 enjoys the combined benefit of better water supply reliability and better yields. Irrigation Type 3 (IT-3) is the most advanced IT, from the point of view of both agro-techniques and irrigation. It improves on-farm gravity conveyance and distribution systems to reduce delivery and application losses, introduces pressure irrigation for certain crops and improves reliability of water supply. It modifies existing cropping patterns by increasing cropping intensity, introduces new cash crops, and increases the proportion of high value vegetable and tree crops. Future scenarios of irrigation and water demand will be based on different combinations of ITs. Production systems may have a higher proportion of IT-2 and IT-3 areas at the expense of IT-1 areas. ■

Technology: Water Purification

Filtering Finesse

With the introduction of Horizontal Roughing Filter/Slow Sand Filter techniques by Janamangal Mahila Samiti, safe drinking water is no longer a dream in coastal areas of Puri district, Orissa

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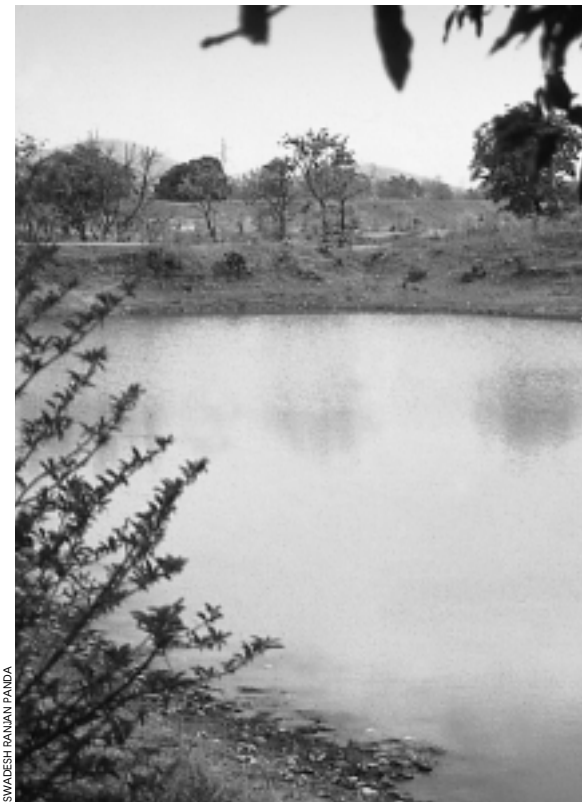
Janamangal Mahila Samiti, Puri, Orissa

The introduction of Horizontal Roughing Filter and Slow Sand Filter (HRF/SSF) to treat surface water has made safe drinking water available in coastal pockets of Puri district, Orissa. This filtration system has been introduced by Janamangal Mahila Samiti (JMS), a voluntary organisation active in the coastal pockets of Puri district. The *modus operandi* followed by the organisation is simple — a suitable tank in the village is identified, after which the organisation installs this filter system with the participation of the villagers. The region receives enough rain that is harvested in community tanks. Till October 1998, five such systems were installed in Brahmagiri and Krushna Prasad blocks.



SWADESH RANJAN PANDA

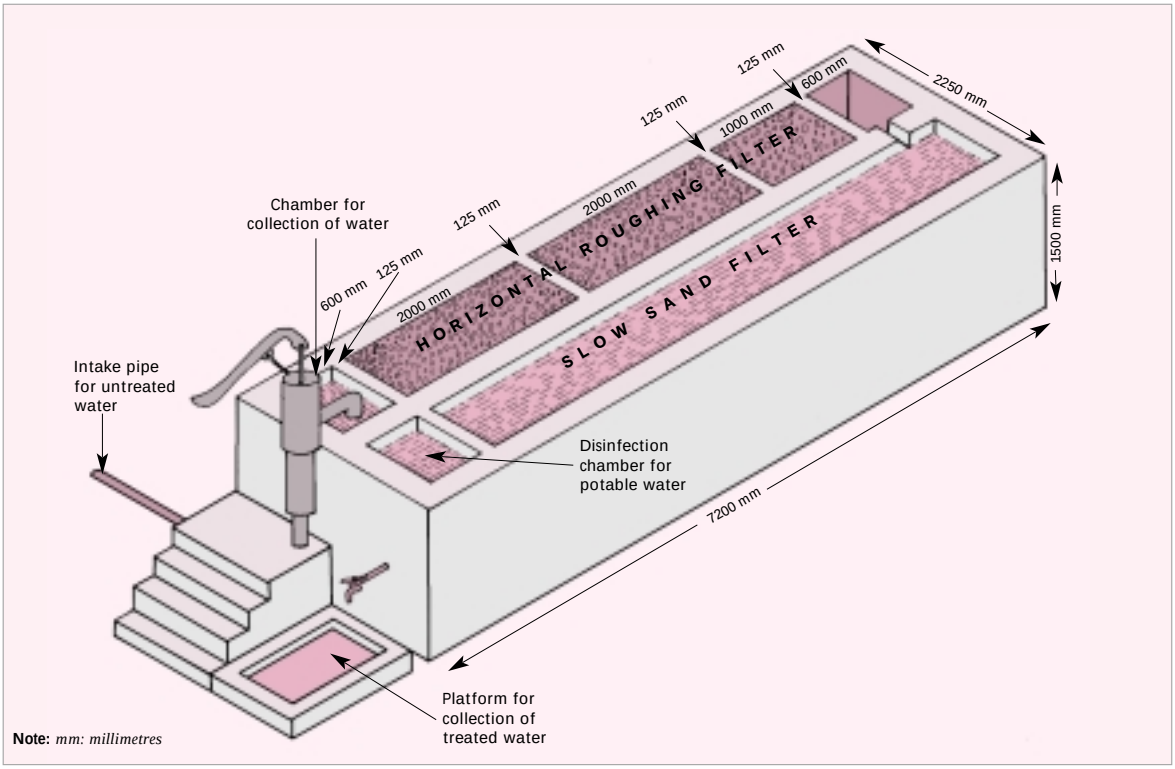
A source of drinking water in coastal Orissa

Communities residing in the coastal blocks of Puri Sadar, Satyabadi, Brahmagiri, Kanas and Krushna Prasad areas of Puri district are inhabitants of a 'no freshwater aquifer zone.' The groundwater is saline. With surface waters being polluted due to human activities and lack of fuelwood making boiling of water almost impossible, diseases like diarrhoea, typhoid and hepatitis are common.

Earlier attempts to solve the crisis have met with limited success. A Danish donor agency, DANIDA, has installed deep tubewells in some villages since 1970 for lifting water from the freshwater aquifers. However, in other villages, these wells were installed in the deep brackish aquifer zone, pumping out saline water, rich in iron and chlorides as there exists no freshwater here. Moreover, the continuous flow of water from these wells has turned agricultural land saline.

As drinking water scarcity continued to haunt the local population, JMS contacted Action for Food Production (AFPRO), a New Delhi-based non-governmental organisation for technical assistance in 1987 for providing safe drinking water. Technical experts from AFPRO designed a structure for underground filtration, consisting of two components — a filter channel with one square metre cross-section and eight metre length, to be laid across the tank embankment, while the other was a *sump* to collect filtered water from the tank through the filter channel for storage and collection. The filter channel consisted of three uniform compartments, the first being packed with broken bats, the second with coarse sand, followed by fine sand in the third compartment. At every outlet and inlet point of the channel, fine graded mesh is implanted to prevent entry of finer materials into the *sump*. The length of a channel varies according to the nature of the site selected for the *sump*.

Fig 1: Simple yet effective
Isometric view of horizontal roughing filter-cum-slow sand filter



JMS constructed three of these filter media in three community tanks. These filters worked successfully for 3-4 years, providing safe drinking water. However, a major defect in the design was that the fine graded mesh used in the channel rusted and the entire filter material like broken bats, coarse and fine graded sand pushed forward and collected in the storage tank. Due to the underground nature of the system, it was difficult to clean the filtered channel regularly.

FILTERING SUCCESS

To counter these problems, the Orissa office of UNICEF provided technical knowhow about the HRF/SSF, designed by the All-India Institute of Hygiene and Public Health, Calcutta. To date, this is the best solution found for obtaining pure and bacteria-free rainwater harvested in community tanks.

While HRF acts as a physical filter and is applied to retain solid matter, SSF is primarily a biological filter, used to kill microbes in the water. Both filter types are of an equal technical level and their operation is characterised by stability. These make full use of the natural purification process of surface water — harvested from rainwater — and do not require any chemicals to support or supplement the treatment process.

The HRF/SSF system is simple to install and operate, needing little maintenance *(see Fig 1: Simple yet effective)*. The HRF usually consists of filter material like gravel and coarse sand that successively decreases in size from 25 millimetres (mm) to 4 mm. The bulk of solids in the incoming water is separated by this coarse filter media or HRF.

The role of SSF is more of a fine filtering media. HRF is able to reduce turbidity to levels that allow a sound and efficient SSF operation. SSF, as the final treatment stage, substantially reduces the number of the microorganisms present in water, while arresting the last traces of solid matter and oxidising dissolved organic compounds.

To prevent seepage in some community ponds where the soil type exhibits significant seepage, the seepage may be controlled by lining the ponds with Agrifilm. Uncontrolled seepage not only causes loss of useful water but also leads to other problems such as breaches in the embankment and waterlogging.

So far JMS has installed five such HRF/SSF structures in Brahmagiri and Krushna Prasad blocks which have proved to be cost-effective and simple, making the periodic cleaning of filtered channels easy and simple. ■

Akshaydhara: An Urban Solution?

By treating domestic wastewater and injecting runoff into underground aquifers, the Akshaydhara model seeks to address the twin problems of water scarcity and domestic wastewater disposal in urban areas

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Urban areas face twin challenges of water scarcity and wastewater disposal. The Akshaydhara model, based on rainwater harvesting and storage and reutilisation of segregated greywater (water recovered after treating all wastewater except sanitary water) for aquifer recharge, may be an option. The model seeks to fulfil water demand while addressing sanitation issues.

Most of the water supply in India is dependent on the monsoon, which comes during the months of June to September. The number of rainy days varies from 5-50 and during the actual rain, spells are generally intense, generating a lot of storm runoff, which, in urban areas, causes local flooding and disruption. Once the rainy season is over, there is water scarcity, with all hopes pinned on relief to be provided by the next monsoon. Another problem faced by the urban population relates to the vast amount of wastewater that is generated. Thus, an ideal solution would be one that would address both issues together: the reuse of wastewater to recharge depleting surface reservoirs and ground aquifers.

The philosophy behind the Akshaydhara model is water management in terms of supply, use and wastewater segregation *(see Fig 1: Total use)***.** Given increasing water demand and an inability to meet this demand, water management becomes a vital issue, given the reliance of the urban population on a centralised and efficient water supply system. One problem in harvesting substantial quantities of rainwater in urban areas is the lack of storage space and the cost of artificially creating such facilities. Wastewater disposal is another problem and there is a need to recycle this water for use.

VITAL COMPONENTS

The Akshyadhara concept, meaning pristine, perennial flow, is based on the results of experiments in Ahmedabad, involving manipulation of shallow aquifers and stormwater runoff through percolation wells for accelerated groundwater recharge and recycling of domestic wastewater through a soil-aquifer treatment system (SAT).[1]

The system comprises of rainwater harvesting followed by surface/sub-surface aquifer storage. An important component of this system is artificial recharging of underground aquifers that have been depleted due to large-scale exploitation. Water for recharging is obtained not only from stormwater runoff, but also from segregated 'greywater' throughout the year after soil-aquifer treatment. SAT involves the percolation of wastewater downwards laterally through the underlying aquifer. It is used as an active filter removal of suspended solids, bacteria and viruses, and reduces nitrogen, phosphates, heavy metals and trace elements. In many urban areas, the component is significantly larger than the rainwater that can ever be harvested. Because of the limiting infiltration/recharge capacity of soils and aquifers, the system has to be a spatially distributed one.

The non-sanitary component of domestic wastewater (greywater) is much larger (more than 70 per cent) in volume and less dangerous than the sanitary component (dark water). Akshaydhara sets out to manipulate the soil-aquifer system to affect treatment of stormwater and domestic wastewater to increase groundwater recharge. Part of the treated, recharged water is pumped and used locally to meet non-potable requirements of the community, thereby conserving high quality water sources. Recharged groundwater through natural sub-surface flow would result in rejuvenating surface waterbodies like rivers and lakes.

The feasibility of an integrated scheme to use stormwater drainage to recharge groundwater was examined through a set of experiments at Ahmedabad.[2] Initial experiments involved filtration of stormwater using gravel beds into borewells with perforations facing

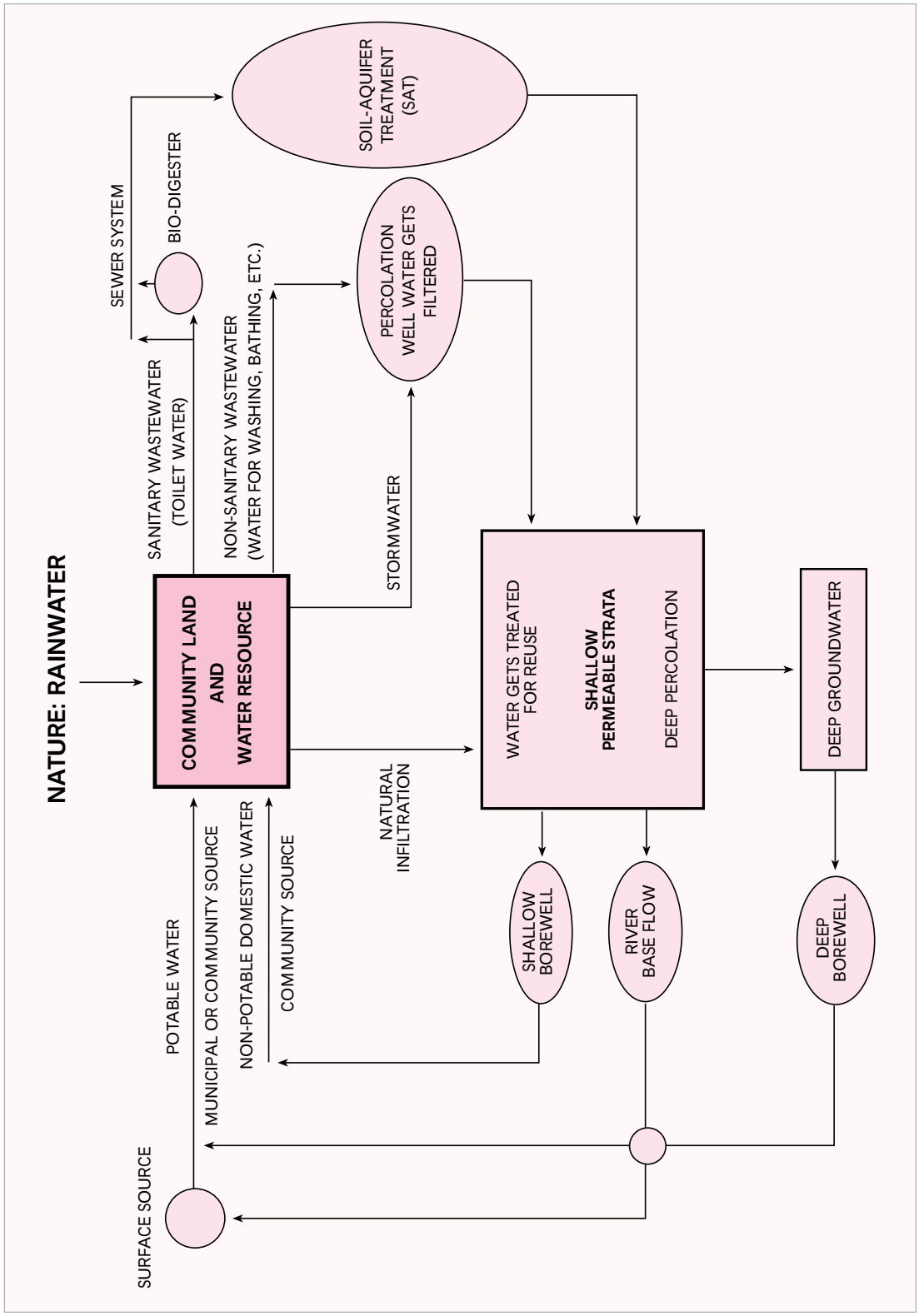


Fig 1: Total use
Akshaydhara concept for total water management includes capturing the rain and reusing non-sanitary water for recharge as well as non-potable use

shallow — less than 20 metres (m), unsaturated sandy horizons. The results, though encouraging, yielded recharge rates too low (5-20 litres / minute) to recommend the method as an effective stormwater recharge measure.

To overcome this problem, it was decided to increase the percolation area of the aquifer being recharged and to provide a temporary underground storage for the large amount of runoff collected during heavy rains. Based on these considerations, a percolation well, in many ways similar to a conventional soak pit, was designed and constructed in Maninagar, Ahmedabad with a catchment area of approximately 1,500 square metres. Despite a heavy monsoon in Ahmedabad during 1994, with at least three spells of more than 100 millimetres of rainfall within 24 hours, the percolation well did not overflow and the collected water was dissipated within 96 hours. The system resulted in a groundwater recharge of about 1,800 cubic metres (cum) during the entire monsoon season. This established the percolation well as an important building block in the Akshaydhara concept.

Encouraged by the results of the experiment, the Ahmedabad Municipal Corporation (AMC) sanctioned a pilot project worth Rs 16 lakh for the construction of 10 percolation wells on an experimental basis. A few of these percolation wells have already been constructed *(see Table 1: Experimental proof)* and have performed satisfactorily by disposing off stormwater in shallow aquifers that had gone dry due to overexploitation in the last few decades.

PUTTING AN END TO WASTING WASTEWATER

Another important component of the Akshaydhara concept is the development of appropriate technology for renovation of municipal wastewater for use in irrigation and groundwater recharge. Between 1995-1998, work on a pilot project in the Sabarmati riverbed, off the Vasna Sewage Treatment Plant, was undertaken. The project comprised of injecting primary settled sewage through infiltration basins and pumping out the treated water from a shallow (approximately 20 metres) borewell located in the middle of the infiltration basin *(see Fig 2: Treating sewage)*. Wastewater was renovated by filtration through soil layers, anaerobic and aerobic oxidation of dissolved organic matter in the filter bed and in the unsaturated zone (less than one metre) below and further filtration during saturated flow (approximately 50 m).

The filter beds were periodically dried to rejuvenate their infiltration capacity. The pilot project was operated for more than six months during which renovated water at the rate of 1,000 cum per day had been obtained through two infiltration basins 100 m x 100 m x 0.5 m, with two pumping wells at their centre. In terms of quality, the renovated water was better than conventional secondary treated water in all aspects *(see Graphs 1* and *2: Improved water)* and the cost of treatment was estimated to be 30 per cent less, including the cost of recovery of the treated effluent water.[3] This effluent water conformed to both World Health Organisation (WHO) and national standards for unrestricted irrigation of even vegetable crops that are consumed raw. It can also be used as process water for industries, thereby reducing pressure on deep aquifers. National Environmental Engineering and Research Institute (NEERI) and Ahmedabad Municipal Corporation (AMC) jointly executed the scheme under a grant from ministry of water resources, government of India.

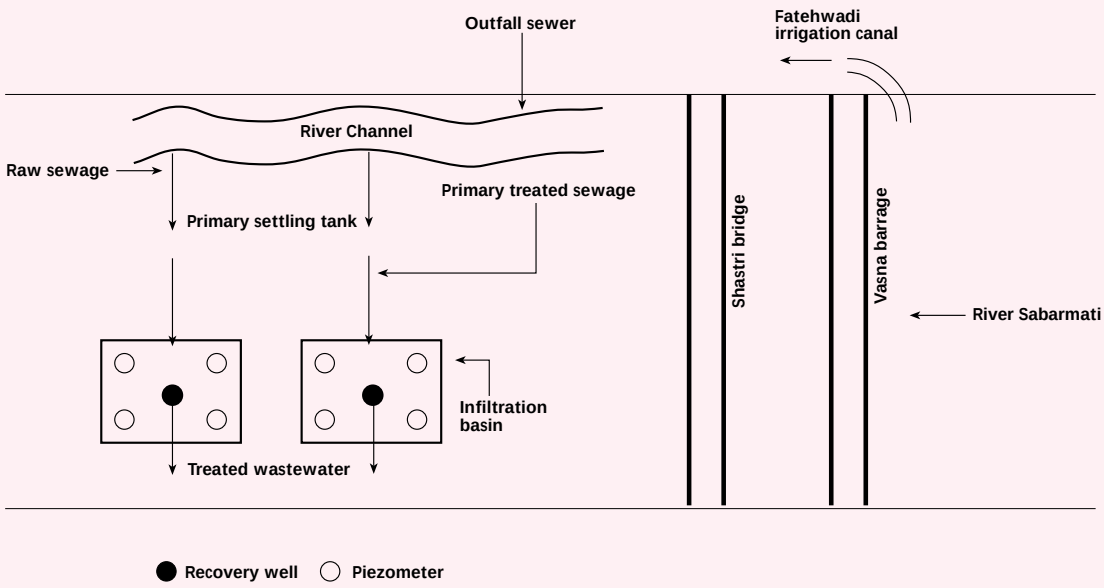
The experiment demonstrated that a soil-aquifer treatment system can work with high loading rates, even using primary treated sewage. Elimination of

Table 1: Experimental proof
Structures / experiments in Ahmedabad for validation of Akshaydhara

Location	Structure / experiment
Smrutisuman flats complex, Paldi	Percolation well for greywater and stormwater renovation and recharge
Prarthana Vihar near Shreyas Tekra Ellis Bridge	Two percolation wells for stormwater renovation and recharge
Basement of shopping complex at Maninagar	Percolation well for stormwater drainage and recharge to avoid flooding of shops in the basement
Thakarsey Charitable Hospital, Himmatlal Park	Percolation well for storm runoff drainage and recharge
In the open field near Gujarat stadium	Percolation well for storm runoff drainage from a large low-lying area
North gate No 17, Sardar Patel Stadium, Navrangpura	Percolation well for storm runoff drainage from a large low-lying area
In the riverbed off Vasna Sewage Treatment Plant	Infiltration basin plus pumping and observation well complex for treatment of primary settled sewage through soil-aquifer treatment concept

Fig 2: Treating sewage

Wastewater treatment through soil-aquifer treatment (SAT) in the Sabarmati riverbed: A pilot scheme



Project hardware

1. Two primary settling tanks
2. Two Infiltration basins (100 m X 100 m X 30 mm)
3. Two shallow tubewells (diameter 300 mm, depth 25 m)
4. Four piezometers for monitoring water levels and quality
5. Two submersible pumps installed in shallow tubewells for pumping treated wastewater

Note: *m: metres; mm: millimetres*

costly conventional biological treatment steps lead to considerable cost reduction without significantly compromising on effluent quality. A full-fledged project of 55 million litres per day capacity, based on the pilot studies, has been submitted to AMC.

EXPANDING HORIZONS

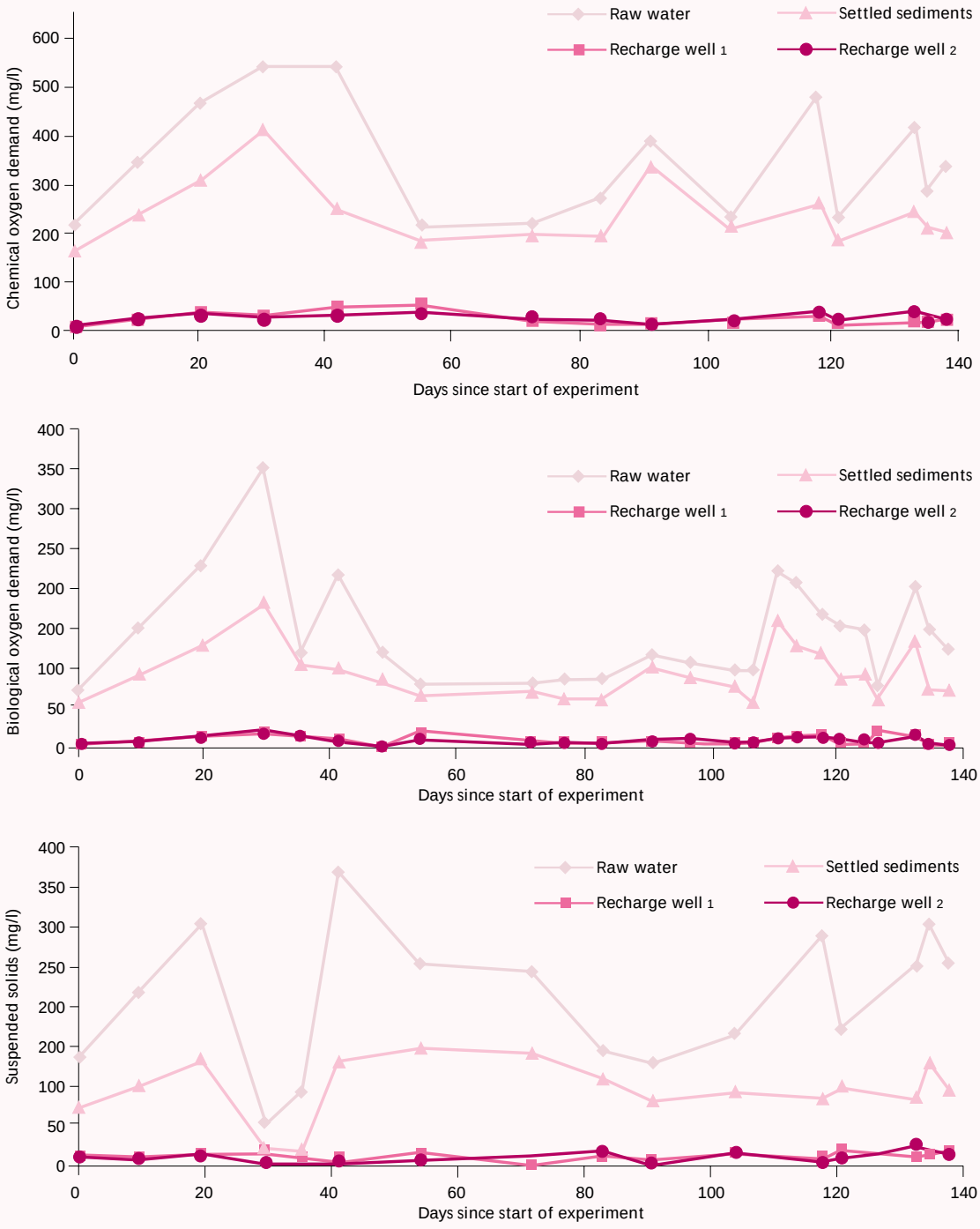
To implement Akshaydhara on a large scale, it is important that sanitary and non-sanitary components of domestic wastewater be separated. Anaerobic digestion of the sanitary component can be achieved locally by employing a bio-digester. Such bio-digesters linked to public latrines and using human excreta as feed-stock are already in use in several parts of India. Liquid effluents from bio-digesters can be discharged either into city sewers or locally used for horticulture. In areas not covered by a sewer system, the fraction not utilised locally may be disposed off into unsaturated soil zones, employing a separate septic system/ percolation well. Where no sewerage system exists, considerable saving in providing sewerage services can be achieved by using small-bore sewers for limited volumes (of the segregated dark water component) of liquid effluents from bio-digesters.[4]

Large volumes of non-sanitary grey wastewater generated from individual or community housing units can also be disposed off into the unsaturated soil zones after passing through small settling basins and sieves, using percolation wells. Since the percolation well is functionally similar to a conventional septic system, the wastewater undergoes anaerobic oxidation followed by aerobic oxidation and nitrification as it passes through the unsaturated soil zone, eventually reaching the groundwater table. An experiment, with financial assistance from Vadodara-based GSFC Science Foundation, has been initiated to establish the rate and degree of improvement that the segregated greywater undergoes during its passage through unsaturated zones.

There is, however, an inherent risk of nitrate pollution in shallow groundwater aquifers in the above mode of domestic wastewater treatment.[5,6] To avoid or minimise the risk, local groundwater is proposed to be pumped 10-20 m away from the percolation well,

Graph 1: Improved water-1

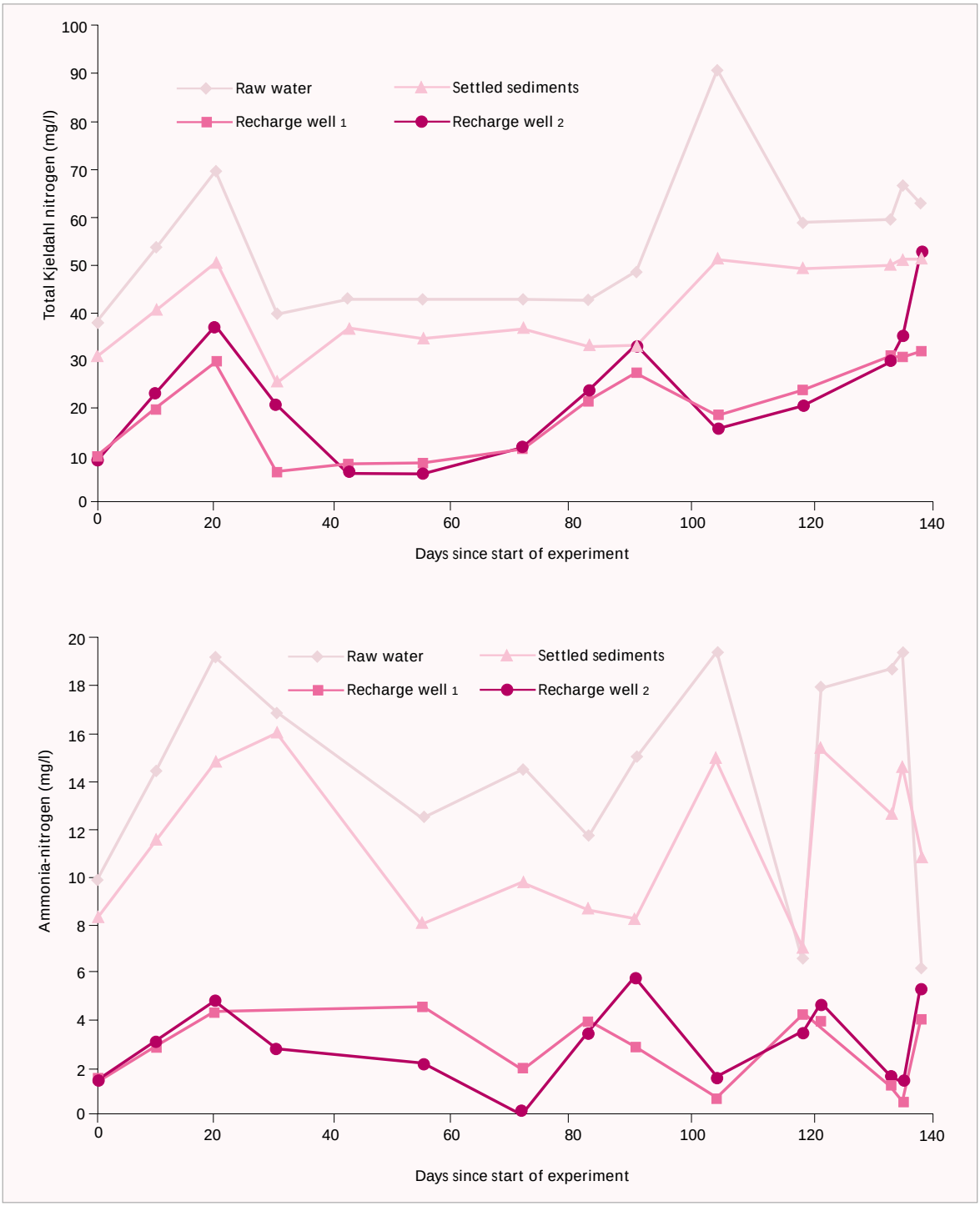
Ahmedabad soil-aquifer treatment system performance with respect to chemical oxygen demand (COD), biological oxygen demand (BOD) and suspended solids (SS)



Note: *mg/l: milligrammes per litre*

Graph 2: Improved water-2

Impact of soil-aquifer treatment on total Kjeldahl nitrogen and ammonia-nitrogen



Note: *mg/l: milligrammes per litre; Total Kjeldahl nitrogen: total amount of nitrogen; Ammonia nitrogen: nitrogen from protein sources and sanitary pollution*

employing a shallow borewell (approximately 30 m deep). The pumped water can be supplied for non-potable household uses through a separate plumbing system. The advantage of such a system is that the user is not required to limit the use of this treated water, as used water is returned back to the percolation well again for treatment and recycling. Nitrate from this water is removed by returning to the percolation well under the prevailing anaerobic conditions in the presence of organic carbon in greywater. The pumping well, thus, serves two purposes: it pumps the treated water for recycling and confines the groundwater zone assigned to treatment/recycling process.

Drinking water, constituting a small component of domestic consumption, should be of the highest purity and is envisaged to be supplied from the community or municipal sources, through a separate plumbing system. To conserve this resource, water may be limited to approximately 20-30 litres per person per day to meet drinking and kitchen needs only.

Thus, through a combination of treatment and recycling of wastewater, conservation of high quality potable water, and recharging storm runoff into aquifers, the declining trend of groundwater levels may be reversed. This will also aid in restoring the hydrostatic gradient towards the surface waterbodies like rivers and lakes, rejuvenating and enhancing their base flow component. With local disposal and reuse of both sanitary and non-sanitary components of domestic wastewater, the pollution loading of the surface waterbodies can be minimised.

In the proposed mode of wastewater disposal, pockets of shallow underground aquifers are likely to receive some amount of pollution. While most of this load is biodegradable in nature, some areas have to be earmarked and monitored for spread of pollution plume. This calls for appropriate research and experimentation in terms of improving the soil-aquifer treatment technology, and increased understanding of pollutant removal and retardation during movement through the soil-aquifer medium, and monitoring containment and movement of sub-surface pollution plumes.

STAGEWISE IMPLEMENTATION

It is possible to implement the various components of the Akshaydhara concept in a stagewise manner, particularly for those cities where some sewer facilities already exist. Even these will be under stress, as single family residential units are replaced by multistorey apartments.

The first stage involves segregating the small volume of sanitary toilet waste and subjecting it to anaerobic bio-digestion and then discharging the liquid effluent into the city sewer system. This step involves only minor modification of the already existing civil work as the drains of the toilet and non-toilet wastewater are already separated in buildings as part of the normal building construction practice.

The second stage comprises construction of percolation wells in housing societies/community units for soil-aquifer treatment of the segregated non-sanitary wastewater and the storm runoff water, to rejuvenate the shallow groundwater system. This would result in reduction of wastewater to be discharged into the city sewer system.

The third stage consists of providing separate plumbing and pumping/recycling system for non-potable water. This would gradually ease the load off high quality public drinking water supply system.

In the fourth stage, the existing wastewater treatment system can be augmented through construction of infiltration basins and soil-aquifer treatment of the organic rich liquid waste collected at the centralised sewage collection point.

In the last stage, the domestic sewerage system can be linked to the city garbage collection system, wherein segregated recyclable waste is collected by the dry waste collection network and the wet biodegradable kitchen waste is disposed off in a community bioreactor, the output of which being liquid can be let out either into the city sewer system or utilised locally for horticulture. With the commissioning of bioreactors for kitchen waste, the sewer system will help reduce expenditure on collection/disposal of the wet biodegradable waste as recyclable waste is more hygienic and environmentally sustainable. The biogas generated can be used for street lighting.

This proposed five stage implementation of the Akshaydhara concept can be modified according to the water and sanitation facilities available to the urban communities.

ADVANTAGE AKSHAYDHARA

The Akshaydhara concept provides the following advantages:

- It reduces the cost of centralised sewage collection, treatment and disposal;
- it reduces cost of high quality water supply and its conservation thereby ensuring resource sustainability;
- the infrastructure and maintenance costs are shared between the city government and residents' communities, thereby involving the residents in maintaining hygienic conditions in their cities; and,
- it rejuvenates surface and groundwater sources. ■

Small yet effective

Artificial infiltration of rainwater has tremendous potential in urban areas

K R Gopinath
K R G Rainwater Harvesting Company, Chennai, Tamil Nadu

Conservation of groundwater is important because it takes years to be replenished. In areas where groundwater is used, care must be taken to minimise the quantity of water withdrawn and bring it on par with the quantity of water being replenished. Water management techniques such as rainwater harvesting, artificial recharge of aquifers (a process of augmenting the groundwater table by artificial infiltration of rainwater and surface runoff) and construction of underground *bandharas* — concrete walls of impermeable soil built across and below riverbeds — can be used. *Bandharas* are underground reservoirs built on rivers to recharge the surroundings of rivers — nearby wells, borewells and ponds.

Artificial infiltration through rainwater runoff can augment groundwater tables, crucial for use during dry months. It also helps to remove suspended solids by filtration through soil and prevents seawater intrusion into freshwater aquifers in coastal areas. Artificial infiltration has other important indirect results such as enhancing crop production, reducing water disputes and minimising crack formation on walls and buildings.

Artificial recharge is a process that is increasingly being adopted in developing countries as well as in the industrialised world *(see Box: International appeal)*.

MANY FACES OF RAINWATER HARVESTING

Percolation pits, one of the easiest and most effective means of harvesting rainwater, are generally 1 metre (m) x 1 m x 1 m square pits filled with small pebbles or brick jelly and river sand, covered with perforated concrete slabs wherever necessary. Whenever the depth of soil is more, recharge through percolation pits with borewells is preferable. The bores are deep pits with dimensions of about 250 millimetres (mm) inner diameter and about 1-8 m depth depending on the soil condition *(see Fig 1: Ensuring percolation)*. It can be located at the centre of the square percolation pit. Ideally, there should be one percolation pit for every 23 square metre (sq m) area.

Rooftops of houses provide another economical form of water harvesting. If properly used, they can augment groundwater tables substantially. To collect rainwater, a roof is connected to a well through a filter by polyvinyl chloride (PVC) pipes. A valve system can be incorporated to enable the initial rainwater to flow out to get rid of impurities collected on the roof *(see Fig 2: Using rooftops)*.

Bathing water can be directed to percolation pits or trees near the house. However, the connecting pipe can have a 'U' bend which will act like a water seal not allowing bad smell or insects into the bathroom.

INTERNATIONAL APPEAL

Augmenting groundwater aquifers is becoming a widespread activity

Countries which have been using artificial recharge techniques include Algeria, Australia, Bulgaria, Egypt, Germany, Israel, Japan, Mexico, Morocco, Romania, Russia, Spain, Senegal, Sweden, Togo, The Netherlands and the United States.

In Germany, a glass of water on the table is considered to have gone through the stomach of nine people — that is, the water is recycled nine times. The circulation of water is the main point in the conservation of potable water. Further, the wastewater is treated and let off to rivers so that the same will recharge the aquifer and help farmers and dwellers on the banks of rivers.

Roads in some of these countries are so designed that during monsoon, the water flows to stormwater drains on both sides of the road. Percolation pits, more than six metres deep, are constructed at regular distances. Not only do these methods avoid flooding of the roads, but also recharge the underground water table, which in turn enables the wells nearby to give better yield.

In countries like Italy, bathing water is collected in an underground cistern and then pumped into a treatment plant and subsequently used for flushing of toilets. In Israel, various water preservation techniques like drip irrigation and percolation pits are being employed. In parts of the US, rainwater is retained in artificial tanks and allowed to percolate to the groundwater table gradually by adopting ditch and furrow methods.

Methods of rainwater harvesting

Fig 1: Ensuring percolation: Cross-section of percolation pit

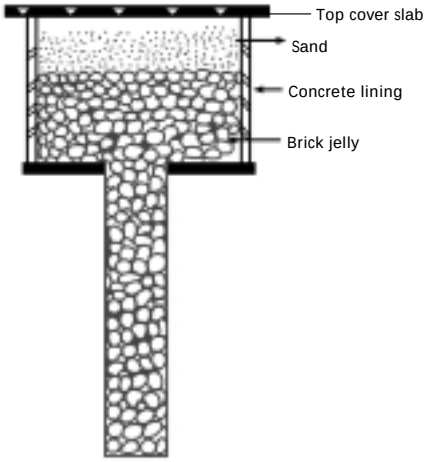
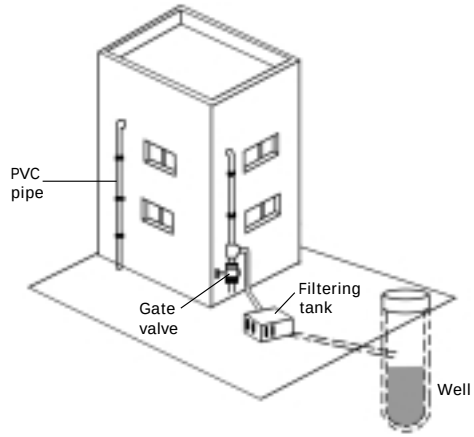


Fig 2: Using rooftops: Roofwater collection



PVC: polyvinyl chloride

Fig 3: Recharging borewell: Rainwater harvesting through defunct borewells

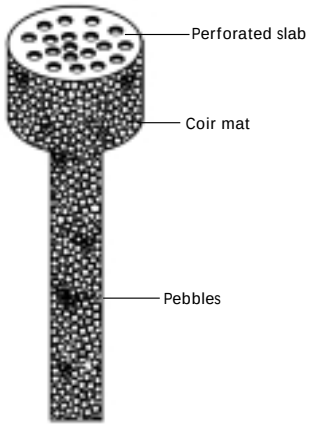


Fig 4: Flood recharge: Plan of ditch and flood recharge project

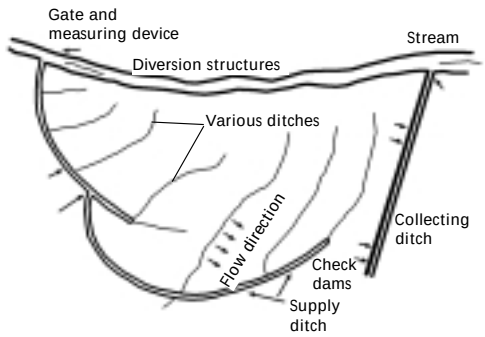


Fig 5: Well recharge: Rainwater harvesting in farm wells

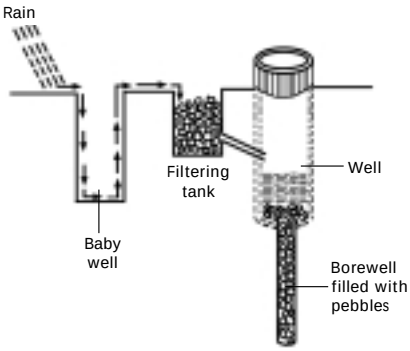
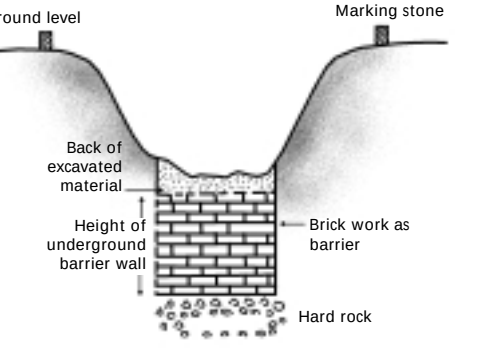
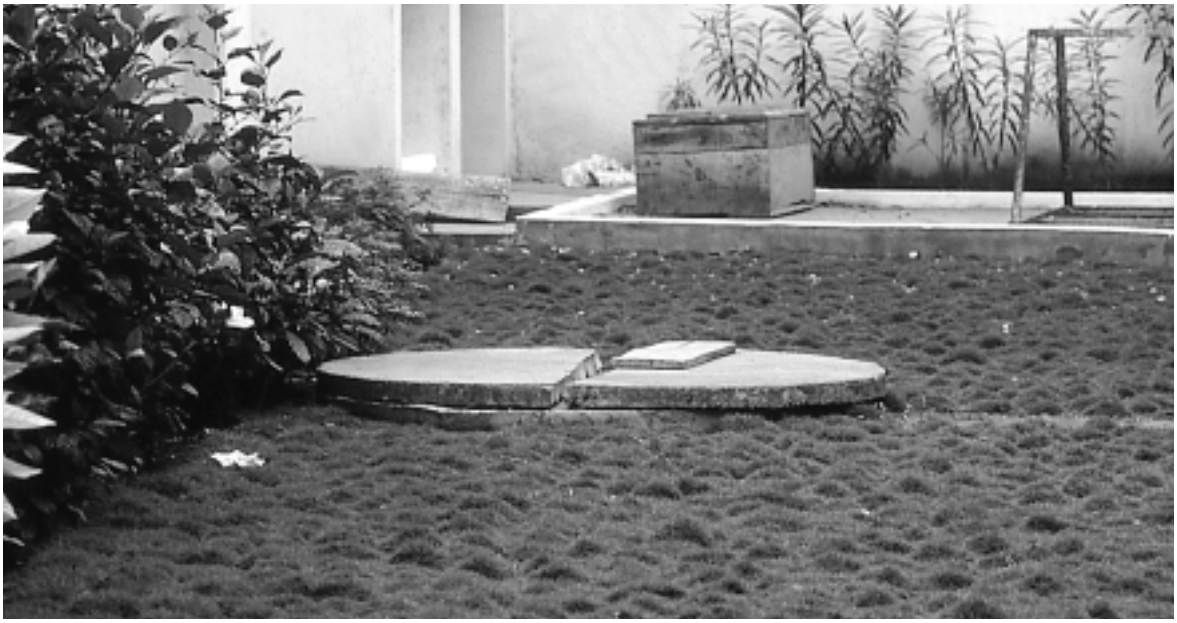


Fig 6: Tapping ground flows: Cross-section across the underground *bandhara*





ANIL AGARWAL / CSE

Artificial infiltration with the help of a recharging borewell

The ground level near the gate of an individual house can be raised to retain as much water as possible inside the compound. Alternatively, an inclined gutter can be constructed across the gate to direct the runoff towards a percolation pit. Multistorey buildings can direct this water to recharge wells.

Stormwater drains inside premises can have 155 mm high boundary walls to ensure rainwater stagnates over the ground only to seep into the soil. Topsoil in an open ground should be removed and replaced with river sand to allow percolation of rainwater. Wherever there is a slope, a dwarf wall should be constructed to a height of around 305 mm to retain runoff and allow for slow percolation.

Due to severe depletion of groundwater levels in urban areas, many open wells, borewells and handpumps have gone dry which can now be converted into useful recharge wells. After filling the wells with pebbles and sand for filtration, rainwater from rooftops and runoff can be diverted into these wells. There should be an effective arrangement for desilting such wells prior to diverting water into them *(see Fig 3: Recharging borewells)*.

Rainwater collected from terraces of a cluster of buildings may be led into nearby ponds (with pervious top layer) through pipelines for recharging groundwater aquifers. Runoff water can also be diverted into such ponds after proper desiltation. A well can be constructed nearby to tap the groundwater recharge.

A ditch system can also be designed to suit particular topographical and geological conditions existing at a site with potential for artificial recharge. It is particularly advantageous in areas where recharge water contains high loads of suspended sediments *(see Fig 4: Flood recharge)*. The runoff generated during the monsoon can be diverted into suitably designed recharge structures in public parks, playgrounds, stadiums, airports, railway stations, bus stations, temple tanks, artificial ponds and huge dugwells.

Stormwater drains should be designed in such a way that two separate segments are made to accommodate water coming from houses and water coming from roads. The segment on the side of the road should be covered with a perforated slab and should have percolation pits at regular intervals of depths of 6-15 m, depending on the soil condition.

Huge quantities of sewage water, generated by households, can be separated and reclaimed through soil-aquifer treatment (SAT) process. This treated water can then be used for recharging dry rivers and used for irrigation.

To harvest rainwater in rural areas, percolation pits with deep bores can be built in agricultural lands for gradual percolation and recharge of aquifers. Construction of small *bunds* on slopes slows down runoff and helps in percolation. Runoff can be diverted into large wells through baby wells and filtering tanks, to avoid silt deposition in large wells *(see Fig 5: Well recharge)*. On riverbeds, *bandharas* can be built at regular intervals below the surface that acts as underground reservoirs and recharge the surrounding area *(see Fig 6: Tapping ground flows)*. ■

Lake Lustre

With a little help from the government, living organisms can help restore urban lakes to their original glory

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The landscape of the twin cities of Hyderabad and Secunderabad are dotted by more than 500 waterbodies, impounded as a part of a scientifically developed irrigation system in this semi-arid region. An environmental survey of these lakes indicates that many of these are in progressive states of degradation. Given the services that these bodies provide in terms of recharging the groundwater, controlling floods and maintaining biodiversity, it is essential that these bodies be protected. Bureaucracy willing, these lakes can be restored through biomanipulation (bringing about changes through the use of living organisms like microorganisms, plants and animals).

The waterbodies of these two cities are no exception. Big and small waterbodies, an integral part of the urban landscape all over the country, are important aquatic ecosystems, constituting an important source of freshwater *(see Box: Hyderabad blues).*

GENESIS OF THE PROBLEM

The potential of urban wetlands to meet at least some of the water demand lies ignored as the state increasingly moves towards importing water from distant reservoirs at huge costs. As a consequence, these local waterbodies, literally in the backyard, are being used as dumping grounds, leading to their gradual degradation.

Freshwater lakes have been victims of three major phenomena — population growth, industrialisation and intensive agriculture — all of which have grossly polluted surface and groundwaters, resulted in biodiversity loss and destroyed the catchment of these bodies, resulting in a progressive reduction of their waterholding capacities. The following are some of the causes leading to degradation of lakes:

- **Pollution due to raw sewage and/or industrial effluents:** Sewage is the main source of nutrients that sets in a chain of events leading to an imbalance in an aquatic ecosystem. Invariably, many settlements in a catchment area are not connected to the city sewer system and sewage freely pollutes the waterbody. The same is the case with industries in the catchment area, which seldom treat their effluents, preferring to let them out into these waterbodies.
- **Silting due to cultural and other factors:** A lot of silt is generated due to construction activities in the catchment area which is washed into the waterbody, thereby effectively reducing the height of the standing water. In addition, every year tonnes of silt is added from the immersion of huge idols in Hyderabad. A lot of floral offerings are also dumped into these waterbodies.
- **Unauthorised encroachment and reclamation:** In the absence of clear-cut boundaries and lack of proper survey records, unauthorised encroachments right up to the lake bed are a common occurrence. This problem is further compounded by high land values. Reclamation of lakes for developmental activities like road construction, flyovers and gardens threaten the very existence of these lakes.
- **Pollution from washing activities:** Lake-dependent communities like washerfolk and small dry farmers use the lake for washing and bathing purposes. Lack of *dhobi ghats* (washerfolk's place) compound the problem of pollution by detergents and organic waste. The phosphates from washing activities in the lake cause eutrophication (increase in nutrient levels, leading to increased biological oxygen demand) — a process that sets in a chain of destructive events leading to the lake's death.
- **Dumping of garbage and solid waste:** In the absence of any watch and ward the lakes have become convenient sites for dumping of garbage — from solid waste to dead animals.

This degrading impact is more severe in the urban environment and the resultant consequences are alterations in the morphology and waterholding capacity, pollution, loss of biodiversity and, at the last stage, total destruction of the waterbody.

Water quality is defined in terms of a number of

HYDERABAD BLUES

The lakes of Hyderabad appear to contain everything but water

An environmental survey of waterbodies in and around Hyderabad classified them into three major categories: those totally reclaimed and lost forever like the Mir Jumla Tank, Ma Sahab Tank and Batkamma Kunta; those in progressive stages of degradation and can be rehabilitated like Saroornagar lake, Mir Alam Tank and Hussainsagar; and, those that are still used as sources of drinking water and have recreational potential like Osmansagar, Himayatsagar and Shameerpet lake. Out of the 170 waterbodies identified by the Hyderabad Urban Development Authority for protection, most belong to the second category — those in progressive degrees of degradation. Persistent efforts to save the lakes has finally made a dent in the form of court interventions, directing the authorities to take appropriate measures.

Saroornagar lake in Hyderabad has all the algal types — *Cyanophyceae, Bacillariophyceae, Chlorophyceae and Euglenophyceae algae* — which indicate organic pollution in the lake. The luxuriant growth of *Microcystis aetuginosa*, *Oscillatoria limosa* (blue-green) and presence of *Nitzschia palea*, *N.obtusa*, *Synedra ulna* and *Cyclotella meneghinlana* are definite signs of the polluted nature of the lake. The absence of desmids (small microplants with a single filament-shaped cell) further indicates high levels of pollution due to the inflow of sewage into the lake.

Lakes like Saroornagar need to be approached from different levels for their remediation: imposing of legal strictures, barring of the lake waters from becoming receptacles of raw sewage, bioremediation and biomanipulation. Lake boundaries should be demarcated and green belts developed along the full reservoir level. Destruction of natural inlets should be prevented. Laying of proper sewer lines should be made a precondition for sanctioning any construction work in the catchment area of these waterbodies and idol immersion sites should be regularly desilted. There must be proper watch and ward systems to prevent solid waste and garbage dumping in the lakes. A recreational zone with garden parks and water sports can be developed. A lake protection cell to coordinate activities of various agencies involved in the protection of the waterbodies needs to be established.

Prevention of pollution from domestic sewage is another priority. A drain from Singareni colony is causing high levels of pollution at present. It should be diverted downstream immediately and all catchment colonies should be compelled to have proper sewer lines. The site of idol immersion close to a temple at the centre of the bund, should be desilted every year to maintain a proper depth of water. A boundary wall should be constructed after a proper survey to prevent further encroachment. Proper location of washing activities by constructing *dhobi ghats* (washerfolk's place) is needed to prevent water pollution.

Saroornagar is the only waterbody in the eastern zone of the city and has a great potential of becoming a recreational site. On the tank *bund* towards the Saroornagar village a stone jetty is already present which can be used for landing. Towards the Saroornagar village, a plantation exists that should be converted into a small park with modern recreational and educational facilities.

K L VYAS

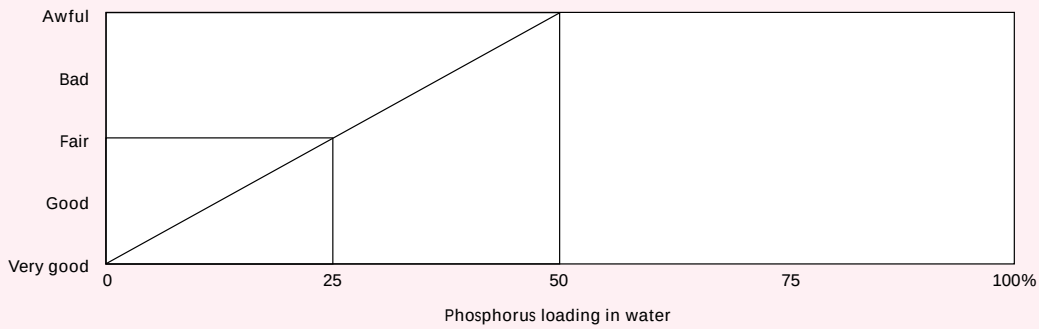
Saroornagar lake is heavily polluted. Any cleanup activity would include restricting further polluting activities

physicochemical and biological parameters, which determine the use of water for potable, non-potable, domestic, agricultural, aquacultural and industrial purposes. In urban ecosystems, the main problem is caused by nutrient enrichment from raw domestic sewage, leading to eutrophication. Eutrophication manifests itself in the form of permanent blue-green blooms, wild growth of macrophytes (plants with large leaves) such as water hyacinth, breeding of vectors such as mosquitoes and snails, generation of foul smell due to gases like hydrogen sulfide (H_2S), ammonia (NH_3) and methyl alcohol (Ch_3OH), fish / bird kills, and groundwater pollution.

Nutrients, nitrates and phosphates play a major role in degradation. On the basis of phosphate loading, W T Edmondson in 1991 classified conditions of a lake in relation to people associated with it as very good, good, fair, bad and awful *(see Fig 1: Bad loading)*. These levels indicate different amounts of phosphorus that can be assimilated by the lake's biomass. A level of 100 per cent phosphorus loading in the graph indicates that this is the maximum amount of phosphorus that the biomass can effectively assimilate. This factor is variable depending on many other parameters like diversity of biomass, flora and fauna, water quality and precipitation. Conditions of most of the waterbodies in Hyderabad can be described as something between fair and bad.

Fig 1: Bad loading

Relationship between phosphorus loading and water quality. A level of 100 per cent loading implies that this is the maximum phosphorus that aquatic biomass can assimilate



Lake restoration is possible if appropriate measures are taken, both at the administrative level as well as to clean up these polluted waterbodies. Nutrients like nitrates and phosphates can be reduced through controlled cultivation and harvesting of plant biomass or biomanipulation. Macrophytes like water hyacinth not only reduce nutrients but also remove plant pollutants like heavy metals and pesticides and act as 'depolluters.' Flotilla of such weeds or their cage culture can be developed and the weeds periodically harvested.

Biomanipulation of trophic levels (levels in the food chain) is an effective tools in lake management. Introduction of composite fish culture (where fish that feed at different layers in the water are introduced) to harvest biomass in surface, column and bottom-feeding niches can effectively reduce nutrient levels. This approach will generate income and reduce nutrient levels resulting in improvement of water quality. Such an approach will be most effective in relatively shallow waterbodies like Saroornagar lake.

A need for a clear-cut lake protection strategy as an integral component of the national water policy is required. At the state level, there should be a nodal agency to coordinate efforts of different departments involved in the implementation of wetland conservation policy. Above all, common people need to be made aware and sufficient pressure needs to be brought upon the policymakers and administrators for taking proper action to protect waterbodies. In the light of the success of 'Save the Lake Campaign' in Hyderabad undertaken to save the Saroornagar lake and its success in influencing the policy of the state government, similar action to protect urban wetlands should be taken all over the country. ■

AMIT SHANKER / CSE

Garbage: One of the many sources of pollution in Hussainsagar lake, Hyderabad

Boosting Yields in Semi-Arid Regions

Modest soil and water conservation measures can go a long way in improving crop yields and protecting against drought in semi-arid regions

R K Sivanappan
Consultant (Water Resources), Coimbatore, Tamil Nadu

If suitable soil and water conservation measures are taken up systematically on a micro or mini-watershed basis, it is possible to avoid the drought-like conditions that prevail in semi-arid regions due to the periodic failure of monsoons. These measures will also help boost agricultural yields.

The link between soil and water conservation measures cannot be ignored. While measures may be directed towards conservation of one, they will often contain an element that will conserve the other. For instance, measures that reduce runoff will also help reduce soil erosion.

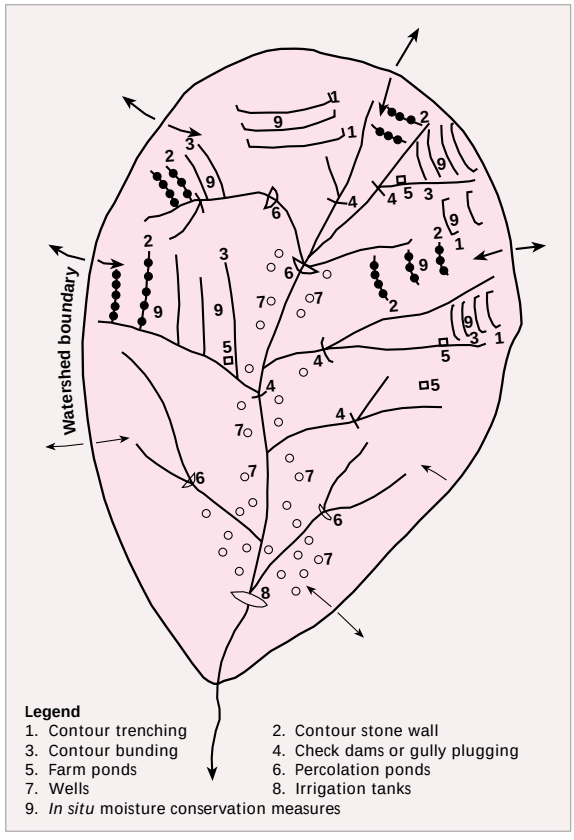
Low agricultural yield in rainfed semi-arid regions is often due to low annual average rainfall, high variability in onset and distribution, and erratic nature of the rains. In addition, often the water retention capacity of the soils is poor. In these regions it is normal for the monsoons to fail once in 3-5 years, when the rainfall is less than 50 per cent of the normal average rainfall of the region. During this period the groundwater table declines. However, by increasing water availability by soil and moisture conservation measures and by providing one or two supplemental irrigation to crops at critical stages, yields can be improved dramatically. This is possible by adopting water conservation and harvesting methods on a watershed basis. When water harvesting measures are adopted, the storage reservoir will be the soil itself, but when water is needed for supplementary irrigation or for livestock or human consumption, a storage facility will have to be constructed.

Watershed development and management is an integration of all technologies within the natural boundary of a drainage area, for optimum development of land and water and to meet the basic minimum needs of the people of the area in a sustained manner *(see Fig 1: Watershed development)*. Each watershed can thus be viewed as an independent unit. Watershed programmes, however, will only succeed if there is participation by the people directly benefiting from the entire exercise.

HARVESTING THE RAIN

Available technology of rainfall management for rainfed farming is developed through an analysis of rainfall, identification of critical irrigation periods of the crops grown, estimation and collection of excess runoff into designed tanks after taking into account various soil and

Fig 1: Watershed development
Various structures that can be constructed for watershed development



water conservation measures, *in situ* moisture conservation, and adoption of suitable irrigation systems. Rainwater harvesting systems for agriculture in the semi-arid parts of India can be classified as follows: Direct rainwater conservation; *in situ* moisture conservation; runoff collection and storage; irrigation technology for harvested water; and, increasing runoff and loss prevention.

Direct rainwater conservation

This approach uses agronomic and engineering measures that will not only harvest and conserve water, but will also prevent soil erosion. The measures include contour farming, strip cropping, farming terraces, cover crops, off-season tillage (in light and red soils), deep tillage (in hard pan areas), summer fallow, mulching (the spreading of discarded or trash vegetation to minimise splashes and other effects of rain on a bare surface) to prevent evaporation, vertical mulch, and providing vegetative barriers on the contours of the land.

Off-season tillage in light red soil helps in increasing moisture conservation and reduces weed growth. Deep tillage helps in increasing water intake in soils having textural profiles or hard pan. In black soil, vertical mulch helps in increasing yields by 50 per cent in low rainfall areas. Surface mulch in post-rainy season reduces evaporation resulting in higher crop yields. Crop residues and leaf mulch at 6-10 tonnes per hectare can be used for this.

Engineering measures should be adopted taking into account the slope, soil type, intensity and total rainfall and other localised factors. Depending upon these parameters, the measures could include contour trenching, staggered trenching, contour stone wall, temporary or permanent check dams and gully control structures.

Table 1: The impact

Impact of soil and water conservation on crop productivity in a watershed in Gujarat

Crop	Yield (tonnes/ha) before treatment	Yield (tonnes/ha) after treatment	Percentage increase
***Kharif* crops**			
Groundnut	0.6	1.64	173
Cotton	0.8	1.44	80
Bajra	0.7	1.49	120
Pulse	0.45	0.6	33
Castor	0.7	1.4	100
Jowar	0.6	0.8	33
***Rabi* crops**			
Wheat	1.6	3.2	100
Gram	0.7	1.4	100

Note: *ha: hectares*

Source: I A Mehta, 1991, Integrated National Watershed Development, *Journal of Soil and Water Conservation*, Sangani, Gujarat, Vol. 35, No. 1 and 2, p. 74-79

Table 2: Realising the potential

Impact of soil and water conservation on irrigation potential in a watershed in Gujarat

Particulars	Before commencement of the project	After completion of the project
Irrigated area	7 hectares	48 hectares
Number of wells	6	19
Depth of water table	20 metres	10 metres

Source: I A Mehta, 1991, Integrated National Watershed Development, *Journal of Soil and Water Conservation*, Sangani, Gujarat, Vol. 35, No. 1 and 2, p. 74-79

Soil and water conservation methods had a good impact on crop productivity in a watershed in Gujarat, with an average rainfall of 583 millimetres *(see Table 1: The impact* and *Table 2: Realising the potential)***.** The measures included construction of check dams, diversion channels, contour bunding, land smoothening and *in situ* moisture conservation.

In situ moisture conservation

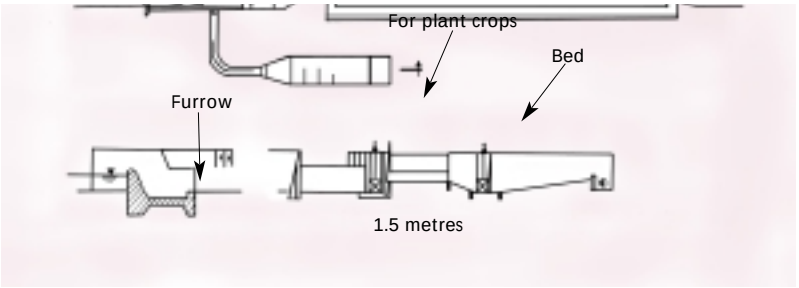
In most of the semi-arid regions, rainfall is erratic and falls within a short time-span. The moisture may not be available to the crop when it is critical for its growth. *In situ* moisture conservation can help in retaining soil moisture regimes for a longer duration. The measures are location-specific. These include forming dead furrow ridging, graded furrows, broad bed and furrows (in black soil), tied ridging, water spreading and compartmental bunding. For tree crops, microcatchments, saucer basins, crescent bundings, semi-circular *bunds* and catch pits can be introduced.

Before *in situ* moisture conservation measures are undertaken, it is important to create vegetative barriers or *bunds* followed by cultivation and plantation on the contours. Typical *in situ* moisture conservation measures are indicated in *Figure 2: Water for plants and trees* and *Figure 3: Capturing water.*

Water harvesting

For dryland agriculture water harvesting implies the collection of excess runoff in a storage tank and using it for agricultural purposes. These tanks can be either farm ponds, percolation ponds or silt detention tanks. The water collected in a farm pond is directly used for protective irrigation. The water stored in the other two structures will be used for recharging the groundwater and for protective or supplementary irrigation by providing open wells or tubewells. The capacity of the farm

Fig 2: Water for plants and trees
In situ water conservation techniques for plants and tree crops



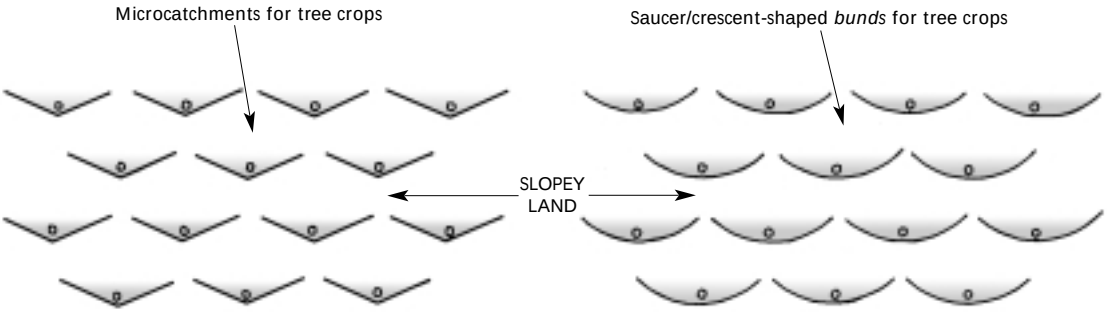
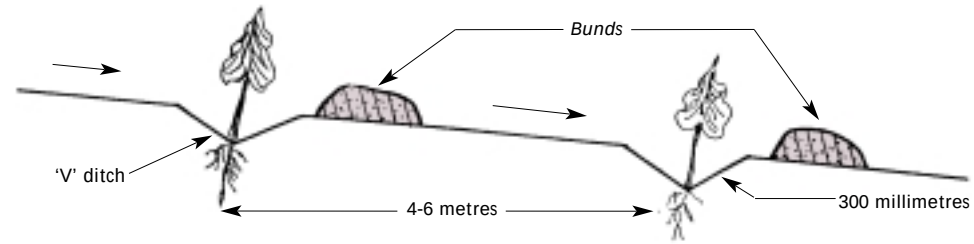


Fig 3: Capturing water
'V' ditch technology



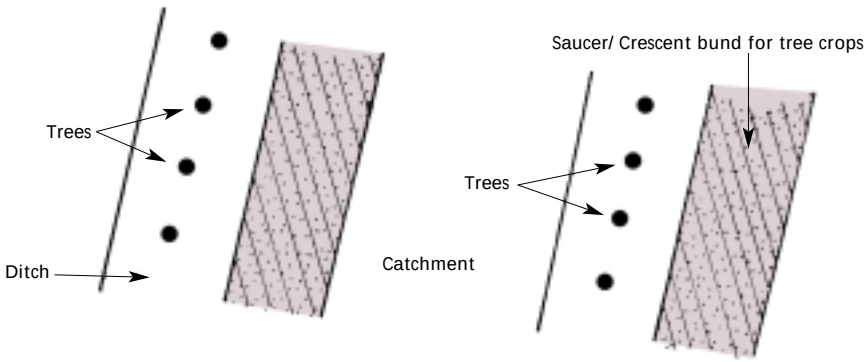
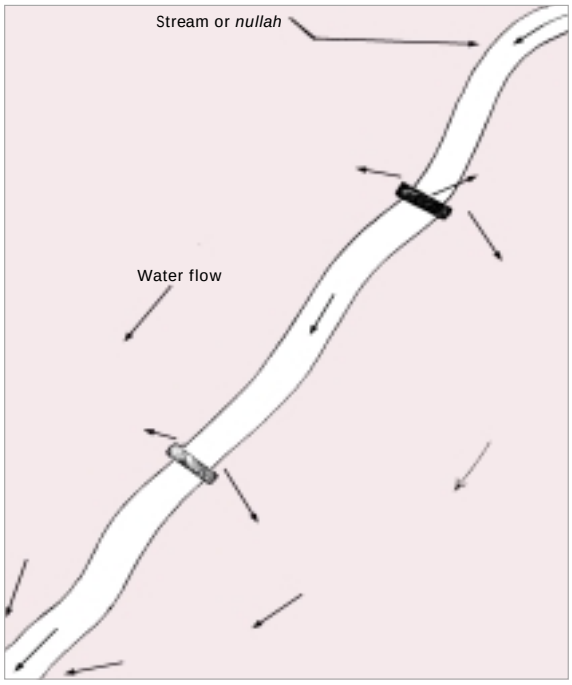


Fig 4: Stopping streamflow
Water spreading by stream diversion



pond or percolation pond is decided by the rainfall, soil, slope, terrain condition and other factors.

Another method of water harvesting is stream diversion *(see Fig 4: Stopping streamflow)*. Short duration, intense storms often produce high runoff that swiftly drain through gullies and creeks, creating floods downstream. This water can be diverted from its natural course and spread over the cultivated area.

Irrigation technology for harvested water

It is important that one or two light irrigation episodes are provided to crops at critical stages of their growth, when the plants are experiencing water stress. The effects of this irrigation are dramatic: when water is supplied at the critical stage, not only is the crop saved from wilting, but the yields also increase *(see Table 3* and *4: Critical irrigation)***.** If soil and water conservation measures are undertaken on a watershed basis, it is possible to make such irrigation a reality in semi-arid regions. The water that will be made available through farm ponds and wells can be used to irrigate crops. These methods include furrow irrigation by surface methods, pair row and skip row irrigation, overhead sprinkler method, pitcher method or porous cup method, and drip irrigation or micro-irrigation methods.

Since water is given only once or twice, the investment cost is generally prohibitive for small and marginal

Table 3: Critical irrigation
Effect of one supplemental irrigation of 50 millimetres on the yield of rainfed crops

Crop	Station	No of trials	Yield (tonnes/hectare) without irrigation	Yield (tonnes/hectare) with irrigation	Percentage increase
Wheat	Dehradun	4	2.14	3.55	65
Wheat	Jodhpur	4	1.98	3.60	81
Wheat	Ludhiana	4	1.92	4.11	114
Wheat	Agra	2	2.19	2.74	25
Wheat	Rewa	4	0.57	1.88	229
Barley	Varanasi	2	2.6	3.36	29
Barley	Ranchi	–	0.55	1.17	112
Sorghum	Bijapur	5	1.65	2.36	43
Sorghum	Bellary	4	0.43	1.37	218
Sorghum	Solapur	5	0.98	1.82	85
Sorghum	Hyderabad	2	1.39	1.92	38
Sorghum	Kovilpatti	3	2.78	2.89	3
Upland rice	Rewa	4	1.62	2.78	71
Bidi tobacco	Anand	4	1.21	1.81	49
Finger millet	Bangalore	–	1.62	2.32	43
Pearl millet	Jodhpur	4	1.66	1.90	14
Pigeonpea	Jhansi	–	0.05	0.33	560
Sunflower	Bellary	–	0.13	0.29	123
Rape seed	Ranchi	–	0.25	0.54	116
Chilli	Bangalore	–	0.21	0.45	114
Bidi tobacco	Vasad	2	1.46	1.75	19
Safflower	Vasad	1	1.56	2.02	29
Mustard	Vasad	1	1.65	2.04	23
Gram	Vasad	1	1.08	1.63	50
Cowpea	Vasad	1	2.04	2.08	1

Source: R P Singh 1983, Farm pond project, All India Coordinated Research Project (AICRP) for Dryland Agriculture, *Bulletin No 6*, Hyderabad

Table 4: Critical irrigation
Effect of critical irrigation on crop yield in India

Region	Crop	Seasons averaged	Yield (tonnes/ha) without irrigation	Yield (tonnes/ha) with irrigation of 50 mm	Percentage increase
Anand	*Bidi* tobacco	4	1.21	1.81	50
Agra	Wheat	2	2.19	2.74	25
Bangalore	*Ragi*	5	1.13	2.92	158
Bangalore	Maize	4	5.4	9.69	80
Bangalore	Cowpea	6	0.24	0.64	166
Bellary	Sorghum	5	0.43	1.37	218
Bijapur	Sorghum	5	1.65	2.36	43
Dehradun	Wheat	4	2.14	3.55	65
Ludhiana	Wheat	4	1.92	4.11	114
Rewa	Upland rice	4	1.62	2.78	71
Rewa	Wheat	5	0.57	1.88	229
Solapur	Sorghum	5	0.98	1.82	85
Varanasi	Barley	2	2.6	3.36	30

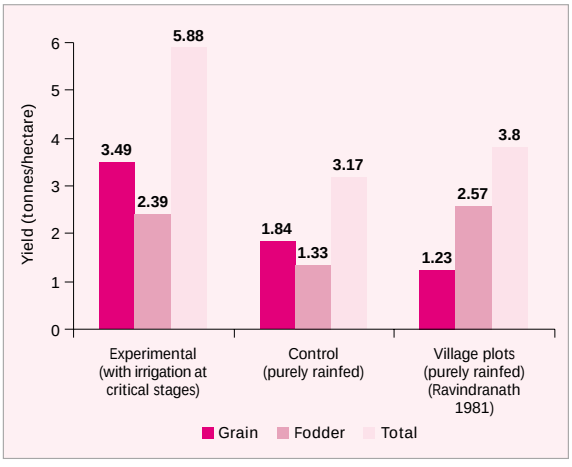
Source: Annual Reports of All India Coordinated Research Projects for Dryland Agriculture, 1985

farmers, which is why the technology has not reached the fields.

A study in Karnataka assessed the feasibility of farm ponds as a source of protective irrigation at critical stages of growth. A pond was built in the middle of the study area where finger millet was grown. The upper portion served as the catchment and the lower portion as cropped land. Five critical phases were recognised and water supplied in three of them using an indigenous human-powered lifting device to lift the water. The grain yield in the experimental fields was 90 per cent higher than the control where no such water was supplied. In addition, straw yields increased by 80 per cent *(see Fig 5: Critical irrigation)*.

This concept is certainly worth emulating. Even though some part of the farm land may be lost due to the farm pond, the yields more than compensate this loss. The net benefit obtained in a near normal rainfall year is substantial, and in severe drought years, this measure could make an enormous difference.

Fig 5: Critical irrigation
Increase in yield of *Ragi* (Grain+ Fodder) with critical irrigation



Source: Ravindranath 1981, quoted in Ramaprasad 1985, Farm ponds for rainfed agriculture, V World Congress on Water Resources, Brussels, Belgium, *mimeo*

Increasing runoff and loss prevention

Modifications to induce runoff include land alteration, soil compaction, and use of soil deflocculant additives. Percolation losses and seepage can be controlled by reducing the wet area, self-sealing by silting, compaction, natural clay soil lining, bentonite lining, alkali soil lining, soil cement lining, and lining with polythene sheets.

POLICY IMPLICATIONS

In spite of the urgent need to undertake water harvesting in semi-arid and arid regions, efforts are unfortunately meagre. Between Rs 7,500 and Rs 10,000 per hectare is all that is required. Government agencies and donors are willing to spend much more for large irrigation projects, but not on these. Even states short of water do not enhance allocation for dryland development.

With soil and water conservation programmes there are certain issues that need to be kept in mind. These include the treatment of the catchment area of the proposed water harvesting structure, efficient water application methods, the riparian rights of the people downstream, and ensuring that hydroelectric reservoirs remain unaffected. Soil and water conservation are intimately linked. Often technologies applied to conserve both have failed. Technologies must be adopted after an assessment of local conditions and with people's involvement.

There is also a need to develop a reliable database of short and long term impacts of *in situ* rainfall and moisture conservation methods for improving replicability. ■

When Traditions and Science Meet

The link between traditions and modern science cannot be ignored. Traditional water harvesting systems can be used to deal with contemporary water problems. With technological inputs, these age-old systems can become more efficient

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The problem of scarcity of drinking water during summer months is faced not only in the Thar desert where rainfall is scanty, but also in high rainfall places like Cherrapunji. In addition to lack of availability of water, there are problems with quality. For example, excess of fluoride, arsenic, iron and total dissolved solids in groundwater is widespread throughout the country.

Several options are available to augment water supply through the use of rainfall. These options depend upon the level and nature of rainfall as well as the kind of problems that need to be addressed *(see Table 1: Providing water)*. For instance, the scarcity problem in high rainfall areas can be mitigated through *in situ* water harvesting for community supply and through augmentation of spring discharge. In the medium rainfall — 500-1,000 millimetres (mm) region of the peninsula — artificial recharge can be used for overcoming the shortfall in summer months. In low rainfall areas (Thar desert, for instance), methods of catchment treatment for increasing the inflow to *nadis* (small depressions resembling ponds), *tankas* (covered underground sumps), *kundis* (traditional tanks in Rajasthan, where the tanks are covered on the top and the surrounding catchment is given an inward slope for water to flow into the tank) and *johads* (basin bounded on three sides by natural hills and an artificial dyke on another side to store the monsoon runoff), need to be adopted. Redesigning of water harvesting structures to reduce evaporation losses is also possible.

The problem of excess fluoride or arsenic in groundwater can be tackled through artificial recharge, which, besides augmentation of groundwater, also reduces concentration of these substances through dilution.

Table 1: Providing water
Methodologies for sustainable drinking water supply

Area	Problem	Remedial methodology
Low rainfall (less than 400 mm)	Inherent scarcity	Enhancement of runoff as in Churu district in Rajasthan
Medium rainfall (500 mm to 1,000 mm)	Overexploitation (lowering of water table)	Artificial recharge and recovery using the same borehole as in Nagpur district of Maharashtra
High rainfall (greater than 1,000 mm)	Hilly terrain, quick runoff	*In situ* water harvesting as in Ratnagiri in Maharashtra and Cherrapunji in Meghalaya
Saline aquifers: Coastal regions (Tracts of Gujarat, Haryana and Rajasthan)	Incursion of saline water in freshwater	Installation of salinity control devices on wells as in Nellore district of Andhra Pradesh
Fluorosis–affected areas of Andhra Pradesh, Gujarat, Karnataka, Tamil Nadu and others	Fluoride content of aquifer above permissible limit	Artificial recharge and recovery of surface water using same well as in Nalgonda district of Andhra Pradesh
Six districts of West Bengal	Arsenic in groundwater	Artificial recharge through village ponds (*pukurs*), construction of dugwells
Andhra Pradesh, Maharashtra, Orissa, Tamil Nadu and others	Excess iron in drinking water	Use dugwells instead of borewells as in Koraput district of Orissa

Note: *mm: millimetres*

SALINITY CONTROL

A simple system detects salt beyond permissible limits and issues a warning

Many coastal areas in India face the problem of salinity intrusion, particularly the coasts of Saurashtra peninsula of Gujarat. In Saurashtra, for instance, an individual pumping freshwater floating above brackish or saline water has no means of knowing the optimal rate of pumping to avoid the incursion of saline water into the well. A salinity control device developed by the National Geophysical Research Institute, Hyderabad, can be used in such a situation to prevent inadvertent contamination of a well. The device continuously monitors the conductivity of water discharged by a well and has a provision for presetting the conductivity value to a desired level. If the conductivity is set at, say, 1,500 mhos, whenever the water coming into the well crosses this value, the device has a relay system for tripping the power supply and stopping the pump. These devices can be installed in wells in areas vulnerable to salinity intrusion to prevent overextraction and to monitor ingress of saline water.

Arsenic and iron-free drinking water can be obtained by reverting back to the traditional open well system from the present tubewell culture. The open well can be easily made hygienic with protective measures. Ingress of saline water in freshwater wells can be monitored and controlled by using a salinity-sensing device *(see Box: Salinity control).*

ARTIFICIAL RECHARGE

Artificial recharge (AR) is the transfer of seasonally surplus surface water to aquifers. Natural replenishment or recharge of groundwater through infiltration, measured at several locations in the country, amounts to 8-15 per cent of the local precipitation.

There are several reasons why this natural recharge needs to be augmented with artificial recharge:

- Given the seasonal character of the rainfall in India, there is surplus surface water during the monsoon season, even in a low rainfall area. This surplus water needs to be saved from becoming runoff to the sea and from evaporation losses, by transferring it underground through AR.
- About 80 per cent of the area of India (approximately 260 million hectares) is located in the semi-arid tropical (SAT) belt. Groundwater is an important source of drinking water and irrigation in this area. The SAT climate is characterised by seasonal (monsoon) rainfall and by high rates of potential evaporation (2,000 mm to 3,500 mm per year) from surface storage structures. A considerable fraction of the rainfall leaves the area as runoff. The area is mostly covered by hard rocks, such as granites and basalts, having low permeability and this means that only a small percentage (8-10 per cent) of the rainfall percolates down annually to replenish aquifers. Water scarcity and poor quality are the most crucial constraints in the development of the SAT area.
- Over the last few years, groundwater extraction has increased several-fold, with the result that withdrawal far exceeds recharge. This means a depletion of the aquifers.
- Overextraction has resulted in the lowering of the water table and deterioration of quality. In the low rainfall zone (less than 400 mm/year), the well waters generally have high conductivity and fluoride concentration above the permissible limit. Open dugwells or handpumps used for drinking water dry up in summer. In many thousand villages, water is supplied through tankers.

AR changes the share of various hydrological parameters of the water balance of a region by increasing the quantum of water added to groundwater and reducing evaporation and the quantum of seasonal runoff. AR can be implemented through construction of percolation tanks (spreading method) or through injection of filtered and chlorinated water in dugwells or borewells.

AR can also be used for improving the quality of water in terms of salinity and concentration of hazardous radicals such as fluoride and arsenic. It can be undertaken through several measures such as contour bunding, farm bunds, gully plugging, *nullah* bunding and anicuts.

There are several indicators of successful AR intervention in a village. These include rise in average water table level, availability of well water year round, proximity of drinking water sources to the women fetching it, increase in the total cropped area and yield per hectare, double cropping, and reduction in incidence of fluorosis and brackishness.

In India, several state governments have constructed thousands of percolation ponds for augmenting the groundwater resources in the command areas. The design of these percolation ponds is similar to minor irrigation tanks but without a sluice. The success of these efforts is unfortunately low. Rarely is sitting of these ponds done after hydrogeological investigations, neither are these ponds maintained. Silt accumulation thus makes them inefficient over time. In some cases, although a percolation tank is constructed, the command area may not have any wells.

For achieving a measure of success, it is necessary, therefore, to conduct water balance studies on representative percolation ponds to calculate the percentage of the total stored water which can contribute to the groundwater. At present, only qualitative indicators of

the effect of the percolation pond in terms of increase in crop yield per hectare or increase in the area under cultivation or groundwater irrigation in the command area are available.

MODERNISING TRADITIONAL WATER HARVESTING SYSTEMS

Several case studies indicate the need for scientific research as well as inputs into making traditional water harvesting systems more effective and responsive to present needs. These case studies also indicate the potential of these systems in dealing with present day water-related problems

CASE STUDY I: Upgrading catchments

The efficiency of runoff available from catchments of *kundis* in Rajasthan can be improved by lining these with water-repelling polymers, leading to more efficient water harvesting systems. Experiments undertaken by the Hyderabad-based National Geophysical Research Institute and Indian Institute of Chemical Technology and the Churu-based Bhoruka Charitable Trust, a non-governmental organisation, indicate that the efficiency of collection can increase dramatically. The results of field experiments conducted on several sites during the monsoons of 1997 and 1998 indicate a runoff varying between 40-80 per cent on treated surfaces as compared to between 1-3 per cent on untreated surfaces.

The region: Low seasonal rainfall, deep and brackish groundwater and extreme climatic conditions cause scarcity of potable water in most parts of the Thar desert in Rajasthan.

The average annual rainfall in the Thar desert varies from 400 mm in the east to less than 200 mm on the western international border. The mean average temperature is high and potential evaporation is as high as 2,500 mm to 3,500 mm per year. The monsoon period is characterised by a few rainy days, and the total precipitation is far less than the evaporation demand.

The availability and distribution of surface water in the Thar desert can be broadly classified by rainfall distribution, geomorphology and import of water from outside. Based on hydrological aspects, the area can be broadly classified into three zones:

- Regions with major surface water supply through the Indira Gandhi Canal (Ganganagar district and the western part of Bikaner and Jaisalmer district);
- regions with primitive or no stream network (areas of Jhunjhunu, Churu, Sikar, Nagaur, Jodhpur, Barmer and Jaisalmer districts); and,
- regions with integrated stream network in the Luni basin, comprising areas in the districts of Jodhpur, Pali, Jalore and Barmer.

The areas occupied by these three hydrological zones are 15 per cent, 52 per cent and 33 per cent, respectively, of the total area.

The water source: The main source of drinking water in areas such as Churu district is the monsoon runoff, collected in traditional water harvesting structures like *kundis*, *tankas*, *johads* and *nadis*. Runoff from high intensity storms is collected in these structures. Unfortunately, the precipitation comes in the form of a few intense thunderstorms. The total number of rainy days varies between 10-15 days, with rainy events being separated by several days. The ambient temperature between these spells is high. This results in a high threshold for initiation of runoff, as most of the rainfall is absorbed by the sandy soil, and a return of the infiltrated moisture from the soil to the atmosphere through evaporation during a dry spell.

Runoff collection in these structures is, therefore, poor due to the high permeability of sandy soils. Tracer experiments in the dune area of the desert indicated that about 70 per cent of the infiltrated rainwater returns to the atmosphere through soil evaporation, amounting to poor replenishment of the aquifer. Due to this the amount of water that can be stored is inadequate to meet minimum domestic requirements even in a normal monsoon year.

Traditionally, the surfaces of the catchment areas of these structures are made more permeable by using *surakhi* (brick fragments and powder) and *kankar* (lime).

Maximising traditional technologies: In order to improve the runoff from catchments, a field study was made. The objectives of the study were to identify suitable non-toxic polymers that could be spread onto the catchment surface to enhance runoff. One main characteristic of this polymer was its hydrophobicity (ability to repel water) in order to prevent permeability and enhance runoff.

After laboratory tests, several polymers were identified for testing in field trials in existing and newly constructed *kundis* in Rajgarh tehsil of Churu district in Rajasthan *(see Box: Polymer particulars).* The results are indicated in *Table 2: Catching more water* for the average runoff generated at treated sites during the 1997 and 1998 monsoons.

The cost of the polymer treatment was 25 per cent of the cost of the traditional method of preparing the catchment surface using lime, *surakhi*, bricks and cement. The technology has proved to be socially acceptable and the people are already drinking water from these *kundis.*

POLYMER PARTICULARS

Polymers come to the aid of enhancing runoff in catchment areas

To improve the runoff that can be effectively captured and stored from catchments, polymer science may offer a solution. The process involves spraying a polymer liquid, one that is hydrophobic (which does not hold water) and combined with a binder, on to the catchment surface to reduce the permeability, and consequently the infiltration rate of the sandy soil. This in turn increases the runoff over the chemically treated surface.

The chemical selected for the purpose should have the following characteristics:

- The material should be non-toxic;
- It should work as soil and sand stabiliser or binder;
- The treated surface should have water-repellant properties;
- the chemically treated surface should last for a few years in the inhospitable weather conditions of the Thar;
- the capital and recurring costs should be less than the costs involved in providing water by tankers, a piped water supply system or the installation and operation of a desalination plant;and,
- the methodology should be simple and easy to adopt.

These experiments, thus, indicate that catchment treatment technology using non-toxic polymer solution for enhancing runoff to water harvesting structures is technically feasible, economically viable and socially acceptable. More research is, however, required to improve the durability of the surface. This technology can be extended to areas having very low rainfall and in areas having excess salinity or flouride in groundwater, for the provision of safe drinking water.

CASE STUDY II: The Cherrapunji challenge

Cherrapunji in Meghalaya is faced with two distinctions, one of them dubious: it has the highest average annual rainfall in the world, a whopping 11,000 mm, and it faces drinking water scarcity for six months in a year.

The drinking water shortage is because of the seasonal nature of precipitation, heavy runoff and the lack of systems to store the rainwater. Based on meteorological, hydrogeological and geomorphological studies, four options for augmenting the water supply can be explored. These are: *in situ* water harvesting, gully plugging, open wells and augmentation of spring discharge.

The region: Cherrapunji town is located at an altitude of about 1,310 metres (m) in East Khasi Hills district, near the southern boundary of the state of Meghalaya. The traditional source of water supply to the township is through springs. The township is faced with an inadequate drinking water supply during the non-monsoon months. This situation appears to be *prima facie* paradoxical as it hints at scarcity in the midst of superabundance of precipitation.

The town is spread over three different altitude levels which are locally referred to as lower, middle and upper Cherra. The estimated total population is around 15,000. The public health engineering department (PHED) is tapping existing spring sources for water supply, some of which are located 8-10 kilometres away. The Mawamluh Cherra Cement Factory has a similar but separate arrangement to meet the water needs of the factory and the employees' colony. The Ramakrishna Mission Ashram authorities have made improvised arrangements for water storage for their own use.

Table 2: Catching more water

Runoff enhancement with polymer treatment in experimental catchment sites of *kundis* in Churu district, Rajasthan during the 1997 and 1998 monsoons

Site	Treatment	Observation period	Total rainfall (millimetres)	Total runoff (millimetres)	Average runoff (per cent)
Bhoruka Charitable Trust	March 1997	1997 monsoon 1998 monsoon	295.1 166.0	215.8 128.0	73 78
Gwalisor	March 1997	1997 monsoon 1998 monsoon	158.4 256.4	130.1 102.5	82 40*
Kyali	March 1997	1997 monsoon	276.0	113.8	41
Chalinabas	May 1998	1998 monsoon	221.6	117.3	53

Note: **The sharp decline in the runoff generated between the two successive years was due to spoiling of the surface by vandals and possible degradation of the hydrophobic properties of the polymer coat.*

Source: Anon 1998, Enhancement of runoff in traditional water harvesting structures in Thar desert by treating the sandy soil of catchment areas with water-based non-toxic polymer formulations, Terminal report for the project submitted to the Rajiv Gandhi Drinking Water Mission by the National Geophysical Research Institute, Hyderabad, *mimeo*

ANIL AGARWAL / CSE

Plenty amidst scarcity: water runoff in Cherrapunji

The problem: The problem of inadequacy of drinking water supply is mainly due to seasonal nature of the rainfall and the quick runoff. There are hardly any natural situations for depression storage or interception of drainage. The inadequacy is also partly due to social reasons. The local community prefers spring water supply over any other source. The population and the per capita consumption have increased and are expected to increase further. It is obvious that reorientation in the existing social thinking is required in order to augment the water supply through use of alternative sources.

Possible options for augmenting the water supply: One of the options that can be explored in the region is *in situ* water harvesting The distinguishing feature of the rainfall at Cherrapunji or elsewhere in southern Meghalaya is its superabundance and its seasonal nature. In such a situation, there is no need of the traditional approach of collection from a donor catchment and storage in a recipient area. The rainfall can be directly stored in a receptacle of appropriate size and distributed through the existing drinking water supply system. The advantage of such an approach is that the source can be created wherever required and need not be tapped from wherever it is naturally available.

The rooftop water harvesting system, as practiced by the public health engineering department (PHED) of Meghalaya, comprises the collection of rainwater from house rooftops through gutters, filtration and subsequent storage in a reservoir above the ground surface with an average capacity of seven cubic metres (cum). These systems are designed to supply 10 litres per capita per day (1pcd) for 90 days, considered inadequate by the local population. The lifespan of these structures is about 15 years. With the cost working out to be about Rs 1,400/cum, this is expensive.

Pits of size 10 m X 10 m X 10 m can be constructed at elevated sites close to a cluster of 10-12 houses. The cost of such a pit, with concrete lining, reinforced concrete roofing with inlet holes, distribution pipelines, two transient storage galvanised iron tanks, etc., based on the 1990-91 rate schedule of PHED works out much cheaper than the system developed by the PHED. In addition, such *in situ* systems are able to supply water at a modest rate of 40 lpcd to an estimated population of 60 persons living in a cluster of 10-12 houses throughout the year, provided that the water is rationed on a daily basis. This water supply will be by gravity flow, as is the case with water supply from springs. The dissolved solids and the iron content will be less than the permissible limits. The water may require chlorination for treatment of organic contamination, but this is also the case with the water supplied by the PHED. The possibility of open cast limestone mines to be adapted for water storage can also be explored.

CASE STUDY III: The Saurashtra Saga

Rather than write off a spontaneous people's movement of water recharging, which may have technical flaws, it is possible, with some technical modifications, to ensure against possible long-term repercussions.

The region: The Saurashtra peninsula in western Gujarat lies in the semi-arid tropical belt. The rainfall is seasonal and averages between 500-600 mm annually. Potential evaporation is between 2,500-3,500 mm. Topographically, it is a plateau drained by several ephemeral (temporary) streams having steep gradients. The surface rock in most of the peninsula is basalt (Deccan Trap). The vertisol (black cotton soil) derived from this basalt rock is good for agriculture. In the southern coastal area, a 10-15 kilometre wide strip is covered by younger age rocks which are mostly limestones and sandstones. The region has three water-related problems:

- Scarcity of drinking water during summer months, which is prevalent throughout the region;
- excess fluoride in groundwater, specially in areas in Amreli district; and,

- excess of total dissolved solids (TDS), mainly in coastal area aquifers, due to overexploitation of near-surface freshwater aquifers, leading to incursion of seawater.

The main crops are groundnut, cotton and pigeonpea. Agriculture is the main occupation and water scarcity is the main preoccupation of the villagers. They have, therefore, practiced artificial recharge during the last few years in an innovative and intuitive way without any scientific background. The people's efforts at water conservation and harvesting (mainly artificial recharge) are inspired and guided by voluntary agencies such as Swadhyaya and the Saurashtra Lok Manch. Over a period of only three years, these organisations have constructed more than 800 percolation tanks and artificially recharged 100,000 wells.

Successful direct artificial recharge: Augmentation of groundwater through artificial injection of surface water through boreholes and tubewells is an established technology practiced in many developed countries on a regular basis. Successful borewell injection is possible if the following problems are taken off:

- Air entrapment;
- clogging of the pores in the well wall because of suspended material in the recharged water;
- chemical compatibility of surface and groundwater

EKLAVYA PRASAD / CSE

Well recharge efforts of Swadhyaya Parivar in Gujarat: While direct recharge of wells may cause siltation (above picture), indirect recharge (picture below) takes care of this problem

— in certain situations, the chemical incompatibility between surface and groundwater results in precipitation of dissolved solids and clogging of wells; and,
- bacterial contamination since the bacteria in surface water can multiply underground and block the passages.

Need for scientific input: In most of the cases, the farm runoff water was directly being led to discharge in open wells through plastic pipes**.** The villagers of the Saurashtra region were not aware of the problems associated with direct recharge into wells through plastic pipes. Although some attempt at removing the silt by collecting the water in a pit is made, this is not adequate. Fine silt and colloidal matter enters the well and will clog the pores in the walls of the well. Organic matter may also give rise to growth of bacteria, which may eventually affect the intake as well as output of the wells. Organic matter, pesticide residues and dissolved fertilisers are also a potential source of contamination. Direct recharge can, therefore, have long-term hazardous consequences.

It is possible to avoid these consequences by improving the present technique being practised by farmers, without reducing the tempo of this useful and rewarding activity. The basic principle behind the modifications is to practice indirect recharge instead of direct recharge. This is possible by adopting the following measures.

For well recharge, a farm pond can be constructed at a distance of 1-2 metres from the open well or borewell. The farm pond can be rectangular (say 10 m x 6 m x 3 m) or in a horseshoe-shape, encircling the well, or in any irregular shape. A layer of pebbles, followed by a layer of coarse gravel, may be laid at the bottom of the pond. Connecting the pond to the well through a sub-surface pipe is not recommended. The water collected in the pond will reach the well as seepage after filtration. Most of the pathogens will also be removed in the process of transfer of water through the process of percolation through overburden and weathered rock. The size of the pond is decided by the catchment area and can be enlarged, if necessary. The pebble and gravel material should be washed or replaced and the bottom of the pond scraped at the end of each monsoon.

Since most of the open wells or borewells serve as dual purpose wells, that is, these can be used for recharging as well as for withdrawal of water, when new wells are constructed, certain modifications can be made. In the case of open wells lined with masonry or bricks, a few 'weep holes' can be left in each layer of lining below a depth of three metres. This means leaving an occasional gap of brick or stone size at each level. Such an arrangement will facilitate the entry of water percolating downward from a farm pond. Similarly, in the case of a borewell, a slotted casing may be used in place of the solid wall casing that is currently put to prevent collapse of the well.

After each major rainfall event and, therefore, each recharge event, the pump can be operated for 10-15 minutes to flush out any colloidal particles which might have still entered the well. Such a pumping for back-flushing or any regular pumping for irrigation will create a hydraulic gradient towards the well and this will induce infiltration from the pond.

The water accumulated in the farm pond can be directly lifted and used for life-saving irrigation in a mid-season drought situation.

CASE STUDY IV: Arsenic relief

A return to traditional water harvesting systems may provide relief to contemporary water problems like arsenic and flouride in groundwater. Construction of sanitary dugwells in the arsenic-affected region can offer a low cost option that can be adopted, operated and maintained by communities themselves.

The problem: In the early 1980s, cases of arsenical dermatitis were reported from some districts of West Bengal. Through analysis of water samples it was found that the groundwater was contaminated with arsenic, well beyond the permissible limit of 0.05 milligrammes per litre. In West Bengal, 1312 *mouzas (*revenue villages) and 15 non-municipal/outer growths in 65 blocks and nine municipalities within eight districts are now affected. These affected districts are Malda, Murshidabad, Burdwan, Hooghly, Nadia, 24 Parganas North, 24 Parganas South and Howrah.

A total population of 5.36 million in these districts has been identified as exposed to arsenic through groundwater that is being used for drinking. This accounts for about 7.87 per cent of the state's population. Due to continuous movement of groundwater and peculiar geochemical conditions, the extent of the problem may increase with the passage of time.

Symptoms of arsenic poisoning include dispigmentation in the entire body, boils on the limbs, keratosis (which looks like callused skin protrusions on palms and soles), burning sensation through the body**,** disharmony in family relations, and social ostracism of the distressed population.

Current methods of dearsenification: Current methods to deal with this problem focus around dearsenification of the pumped water. This, however, is not the only solution to the problem. It is vital to explore all available options. There are several options based on traditional water harvesting systems that are available. These include:
- Rooftop water harvesting and storage or artificial

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Result of consuming arsenic-laced groundwater: a victim from West Bengal

recharge through a filter pit adjacent to handpumps in a school building, *panchayat* office, etc.,

- conversion of commonly occurring *pukurs* (village ponds) into infiltration basins and installation of a handpump or shallow tubewell nearby; and,
- construction of a hygienic open well to tap the phreatic (unconfined) aquifer. Arsenic levels in this groundwater will generally be below the permissible limit.

In places where the roof material is made of biological material, rooftop water harvesting may not be feasible unless the roof material is replaced.

The logic behind the construction of dugwells is simple. Arsenic beyond permissible limits (0.05 mg/l) is found in the water from deep tubewells at depths below 25-30 m or more. On the other hand, it is generally within the safe limit in the phreatic or unconfined aquifers, which are at higher levels. It is this fact that can be tapped to avail arsenic-free water. Even if water at this level has arsenic above the permissible limit, this will be oxidised and coprecipitated with iron when exposed to aeration in an open well. Such a process will not take place in a tubewell fitted with a handpump or an electric pump since this water will not be exposed to aeration. Periodic water analysis for arsenic content is, however, necessary.

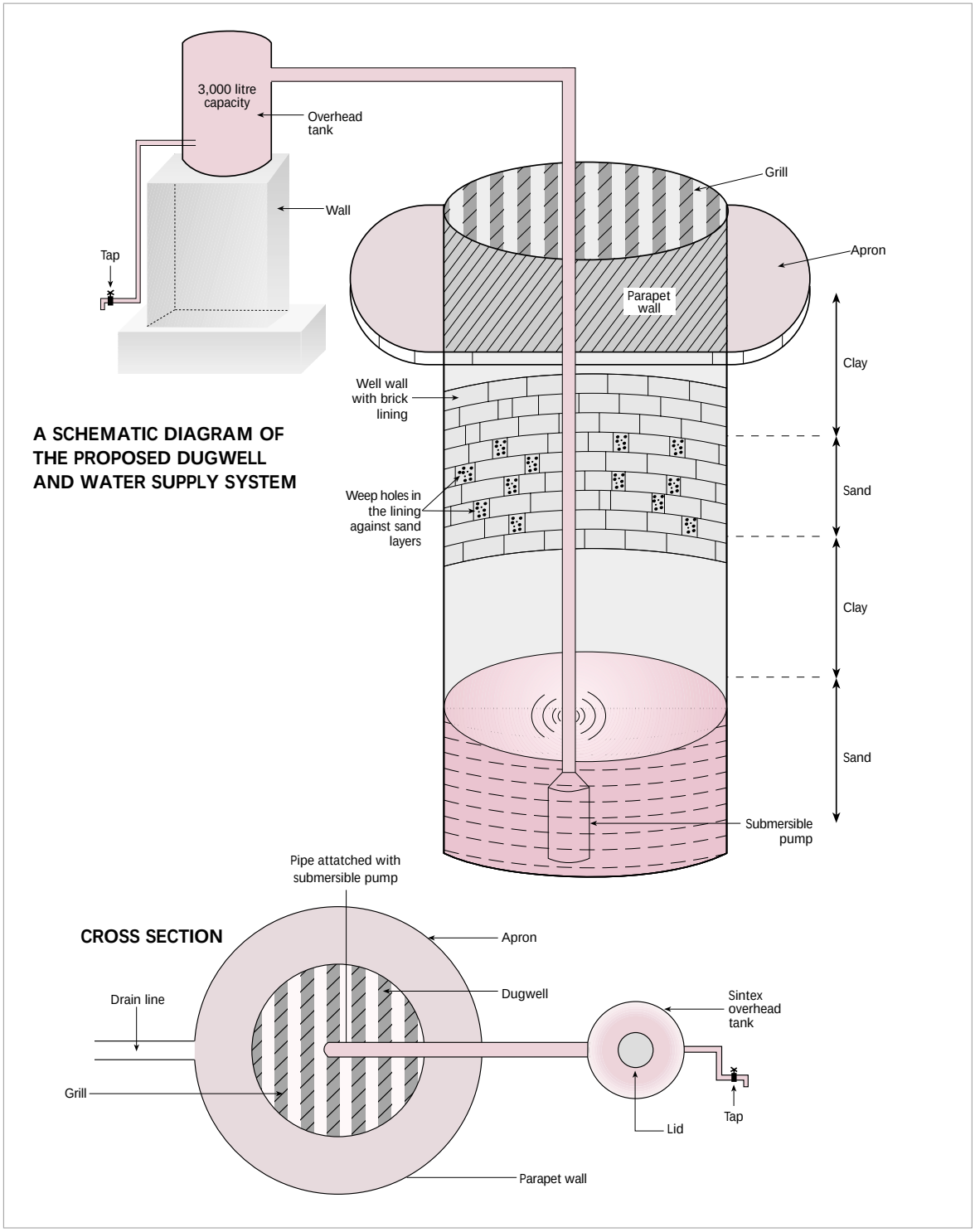
Resistance to the use of water from dugwells stems from the fact that often these might have bacteriological contamination. Removal of bacteriological contamination is much easier than removal of arsenic from water. The contamination can be easily avoided by the construction of parapet wall and a circular cement path around the well. A brick lining of the clay portion of the excavated well will prevent collapse. The dugwell water will be exposed to aeration while a tubewell up to the same depth will not have this advantage. An iron grill can be fixed on the dugwell to prevent direct withdrawal of water through dipping of pots and buckets, which can lead to contamination. Apart from constructing adequate structures, the water could be chlorinated before consumption, if necessary *(see Fig 1: Simple and clean)*.

To maintain the water quality in the dugwell, the following steps can also be adopted:

- No one should be allowed to draw water directly from the well;
- water pump would be installed along with a pipe, which would be connected to a tank. The tank can have a tap through which people can take water;
- to prevent seasonal runoff from entering the well, a

Fig 1: Simple and clean

A simple sanitary dugwell that keeps the water free from bacterial contamination can be used as an arsenic-free source of water in West Bengal



parapet wall can be constructed;
- water from the well should only be used for drinking and cooking purposes; and,
- monitoring by the village community is necessary.

CASE STUDY V: Validating traditional technologies

The village communities of Alwar district, after reviving five rivers were thirsting for a scientific explanation to explain this miracle. After all, it is not every day dead rivers are revived or that they become perennial. While the Arvari, Ruparel, Sarasa, Bhagani-Tildeh and Jahajwali were revived, the Arvari turned perennial. The miracle was demystified through a 'modern' scientific explanation.

The potential of artificial recharge: The reason behind this miracle can be described in two words: artificial recharge. While natural recharge is the process of infiltration of a portion of the rainfall through soil to replenish groundwater, artificial recharge is the transfer of the seasonal surplus water to aquifers through human intervention. The villagers had done precisely that by constructing various water harvesting systems and retaining the rainwater for a longer period within their area. They were essentially practicing the technology of artificial recharge.

The region: Alwar district is located in the northeastern part of Rajasthan. The average rainfall is about 600 mm and most of the rain (about 80 per cent) occurs during the monsoon months. A large fraction of this rainfall comes down in the form of three or four storm events. The hilly terrain and the precipitation pattern are conductive to quick runoff of a large percentage of the rainfall. This natural situation was further exacerbated by the deforestation taking place over the last 100 years or so. The net result was that most of the incident water was leaving the area during the monsoon months as runoff.

Water conservation efforts: Workers of the Tarun Bharat Sangh (TBS), an Alwar-based non-governmental organisation, began water conservation efforts in the region with the involvement of the village communities. These efforts included the construction of more than 3,000 *johads* or check dams in the region up to 1997. These *johads* created micro-percolation tanks that collected the seasonal runoff and let it percolate underground.

The impact: The change brought out by the water harvesting structures can be explained through a schematic diagram *(see Fig 2: Monsoon magic)* and a guesstimate of the water balance of a typical river in the area *(see Table 3: In the balance)*. The numbers in the table are based on the author's experience elsewhere and not on actual experiments or data collection in the area visited. Some facts:

- Considerable work was done in arresting runoff and storing it in small size reservoirs in the catchment area. This has given rise to the transfer of water to aquifers and addition to soil moisture through artificial recharge and water conservation at farm level, and reduction in the quantity available for monsoonal surface runoff.
- The streams have changed from ephemeral to perennial. The stream water in the non-monsoon season is clear, with no suspended matter, and the flow is gentle. This means that the stream water is contributed by the groundwater system. Although there is a reduction in seasonal runoff, there is no substantial reduction in the total annual runoff (discharge from the stream).
- There is considerable increase in biomass production and, hence, in evapotranspiration.
- The annual potential evaporation in the area is about 2,500 mm. The small size reservoirs will lose some water through evaporation.
- *Table 3* shows that the runoff has not been substantially reduced: it has been regulated. The static groundwater table in the area had gone below the bottom level of most of the wells and also below

Fig 2: Monsoon magic
Changes in water table before and after water harvesting

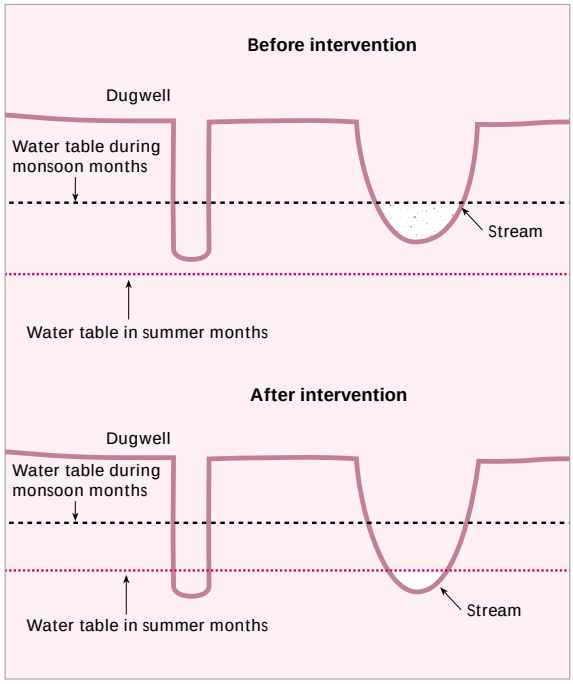


Table 3: In the balance

The table indicates the Arvari watershed water balance scenarios before and after water harvesting interventions. Before intervention, seasonal runoff, evaporation and evapotranspiration, soil moisture and deep recharge consumed the total rainfall. After intervention, runoff in the river was studied by observing the seasonal runoff, effluent groundwater flow which discharges into the river during the non-monsoon months and soil moisture. The seasonal runoff prior to the intervention was considered as 35 per cent of the total rainfall whereas after the construction of the *johads* it reduced to 10 per cent of the total rainfall. Before intervention the effluent seepage never existed. This was revived by the *johads.* Such changes in the runoff pattern were possible by regulating the seasonal runoff, which resulted in water availability in the entire region.

Before intervention (BI)	Percentage of rainfall	After intervention (AI)	Percentage of rainfall
Rainfall	**100**	**Rainfall**	**100**
1. Water recharge	**15**	**1. Water recharge**	**40**
(a) Natural water recharge, of which	15	(a) Natural recharge	15
i) Soil moisture for recouping the annual soil moisture deficit	5	(b) Artificial recharge through water harvesting structures	25
ii) Base flow (return from groundwater to surface stream)	5	Total recharge of 40%, out of which	40
iii) Deep recharge below well depths and stream bed level			
iv) Used by people for irrigation	4	i) Soil moisture (a), for recouping the annual soil moisture deficit,	5
	1	ii) Soil moisture (b), retained as a result of afforestation, farm bunding and other runoff arresting activity,*	5
		iii) Soil moisture (c), restored back to the soil from the 5 per cent of groundwater that is used for irrigation,*	3
		iv) Base flow	5
		v) Effluent seepage of groundwater into the river during non-monsoon months,	17
		vi) Deep recharge (below well depths and stream bed level)	5
2. Seasonal runoff	**35**	**Seasonal runoff**	**10**
3. Evaporation and evapotranspiration	**50**	**Evaporation and evapotranspiration**	**58**

Note: *Soil moisture retained as the result of water harvesting activities and groundwater that is used for irrigation is lost in the form of additional evaporation and evapotranspiration. Referring to the column after intervention (AI) out of the total recharge of 40 per cent, eight per cent of soil moisture (b and c) is lost through evaporation and evapotranspiration. Thus eight per cent has been mentioned twice while calculating soil moisture (b and c) and evaporation and evapotranspiration.*

the bed level of the river. As a result, both were remaining dry during the non-monsoon months. The additional recharge, brought about by the various water harvesting structures, has raised the water table above both these levels. Most of the wells, therefore, have water during the summer months and are used for irrigation. The area has no surface or canal irrigation. The unutilised groundwater enters the river practically all along its length as effluent seepage. The river has turned perennial mainly because of this regulated distribution of the runoff over the year, in place of the earlier situation in which most of the runoff was taking place only during monsoon months.

Government fears: The TBS work in the Alwar region had led to apprehensions in the minds of government officials and people leaving downstream. Officials felt that the people living downstream were being deprived of their share of the river water because of the harvesting (impounding) activity in the upstream reaches. However, *Table 3* indicates that the water that may be captured on the surface and, hence apparently not available to the people downstream as surface water, is actually available to them as groundwater returning to the river as effluent seepage. Only a small percentage of the total precipitation endowment of the catchment area of the river has been consumptively used by the people, cattle and biomass upstream. ■

Enhancing Efficiency in Freshwater Use

The International Environmental Technology Centre, Japan, a unit of the United Nations Environment Programme, aims at providing sustainable technologies for freshwater use

Makoto Fujita
International Environmental Technology Centre, Osaka, Japan

The Japan-based International Environment Technology Centre (IETC) of the United Nations Environment Programme (UNEP) has the mandate to promote the adoption and use of environmentally-sound technologies (ESTs) for sustainable management of the urban environment and of freshwater resources in developing countries and countries with economies in transition. The approach adopted by IETC is to facilitate information dissemination and exchange, using interactive electronic software.

IETC has developed an electronic searchable EST directory and a original database management software called 'maESTro'. The EST directory contains three kinds of databases on ESTs — institutions, information systems and technologies. Information can be searched with keywords like 'rainwater', for example, by location, like Asia, Central Asia and India, and also by themes, like freshwater, drinking water supply and water treatment.

Information on technology consists of general description, specification, advantages, disadvantages, suitability and potential environmental impact.

The main features of maESTro are:

- It is free of charge;
- it enables information networking;
- it can be disseminated through the internet, CD-ROMs, floppy disks and conventional printed reports;
- it is regularly updated (at least weekly, and sometimes daily); and,
- it uses Directory Interchange Format, a common format used by the World Bank, UNEP and other organisations.

IETC has been collecting and compiling worldwide data through maESTro from all its global partners.

The IETC has also prepared a *Source Book of Alternative Technologies for Freshwater Augmentation* to provide managers and planners in the water supply and environmental sectors, especially in developing countries, with information that is appropriate to maximise and augment available freshwater resources using appropriate technologies.

Each source book consists of three main parts. The first part provides an overview of the survey results and identifies the need for the identification of freshwater augmentation technologies. The second part presents technology profiles showing viable alternative technologies used for freshwater augmentation, water quality improvement, water treatment and reuse, and water conservation. The information provided in this part is based on an extensive literature review and field surveys carried out in the region. The different technologies include water conservation, wastewater reuse, rainwater harvesting, artificial recharge of groundwater, desalination technologies and other related information. Each technology is analysed in terms of the extent of its use; its operation and maintenance; level of involvement; cost; effectiveness; suitability; cultural acceptability; advantages and disadvantages; and, any further development of the technology that may be required. The third part contains selected case studies to illustrate and summarise specific technologies that have been adopted in respective regions.

Regarding freshwater issues and the ways in which freshwater resources can be increased, IETC is looking into alternative and innovative ways by which water can be found and used especially by people in the cities where water scarcity is highest. It is in the process of developing a project to identify alternative and innovative ways of giving urban dwellers access to adequate supply of water to meet their needs.

The use of rainwater as a supplementary source of water and for flood control is being explored. IETC is also planning to spread awareness about the need of efficient water use and is examining whether this is possible through centralised or decentralised water supply systems. Efficient water use technologies and profiles of case studies are being compiled. ■

CHAPTER 6

Policy Dimensions

- To meet water needs, water must be made everybody's business. Water harvesting must be made a national movement where decaying water harvesting systems are revived and new ones created where no such system exists.

- The reasons for the progressive decline in traditional water harvesting systems are many. These range from government apathy and policies that deliberately promote their decline on one hand, to a declining interest on the part of communities to nurture these systems on the other. The growing use of energised systems to increasingly deep aquifers have also played their part.

- Policymakers are unable to think of innovative ways to deal with water-related issues. Their solutions often tend to be big and so mega projects are offered as solutions. The need to combine the small with the big often escapes them. Another issue that fails being addressed is water demand management. Unless water demand is managed and water use controlled, no project, big or small, will succeed.

- It is impossible for the state to meet the water requirements of the growing needs of the people. The people themselves must play a more active role. For this, there is a need for social mobilisation and community empowerment so that communities have rights over the resources that they regenerate and manage. An enabling environment for water management would mean decentralisation and community empowerment and laws that promote both. *Panchayati raj* institutions could offer a platform to bring this about.

- Water is a social platform that brings about significant social change and betterment of the people. Community-based water harvesting in rural areas is a key to various ills that plague resource-degraded regions. Water is a vital resource that can bring about natural resource regeneration. A regenerated ecology is a regenerated economy. It influences the literacy rate and health status of the women. Community action brings about cohesiveness in the society which is then capable of addressing issues that go far beyond water.

- Water harvesting is not something that is needed by the rural population alone. A growing number of urban cities and towns are also facing problems due to mismanagement of water. These need to be addressed through mobilising the people as well as enacting legislations that promote water harvesting on one hand, and regulate water extraction on the other.

- Promotion of rainwater needs research — research that is people-oriented rather than technology-oriented. The health impact of consuming drinking water needs to be assessed, in terms of sources of pollution, how these can be minimised and treated. The issue is more serious in urban areas where the pollution load is heavier.

A Case for Rainwater Harvesting

Hopes of reviving dying traditional rainwater harvesting systems lie in extending their scope and revitalising local community institutions

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Traditional water harvesting systems are by no means dead. In various stages of decay across the country, these can still be revived. However, their full potential will only be realised if local community institutions are revitalised. Though they are not replacements of other forms of harnessing water, these systems nevertheless have a major role to play in conserving land and water resources and increasing land productivity on a sustainable basis.

Nearly ten years ago the Centre for Science and Environment had organised a national conference on traditional water harvesting techniques. The publication *Dying Wisdom* documented extensive, diverse and centuries old traditions of water harvesting in different parts of the country; the important role played by local community effort in constructing and maintaining them; the deterioration of these systems and institutions; and, the neglect on part of the state to sustain and build upon these traditional ways of harnessing water. The conference made an impassioned plea on the need to preserve and protect these traditional techniques.

I would like, specifically, to comment on (a) current state of traditional water harvesting systems and the factors which have brought them to their present predicament and measures need to resuscitate them; and, (b) the scope for, and means of, extending local water harvesting on a much wider scale.

DECLINE OF TRADITIONAL SYSTEMS

The *khadins* of Rajasthan, the community wells of Gujarat and the 250,000 irrigation tanks spread all over the country are outstanding examples of traditional water harvesting. There is a widespread impression that these systems have become derelict — physically and institutionally. Borewells, tubewells and piped public water systems drawing water from rivers and surface reservoirs have indeed distracted attention from traditional systems, overshadowed them and, in many cases, even put them out of use. The progressive reduction in the area irrigated by tanks and other minor surface sources reported by official statistics would seem to corroborate the impression of widespread and progressive decay.

But this picture may be overdrawn. Studies of a number of specific tanks in Tamil Nadu give a rather mixed picture. Physical degradation such as siltation and encroachment of feeder channels, encroachment of foreshore areas, siltation of tank beds, and extensive damages to sluices, regulators, surplus weirs and distribution networks were found to be widespread. Some of the tanks have indeed gone out of use or have suffered a significant reduction in irrigated area. But this is not the case for all tanks — a majority of those investigated are very much in use; in many, there is no indication of a significant reduction in the area irrigated by them; and, a large number continue to function despite significant changes in local institutions and power structures. Community-managed institutions have been found to be active in a sizeable proportion of the tanks which were studied.

Practically, all public resources allocated for expansion and improvement of irrigation facilities have gone into developing large canal systems and groundwater

The deterioration is no doubt partly due to government negligence of regular repairs and maintenance. There are innumerable instances of damage to systems caused by floods and other natural calamities. Investment in rehabilitation of existing works and construction of new tanks, local division works and the like is meagre. Practically, all public resources allocated for expansion and improvement of irrigation facilities have gone into developing large canal systems and groundwater. At the same time, the expansion of roads, railways, and residential settlements has also increased.

Such developmental projects have interrupted natural drainage courses and adversely affected flow of water into the traditional water harvesting systems. Planning of such projects has been unmindful of this consequence.

Having said this one must also recognise that the linking of existing tanks to larger reservoirs (which are called system tanks in Tamil Nadu) has, at least in some areas, helped increase the volume and assurance of supplies to local community storage. It must also be said that responsibility for their deterioration cannot be laid wholly at the doors of government. We need to examine the reasons for the weakening of interest among beneficiary communities in keeping the traditional systems in good repair. Several factors have contributed.

The massive increase in demographic pressure on land has contributed significantly to extension of cultivation to marginal lands, encroachment of common lands, government and forest lands, and deforestation. Deforestation of upper catchments aggravates soil erosion and siltation of natural drainage channels and reservoirs. Encroachment of tank foreshore areas and feeder channels and conversion of tank beds to residential and industrial sites are again due to growing demographic pressure.

Second, the capacity of the traditional systems being constant, perhaps even declining, have proved to be inadequate to meet the needs of a growing population. This has forced communities and governments to look for alternatives. New technologies have become available which, on the face of it, make it possible to augment water supply beyond the limits of existing traditional devices.

Over most parts of the country, rainfall is concentrated in 3-4 months and is very unevenly distributed across space. Productivity of rainfed agriculture over vast areas remains low because of inadequate and unreliable rainfall. Under these conditions, larger reservoirs are needed to impound surplus monsoon precipitation in high rainfall areas for providing larger, more assured supplies for utilisation during the main crop season and also to extend the crop season. Since irrigation increases the productivity of land manifold, interest in and pressure for construction of reservoirs is understandable. Nor can it be faulted so long as the resulting increase in productivity is much larger than can be obtained even after locally available water resources are fully

S RAJAM

The irrigation tanks of South India vary in size. Sometimes it is difficult to see the land on the opposite side. Often, the overflow of one leads to another in a cascade-like fashion

harnessed and the benefits accrue to areas with low productivity and relatively low level of incomes.

The introduction of drilling methods and energised pumping permit tapping deeper strata of groundwater, which is impossible with traditional devices. This is one reason why public water supply systems have gone in for tubewells and piped water supply systems. In the case of irrigation, tubewells and electrical / diesel pumps enable larger volumes of water to be lifted per unit of time. Moreover, they give individual farmers much greater control over when and how much to irrigate, and flexibility to adjust irrigation according to the needs of crops. Farmers are naturally attracted to go in for wells and tubewells because they enable them to irrigate larger areas and realise higher productivity.

All this does not, of course, warrant unqualified acceptance of the way in which these 'modern' techniques have been exploited. On the contrary, the scale and manner in which they have been applied and managed is seriously flawed in several ways. The development of canal and pump irrigation does not justify the scant attention given to the restoration and improvement of existing local systems, and to exploring possibilities of similar additional works for fuller, more effective harnessing of local water resources. At the same time, modern techniques have been promoted indiscriminately, without proper assessment of costs and benefits. Costs have invariably been underestimated and environmental costs altogether ignored even as benefits have been consistently overstated. There are far too many instances of bad management and indiscriminate irrigation leading to land degradation. Policies (like cheap electricity and diesel, low interest credit and lax loan recovery) have encouraged inefficient use of water and overexploitation of groundwater in most parts of the country. Correction of these deficiencies is essential.

The deterioration of traditional local systems is also due, to an important degree, to the weakening of local institutions for maintaining the existing facilities and managing them. It would be erroneous to suppose that in the past local institutions were everywhere and always strong or effective. But there is ample evidence that they did function fairly smoothly in a large number of cases. How well they functioned depended crucially on the cohesion of the community and the existence of a village leadership capable of enforcing compliance with customary rules with a numerically small, dominant upper caste group controlling much of the land and the absence of factions in that caste. That this group stood to benefit significantly from irrigation gave them a strong incentive in ensuring proper management of tanks and other land community works.

These conditions, however, did not obtain everywhere or in equal measure at all time. The effectiveness of the local institutions, therefore, always varied a great deal. Nor were they 'equitable': one should not forget that scheduled castes were not allowed access to village common wells / ponds for drinking, washing and bathing. The question of access to irrigation water from tanks made no difference to them because they have little or no land to cultivate.

The situation has changed materially in several respects. In some parts of the country ownership of land which used to be concentrated in numerically small upper caste groups has passed (for a variety of reasons, including migration of upper castes to urban areas, land reform legislation and rising political consciousness of the other castes and communities) to the numerically large, middle and so-called 'backward' castes. The earlier congruence between social and economic hierarchy in the village and the resulting concentration of local power in the upper caste has, therefore, weakened.

...the scale and manner in which modern technologies have been applied and managed is seriously flawed in several ways

The strength of local power centres was also dependent on the village being a relatively self-contained socioeconomic entity. Increasing commercialisation of agriculture and growing importance of government bureaucracy, legislators and political parties have progressively weakened the traditional centres of power within the community. With growing political consciousness, lower castes with little or no land, artisans and service castes are no longer willing to accept local authority based on caste status and land ownership. The sense of collective interest has been further weakened by the emergence of individually-owned wells and tubewells especially among stronger farmers who are community leaders.

The cumulative effect of all this, taken together with the fact that available facilities had to serve an increasing number of claimants, also played an important role in weakening the ability of local institutions to make and enforce rules concerning community matters. Correcting these institutional weaknesses must receive as much attention as additional investments in any programme for making local, community-controlled water harvesting systems become a far more important part of India's water control systems.

REVIVING WATER HARVESTING

In terms of the future role of water harvesting, the first obvious priority is the rehabilitation and restoration of 'traditional' water harvesting systems to their full potential. These systems are numerous. According to

the Minor Irrigation Census of 1986-87, nearly 250,000 tanks and close to 450,000 small-scale diversion and lift irrigation works are in active use, spread all over the country. Some 50,000 works are reported out of use. The number of communities served is very large and, for a good proportion of them, these works are the main source of water other than rain. The area irrigated by them, though small in relation to other sources, is substantial. More importantly, the declining trend in the area irrigated — come down from seven million hectares (mha) in the 1960s to an estimated 5.5 mha currently — is indicative of their deterioration. Getting these existing works back to their potential should, therefore, be the first order of business.

Though programmes for restoration and modernisation of tanks and other traditional local systems exist, these are minuscule in relation to needs. Schemes decided and implemented entirely by government's engineering establishments tend to be preoccupied with physical improvements; the works themselves are not related to the problems specific to each tank; they are very expensive in terms of outlays per unit area; and, there is little knowledge (or even concern to find out) about the performance of the works after they are complete and their impact on productivity. This approach must change.

More resources, of course, need to be allocated for rehabilitation of existing water harvesting systems. It is possible to find substantial resources for this purpose from existing rural development and poverty alleviation programmes if only they were better organised. Far more important is the effective use of the resources. This calls for several measures.

Standardised packages will just not do. Rehabilitation schemes must be tailored to the local needs and

Schemes decided and implemented entirely by government's engineering establishments tend to be preoccupied with physical improvements

circumstances of specific systems. This is not possible with the information currently available. A phased programme for assessing the condition of existing facilities individually is essential. An inventory of these facilities is a necessary first step. This can be done expeditiously with the help of records maintained by government departments verified by satellite imagery. A more precise assessment of the condition of specific works, and needed remedial measures to restore them to their full potential, will require a phased programme for detailed ground-level investigation.

Such investigations will, of course, need technically qualified personnel. But these personnel need not all be from government. Non-governmental organisations (NGOs) can play an important complementary role. More importantly, the communities served by each tank need to be involved in the process. This will begin a process of getting communities interested, making them aware of the rationale of improvement and eventually involving them in the process of rehabilitation. It will help bring local knowledge of problems and ideas regarding possible solutions based on long, first

Rehabilitation schemes must be tailored to the local needs and circumstances of specific systems. This is not possible with the information currently available

hand experience — knowledge which no amount of sophisticated surveys by outsiders can match — to bear on preparation of schemes suited to the specific needs of each location.

While government personnel and NGOs will have an important role in the planning process, it does not follow that the implementation of schemes and their management should rest wholly with government. Local water harvesting works will not realise their potential unless the beneficiary communities have a sense of stake in them and manage them on their own. Involving the communities in the process of planning and construction helps in this, the more so if they are required to contribute part of the costs. It is likely to be strengthened by divesting the public works department of the power to decide on resource allocation priorities and entrusting this function to elected *Panchayati Raj* institutions, leaving them to mobilise additional resources of their own.

On the other hand, the government has an important role in creating and sustaining an environment conducive to community-based institutions. Specifically, it needs to enunciate a framework by which individual local harvesting systems are to be managed and sharing of water among communities in a common watershed is to be regulated and the mechanisms for sorting out differences among them. Strong and impartial enforcement of these principles, especially in clearing encroachments and other impediments to proper use, are critical. Legislation should, however, confine itself to enunciating general principles of community management leaving sufficient flexibility for details to be settled by the concerned communities through mutual negotiation.

The NGOs have a key role in (a) helping individual communities to evolve workable arrangements for common management based on their specific traditions,

custom and circumstances; and, (b) improving water literacy of the user communities so that they will better understand the role of water, the relation between the way its use is managed, and the outcome in terms of quality, productivity and equity.

EXPANDING WATER HARVESTING

Besides rehabilitating existing traditional water harvesting systems, there is scope for enlarging their role. One way is to explore and take advantage of the possibilities of linking more of the existing rainfed tanks to larger reservoirs. The policy, followed by some states, of prohibiting such linkages must be reversed. Using large reservoirs in combination with tanks dispersed in their command should be accepted as a guiding principle, both in existing canal irrigation systems and in designing new systems.

Such a strategy has the double merit of reducing the scale of large reservoirs needed to harness available water even as it increases the flexibility of users and user communities to ensure more effective use of water. This is evident from the experience of system tanks in South India. It has also been shown that by linking the tanks in Saurashtra to the Narmada reservoir, and operating them in an integrated manner, the storage capacity needed at Sardar Sarovar can be substantially reduced without affecting the total quantum of water used. The advantages in terms of reducing the height of the Sardar Sarovar dam and consequent saving in costs as well as the substantial reduction in the extent of submergence argue for a serious consideration of such an approach.

WATERSHED DEVELOPMENT

By far the most important means for expanding the role of local water harvesting is integrated watershed development. Nearly two-thirds of the country's cultivated land still depends exclusively on rainfall. Even if the estimated potential for large storage and groundwater were fully exploited, a major part of the area will remain dependent on rainfall. Inadequate water availability for domestic use, animals and for agriculture is, and will remain, an endemic problem in a large part of the country, especially in areas with low rainfall.

Aggravated soil erosion due to denudation of upper catchments has probably reduced the quantum of

AKHILESH/ CSE

Populist policies like subsidising diesel result in energised overextraction of groundwater

A drawback of most soil and moisture conservation programmes is that these focus mainly on the nature of the works, without assessing the difference they will make to the quantum of effective availability of water

rainfall retained in the soils of the catchment and has increased surface runoff. Both have adverse effects on productivity. The available evidence suggests that in most states there has been little, if any, increase in productivity of rainfed land over the last two decades. In sharp contrast, productivity of irrigated lands has everywhere shown a sustained rise. These trends imply widening disparities between irrigated and unirrigated areas, and probably between farmers/communities with and without irrigation which is obviously a cause for concern. The interests of achieving and sustaining an adequate growth in agricultural productivity of rainfed areas as well as considerations of equity demand a bigger, more effective programme to raise productivity of drylands. Improved soil and moisture conservation is of critical importance for this purpose.

The central purpose and rationale of watershed development is to ensure that as much as possible of the local precipitation is harnessed and retained for use in the watershed. This can be done by restoring adequate vegetative cover in the upper slopes to reduce the rate of runoff; soil conservation measures to increase the quantum of precipitation absorbed and retained in the soil; and, creation of small ponds to store part of the precipitation and to facilitate larger recharge into the local aquifers.

In the process, availability of water for domestic and agricultural uses will increase. This would enable farmers to better cope with fluctuations in rainfall, get more assured and higher yields during the main crop season, and perhaps also sow more of their land in the dry season which follows.

How much more water can be retained in a watershed depends on numerous factors. The scope for increasing the quantum of moisture retained depends on the existing soil cover status (in terms of depth and structure) and the extent to which soil conservation measures can improve these parameters. This potential is likely to be more in watersheds with heavily eroded soils and degraded land and less when rainfall is in excess of the capacity of the soil to store moisture or when it comes in infrequent and intense spells. The possibilities of retention are greater if surplus monsoon rains can be stored either on the surface or underground. The potential for increasing the effective retention of local rainfall for use and the means appropriate for the purpose will naturally vary between regions.

A drawback of most soil and moisture conservation programmes (including integrated watershed development schemes as presently conceived) is that these focus mainly on the nature of the works (restoration of vegetative cover in the upper catchment, contour *bunds*, check dams and farm ponds), without assessing the difference they will make to the quantum of effective availability of water by way of carryover storage in the soil, in tanks/ponds and underground. Even less attention is given to planning the mix of interventions in such a way that the impact would be maximised in relation to costs involved.

Notwithstanding these caveats there can be no doubt that there is substantial scope for capturing, through local water harvesting, a larger proportion of rainfall. With accumulating knowledge from experience and further research, the limits can be further extended. Exploiting this potential and managing the additional supplies judiciously is imperative if there is to be a significant and sustained improvement in the productivity of rainfed agriculture.

LACUNAE WITHIN

India has had a long history of research and other programmes for soil conservation and improved methods of dry farming but, unfortunately, they have not been particularly successful. Mere interventions on agricultural lands are not enough.

The idea of integrated watershed development was accepted as official policy nearly 25 years ago. But fragmented programmes based on concepts of older vintage — such as soil conservation on agricultural land, soil conservation of river catchments, wasteland development schemes — continue. The concept of integrated watershed development has been tried out in some areas by the Indian Council of Agricultural Research in addition to several projects implemented with funding from various multilateral donors. The government itself has launched a programme called National Watershed Development Programme for Rainfed Areas. But, in reality, planning, management and integration are confined only to the title.

The idea of integrated watershed development was accepted as official policy nearly 25 years ago. But fragmented programmes based on concepts of older vintage continue

The way watershed programmes are currently planned and implemented, there is little hope that these programmes will make any significant or sustained impact in terms of raising productivity levels. Arresting the degradation of land and ensuring that they are brought to their full production potential is even less likely. The main deficiencies are:

- Proliferation of programmes and agencies for land improvement and soil and moisture conservation;
- persistence of piecemeal and fragmented intervention aimed at particular classes of land (such as rainfed farmlands, command areas of irrigation, saline and alkaline lands, wastelands and forests);
- absence of arrangements to ensure coordinated action (in design and implementation) among concerned government agencies;
- planning of interventions by government agencies without meaningful consultation, not to speak of involvement, of affected communities;
- lack of follow-up on the part of agencies to monitor the condition of the works after completion, and evaluate their actual impact in relation to expected impact over an appropriately long period of time;
- preoccupation with physical works (check dams, contour *bunds*, farm ponds, and afforestation) without any attempt at spelling out the expected impact in terms of the increase in quantum of moisture retained in the watershed, the sources of the increase, the nature and extent of the vegetative cover, and magnitude and time profile of impact on landuse, cropping and output;
- near total indifference to defining the arrangements (rules, responsibilities and mechanisms) for continuing maintenance of works, on the basis of which access to and use of additional water and biomass on public and common lands will be regulated, and the distribution of costs and benefits between the state and different segments of the community;
- the task of setting up appropriate institutions to ensure proper management of the watershed according to the rules remains unaddressed;
- the beneficiary communities are unaware of the rationale of the schemes or the benefits to be expected; nor have the community institutions (including the *panchayat*) been assigned a role — much less a well defined role — in the continuing management of common facilities created in the watershed; and,
- rights of ownership and powers to regulate use of common facilities and resources vested with the community are inadequate for them to manage developed watersheds. On the contrary, most of the non-private land is legally owned by different government departments (revenue, forests, public works department) which are loathe to part with their ownership and control. Community participation and control, so crucial for effective watershed planning and management, are not possible under the existing legal framework.

THE WAY AHEAD

The effective resuscitation and more widespread adoption of water harvesting techniques calls for drastic changes in the way these programmes are conceived, planned and organised. To begin with, we need to broaden our concept of water harvesting. Water harvesting, in its broadest sense, is essentially a way of harnessing, through various forms of collection and storage, precipitation in seasons and regions which are in excess of their requirements for use in seasons/regions where rainfall is short of requirements. In this perspective, even large reservoirs are a form of water harvesting.

At the same time, experience has highlighted the dangers — by way of degradation, loss of valuable land, forests and other resources and disruption and dispossession of communities displaced — of excessive preoccupation with larger reservoirs, their poor planning and management. While it is incorrect to suggest large and small water storages of surface and groundwater as mutually exclusive alternatives, the balance between them is a very important issue. Much greater attention to local water harvesting is essential for raising the productivity of rainfed lands, for reducing the dependence on larger reservoirs, for exploiting the overall water potential, and for more efficient management of water in large systems.

Many of the traditional forms and practices need change in the light of changing demographic, sociopolitical and economic contexts

There is much to be learnt from both 'engineering' techniques and institutional arrangements of traditional systems. That there is a need for a greater effort in this respect is also beyond doubt. We must, however, pay more attention to their underlying principles rather than get fixated on the particular forms and practices associated with them. Many of the traditional forms and practices need change in the light of changing demographic, sociopolitical and economic contexts. Many new techniques of engineering, construction and management are available. We should not, in the name of preserving traditions, deny ourselves the benefit of using these new techniques. We must at the same time

be conscious of the dangers of blind and indiscriminate adoption of the modern techniques. The latter must be used selectively, modified and adapted imaginatively to the needs of specific contexts, which are highly variable.

All the existing schemes affecting land, water and forests should be merged into a single, unified programme for watershed development. Starting with integrated planning and management of land and water in microwatersheds at the village level, these plans should be aggregated through basins of small rivers and tributaries of large rivers to sub-basins of major rivers and eventually covering entire basins.

At each level, responsibility for preparation of programmes, implementing and monitoring them should be unified under agriculture, forests or irrigation departments (depending on the nature of the watershed) with officials from each department being part of the team and reporting through the land and water development hierarchy. The restructured arrangement should be such that the watershed committee comprising community representatives should be an integral and effective part of the decision-making mechanisms at every level. The diverse interests within each watershed community need to be involved to facilitate formulation of generally acceptable rules regarding contributions to creation and maintenance of facilities, use of the facilities and sharing of the benefits. These should evolve by consensus. Failing that, a mediated process of negotiation and compromise should be followed. The latter requires a well-defined framework of general principles regarding property rights, cost and benefit-sharing to be legislated and enforced by government.

All the existing schemes affecting land, water and forests should be merged into a single, unified programme for watershed development

Participatory planning is still no more than a slogan in government programmes. The tradition of consultation, leave alone participation, is weak; and, the problems are numerous and difficult. NGOs, which appreciate the importance of this, have had to put in patient and sustained efforts to bring it about. These efforts are limited, their strategies vary and so do their accomplishments. But attempt to promote community-managed watershed development on a wide scale must learn from these experiments.

Reorganisation of administration along lines suggested involves upsetting existing arrangements in terms of division of functions and associated powers, both at the political level — between ministers, between political functionaries and officials — and between different segments of the bureaucracy. It is understandable that the bureaucracy is not particularly enthusiastic about it. Less easy to understand, and correct, is the deep-seated scepticism — bordering on distrust — among politicians and bureaucrats about community participation. Indeed, their attitudes even about consulting affected communities are lukewarm.

Calculated strategy is needed to break this logjam. It has to recognise and accept that reforms of such a fundamental nature cannot be accomplished in one stroke but will have to be engineered in a phased manner.

A practical strategy, I dare suggest, might be prepared along the following lines:

- Start by getting rid of the needless and counterproductive proliferation of land and water development programmes and replacing them with a unified administration for integrated planning and implementation of watershed development;
- affirm government's commitment to participatory, integrated watershed development and spell out the nature of the organisational structure and mechanisms which are ultimately sought to be put in place;
- encourage official watershed development agencies to get into the habit of consulting community representatives, making them better informed about the rationale of the programmes, and involving them in collecting and interpreting information and exploring alternative interventions and their implications;
- demonstrate, in selected watersheds, what a properly planned and managed watershed programme can do by way of increasing overall production and employment;
- experiment, in active collaboration with NGOs, innovative technologies to design more effective interventions, reduce costs and increase the returns by securing high biomass output and adding value to them;
- identify and remedy legal and sociopolitical impediments to community participation; and,
- devise measures to create stake and incentives for community participation in watershed management and for equitable distribution of benefits to the resource–poor segments.

All this is bound to be a long haul, but without it the resources and effort spent with much fanfare on land and water development will be wasted. What is more, the prospects of arresting and reversing land degradation, of restoring land to its potential, and progressively increasing it by the application of technology will be in serious jeopardy. ■

Wanted: Fresh Ideas

Effective water resources planning needs a whiff of fresh air infused into stale minds

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Changes are needed in our ways of thinking if the ideas of community-based water harvesting and watershed development are to make headway. Such ideas have doubtless been gaining ground in recent years. When they are put forward in seminars and conferences, they generally receive nods of agreement. However, we must not be misled by this apparent agreement.

The orientation which began to be absorbed over a century ago along with a modern engineering education, and which led to a water management paradigm, away from traditional practices, has not disappeared. It is in fact firmly entrenched and resistant to change. From the engineering establishment, it spread long ago to the bureaucracy and politicians, and forms now the prevailing climate of inhospitability to the kind of ideas being espoused by the community-based paradigm. While lip-service may be paid to these ideas, the inclination of most policymakers and planners is towards large-scale, technology-driven, engineering-dominated, and non-participatory projects rather than towards local, small-scale, people-centred, participatory schemes and activities.

It would doubtless be said that there is no conflict between the two paradigms and that both are necessary. Having delivered that piece of wisdom, the promoters of the old paradigm will instantly forget small, local schemes and go back to big projects.

There has been a long-standing preoccupation in India with the idea of a transfer of surplus waters from the northern and central rivers to the southern parts of the country which are chronically water-short. Several decades after K L Rao mooted a Ganga-Cauvery link or Captain Dinshaw J Dastur talked about a 'garland canal', those ideas continue to beguile the general public. From 1980s onwards, the National Water Development Agency has been studying possibilities of storage, links and transfers. In the deliberations of the National Commission on Integrated Water Resources Development Plan, of which I am a member, a recurring theme is 'inter-basin transfers'. There is also the desire to tap the waters of the Brahmaputra river and take them to areas where the need exists. In energy planning, a much-canvassed proposition is that there is a huge hydroelectric potential in the Himalayan rivers and that this should be realised through a number of projects. The entire focus of India-Nepal talks on water resources has been on large projects such as Karnali, Pancheswar and Saptakosi.

Thus, the establishment view is that development is impossible without large projects — water harvesting and watershed development schemes can at best be minor components of overall planning. That local efforts could cumulatively make an enormous difference to the overall picture is rarely recognised. The dismissive view that such schemes cannot make a significant contribution to the augmentation of the water availability is an *a priori* one, not based on a detailed examination of possibilities. The whole weight of bureaucratic, engineering and political opinion is against taking these possibilities seriously.

V GANGADHAR

Impractical ideas like interbasin river transfers continue to be promoted, irrespective of scale and cost

There are many elements in current policy thinking that militate against local small efforts. Let me mention some of them:

- Demand is taken as an inexorable factor. Large projections of future needs of water (like drinking, municipal uses, agriculture, industry and power generation) are made, and planning proceeds from these projections, which are regarded as sacrosanct, to supply-side solutions. Mega-projects then seem inescapable.
- We then think in terms of 'harnessing' rivers and we tend to regard water that goes to the sea as 'wasted'. The very expression 'water resources development' has acquired a specialised meaning: it is implicitly taken to mean dam-and-reservoir projects, as has the term 'augmentation,' which has figured prominently in the Indo-Bangladesh talks about the Ganga. It is significant that the name of the commission to which I referred earlier is not 'National Commission for Integrated Water Resources Planning' but 'National Commission for Integrated Water Resources Development Plan'.
- Allied to this is the assumption that water planning is essentially a matter for engineers. It is significant that the Central Water Commission, which regards itself as the apex body for water planning in this country, is not a multidisciplinary body encompassing agriculture, environmental sciences, economics, sociology or law, but is merely a body of engineers.

Planning tends to remain in the hands of the state, that is, bureaucrats, technocrats and ministers

- It is generally accepted that the basis for national water planning should be a *hydrological unit* such as a basin or sub-basin. The national water policy says so. Thus standard practice is to speak of *integrated* planning. While these are unexceptionable ideas, our planning continues to be project-based. The basin merely provides a background for this, and the language of 'integration' is a gesture in the direction of current terminology, whereas the approach remains that of centralised planning of a number of large projects in certain selected locations within a basin or sub-basin. The fact that an integrated, multidisciplinary approach is equally, if not more, consistent with microwatershed development is rarely recognised.
- Planning, as understood on these lines, tends to remain in the hands of the state, that is, bureaucrats, technocrats and ministers. There is hardly any room in this kind of approach for participatory, community-based planning. Moreover, governments are not very comfortable with non-governmental organisations.

GETTING WATER MANAGEMENT RIGHT

Against this background, a reorientation is needed. I would propose the following points for consideration:

- We must reverse the usual approach of proceeding from projections of demand — as if demand was autonomous and sacrosanct — to supply-side solutions. We should proceed from limited availability to demand management and resource conservation. Such a reversal will become even more imperative as water, a scarce resource, becomes still scarcer.
- Economy in the use of this scarce and precious resource and conservation of available supplies will have to be central to planning. Water resource 'management' rather than 'development' should become the watchword for the future.
- Supply-side responses are not to be ruled out, but they need not only mean large projects. Significant augmentation is possible through local water harvesting and water management. Scepticism regarding this possibility can only be removed by extensive trials on a nationwide scale.
- The focus should shift from the basin or sub-basin to small watersheds, which is also a hydrological unit. Water planning should be essentially local. Efforts should be to make each locality manage its own water needs.
- There have been some very successful instances of local water management and social transformation such as in Ralegan Siddhi and Sukhomajri. But these are isolated examples. It is necessary to identify the factors which have led to their success or failure, and those that facilitate or inhibit replication. The thrust in future water planning must be on covering the entire country with a vast network of thousands of such local initiatives. It is in this, and not in grandiose projects, that the answer to future water needs lies.
- Traditional systems of water management which have fallen into disuse such as the tank systems of Tamil Nadu and Karnataka or the stepwells of Gujarat and Rajasthan, need to be revived and strengthened. This must be another thrust area in future water planning.
- Large projects must be undertaken only after examining all other possibilities, and after a stringent scrutiny, even for hydroelectric projects. Demand management, economy in use, elimination of waste, extracting the maximum value out of capacities already installed, and extensive decentralised generation, will have to be given pride of place in our energy planning. People's participation in such project planning would also need to be ensured from the earliest stages.

These are some of the ways in which our thinking needs to change. ■

Reconciling the Private Well with the Community Tank

Tubewells within hydrological boundaries of tanks adversely affect the latters' health. If tanks have to be maintained as a common property resource, it is essential that users participate and the use of well water is regulated

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In southern India, ancient tanks are one of the oldest sources of water harvesting structures, accounting for about one-third of the irrigated rice area. But today, performance of these tanks is poor, due to inadequate operation and maintenance (O & M), overdevelopment of groundwater sources, disintegration of traditional irrigation institutions, heavy siltation and encroachment.

The neglect of these tanks has meant less water to farmers. To offset the decline in tank water supply, farmers have resorted to supplemental well irrigation to avoid crop losses. Since only about 15 per cent of the farmers in a tank command area own wells, and there is a growing demand for well water, these owners act like local monopolists and are able to charge high prices for well water. However, making profit through a privately owned water source like a well within the hydrological boundary of the common property resource like a tank poses serious threat to the survival of the tank. This is because of the declining interest among well owners to maintain tank structures. What is needed is integration of existing tanks with wells through collective action.

In this paper, an attempt has been made to analyse the performance of the Panchayat Union (PU) tanks (whose command area is less than 40 hectares) and public works department (PWD) tanks (whose command area is more than 40 hectares). This analysis is based on a detailed census of 2,900 tanks and a detailed tank performance and resource mobilisation study for 566 tanks. The study includes districts in Tamil Nadu that are tank-intensive (where tank irrigation is the major source of irrigation) and less tank-intensive (where tank irrigation is negligible). The data relates to a five year period from 1989-90 to 1993-94.[1]

DECLINE IN TANK USE

In the country as a whole, the share of tanks in total irrigation has declined from 18.5 per cent in 1960-61 to about seven per cent in 1990-91. In Tamil Nadu, the decline has been from 38 per cent to about 23 per cent during the same period *(see Table 1: Changing sources)*.

The main factors leading to a decline in the capacity of tanks, besides variation in rainfall, has been siltation because of poor maintenance of the catchment area; encroachment of the tanks and their catchments; and, obstruction of the channels feeding the tanks. It is clear that rainfall has always been variable. The overall decline in the performance of tanks cannot be attributed to this variability in rainfall. The influence of the north-east monsoon rains on the tank irrigated area in the state was more than that compared to the southwest monsoon. It was estimated that in five out of ten years, tanks got deficient supply of rainwater; for three years the tanks failed; one year the tanks had surplus storage; and, another year the tanks got full supply. Furthermore, the correlation coefficient between the area irrigated by tanks and the rainfall was only about 0.20 to 0.30. This indicates that apart from rainfall there are several other factors which have contributed to the overall decline in tank performance in the last few decades.[2]

Making profit through a privately owned water source like a well within the hydrological boundary of a common property resource like a tank poses serious threat to the survival of the tank

MANAGEMENT OF TANKS

In ancient times, tanks were considered to be the property of rulers. The farmers paid a portion of the produce to the rulers and they were in charge of the maintenance

Table 1: Changing sources
Percentage of area irrigated by different sources in India and Tamil Nadu

	Source	1960-61	1970-71	1980-81	1990-91
India	Canals	42.05	41.28	39.40	35.63
	Tanks	18.50	13.22	8.24	6.84
	Wells	29.56	38.22	45.70	51.04
	Others	9.89	7.28	6.66	6.49
	All	**100.00**	**100.00**	**100.00**	**100.00**
Tamil Nadu	Canals	35.80	33.90	32.70	32.40
	Tanks	38.00	34.50	32.10	22.38
	Wells	24.20	29.80	33.80	44.61
	Others	2.00	1.80	1.40	0.61
	All	**100.00**	**100.00**	**100.00**	**100.00**

Source: *Tamil Nadu – An Economic Appraisal* (Various issues).

of tanks and supply channels. The rulers ensured the maintenance of tanks and channels, as they reaped the benefits of farming in large areas. However, in 1886, the British introduced the *ryotwari* system of land tenure. Tanks with a command area above 40 hectares (ha) were brought under the control of the PWD while smaller tanks with a command area of less than 40 ha were left under the administrative control of local bodies or vested with the villagers themselves. The farmers attended routine maintenance works under the *kudimaramath* system, the traditional system of community management of irrigation tanks. However, within a few decades, farmers' involvement in *kudimaramath* declined.

The reasons for the decline include changes in landholding pattern in the tank commands. Not only has land in the tank command area been divided and fragmented, but there has also been changes in the caste composition of landowners.[3] Earlier, the *kudimaramath* system had the support of the *zamindari* system that reinforced the then prevailing feudal social relations. With the abolition of the *zamindari* system, the newly emerged social relations were no longer conducive to the communal maintenance of tanks.[4] The handing over of tank maintenance to PWD was another important reason for the decline of community management as PWD engineers were not empowered to enforce *kudimaramath*. Revenue officials felt that the very creation of the PWD led to the decline of *kudimaramath*. After the late 1860s, *kudimaramath* was pronounced dead or declining in official documents.[5]

The farmers were also tempted to believe that with the creation of the PWD bureaucracy, tank maintenance was no longer their duty but the state's responsibility.[6,7] High level of taxation and appropriation of the work by the state like tank repairs, have also been cited as the reasons for the reluctance of farmers to take up *kudimaramath*.[8]

TANK PERFORMANCE OVER THE YEARS

The number of tanks fluctuates from year to year as reported in the *Season and Crop Reports* published by the government of Tamil Nadu *(see Table 2: Tank numbers)*. The area irrigated by tanks has declined over the years. However, paradoxically, between 1960-61 and 1993-94, there is a general increase in the number of tanks in the four districts studied. The possible reason for the significant increase in the number of tanks could be that a large number of ex-*zamindari* tanks which are concentrated in old Ramanathapuram district were standardised under the tank restoration scheme, which was started in 1960-61. Their number has been added to the existing number of standardised tanks every year. Therefore, an enumeration of the tanks was taken up to find out the status of tanks and to study whether these structures had become defunct due to encroachment, siltation, pollution of tank water, intensive well irrigation or due to the disintegration of traditional irrigation institutions. The sample size of the tanks surveyed was 10 per cent.

Defunct tanks

In the tank-intensive regions of the state, the percentage of defunct tanks was marginally higher among PWD tanks — 2.62 per cent of the total number of PWD tanks counted. The percentage of defunct PU tanks was only 1.21 per cent. In the less tank-intensive regions, the percentage of defunct tanks was higher among PU tanks — 76 per cent — as compared to 64 per cent for PWD tanks *(see Table 3: Measuring the defunct)*.

The main reasons for the higher percentage of defunct tanks in the less tank-intensive districts was the predominance of well irrigation which resulted in the disintegration of irrigation institutions. Urbanisation, government takeover and conversion of those tanks

Table 2: Tank numbers
Number of tanks in some districts of Tamil Nadu and the entire state

Year	Select districts				State	
	Undivided Ramanathapuram	Tirunelveli	North Arcot	Chengalpattu	Number of tanks	Area irrigated (hectare)
1960-61	3,824	2,407	3,189	3,253	29,903	936,400
1961-62	3,825	2,407	3,189	3,253	34,467	939,515
1963-64	5,366	2,772	3,189	3,197	36,808	914,525
1970-71	5,412	2,417	3,189	3,232	35,822	897,923
1983-84	7,198	2,795	3,022	3,644	37,716	807,069
1984-85	7,053	2,795	2,894	3,644	37,629	715,029
1993-94	7,424	2,798	3,146	3,628	38,842	668,133

Source: Season and Crop Report, various years

close to the cities for public use, encroachments in the tank beds, and heavy siltation compounded the problem. In these districts, tanks are functioning merely as percolation ponds. Even in some of the large, well constructed tanks, farmers do not open the sluice gates for irrigation and allow the tank water to be fully used for recharging wells. This is because:

- There are a large number of wells in these tank commands, mostly owned by farmers having more acreage. This averages out to one well per cultivator. The farmers are therefore not willing to use tank water for direct irrigation as this may lead to disputes and inefficient water use.
- Tank irrigation is not a dependable source in poor monsoon years because of poor storage capacities, and because structures like sluices and channels are under disrepair.
- Since electricity is available at full subsidy, well irrigation is more efficient for cultivating commercial crops in specific periods.

The results based on the 10 per cent sample survey indicate that if all the tanks in the state are considered, then about 562 tanks are defunct in the tank-intensive districts, and about 960 in the non-intensive districts. Furthermore, if the total area under defunct tanks is calculated, it will be 36,670 ha in the less tank-intensive areas and 19,235 ha in tank-intensive districts. The total loss in tank-irrigated area of the state will be around 56,000 ha. Assuming that the tank irrigation potential is about 0.9 million hectares (mha) in the

Table 3: Measuring the defunct
Comparison of functioning and defunct tanks across regions

Region / tank type	Number of tanks		Mean command area (hectare)		Number of fillings		Gap in the command area (%)	
	PU	PWD	PU	PWD	PU	PWD	PU	PWD
I. Tank-intensive region								
a) Total tanks counted	2,064	487	—	—	—	—	—	
b) Functioning tanks	2,039 (98.8)	474 (97.4)	12.67	105.2	1.3	1.35	0.35	0.50
c) Defunct tanks	25 (1.2)	13 (2.6)	15.81	74.81	—	—	100	100
II. Less tank-intensive region								
a) Total tanks counted	67	90	—	—	—	—	—	—
b) Functioning tanks	16 (23.9)	32 (35.6)	22.48	79.75	1.2	1.30	7.58	22.0
c) Defunct tanks	51 (76.1)	58 (64.4)	18.16	99.46	—	—	100	100

Note: *Figures in parentheses represent the percentage of tanks to the total number of tanks in each category;*
PU: Panchayat Union; PWD: public works department

state, and a conservative estimate of about 50,000 ha is assumed to be lost due to defunct tanks, the present area actually irrigated by tanks (taking the highest area irrigated by tanks in the last 10 years — 0.67 mha in 1994) still falls short of the potential area by about 0.2 mha. Even if the growing contribution of wells in the tank commands is excluded, the gap in area irrigated exclusively by tanks may rise to about 0.4 mha, which could be attributed to the mismanagement of tanks.

INTEGRATION OF TRADITIONAL SYSTEMS WITH MODERN NEEDS

The decline in the tank-irrigated area over years has forced farmers to integrate several activities to manage the increasing demand for water. For instance, through individual action they have invested in wells and encroached on the common land. Through collective action they have undertaken social forestry in the tank foreshore. They have raised resources for O & M expenditure, contributing in cash and by labour. The paper discusses the impact of these activities on the tanks.

Tank Performance

Tank performance is generally measured as the ratio of actual area irrigated by the tank to the total command area. The definition, however, does not purely reflect the actual tank performance since the wells in the tank command also contribute to tank performance both as a supplementing source in the wet season and as a sole source of irrigation during the dry season. Furthermore, the data on area irrigated exclusively by wells and tanks are not available at tank-level from the village records. Also, the higher number of wells reflects the uncertainty in tank water supply and the farmers' ability to cope with the deficit supply compared to tanks with adequate water supply whose dependence on wells will be comparatively less. In many parts of the state like North Arcot district, there is strong evidence to show that the excessive growth of wells has contributed to the decline in the 'real' performance of tanks. Therefore, comparing the performance of tanks without accounting for the impact of the wells would be misleading. To account for wells, the following approach was adopted: The actual area irrigated by the tanks was calculated by subtracting the actual area irrigated by the number of wells above the threshold number (the sample mean) from the total area irrigated in the tank command.

Tank performance and private action

The most direct private actions include the investment in wells for irrigation in the tank command and the encroachment in the tank foreshore. The well density (number of wells per ha of command area) was relatively higher in PU tanks (0.42) than in PWD tanks (0.35), and these were not statistically different *(see Table 4: Tank performance).* The reason for the higher number of wells in PU tanks is that the duration of water supply is comparatively lesser in PU tanks (2-3 months) than in PWD tanks (3-5 months). This density of wells also had a negative influence on tank performance as tanks without wells supplementing the supply of water had performed better.

Land encroachment on the tank foreshore is very common in virtually all tanks. The foreshore lands are normally classified as tank *neer piddippu* — lands that

Table 4: Tank performance

Parameters influencing tank performance under different levels of adjusted tank performance

Tank type	Well density (number/ha)	Adjusted tank performance (per cent)	O&M expenditure (Rs/ha/year)	Resource mobilised (Rs/ha/year)	Encroachment (% of water spread area)	Farmers' participation (humandays/ha/year)
PU	1.30	<25	73.80	28.00	34.44	0.28
	1.00	25-50	12.07	0.60	20.26	0.20
	0.30	50-100	154.00	8.25	12.24	0.56
	0.00	.100	24.00	0.00	8.22	0.72
Mean	0.42	75.70	154.00	9.00	16.23	0.54
PWD	1.25	<25	28.50	68.80	19.76	0.09
	1.00	25-50	108.00	61.30	11.66	0.35
	0.30	50-100	73.20	9.45	6.99	0.49
	0.00	>100	nil	nil	nil	nil
Mean	0.35	83.30	74.00	14.00	10.23	0.30

Note: *PWD: Public works department; PU: Panchayat Union; ha: hectares O & M: operation and maintenance*

After encroaching on tank foreshores, the encroachers petition the government for allotment of these lands. This directly influences the effectiveness of these tanks

are submerged when the tank is full. Since tanks are not full in most years, farmers encroach upon this land for crop cultivation. The encroachers then petition the government to allot the foreshore lands for cultivation. On this basis, government agencies issue a *kulakorvai patta* — right to the encroacher-farmer. But the level of encroachment then directly influences the effectiveness of the tank. A smaller catchment and foreshore means that the capacity of the tank is reduced. The survey found that the encroachment level in PU tanks was higher, the reason being that since these tanks are smaller in size with fewer number of farmers involved. This made encroachment easier. *(see Table 4: Tank performance).*

Tank performance and collective action

Given that tank performance is dependent on several parameters, it is possible to mathematically estimate tank performance *(see Box: Calculating tank performance)***.**

Even though the state level outlay per hectare of command area at current prices has increased from Rs 26 in 1978-79 to Rs 161 per ha in 1994-95, the state outlay at constant (1980-81) prices has increased only marginally from Rs 33 to Rs 43 per ha *(see Table 5: Tank expenditure).* In the case of PU tanks, the O & M expenditure is given to the local *panchayat* to maintain the tanks in a five year repair cycle. In the case of PWD tanks, the O & M maintenance expenses are made on a priority basis, where tanks with breaches and other problems which demand immediate attention will be attended to by the PWD sub-divisional office. The survey revealed that the average amount spent on operation and maintenance was higher for PU tanks (Rs 154/ha), compared to PWD tanks (Rs 74/ha). Since the amount was spent depending upon the urgency of the tank repair and local political pressure, the level of tank performance and the amount of O & M expenditure could not be correlated.

The survey found that the farmers were compensating for the state's failure to spend on the maintenance of tanks. Farmers mobilised financial resources from tank usufructs. The major sources of income were sale of fish raised in tank water; sale of trees grown on the tank *bunds* and the waterspread area; sale of silt; and, collection of fees/rent from duck and cattle herders for allowing their animals to graze in the tank command area after the harvesting of rice crop. The survey found a negative relationship between tank performance and resource mobilisation. The resource mobilised per ha of command area was found to be higher in tanks with poor performance. Resources mobilised were Rs 28 per ha per annum in PU tanks and Rs 68.80 per ha per annum in PWD tanks with performance less than 25 per cent. Resource mobilisation was just between Rs 8.25-Rs 9.50 per ha per annum (both PU and PWD) with performance rates between 50-100 per cent.

One reason for poor mobilisation of resources could be the lack of cooperative efforts in PU tanks. The survey found an absence of water users' associations in these tanks, mainly because PU tanks are supposed to be maintained by the *panchayats*, supposedly people's representative bodies. However, for many years, the *panchayats* did not have elected representatives as elections to the local bodies in the state were not held. It was only in 1996 that the elections were held.

Another reason for the poor performance of the *panchayat*-managed tanks could be the higher encroachment and well density in PU tanks as compared to PWD tanks. As much as 31 per cent of the PWD tanks had informal water users' organisations, whereas only 14 per cent of the PU tanks had the same. The functions of these organisations include the appointment of *neerkattis* (common waterperson), organising and coordinating tank maintenance works (mainly cleaning supply channels and main canals), resource mobilisation for tank maintenance and lobbying with government departments for better maintenance of tank structures. Farmers' participation in tank maintenance was also comparatively higher in PU tanks (0.54 humandays/year/ha of command area) than in PWD tanks (0.30 humandays/year/ha of command area). The results indicated a direct correlation between the performance of tanks and farmers' participation. The area under encroachment in PU tanks was 16.23 per cent as compared to only 10.23 per cent in PWD tanks. In the case of encroachment in the catchment, supply channel and waterspread area, it was 16.23 per cent in PU tanks as compared to only 10.23 per cent in PWD tanks.

Water market

Earlier studies have indicated the active role of water markets in low rainfall years. In PU tanks, for one rice crop, water was sold for about 57 hours, and about 61 hours in PWD tanks, while the water bought was about 70 hours in PU tanks and 64 hours in PWD tanks. The price of water varied from Rs 10 to Rs 30

As much as 31 per cent of the PWD tanks had informal water users' organisations, whereas only 14 per cent of the PU tanks had the same

CALCULATING TANK PERFORMANCE

Mathematical calculations indicate that two factors that influence tank performance are well density and farmers' participation in tank maintenance

The exact relationship between tank performance and various parameters affecting the tank performance is, indeed, complex in nature and hence regression analysis is used to capture these interrelationships. Using adjusted tank performance (ATP) as dependent variable, multiple linear regression equation was estimated to identify the factors influencing tank performance. The equation is:

$ATP = a+b_1FPART+b_2OME+b_3REV+b_4ENC+b_5WELL$

Where,

ATP = Adjusted tank performance (per cent)
FPART = Farmers' participation in tank maintenance works (five years' mean in humandays/year),
OME = Operation and maintenance expenditure (five years' mean in Rs/ha)
REV = Resource mobilised for tank maintenance (five years' mean in Rs/ha)
ENC = Encroachment in tank waterspread and foreshore area (per cent)
WELL = number of wells per ha of command area.

The regression coefficients are presented in the table below. Even though the R^2 was 0.34 for PU tanks, it is found to be statistically significant at one per cent level. The variables, namely, operation and maintenance (O & M) expenditure could decrease the ATP by 0.003 percent. And an increase in the density of wells above the mean level by one per cent could reduce the tank performance by 0.07 per cent and an increase in encroachment above the mean level by one per cent could decrease the tank performance by 0.20 per cent. An increase in farmers' participation in tank maintenance by one per cent could increase the adjusted tank performance by 0.45 per cent.

The R^2 for PWD tanks was 0.47 and it is comparatively higher than that for PU tanks. Two of the five independent variables are statistically significant, namely, well density and farmers' participation in tank maintenance. The regression coefficients indicate that a one percent increase in the well density above the mean level could reduce the performance by 0.11 per cent and a one percent increase in the farmers' participation could increase the tank performance by 0.37 per cent. Thus, both in PU and PWD tanks, the influence of well density and other associated factors on tank performance was clearly demonstrated. One of the direct impacts of higher well density is the emergence of water markets in the tank command area.

The negative coefficient for the O & M expenditure on tank performance could be due to the increased investment by tank management authorities on poorly performing tanks but without significant revival in the performance of those tanks as the farmers could have already diverted to private investments to wells. There are two other reasons:

- Because of severe financial constraints faced by both the government (PWD) and the *panchayats,* the tank repair works are taken up only on a rotation basis, that is, once in five years.
- The tank maintenance and repairs are done without any efforts to improve irrigation institutions. This argument is supported by the fact that the PU tanks which had a higher density of wells performed poorly, as compared to PWD tanks. The financial resources mobilised by farmers from the tank usufructs were higher in defunct or poorly functioning tanks. Furthermore, the revenue mobilised in over 80 per cent of the tanks was spent for unproductive purposes such as temple repairs, celebration of village festivals and other common village purposes and not invested into tanks.

Table: Calculating performance

Performance analysis of PU and PWD tanks dependent variable: adjusted tank performance (ATP)

Independent variables	PU Tanks		PWD Tanks	
	Regression coefficients	T-value	Regression coefficients	T-value
Farmers' participation (humandays/ha/year)	0.025	1.89*	0.0412	1.786*
O&M expenditure (Rs/ha/year)	-0.00002	-3.34**	0.00001	0.34 NS
Resource mobilised (Rs/ha/year)	-0.000064	-1.07	-0.00008	-0.67
Encroachment (%)	-0.0095	-2.75**	-0.0041	0.33 NS
Well density (wells/ha)	-0.1328	-8.21**	-0.2631	-7.34**
	R^2 = 0.34	F-39.60**	R^2 = 0.47	F = 0.00**

Note: **Significant at five percent level **Significant at one percent level NS: not significant PU: Panchayat Union PWD: Public works department ha: hectares O & M: operation and maintenance*

Table 5: Tank expenditure

State level operation and maintenance expenditure on tanks in Tamil Nadu

Year	Maintenance and Repair outlay (Rs in lakhs)	Nominal outlay (Rs/hectare)	Real outlay (Rs/hectare) at 1980-81 prices
1978-79	124.71	25.98	33.35
1979-80	129.91	27.06	30.17
1980-81	160.05	33.34	33.34
1981-82	152.81	31.83	28.86
1982-83	177.64	37.00	31.09
1983-84	155.67	32.43	25.16
1984-85	159.15	33.15	23.92
1985-86	237.44	49.47	33.13
1986-87	234.65	48.89	30.69
1987-88	354.83	73.92	42.68
1988-89	320.87	66.85	35.82
1989-90	320.73	66.82	33.16
1990-91	324.36	67.58	30.35
1991-92	497.20	103.58	42.27
1992-93	527.80	110.00	–
1993-94	741.65	155.00	–
1994-95	774.30	161.31	–

Source: Notes on the funds required for maintenance and repair for minor irrigation works — revised estimate, Chief Engineer (Minor Irrigation), Chepauk, Chennai, *personal communication*

per horsepower-hour. In PU-irrigated farms, 50 per cent of the PU farmers who bought water had to part with one-third of their crop produce to the water-sellers. In PWD tanks only about 14.50 per cent of water-buyers had to part with one-third of their crop produce. This indicates that tank water scarcity was more pronounced in PU tanks than in PWD tanks, because of which a higher percentage of well owners in PU tanks could extract more rent (one-third of crop produce) from groundwater.

Also, the average price of water was Rs 11.60 per horsepower-hour in PU tanks, whereas it was only Rs 10.40 per horsepower-hour in PWD tanks. The share of cost of well water purchased was 19 per cent to the total return from rice cultivation in PU tanks, while it was only 11.60 per cent in PWD tanks. The higher price of well water and the higher share of cost of well water in total revenue of the farmers in PU tanks than in PWD tanks, indicates that the water market was less competitive in PU tanks than in PWD tanks. This could be due to higher dependence on purchased well water for successful crop production in PU tanks than in PWD tanks, which reinforces the existence of greater water scarcity in PU tanks than in PWD tanks.

As tank water supply decreases, normally the price of well water increases substantially *(see Table 6: Paying the price)*. The survey found that when the tank water supply is lower than 25 per cent of the full tank capacity, the water-buyers had to pay more than one-third of their crop output, which works out to more than 40 per cent of the net profits from rice production to buy water. It was estimated that about nine per cent of the income that would accrue to the non-well owning farmers was captured by the well owners in PU tanks, and about 7.5 per cent in PWD tanks. The total costs to the buyers per tank would be about Rs 313.60/ha with two irrigations and Rs 1097.60/ha with seven irrigations in PU tanks. Costs will be Rs 275/ha with two irrigations and Rs 963/ha with seven irrigations in PWD tanks. Considering that about 30 farmers own

Table 6: Paying the price

Well-owners share in tank irrigation, Tamil Nadu

No of well irrigation	Actual well water cost		Total cost based on well-owners price (Rs/ha)		Well-owners share in non-well owners' profit (Rs/ha)	
	PU	PWD	PU	PWD	PU	PWD
1	34.4	36.8	348	312	313.6	275.2
2	51.6	55.2	522	468	470.4	412.8
3	68.8	73.6	696	624	627.2	550.4
4	86.0	92.0	870	780	784.0	688.0
5	103.2	110.4	1,044	936	940.8	825.6
6	120.4	128.8	1,218	1,092	1,097.6	963.2

Note: *PU: Panchayat Union; PWD: Public Works Department; Rs/ha: Rupees per hectare*
Average duration of irrigation = 15 hours/irrigation/ha; actual well water cost (taking into account the fixed and variable costs) was Rs 18.4/hour in PWD tanks and Rs 17.2/hour in PU tanks; average well owners price was Rs 10.4/hour in PWD tanks and Rs 11.6/hour in PU tanks.

wells in a typical tank command area which covers about four hectares per well, the total area supplemented by the water market will be about 120 hectares per tank. The income of the well owners will be about Rs 94,080 per annum with five supplemental irrigations and it will be about Rs 1,31,712 with seven supplemental irrigations in PU tanks. In PWD tanks, it will be about Rs 82,560 per annum and Rs 1,15,584 per annum with five and seven supplemental well irrigations, respectively, thus indicating the private prosperity of well owners in the tank commands.

CONCLUSIONS

It was evident from the survey that the overall tank performance negatively affected by the growth of private wells in the command area. This private appropriation of community tank water and seepage from tank irrigated fields benefits the individual farmer who owns wells. The conflicting interests of private well owners as against the sustainability of tank irrigation should be noted and efforts made to discourage the growth of private wells in tank commands. Instead,

The conflicting interests of private well owners as against the sustainability of tank irrigation should be noted and efforts made to discourage the growth of private wells in tank commands

wherever there is a strong case for the use of supplemental well water, it should be made available solely through community wells, which would strengthen the community management of both tank and well water in tank command areas.

In tanks where well density has exceeded one well per hectare of tank command area, tanks have become defunct. In such cases, tanks only serve the private well owners by recharging their wells. These tanks have simply become percolation ponds in such areas. The private well owners are able to earn substantial income from the sale of this commodity — ranging from about 15 per cent to one-third of the total cost of cultivation of non-well owners. While the tank-level study points to the negative impact of wells on the long-term sustainability of tanks, variation in farm-level rice productivity suggests that well irrigation in tank commands could increase the rice yield in the short-term. Thus, the short-term objective of the private well owners is in conflict with the long-term sustainability of tanks as a common property resource.

Furthermore, the marginal cost to the individual farmer due to long-term decline in tank performance is lower than the short-term marginal benefit from investment on wells. This gap is further widened because of the local monopoly in water markets which leads to high profits for well-owners. Therefore, the benefits of the common property resource continue to be mismanaged. Given this situation, the long-term sustainability of tanks demands investment in community wells so that there is equity in groundwater resources.

In order to maximise benefits, it is important that tank management be strengthened to have indirect control over the concentration of wells as well as on water markets. Through a rotational system of water delivery from sluices, the wells would get adequate recharge and tank storage can also be prolonged thus reducing the heavy dependence on wells.

In addition, the entire water resources within the hydrological boundary of the tanks should be declared a common property of the village community. The water users' associations should be empowered to decide the extent and purpose of the use of the tank water. It is important to note that the farmers' participation in tank maintenance had a significant impact on overall tank performance, both in PU and PWD tanks. The presence of water users' organisations had a positive effect on rice yield at the farm level due to improved water management. The increased role of people's participation in tank management would also minimise conflicts between tanks and wells.

Notes:

a. Resource mobilisation includes tangible economic benefits obtained from tank usufructs such as sale of trees raised / naturally growing in the tank *bunds* and the waterspread area, sale of fish, duck rearing, sale of silt and revenue collected for permitting cattle grazing in tank waterspread and / or command area after the harvest.

b. By real performance we mean the actual performance of tanks excluding the contribution of wells (positive or negative) to the overall observed tank performance measured, which is usually measured as the ratio between actual area irrigated by the tank to the total registered command area of the tank.

c. Janakarajan (1993) observed strong negative relationship between well density and the effectiveness of traditional irrigation institutions (TIIs). He further observed that the TIIs are effective in those tanks where the well density is typically below 0.40 wells per ha. In the present study, the threshold number of wells for PU and PWD tanks are 0.42 and 0.35, respectively. Hence, it is reasonable to assume that for those tanks having well density above these levels, the wells were assumed to be negatively contributing to tank performance. ■

Biodiversity in Artificial Wetlands

Wetlands offer a haven to biodiversity. It is possible to revive wetlands but water managers must become conscious of integrating human and biodiversity needs

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Wetlands are a rich source of biodiversity. In India, natural wetlands are restricted to the Himalaya, the Ganga-Brahmaputra floodplains, and deltaic and coastal areas. All the other wetlands are artificial *(see Table 1: Wetland types)*.

Biodiversity is associated with shallow wetlands. With the degradation of these wetlands, biodiversity declines. There is an urgent need to revive these wetlands, which is possible, as experiences in Maharashtra indicate. These efforts have community participation as an integral part of the scheme, and, unless this is assured, efforts may come to naught.

STOPPING WATER

Dam-building or obstruction of natural courses of streams and rivers began in the second half of the 19th century, gathered momentum in the first half of the 20th century, and reached devastating proportions after Independence. Rivercourses were transformed beyond all recognition, resulting in natural habitat destruction for numerous life forms, including plants.

Maharashtra is foremost in India in constructing artificial reservoirs, with over 4,000 medium and large waterbodies built all over the state. At one time, the landscape of Maharashtra must have been bereft of waterbodies. Migratory waterfowl like ducks and geese used to avoid this region and fly over it to land in Karnataka, which was well endowed with tank irrigation, and, hence, wetlands. For example, bar-headed geese (*Anser indicus*) were seldom recorded in Maharashtra before Independence. Now this rare, handsome goose is increasingly visiting this state to spend winter in some irrigation reservoirs. In recent years their number has gone up from about 80 to around 500.[1]

Birds have been observed on a string of human-made wetlands along the Pune-Solapur road east of Pune city. In winter these shallow waterbodies offer a spectacle of huge bird assemblages consisting of a variety of species — herons, storks, spoonbills, ibises, ducks, cranes, waders and flamingos. These human-made reservoirs of Saurashtra, Rajasthan, Haryana, Punjab, Madhya Pradesh, right down south to Karnataka, Tamil Nadu and Kerala offer refuge to thousands of birds. These include pelicans, black-necked storks and snakebirds, which are on the list of globally threatened species.[2]

THE IMPORTANCE OF BEING SHALLOW

It is the shallow waterbodies that attract birds and numerous other life forms. Deep reservoirs and deeper portions of lakes are not rich in biodiversity. This is because with increasing water depth, light penetration decreases rapidly as does oxygen. As anaerobic conditions are created, plants and animals find it difficult to get food and survive. Deep lakes tend to be biological deserts and food chains, from simple to complex, fail to develop. Efforts to establish a fishery in such lakes are generally not successful.

Human-made reservoirs offer refuge to several bird species. Migratory birds now visit these wetlands, often in states they never visited before

On the other hand, light penetration and supply of oxygen are both adequate in shallow lakes for the development of complex food chains. These constantly react with biotic elements, leading to changes in water chemistry and edaphic factors. The water inputs and outputs, water level fluctuations and the water residence time make these waterbodies biologically very active. Unfortunately, these ideal conditions are fulfilled at few human-made waterbodies. The purpose of human-made reservoirs is to provide human needs for drinking water and irrigation and, hence, the input-output regime is geared to human needs. Thus, when a storage is created by obstructing the course of a stream or river,

Table 1: Wetland types
Wetland information at a glance

Wetland type	Location	Wetland values	Wetland uses	Measures required
Glacial lake, Tarn	Glacier	River recharge	Conservation	Protection
Headwater wetlands	River source	High biological value, wildlife value	Maintenance of springs	Restoration of forest
Steep gradient rivercourse	Source region	High biological value, flora and fauna	Fish spawning	Maintain flow, forest
Ponds and springs	Near hill settlement	High biological value, wetlands, drinking supply	Drinking water supply	Maintain springs, prevent bathing, washing
Village pond	Below hill slope	Storage, percolation	Water supply, regeneration	Maintain catchment, banks, prevent siltation
Barrages/dams in hills	Valley between two hills	Storage	Water supply, hydroelectricity	Maintain catchment, prevent bathing, washing
Percolation tank	On gentle slopes	Groundwater recharge	Supply to wells	Maintain natural habitats, reduce siltation
Adjacent river basin	Level land below hills	Groundwater recharge, hyporheic zone maintenance	Fish, crabs, riverine vegetation	Maintain flow, banks, buffers and habitats
Floodplain wetlands	In the floodplain	Groundwater recharge, flood control	Fish, tourism	Prevent siltation and pollution, maintain habitats
Human-made reservoirs	In the plains	Storage, fish and wildlife value	Drinking water, irrigation and hydroelectricity, tourism	Prevent siltation and pollution, maintain habitats
River basin between two reservoirs	Plains	Groundwater recharge, maintain water quality	Biodiversity, aesthetics, health requirement	Keep buffers and greenways, filters and natural habitats
Canal-side seepage	Plains	Marsh values, if properly managed	Fish, crabs, aquatic vegetation	Prevent pollution
Canal-fed reservoirs	Canal system	Storage, fish and wildlife value	Fish, thatch production	Prevent siltation and pollution
Deltaic wetlands	River deltas	All wetlands values	Water supply, flood and sea ingress control	Maintain quality of water habitats
Lagoons	Near the seashore	All wetlands values	Water supply, flood and sea ingress control	Maintain quality of water habitats
Creeks, mangroves	Near the seashore	High biological value, high productivity	Fish, marine animals, fuel-wood, timber, fodder	Prevent pollution, streamline shipping
Near-shore shallow marine areas	Near the sea	High biological value, high productivity	Fish, marine life	Maintain buffers, follow Coastal Regulation Zone (CRZ) rules strictly

Note: *This is not a comprehensive or complete table. It only shows how the data should be arranged to improve understanding of bureaucrats, politicians and indeed all those who have no idea of the wetland concept.*

flows and floods are stored and not allowed to perform their natural functions. Natural aquatic ecosystems, through their most important characteristics of flow and flood, maintain a stream flow, attenuate floods, replenish and recycle nutrients, recharge groundwater and provide habitats to many life forms. When flows are converted to stagnation and floods are not allowed to perform their functions of cleaning and replenishing river basins, the normal, natural regime of an aquatic ecosystem changes, affecting water quality, channel geometry and riparian zones, floodplains and even deltas. This drastically transforms riparian and in-stream habitat conditions, destroying their life-support systems, especially vegetation, and creating different temperature gradients. If such changes are drastic, the aquatic ecosystem fails to support biodiversity. Human-made waterbodies then do not attract waterfowl and other fauna. All over the world, therefore, efforts are afoot to bring the aquatic ecosystems back to their natural regimes and functions as far as possible.[3]

All our aquatic ecosystems are under increasing human impact. If we examine them from their source in

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Birds are the natural inhabitants of the wetland ecosystem. Home to rich biodiversity, if the ecosystem is not well maintained, this biodiversity declines

the mountains to their ultimate dissipation in the sea, there is hardly any kilometre (km) distance where some kind of human activity is not impacting them. The source region of rivers and streams where the stream picks up nutrients and sediments and has a high velocity and erosive force, needs to be covered with dense vegetation to gather precipitation, take it down underground and release it throughout the year through springs. This is the region where wildlife values are high and is a breeding ground for many life forms. The cutting of forests, shifting cultivation and grazing have impoverished these zones, dried up perennial springs, increased runoff, leading to silting of reservoirs built near the borders of hills and plains.

RAY OF HOPE

Some communities have wisely protected wetlands, where it is still possible to find extensive biodiversity. The village community of Tekpowale, about 70 km west off in the Western Ghats, in a remote corner of the Panshet dam, protects the stream source. The sacred grove surrounding it is a wonderful gene pool, albeit surrounded by a biological desert due to the cutting down of the forest for shifting cultivation.[4]

On the hill slope below the grove, the villagers have excavated a pool, impounding the crystal clear water of the stream. This pool supplies the drinking water needs of the village all through the year. No one is allowed to use this water for other purposes such as bathing, washing, irrigation or any other use. The water trickles down the slope through a small outlet. The pool's surroundings are forested, providing the water with ample supply of fallen leaves, twigs and soil nutrients. The shade of trees keeps the water temperature low. Such conditions are extremely conducive to biodiversity regeneration and the pool is home to large-sized *mahseer*, the renowned game fish of these hills. Villagers do not allow fishing in the pool. The biological control over the fish population is exercised by a pair of brown fishing owl (*Bubo zeylonensis*) who live in a large fig tree overarching the pool.[5]

Unfortunately, the other villages have not followed this example and have cut down forests on hilltops for shifting cultivation, which became widespread when the dam submerged their fertile lands in the valley. Non-governmental organisations trying to help these dam-affected people should try to emulate those villagers by restricting cultivation and grazing on hilltops, allowing the regeneration of vegetation which will help make the springs perennial, and alleviate the acute drinking water shortage from which they suffer. Community-level protection will enhance biodiversity also.

Once communities protection of hill slopes is ensured, state irrigation departments can excavate small pools to impound streams. This cost-effective measure will go a long way in supplying drinking water to hill residents, and will lighten the load of women who have

to walk long distances, especially in summer, to get drinking water.

To conserve and enhance biodiversity it is important to wisely manage our streams and rivers. Wetlands — artificial and natural — should become an integral part of water management. Today, examples of biologically rich wetlands and waterbodies are considered for conservation and protection in isolation, giving little importance to, or recognising, the linkages these have with the stream and river systems. The Keoladeo Ghana National Park, the Harike wetland, Loktak lake and Chilika lake are some examples of these. These conservation efforts are not coordinated with the work of river managers. It is difficult for the irrigation departments to reconcile biodiversity needs with the needs of human beings. Let us see how this can be brought about.

Even near the source of the stream, water can be wisely harvested. As the stream goes down the slope towards the plains, it gives rise to a number of habitats including rapids, pools, crevices in rocks, boulder-strewn basins and the cover of typical bank vegetation. These are home to numerous life forms, from tiny invertebrates, to reptiles and mammals. These are their breeding areas also. It is, therefore, necessary that these habitats and bank vegetation are diligently protected. Their importance is hardly understood today. There is no government agency which is entrusted with this task. Local communities and non-governmental organisations working for catchment area development should recognise their importance and afford them the necessary protection. Sanctuaries and other wildlife protection areas may harbour such habitats within their boundaries. Forest and wildlife departments should also recognise their importance and manage them accordingly.

As the stream proceeds towards the plains it increasingly meets obstacles, the velocity decreases and sediment deposition rates increase. Human settlements grow alongside it, collecting its water and sediment in village ponds. Even large dams are not built at appropriate neck-points. They store floods and release them in dry months. They submerge the narrow alluvial floodplains of these streams and spread their tentacles far and wide, deep into adjacent valleys. These far flung reservoirs present a magnificent spectacle, during and after the monsoon period. But in summer, with all water drained out, the valley submergence area is a biological desert with not a blade of grass growing anywhere. If shifting cultivation is practised in the catchment, the rate of siltation increases in the reservoir. The silt, however, quickly degenerates in the anaerobic conditions created by these deep reservoirs and becomes useless for regeneration. These deep reservoirs have very little biodiversity value as a result.

Thought biodiversity restoration in such waterbodies is difficult and expensive, cost-effective measures can be attempted. Generally, reservoir waters extend into the side valleys where mountain streams empty into the reservoir. If a low barrage or cascade dam is built across

ARVIND YADAV / CSE

Pelicans – resident of wetlands

such a stream, it creates a shallow waterbody (wetland) which remains in existence for a few months after the monsoon. This can help fish spawning and rearing which then can get some food, something that the deeper portions of the reservoir cannot provide. This has happened in the Koyna reservoir in Maharashtra. On the advice of the author, the irrigation department of government of Maharashtra has built a cascade dam in a side valley of Chaskaman reservoir (about 70 km northwest of Pune) which has become a breeding site for indigenous stream fish.

Bank stabilisation measures are also essential on these valley reservoirs. Caving-in of banks due to cutting of vegetation is a common feature. Small trench and contour *bunds* along the submergence periphery; planting of grasses and shrubs to hold soil; and, tree-planting above the high flood level will stabilise banks. By the shade these trees provide, the water temperature is reduced, providing a basis for biodiversity regeneration.

Such work does not form part of the present system of reservoir management. Bank stabilisation should be an essential part of management and funds should be allocated for this work. This will reduce siltation and protect the life of the waterbody besides helping biodiversity. Such work has been taken up on the periphery of the Panshet reservoir. In the last 12 years a mini-forest has developed on the reservoir bank. Birds, reptiles and herbivores such as the barking deer have found a refuge there.[6] Downstream of the dam, the surroundings fall prey to a lot of blasting, digging and excavation. These areas include bare hill slopes, depressions and quarries.

POSSIBLE SOLUTIONS

Whenever excavation and digging takes place, it is essential to separate the topsoil layer and use it later to cover heaps of rubble and other debris. Even a thin layer of soil spread over these is enough to produce conditions in which herbs and grasses, fungi and lichens can germinate. These start the decomposition process and produce conditions for germination of perennial vegetation. The whole area can be greened within a short time, as has been done downstream of Chaskaman dam.

A lot of water oozes out of dam walls, either as a leak or through its galleries. It can be diverted to fill up depressions and quarries, and with inflows and outflows a viable system of wetlands can be established. An experiment was conducted downstream of Panshet dam with the involvement of the irrigation department. A series of low *bunds* created five ponds which are fed by an outflow from the dam. The water flows into a quarry which is connected to the river. The whole area is protected from grazing and cutting of vegetation. Between 1995 and 1998, this wetland became a breeding ground for riverine fish, sustaining a varied habitat pattern. The area now has over 300 species of plants, only about 20 of them planted as saplings, the rest being natural regeneration. Terrestrial and water snakes, monitor lizards, freshwater turtles and birds such as egrets, pond herons, chestnut bitterns, spotbilled ducks, lesser whistling teals and kingfishers are present. Once a stony, barren valley bottom with all its soil layer removed for dam building, it is now rich in biodiversity. The local communities are given the benefit of fishing and grass cutting. With protection the quality of grass has vastly improved, compared to times when the area lay unprotected and grazing was unregulated.

PUNE'S PRIDE?

Pune is situated on the confluence of two rivers. As the city started to grow industrially in the 1970s, the rise in population and hutments started impacting the rivers. The underground drainage system began to collapse by the sheer weight of the sewage generated. The rivers began receiving an increasing load of sewage leading to water quality deterioration. Natural vegetation and habitats around the rivers vanished. In 1954, a botanist had collected over 400 species of plants in these river

T ACHARYA

The heavily polluted Mulla-Mutha river in Pune has been reduced to a mere receptacle of the city's waste

basins. In 1982-83, when I carried out a survey, their number had declined to less than 150. The proportion of plants we call weeds had increased in the total. The biological oxygen demand (BOD) of water was far beyond acceptable limits and oxygen content low.[7] The once-thriving riverine fishery was no more and the aquatic life consisted mostly of invertebrates, which could tolerate low levels of oxygen. With this background, we prepared a plan to develop the riverfronts of Pune. The plan aimed at rejuvenating natural habitats along the river and yet providing for, and streamlining the uses that the citizens made of the rivers. In the plan, space was allocated for regeneration of bank and other riparian vegetation, parks and gardens, open space for school playgrounds and public outdoor relaxation, for an aquatic bird sanctuary as also for bathing, washing, cleaning of vehicles, religious rites, even for vehicle parking. Care was taken to maintain a flow of fresh air from the west using the river basin as a corridor. This was to reduce atmospheric pollution and disperse vehicle emissions. The riverfronts were designed to revive nature, provide public amenities and encourage healthy recreation.[8] Unfortunately, such planning was unheard of in those days. Even today the Pune Municipal Corporation is debating whether to commercialise the riverfronts by allotting space to hotels, recreation parks, aquatic sports or to treat them as a public amenity by controlling pollution. Meanwhile, the river and their surroundings continue to deteriorate.

Reservoirs built in the plains are generally shallow waterbodies, evoking many functions of wetlands. However, they also act as sinks, collecting sediments and point and non-point pollution from their catchments where human activities are carried out. For example, a lot of untreated sewage and industrial effluents from Pune city flows into the Ujni reservoir, 100 km east of Pune on the Pune-Solapur road. Ujni also collects runoffs from irrigated agriculture (sugarcane and vegetables) and chemical plants located in its immediate vicinity. The BOD is high. Vegetation and habitats along the river and streams are mostly destroyed. Water in village wells showed faecal and chemical contamination. A survey of peripheral villages indicated high incidence of intestinal diseases.

NOT SURPRISING

Between 1985-1987, the Wetland Management Committee of the government selected 10 wetlands to prepare master plans and develop them. I got an opportunity to develop a master plan for Ujni reservoir. It aimed to reconcile humans and wildlife through habitat development in and around the reservoir.[9]

The reservoir attracts a large number of waterfowl as it lies on their western migratory flyway. It also sustained a fishery, depending on fingerlings from Calcutta after indigenous species' breeding habitats degraded. Resident birds lacked breeding sites. The availability of foraging habitat varied with the water level, itself depending on irrigation and drinking water demand. Eutrophication encouraged weeds like *Ipomea carnea*, *Eichhornia crassipes* and *Paspalum sp.*

The plan studied the needs of people, of birds and other aquatic life, water levels and its chemistry. Then a mosaic of habitats near the reservoir periphery was developed as a demonstration projects. Weeds were manually removed and a part of the submerged area was prepared for natural regeneration. Islands were built for bird-use and saplings planted as future nesting trees. Small earthen barrages were built to make shallow ponds with undulating and rough substrate to provide suitable areas for fish spawning. Wet and dry meadows, bank vegetation, riverside trees and shrubs and an energy plantation were put in place to satisfy the needs of local people. Improved varieties of grass, indigenous trees and medicinal plants were planted. The aim was to put the reservoir waters to multiple uses.

Initially we had excellent local cooperation with control of overgrazing and tree-cutting. The results were apparent in the first year itself. With the removal of weeds excellent aquatic vegetation regenerated (*Cyperus* and *Scirpus spp*) and the fish ponds attracted many indigenous riverine fish. The villagers had a field day collecting fish when the ponds began to dry out. Islands began to be used by birds for resting and loafing. Birds that resorted to an island to nest were protected from grazing animals and pariah dogs. With saplings showing remarkable growth, it looked like the habitat pattern we had in mind was taking shape and would develop on sound lines. However, a government resolution that called for the creation of a bird sanctuary on the reservoir — thereby restricting peoples' activities and landuse — aroused the anger of local communities who directed their ire against the project. The agitation that followed destroyed this constructive work as local communities went against it.

It was the result of the usual government practice of refusing to take people into confidence! In any case we had the satisfaction of witnessing the rejuvenation of nature in and around a large human-made waterbody.

There is, however, a silver lining. This experience shows that though humans have radically transformed the character of aquatic ecosystems in India, scope for restoring nature is immense. This work is labour-intensive but compatible with our cultural ethos and, if properly handled, can generate employment. It will help rejuvenate natural resources, improve water quality, revive underground sources of water, supply basic necessities of life, bring down prices in the market, and enhance biodiversity qualitatively and quantitatively. ■

Participatory Watershed Development: An Institutional Framework

Panchayati raj *institutions offer a platform for devolution of power and community empowerment*

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Development of Total Watershed Planning (TWP) requires participation of people at every stage, from conceptualisation and planning to execution because TWP entails vital questions of location-specificity, equity, access to common property and regulation of end-uses, which imply that the usual top down technomanagerial approach cannot work. The question is not merely one of an efficient delivery mechanism. Rather, it raises a range of issues concerning the sociopolitical framework of empowerment, within which the alternative growth path, with people at the centre, can become a reality. To be the vehicles of a fundamental social transformation, development programmes must be conceptualised as part of a process of community empowerment. To move towards such a conceptualisation, we need to examine the respective roles that different change agents will have to play in this context.

There is universal agreement regarding the failure of government agencies in executing watershed programmes. A Vaidyanathan, an irrigation economist, narrates the problems that arise in the implementation of watershed programmes by government agencies. Lack of effective coordination between different departments trying to tackle an activity involving a multiplicity of disciplines, and a unified approach, is seen as the critical bottleneck.

We live in an era of liberalisation. But it is also the era of non-governmental organisations and the 73rd Constitutional Amendment which empowers *panchayati raj* institutions (PRIs). In this paper, we suggest that there could be dangerous ways in which the two may end up meaning the same thing! In the present climate of liberalisation, advocacy of *panchayats* and non-governmental organisation (NGOs) should not become a pretext for the withdrawal of the state from spheres of action where its role is both indispensable and irreplaceable. A global consensus is emerging towards abandoning of state economic dominance. Dismantling of unnecessary and inefficient controls is seen as unshackling the forces of creativity and enterprise. However, we must not lose sight of the other critical element of the emerging global consensus: That the state must not abandon its crucial role in constructing social safety nets for the poor who have to often bear the brunt of the reform process and that the state must ensure a sufficiently high level of investment in the social sector. Market forces and the private sector will not do this, the state must.[a]

The aim must be to gradually move towards what has recently been described as 'the post-bureaucratic or interactive' mode of implementation, 'in which everyone takes responsibility for whole'

With the passage of the 73rd Amendment, a somewhat naïve and widespread presumption has arisen that decentralisation of power has occurred. But our three years' experience of *panchayati raj* in Madhya Pradesh suggests a different understanding. A constitutional amendment is only the start of a long journey in the direction of decentralisation and people's empowerment. In the short run, in states like Madhya Pradesh, it has only meant that the local political elite has consolidated its power. Generally, the lower the degree of prior political conscientisation of the people, the more ineffectual has been the coming of *panchayati raj*. To break the nexus of power relations characterising India's rural areas, especially tribal areas in transition, the state must intervene, particularly where grassroot political forces are weakly organised.[b] This does not mean that we are advocating a continuation of the present mode of state intervention. Indeed, the precise role of the state needs to be completely redefined.[c] Representatives of the state machinery in the most backward regions of India will

have to completely relearn how to interact with grassroots organisations (GROs), PRIs and scientists, in a new institutional context and mechanism for change.[d,e] The aim must be to gradually move towards what has recently been described as 'the post-bureaucratic or interactive' mode of implementation, 'in which everyone takes responsibility for whole'.[f] This requires that the community is revitalised and empowered to exercise control and vigilance over resource use. Such a vision presupposes a great deal of spadework — mobilisational, technical and institutional — directed towards the empowerment of the people. For this, the strengths of various potential agents of change must be fully utilised in a way that they complement each other without making the mistake of attributing to agencies roles which they simply cannot fulfill. In our view, government, NGOs and PRIs need to come together synergistically to contribute to the success of this endeavour — each has a role to play which is as indispensable as it is unique.

POINT OF DEPARTURE: CONTEMPORARY TRIBAL TRANSITION IN INDIA

All these considerations apply with even greater force to *panchayati raj* in tribal areas. Any such attempt must begin with an understanding of the *differentia specifica* of tribal transition in India today. With this backdrop one can appreciate the enormity of the challenge facing people's empowerment in tribal India and also visualise the kinds of intervention that may be necessary for this goal to be realised. The stereotype view of tribals as living in isolated, self-contained, food-gathering communities is no longer accurate. Tribes are in transition everywhere, moving into agriculture and subject to myriad forms of exploitation by the non-tribal majority.[g] While it is true that this transition has been taking place at different time-points, at a variable pace, and in a diversity of forms in various parts of the country, we believe that the most important features of this process can be summarised as:

- Internal colonialism;
- resource emasculation; and,
- subjugation to interlocked modes of exploitation wielded by a non-tribal axis of power.[h]

A unique feature of the geographical distribution of tribals in India is the simultaneous occurrence of great concentration and their existence as a numerical minority of the region's population. In the literature, emphasis is generally placed on the first part of this dual phenomenon without recognising that it is the latter aspect which imbues the demography of tribal India with a striking singularity. What is not generally recognised is that in most areas of tribal concentration, tribals constitute a minority of the population of the region. We have shown in great statistical detail that this is true at not only the national and state level but also at the district and block levels. The most important consequence of this status of tribals in India has been that it has prepared the objective basis for the process of internal colonisation and resource emasculation that tribal areas without exception have been subject to. While being ready targets for the exploitation of timber and other forest produce, the tribal areas of our country have otherwise largely suffered isolation and neglect. The relentless process of deforestation has both ruined original tribal habitats and forced the tribals to move out of the forests. Having first been driven over centuries to retreat into refuge zones such as hills and forests, tribals are now being forcibly pushed out of an ambience with which they had gradually developed a close relationship. Following the breakdown of their relationship with the forest, tribals in several areas have made a hesitant and faltering entry into agriculture, where the interlocking of modes of exploitation has made them immediate victims. Almost all the critical power positions in these tribal enclaves are occupied by non-tribals.

In some cases, while tribals may inhabit hamlets in which they have an overwhelming majority, these hamlets form part of a *panchayat* which include other villages, which are both much larger and have a non-tribal majority. Thus, on the whole, the *panchayat* has a non-tribal majority and it becomes open to non-tribals to contest *sarpanch* elections, thereby consolidating and legitimising their long standing oppression of the tribal people. It is also very interesting to see how the ruling non-tribal coalition is trying to draw upon the support of some of the newly elected *sarpanches* (both tribal and non-tribal).

The strengths of various potential agents of change must be fully utilised in a way that they complement each other without making the mistake of attributing to agencies roles which they cannot fulfill

Following the growing contact with market forces, the process of differentiation with tribal communities had gained momentum and that this process had gone quiet far by the time of the recent *panchayat* elections. Many of those elected as *sarpanch* belong to this elite group within the tribal communities. These tribal *sarpanches* are today, ironically becoming the lynchpins of the anti-tribal alliance, providing it with a newly acquired legitimacy in the new context of *panchayati raj*. Firing from the shoulders of these elected tribal people's representatives, is probably the most effective way for the traditional non-tribal alliance to legitimise its functioning.

Today, opposition to many people's organisations is being mouthed by a few of these *sarpanches*. The work of

these organisations has awakened a new consciousness regarding the need for transparency and honesty in the execution of development programmes. The wide-ranging people's vigilance is proving lethal for *sarpanches* who exercise control over a large corpus of development funds. Irregularities in the use of materials, manipulation of the muster rolls, non-payment of minimum wages, nepotism in selection of beneficiaries in government programmes such as Integrated Rural Development Programme (IRDP) and Indira Awas Yojana by these *sarpanches* is being openly questioned by the people. These *sarpanches* naturally turn against the GROs, which in their perception, have awakened this consciousness and courage among the people.

PANCHAYATI RAJ: A NEW PERSPECTIVE[i]

The *panchayati raj* initiative is, therefore, quite clearly stymied by the nature of existing power structures in rural India, especially in areas without much of a history of grassroots struggles. The people's representatives it has thrown up are those who occupied traditionally dominant positions at the local level. Such a perception must not, however, be taken to constitute the complete truth about *panchayati raj*. A more dialectical and dynamic view would be to perceive the seeds of change inherent within this initiative and the unprecedented avenues for social churning it creates. After all, each step taken by the state, even if it merely professes greater democracy, opens up a vista of possibilities in that direction. Every such step represents a concession the state is forced to make, in order to legitimise its existence in the eyes of those it rules — in effect, breaking new ground which can be exploited by grassroots agent of change.[j] Our view of the state must not be of a monolith, acting with single-minded purpose and in one direction. The state, especially in the remote parts of the country, must be seen as a loosely defined terrain, itself an arena for struggle.

Indian democracy derives its strength from the simultaneous operation of at least six parallel and independent processes, wherein the corrupting tendency of one institution can be partially corrected by the other five

The PRIs are best viewed as the lowest but most important rung of the state structure, and offer immense possibilities of carrying forward the movement towards empowerment of the rural poor. Indeed, in order to place PRIs in the right perspective, we must take cognisance of the fact that Indian democracy derives its unique strength and impulse from the simultaneous operation of at least six parallel and independent processes. Parliament, which is the analogue of the PRIs at the national level, is only one of the six, the other five being the judiciary, bureaucracy, media, professionals (such as academics and intellectuals) and citizen's groups (such as NGOs and trade unions). It is true that corrupting tendencies necessarily characterise any structure of power and this has been particularly true in the recent history of Indian democracy for each of these six institutions. But it is also a fact that each of these six elements has, to a greater or lesser degree, exercised a corrective influence on such tendencies in every other element.

It is equally essential that, therefore, all these six processes are activated at the district level as well, even while giving primacy to the role of the PRIs. In our preoccupation with the *panchayats*, we must not overlook the extremely vital and indispensable role of these other five institutions, whose activation would give true life to the PRI process. It is unfortunate that these are generally quite dormant at local levels, especially as one moves into the remote tribal tracts. Empowerment of the *panchayats*, therefore, must entail strengthening of all six processes and making them accountable to the people. In fact, for the full potential of PRIs to be realised, at least two vital inputs are required to be derived from the other five processes:

a) A powerful grassroots initiative towards a pro-poor alliance, deeply sensitive to the women's questions; and,
b) a strong thrust towards technical capability enhancement to effectively empower PRIs to carry out the responsibilities being devolved upon them.

NEEMKHEDA: COLLECTIVE INSTITUTIONS FOR REGULATION OF COMMON PROPERTY RESOURCES

The most important common property resource (CPR) of any watershed is water and conflicts over its distribution are a familiar characteristic of any economy based on private property. The Neemkheda watershed was no exception.[k] The *nullah* running through the village is about 1,000 metres (m) long. Farmers have fields on either side of the *nullah,* through its entire length. Over the years, the rich, especially non-tribal farmers on the upstream side, had constructed underground channels (*naardas*) from the *nullah* to their wells, which meant they could make a permanent, continuous withdrawal of water from the bed of the *nullah.* Farmers also used electric pumpsets and diesel engines to draw water from the *nullah* surface. As a result, no water was left for downstream farmers in recent years. The *nullah* would also dry up soon after the monsoon was over. While the upstream farmers' lands are in a geological zone which is rich in groundwater, the opposite is the case for downstream farmers, who are all tribals

and among the poorest in the village.

When Samaj Pragati Sahayog (SPS) started work in the village in 1992, there was a great deal of agitation over the issue among the people. The village was riven with conflicts but the division was essentially between the rest of the village and a small coterie led by the richest non-tribal farmer, a moneylender and a highly influential tribal *panchayat* leader (the *sarpanch* of the village *panchayat* till 1994 and since then the vice-president of the Bagli Janpad Panchayat).[l] This coterie, constituting just ten per cent of the population, had traditionally ruled the village — as decision-makers, employers, and moneylenders, forming an axis of influence dispensing favours and also in dealings with the world outside, such as with the forest and revenue bureaucracy, the police, courts, cooperative societies and *mandis*.

A four day non-violent *satyagraha* galvanised the village and united the village against the ruling coterie. This wore down the opposition and dwindled their support

Since we were taking up a number of works to treat the catchment of the *nullah* and also impound its flow, we were particularly concerned that the benefits of these activities should not be cornered by a rich, upstream minority. A large majority of the villagers had a very fine understanding of the intricate ecological relationship between the water of the *nullah* and the village groundwater. Our organisation had used various government schemes to excavate, deepen or repair wells of virtually every farmer in the village. The people of the village were quick to sense that this increased extraction of groundwater could have an adverse impact on *nullah* water flows. But they also saw that that there was now a reduced need to depend directly on the surface of the *nullah*. At the same time, works on the *nullah* which impounded and slowed down its flow, would help recharge the wells and maintain the balance of groundwater. Thus, in their view, it was imperative that all farmers who had constructed *naardas* should permanently shut them down. This would also enable their groundwater-deprived poorest brethren downstream to use the *nullah* water to grow irrigated crops for the first time in their lives. After concerted efforts over a period of nearly three years, a historic agreement was forged in October 1995, which was signed by 99 per cent of the co-riparians of the *nullah*.

The agreement ran as follows. All farmers will shut their *naardas* leading from the Neemkheda main *nullah*. All farmers who own wells will not use electric pumpsets or diesel engines to draw water from the *nullah*. Only those farmers who do not have wells will be allowed to take water from the *nullah* for irrigation. Even this withdrawal will be taken by rotation, in limited quantities only, and in strict accordance with collectively agreed rules. Each year, from the date when the flow in the *nullah* stops, no one will be allowed to draw water, which will be reserved exclusively for the cattle of the village.

Thus, all six *naardas* in the village were shut down using cement. All 20 farmers withdrew their engines or pumpsets from the *nullah*. For the first time in their lives, 15 downstream co-riparians were able to grow irrigated wheat and gram. The most striking elements of the agreement were:

- Conjunctive view of surface and groundwater;
- thrust towards equity by farmers, many of whom were poor tribals themselves; and,
- concern for non-human species, which is natural to tribals.

The agreement was resisted by the former ruling coterie which threatened violence (using outside elements, including the clout of the Bagli Janpad Panchayat) to destroy the agreement. The response of the village was a non-violent *satyagraha*, which lasted four days from October 17-20, 1995.[m] This action galvanised the spirit of the village and an unprecedented unity was achieved against the former ruling coterie. An informal social boycott also slowly wore the opposition down, their support dwindled and agreement won the day.[n] Actions such as these have helped forge a formal but lively structure of decision-making — the village watershed committee.[o] Today, all watershed works are carried out by this committee through a cadre of youth who are increasingly becoming capable of handling the technical, organisational, financial and mobilisation aspects that the work entails, all on their own.[p]

PROTECTING THE FORESTS: LESSONS FROM A FAILURE

However, our story is not one of success alone, and our failures are as instructive in understanding the dynamics of the interrelationships between PRIs, NGOs and the state. Apart from water, the most important CPR in a tribal area is the forest. Forest lands typically surround several villages and need, for their protection, the combined and united efforts of people from all these villages. Our attempt to help in the formation of *van suraksha samitis* (forest protection committees) was strongly opposed by the three *sarpanches* of neighbouring *gram panchayats*. These *sarpanches* were essentially alarmed at the fact that we were paying statutory minimum wages in Jawahar Rozgar Yojana (JRY) works.[q] Their aim was somehow to thwart the expansion of our organisation into more villages of the area.[r]

This was a tactical ploy, which succeeded to some extent, because of the logistical problems in enforcing

regulated access to the forest, in the face of a corrupt — at best quiescent — forest bureaucracy. As is well known, forest guards in tribal areas run their own version of a licence-quota-permit *raj*, making no attempt at all to protect the forest, but only to extract a price for selective passage into it. In a situation where the relatively powerful local elements have open and unequal access to the forest, it becomes extremely difficult to arrive at unanimity in collective regulations on forest use. Indeed, since the forest borders several tribal settlements, it is hard to check those intent on violence against peoples' plantations, especially if the forest department chooses to look the other way. It is truly ironic how a bureaucracy which has evicted thousands of tribals from forests all over Madhya Pradesh, in the name of environmental conservation, refused to support a disciplined cadre of tribals trying to protect 60 hectares of forest land. They remained silent witnesses to the destruction (in August 1996) of a part of the plantation developed by the people of Neemkheda, all in the name of political expediency.[s]

LAND RECORD REFORM: SOCIETY LAGS BEHIND THE CONSTITUTION

The fact that as elementary a right as entitlement to minimum wages can provoke such violent opposition, indicates how far certain regions of our country are lagging behind the most basic provisions of the Indian Constitution. Another striking example of the same phenomenon is provided by our attempt at tribal land record reform. We found that any attempt to entitle tribal farmers to their rights in this respect, raises the same kind of storm, led by those who believe themselves to be the greatest losers in the event of such reform — the local revenue bureaucracy.

Indeed, it is fascinating to observe how this element of the state machinery is fighting for its life, as it were, in the face of the twin threat it perceives from the incipient forces of change emerging on the horizon — the GROs and PRIs. Trying to kill two birds with one stone, sections of the bureaucracy are trying to undermine the revolutionary potential of *panchayati raj* by misguiding or forming unholy alliances with gullible / pliable elements in the PRI structure against the GROs. Through campaigns of disinformation, vilification and terror, elements in the local revenue bureaucracy (backed by local political bosses) try to drive a wedge between grassroots organisations and the *sarpanches*. It is easy for these bureaucrats, who are perceived as having access to superior information, to mislead *sarpanches* into believing that GROs have drawn money away from the *panchayats*, and if they are not checked in time, GROs will usurp all the powers of the *panchayats*. Systematic terror campaigns including death threats to members of GROs have also been deployed. *Sarpanches* sympathetic to GROs are selectively intimidated into taking a stand against them. Either way, many *sarpanches* end up becoming tools in the hands of the anti-tribal vested interests and a means of countering genuine people's struggle.

SPS got a taste of this completely new form of social dynamics in tribal societies in transition during our campaign for regularising and updating land records in the 90-village tribal enclave in Bagli tehsil. The significance of this reform of records which have not

The significance of this reform of records which have not been updated for generations is probably as great as land reform in the tribal areas of our country

been updated for generations is probably as great as land reform in the tribal areas of our country. Indeed, in these areas, we should say that the real challenge is landuse and land record reform. The problem in tribal areas is not so much pure landlessness but the poor quality and low productivity of landholdings. Efforts of tribal farmers to raise yields are thwarted by the fact that they do not have a proper title to land which they have been tilling for years. As a result, tribals were deprived of all the rights of farmers — unable to access credit, electricity or agricultural inputs and deprived of benefits of various anti-poverty programmes.

SPS, in association with a dynamic collector of Dewas district (in her first posting), set about trying to correct the situation in January 1995. It was decided that a land records camp would be organised in village Neemkheda where people from all 90 tribal villages would be invited. Our contacts in the area had suggested that at least a few hundred people would turn up for the camp. Straightaway, the sub-divisional officer (revenue) of Bagli tehsil denied that there were any outstanding cases at all. The collector, however decided to go ahead just to see what happened. On January 7, 1995, over 5,000 people thronged the small tribal village of Neemkheda and the work of the *patwaris* carried late into the night, so much so that it had to be carried forward into the next day! Arrangements for the 15 *patwaris* to work were made by the people of the village in their own houses. Members of SPS, assisted by college students from Indore, all of whom had been trained to read and understand the Land Revenue Code, acted as the watchdogs, as the government reached the peoples' door.[t] The sub-registrar set up office in Neemkheda and created history of sorts by undertaking registration of land transactions under the open blue sky — at the correct rates, too.[u] The camp was such a success and

there were so many cases still outstanding that the collector announced another camp 15 days later, and so on, till the entire backlog was cleared. The camps (three in all) attended by more than 13,000 people from over 60 villages, created a storm in the local revenue bureaucracy. The distribution of 600 land revenue books was estimated to have itself caused a loss of Rs 30 lakh to the officials, since the 'market price' of each book (virtually free, in fact) was cited as Rs. 5,000 .[v]

The sub-divisional officer (SDO)-revenue decided that he had had enough and prepared to take matters into his own hands. Exploiting his great hold over the newly elected *sarpanches* and the Bagli Janpad Panchayat (of which he was the chief executive officer), he mobilised *panchayat* opinion against our organisation, drawing in a powerful local politician in the process. Representations were made to the chief minister against us, based on a range of trumped up charges of corruption and alleged humiliation of the *panchayats* by our members. This campaign of the SDO was a great challenge to our work and he soon began to operate in close tandem with those opposing us in Neemkheda.

This proved to be his undoing. The village was coming into its own, gaining in renewed self-confidence. Over time, a majority of the *panchayat* leaders were convinced that the allegations against us were false and ill motivated. A team from the *zilla panchayat* made an enquiry into the charges levelled against our organisation and completely cleared us of all charges. The team concluded that a handful of *sarpanches,* who were themselves averse to paying minimum wages, were behind the opposition to our work. They urged the *sarpanches* to give up their prejudiced positions and work in close cooperation with our organisation for the development of the area. By establishing a direct link with the *panchayat* leadership, we were able to dispel many of the misgivings spread by negative elements in the bureaucracy. Gradually, most of these *sarpanches* have been able to see the value of allying with us, and more and more of them invite us to work in their villages. In fact, the opposition to our work has proved extremely useful in helping us clearly identify the most promising, honest and committed *panchayat* representatives, who are now becoming the core cadre of our organisation and constitute a potential tribal leadership of the area, which can pose a real challenge to the traditional axis of power, especially with the enactment of the Sixth Schedule.

BHURIA COMMITTEE AND ITS AFTERMATH

Gradually, we have realised the need to focus our empowerment programmes not so much on the *sarpanches* but the *panchayat* as a whole and even more than the *panchayat,* in the ultimate analysis, on the *gram sabha* (village assembly). For it is really only the *gram sabha* which can accurately represent the interests of the village. Hopes in this direction soared with the finalisation of the report of the Bhuria Committee of members of parliament and experts set up by the ministry of rural development, government of India, to make recommendations for extending *panchayati raj* to scheduled areas. As a principal architect of the Bhuria Committee report on extension of *panchayati raj* to scheduled areas remarks:

> "There is only one remedy against the authoritarian ways of a representative system. The representatives must be made answerable to the *gram sabha.* This is also the tradition of the tribal society. The tribal people want to maintain this tradition. Therefore, at least in tribal areas, all powers in the new self-governing system should be given in accordance with their tradition to the village community and not to the elected *panchayats.* In principle, the status of the village *panchayat* in the village should be that of a committee which may be assigned specific tasks by the *sabha* to be executed on their behalf under their direction. The *panchayat* will act on behalf of the village community only until the community so desires" (Twenty-ninth Report of the Commissioner on Scheduled Castes and Scheduled Tribes, 1987-89, p.365).

After a great deal of procrastination, in late 1997, parliament passed a law which supposedly puts the recommendations of the Bhuria Committee into effect. However, it is extremely unfortunate that some of the most important suggestions of this committee have been overlooked in the Panchayats (Extension to Scheduled Areas) Act, 1996. For example, there is no mention whatsoever of the autonomous district and sub-district councils recommended by the Bhuria Committee, which were meant to take care of the problems arising out of tribal enclavement. The powers of the *gram sabha* have also not been adequately strengthened or codified, relegating it to the status of a consultative, advisory body without the necessary teeth, economic resources or powers of implementation. Thus, tribal enclavement and differentiation are both likely to jeopardise the functioning of the *gram sabha* in its present form.

NGOs TECHNICAL EMPOWERMENT ROLE

A pertinent question is whether the *gram sabha* (or even the *gram panchayat*) possesses the requisite skills and competence to carry out the massive responsibilities being loaded on to its shoulders. This is another crucial dimension of the role NGOs and people's organisations have to play. Such organisations can assist in the enhancement of the capability of *gram sabhas* in a

range of activities so as to enable them to discharge their functions effectively. Right from resource mapping, land literacy and planning of works to their execution and evaluation and accounting, there is need to empower specially-gifted and motivated members of the *gram sabha*. This can be effectively done by GROs who have won the confidence of the *gram sabha.*

Rural, especially tribal, people are repositories of a unique and remarkably advanced understanding of the intricate workings of the natural ecosystem. The process of empowerment must entail the restoration of self-confidence among the people regarding their own immense capabilities. However, given the relentless march of technological processes and new forms of state intervention, it is clear that any narrow romanticisation of such a perspective would be fatal. Effective empowerment of the people necessitates technological capability and development and leadership formation, with an enlarged awareness of the unremitting evolution of legal and administrative structures which increasingly impinge upon their lives. We believe that such dissemination has today become an essential prerequisite for, and also carries within it the seeds of, the demystification of expertise which is an imperative of a truly democratic society.[w]

What we envisage are people's organisations run by resource personnel who are capable of mobilising both scientists in different disciplines and the village people to harness together their respective insights to develop and implement real solutions to the problems of each area.[x] These personnel live and work amongst the people and make every conceivable effort to learn the variety of local knowledge transmitted through generations and which are today threatened with extinction by the dominant discourses of our time. The aim is to carefully document their world-view and to build upon it through a creative interaction with the insights of modern science. This also helps technology developers who want a feedback from field performance as well as more information on field conditions, which are crucial inputs for any programme of technological development.

Though tribal people have a remarkable understanding of natural ecosystems, given the relentless march of technological processes and new forms of state intervention, any narrow romanticisation could be fatal

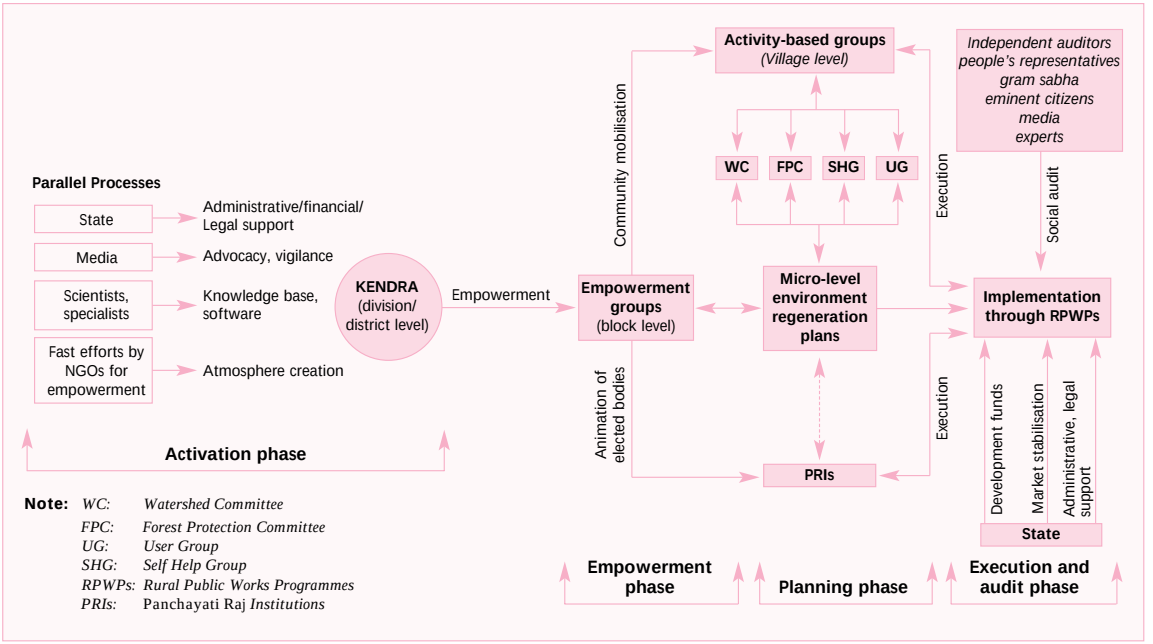
All this would help carry out detailed microlevel planning and capability enhancement necessary for *panchayats* to become genuine agents of decentralised development and for their electorate to become participants in this development process. Gradually the NGO/expert involvement, which in the initial stages needs to be more intense than at present, would be phased out. Ultimately, the process must lead to the formation of a local leadership which is capable of taking over and carrying forward development plans of the area on its own initiative and conduct empowerment programmes for people from other areas.[y]

FRAMEWORK FOR DEVOLUTION

This paper has tried to suggest a broad framework within which the modalities of cooperation between different change agents could be out for an effective devolution of power in rural India. The aim of the exercise is to achieve the empowerment of people and to enable them to carry out these programmes increasingly on their own, through *panchayati raj* institutions. However, it is shown that for such a dream to become reality, a large number of inputs from the other five parallel processes of the Indian democracy would be required in a phase which could be said to constitute the necessary transition period. The length of this period would vary across different regions of the country, but could broadly be regarded as varying inversely with the pre-existing level of mobilisation of the people.

Each element plays its own unique role in this collage of interventions, as every input is vital. SPS has seen how a grassroots NGO working in close tandem with an increasingly empowered *gram sabha* can achieve great success in handling difficult issues such as management of common property resources, equity in distribution, and regulation of end-uses. We must also acknowledge, however, that the role of the state would remain crucial for a long time to come. Our experience illustrates the fact that the state can provide great support to grassroots organisations trying to empower the poor.[z] The state also provides the resources while scientists give the technical inputs. NGOs must ensure that the allocations being made for rural development (which, though inadequate relative to requirements, are truly massive in absolute terms) actually reach the people. People's money must go back to the people. Assisted in a big way by student power from universities, they can also help develop links between field and lab, apart from mobilising the people and providing them requisite knowhow about government schemes, and the rules and procedures of *panchayati raj*. In this way, the ground is prepared for genuine decentralisation of power and effectiveness of PRIs, which must be the ultimate goal of the entire exercise, with inputs from outside sources diminishing over time.

Fig 1: New structures
Participatory implementation structure of watershed programmes through empowerment



TOWARDS A NEW STRUCTURE OF IMPLEMENTATION OF WATERSHED PROGRAMMES

A schematic view of a new implementation structure for watershed programmes is presented in *Fig 1: New structures*. Central to this structure is the establishment of a district-level People's Empowerment Kendra (centre), run by resource personnel capable of bringing together experts, administrators and the people, to act as the nucleus of the process of transformation. The *kendra's* personnel draw upon and channelise the energies released by past empowerment efforts of such literacy movements, struggles around natural resources, minimum wages and public accountability. The *kendra* carries these forward while devising its own empowerment strategies. The *kendra* also mobilises honest and committed persons in the parallel processes and draws upon the scientific expertise from universities, research institutions and NGO/GROs. Based upon these inputs, the *kendra* trains and sets up block level empowerment groups, who are to be the catalysts of change in rural areas. These trained personnel, who are the cadres of the whole process of empowerment further train village-level volunteers at two levels:

- At the community level, to set up activity-based groups (ABGs) such as self-help groups, cooperatives, forest protection committees and watershed committees. These activity-based groups are the grassroots rung of the implementation structure; and,
- at the *panchayat* level, to activate the *gram sabha* and the *gram panchayat*, building leadership potential and setting up structures of accountability.

It is this mobilisation and empowerment of village-level bodies which makes it possible to devise and implement programmes that take into account location-specificity, people's participation, equity in access to CPRs and end-use regulations. Of course, the programmes are finalised through an interactive process of exchange with the *kendra* and the district administration.

Once the plans are finalised, the implementation is done through the medium of the ABGs. Not only are the funds provided by the district administration, the ABGs receive regular assistance from agencies of the state in the form of credit support, market stabilisation and administrative and legal support in struggles against vested interests. In the monitoring and evaluation stage, the *kendra* once again assumes the central role, suggesting corrective measures and proper time-phasing of works. Finally, auditing of expenditure is also seen, not in the narrow accounting sense, but as a transparent social process, which entails the simultaneous participation of independent auditors, experts, local people, their elected representatives and the media. Undoubtedly, an unprecedented and fairly complex, turbulent mechanism, this would nonetheless ensure that the money is honestly spent in works of sound quality, which balance

AMIT SHANKER / CSE

The Neemkheda watershed was once a scene of bitter conflict and divide between the rich and poor farmers. A small portion of the population would appropriate most of the water. Through persistent efforts by the people, spanning over three years, an agreement which distributed the water more equitable was signed in 1995

considerations of long-term sustainability and popular appeal. As a final word, we would suggest that the implementation structure thus set up should include in its purview all rural development works. It would, thereby, become the kernel of a completely new mechanism of participatory development in rural India.

Notes

a) UNICEF's *State of the World's Children Report* (1992) on children's plight during the transition to a market-based economy in Central and Eastern Europe, provides us evidence of the sort of blunders we must not make in our reforms. Cuts in welfare expenditure have led to a breakdown of social security, and, in one instance to a doubling of the infant mortality rate within two years.

b) The state must be conceived of in the 'hegemonic' sense of Gramsci — as a contested terrain, but understood in a specifically Indian context, to serve the poorest and marginalised classes.

c) See Dreze and Sen 1995 (Chapter 2) regarding a discussion on the kind of role the state must continue to play in the present era of liberalisation. In a private communication, Dreze points out that even at the height of the Thatcher era in Britain, government expenditure formed 40 per cent of national income, almost double the present Indian level. Advocates of liberalisation should be asking for an increased role of the state in the Indian economy!

d) To be distinguished from a number of NGOs, who have little or nothing to do with ground realities, sometimes only existing on paper. GROs are also distinct in mobilising struggles as well.

e) It is ironic that while the bureaucracy is shedding its feathers in the urban-industrial context, the tutelage exercised by its remote, mofussil counterparts in the tribal hinterlands of India remains unbridled.

f) It refers to a body of work which has the potential to constitute a 'paradigm shift' in organisational theory. This is not the romantic work of anarchists or impractical dreamers but of people dealing with the challenges of corporate inefficiency in advanced capitalism arising from the ossification of the bureaucratic style of functioning.

g) Data from the 1981 Census show that over 93 per cent of tribal workers in India were already engaged in agriculture and allied activities, more than two-thirds of these being cultivators.

h) What is provided is a brief summary of the detailed account of these features in Shah *et al* (1997), Chapter 5.

i) The rest of the paper draws upon the more detailed discussion in Shah *et al* (1998,) Chapter 9.

j) The stipulated reservation for women, for example, is a landmark victory for the growing women's movement in India. How radical a step it potentially is can be gauged from the tussle taking place in the Indian Parliament on the issue.

k) Neemkheda is a tribal village in the Bagli tehsil of Dewas district, Madhya Pradesh.

l) Madhya Pradesh has adopted the three-tier *panchayat* system: *Gram Panchayats* at the village level (clusters of 1-4 villages), *Janpad Panchayats* at the *tehsil* level and *Zilla Panchayats* at the district level.

m) This *nijbal satyagraha* received support from eminent citizens all over the country. The spirit of sacrifice and unity of the tribals was lauded as a shining counter-instance to the growing consumerism and divisive tendencies of the late 20th century, and was hailed by Baba Amte as the beginning of a *jaldaan andolan* in India, a reminiscent of Vinoba's bhoodan.

n) In November 1995, the landowner-moneylender moved the Bagli Sessions Court against the Neemkheda water agreement and Samaj Pragati Sahayog, claiming an easementary right to the *naala* water. In a landmark judgement, after hearings lasting over a year, the Court dismissed his plea. For details, see Samaj Pragati Sahayog (1997).

o) This has become a model for other watershed projects in the area and it is hoped that the benefits of the experience will be transmitted to people all over Madhya Pradesh and beyond through the Baba Amte Lok Sashaktikaran Kendra (Baba Amte People's Empowerment Centre) being set up in Neemkheda.

p) Experience suggests that it is possible to build on the pre-existing knowledge of local conditions of members of the VWC so that, in a fairly short period of time, they become capable of handling the technical aspects of planning and construction, and they only continue to require help in measurement, accounting and book keeping. It is observed that the initial time required in capability enhancement of the VWC must be seen as a major investment in human resource development.

q) When paying statutory minimum wages was started, it was for the first time in the history of Bagli tehsil that this had happened, especially the payment of equal wages to women. The mode of payment was unprecedented, with its unfailing regularity and open procedures. There is uniformity in all the opposition faced in the way in which the payment of minimum wages to labour employed in public works keeps cropping up as the major bone of contention and source of conflict.

r) A few months earlier a *sarpanch* tried to stop deepening of a large village pond and was defeated by the organised resistance of the people of his own village. The key issue there too, had been the payment of minimum wages.

s) A local politician was backing the *sarpanches*. People's efforts can be described as a failure only if measured against the very highest standards of attainment, but the campaign achieved 60 per cent survival.

t) An achievement of the camp was the demystification of government rules and procedures by making information and officials accessible to the people.

u) The NGOs can monitor the public distribution system (PDS), especially in remote tribal areas. Efforts in this direction have made a major dent in ensuring short-run food security. All that has been done really is to first get the PDS to where it had never reached, and then to ensure that its functioning is transparent and people-friendly. For a detailed account, see Samaj Pragati Sahayog (1997).

v) The amount being shared, in well-defined proportions, by officers at different rungs of the *tehsil* revenue hierarchy.

w) A highly successful initiative in this direction was the campaign for the empowerment of all the *panchayats* in the area in handpump repair and maintenance. In a camp held in Neemkheda in December 1994, 45 tribal people, including 12 women, were trained by the tribal youth of Neemkheda, who had already received training at the Social Work and Research Centre, Tilonia, Rajasthan. In a region beset with gastrointestinal diseases, this has led to a massive reduction in waterborne infections in the last two years, with all 400 handpumps being maintained in working order by the tribal themselves (Samaj Pragati Sahayog, 1997). This has also helped the organisation gradually win the confidence of *panchayat* leaders in the area.

x) Two significant initiatives being taken in this direction in Madhya Pradesh in 1997 — the Baba Amte Lok Sashaktikaran Kendra, being set up by Samaj Pragati Sahayog at Neemkheda, and Lok Shakti, being set up in the Bilaspur Division at the initiative of the Divisional Commissioner, government of Madhya Pradesh. Both institutions aim at empowerment of cadres who will be able to carry forward development programmes on their own initiative, while preparing other cadres to do the same.

y) With the VWC gaining in confidence and capability, our involvement has been progressively declining to one of providing technical guidance and logistical support. Over time, our energies are increasingly devoted to mobilisation of villages, empowerment and research programmes, and development of computerised software for watershed planning.

z) Lok Shakti is being set up at the initiative of the Commissioner of that division, noted for his work on people's empowerment. His work shows how the system can be stretched from above, to assist grassroots struggles for change from below. So long as these officers are willing to ally themselves to such struggles, they can play an invaluable role in deepening the content of Indian democracy. ■

Enabling Law for Water Harvesting

Traditional water harvesting systems need legal support for sustainability, more so in an environment that does not favour decentralisation

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The concept of sustainability has several dimensions — technological, economic, social and political *(see Box: Nurturing sustainability)*. Given these dimensions, decentralised governance is the only solution. But its effectiveness will depend upon the legal and institutional mechanisms in place. Unfortunately, in India, not only have our laws been stumbling blocks, the efforts by the government towards decentralisation are also at best illusory.

Political sustainability is the most crucial of all aspects of sustainability. It implies that the operation of traditional water harvesting systems should acquire political acceptability and remain immune to political changes, that is, changes in government should not change the policy on traditional systems nor affect their functioning adversely.

In India, the legal framework relating to modern water technologies has its origin in the colonial period, which has been carried into the post-Independence period in an almost identical form. The framework on which water law was based in this period is the Anglo-Saxon legal system, which continues to be the foundation of the Indian legal system today.

Traditional water technologies, on the other hand, many of which go back to the era before Christ, have had their legal framework emerging from an entirely different jurisprudential base. The most significant difference between these systems of law, which has a bearing on water technologies, is the relative importance given to the two sources of law — statute and custom.

CUSTOM IN TRADITIONAL JURISPRUDENCE

Statute or legislation in the modern sense of the term is of very recent date. Custom, on the other hand, derives from a far older jurisprudence than the imported Anglo-Saxon variety, and has evolved from a system with a fundamentally different basis — a difference with regard to the sources of law.

In modern times, the three identified sources of law are statute, precedent and doctrine — in that order of precedence. But wherever precedent or doctrine contradict statute, however old, statute will prevail over the other two.

The three sources of law, in the traditional Indian jurisprudential framework are, however, *dharma* (religious moral duty), royal order and custom. A delicate balance was maintained among the three sources, which did not give authority to any one over the others. Both the ruler and the ruled were subject to the moral authority of *dharma*. However, the rule of *dharma* did not become law until it entered into behaviour and was accepted by the population as a customary rule.

The governance of water and other natural resources, being essentially decentralised in character, had its legal basis almost entirely in custom

Kingship was regarded as an institution necessary for the maintenance of social order. The ruler's function was to protect the subjects and guarantee their security and maintain public peace and harmony. This was the ruler's *dharma*. The king's authority to order was coupled with the power to impose fine and corporal punishment.

Custom was distinguished from both *dharma* and royal ordinance; *dharma* has a transcendental character, the law that "ought to be", while custom was a purely social phenomenon. Custom was known to have formed a "special law" regulating the various social groups, castes, corporations or guilds, and families in the different regions of India.

The governance of water and other natural resources, being essentially decentralised in character, had its legal basis almost entirely in custom. While royal orders relating to the management of water were no

NURTURING SUSTAINABILITY

Technological, economic and social sustainability are all interrelated

Technological sustainability

The technology of water harvesting systems is time-tested and has proven to be sustainable. Sustainability is defined as the extraction of a resource or raw material in a manner that does not exhaust the resource, nor adversely affect its natural rejuvenation.

Traditional water harvesting systems are almost entirely subject to natural rainfall patterns and are designed to collect, retain or divert only that amount of water that is seasonally made available through rainfall, which could be utilised with optimum benefits and negligible damage to land resources. Sustaining the technology itself is based on the detailed knowledge of local environmental conditions.

An institutional arrangement for traditional systems must provide the scope for the practice of this technology. That is, for the making and the observance of rules relating to the design of such systems and their management.

Economic sustainability

The economics of traditional water systems involves the investment of specific amounts of money, material and labour to harvest a particular quantum of water from which optimum benefits may be derived for the largest possible size of population for the longest period possible.

A critical factor in achieving a high input-output ratio is the size of the catchment, which determines the amount of water that is harvested. Unless a balance is maintained between the size of catchment, the quantum of water, and the inputs in constructing, operating and maintaining the system, the greatest benefit for the largest number of people for the longest period of time (between seasons of rainfall) cannot be achieved.

The main reason behind the decline of traditional water harvesting systems is the decline in economic sustainability due to the loss of balance among these factors, particularly the access to catchment areas. Institutional mechanisms to meet the requirements of economic sustainability have to provide for the sustenance of the catchment, inputs of labour, money and material, and for optimum distribution of benefits.

Social sustainability

The characteristic feature of traditional water harvesting systems has been the underlying social sanction that has supported the systems for long periods of time. Social participation in the creation and operation of these systems, significantly distinct from actions of the state, has generated and nurtured the institution of common property.

However, the concept of common property by itself does not imply equity in sharing the benefits of the system. Within a prevailing socially stratified community, commonly held values in respect of the technology and its necessity and utility have contributed to its sustainability.

Studies on traditional systems have revealed that equity is not a fixed concept. Instead, its definition is grounded in each local situation and is closely related to the technological features of the system. The practice of equity, its definition and observance, has to be part of the decentralised system of governance.

Social sustainability includes the fulfillment of the vital function of conflict resolution. This function includes the active prevention of conflicts as much as resolution of conflicts that may arise. Institutional mechanisms are required for the purpose of maintaining social sustainability of the systems. The tasks of such institutions would be:

- to promote and uphold a value system with regard to the technology;
- to address and resolve issues of equity; and,
- to manage the prevention and resolution of conflicts.

doubt employed, they were only in support of custom, and not in supercession of it.

The king's duties reveal the importance of custom as against the legislative power of the ruler. Robert Lingat, a historian, points out that the texts recommend that the king, for the protection of the subjects, must pass orders. The duty to be impartial, not to be "carried away by anger or cupidity", was enjoined upon him. The king had the authority to order and the power to punish — even impose death penalty — on anyone who transgressed royal orders. However, this undisputed law-making and judicial authority of the king did not permit him to modify *dharmic* laws. In other words, the king "should not and cannot legislate in the domain of *dharma* in general".

A similar restriction prevailed in matters related to common customs of regions and groups. Since it was the duty of the king to support *dharma*, to maintain public peace, he could not abrogate any custom, if such abrogation would lead to disorder in society. The custom may be contrary to *smriti* (tradition, or remembered wisdom gathered by the sages) but the king was not to intervene unless the usage was likely to create stress and discontent by reason of its immorality or unjustness among the subjects. Lingat reports that such interventions by the king in *dharma's* domain "were very rare". Where strict observance of the rules of *dharma* would lead to disorder, the king must abstain from intervention and allow his subjects to continue to observe their customs. Thus, customs of countries, castes and families and other groups were to be maintained intact. Otherwise, the public would revolt, the subjects would turn against the king, and the army and the treasury would be destroyed.

The king was also bound to respect, and to cause to be respected by others, the customs of populations living on the frontiers or in the mountains. Custom also supported the autonomous functioning of numerous autonomous bodies. The structure of the state was characterised by extensive autonomy in the functioning of guilds, corporations, artisans, religious fraternities, and local governing bodies. The conventions of these

bodies were recorded in writing, constituting their statutes or bye-laws. The king was bound to put his royal seal on these agreements, when called upon to do so, as well as insist upon these conventions or regulations to be respected by all sections of society.

Under traditional systems of governance, royal sanction gave official recognition to local regulations. The king was expected to see that the customs were observed and he could prohibit any regulations only if they were likely to breed disorder or if they were contrary to the interests of the state. This activity of the king was interpreted, not as "legislative" in the domain of custom, but as "administrative", the objective being the maintenance of peace.

Therefore, custom has always had a very important place in the Indian legal system prior to the introduction of English law. It was sustained by the ruler, as well as by *dharma*, the moral authority which activated both. Custom was "at once, a source, an instrument and a product of *dharma*". The distance between law and custom was itself a tradition in India.

CUSTOM IN THE MODERN LEGAL SYSTEM

While custom continues to be relevant in Indian society, its position in law has weakened considerably. Early Anglo-Indian case law confirmed the primacy of custom over the written law. However, English law, by reason of its fundamental difference in doctrinal foundation, interprets custom through the perspective of statutory law, through the notion of "legality", rather than the notion of "authority" which underlines Indian legal tradition. English law is founded on the primacy of written law — on statute. All other sources of law — case law, legal doctrine, jurisprudence — are only subsidiary to it. Thus, custom, even if it had been the source of law, had to be sanctified by law or statute declared by the state. The judiciary was bound to assess the legality of a custom, besides its justness. In other words, custom has no existence outside statute law. With the adoption of English law the pre-eminence that custom had in legal tradition was lost. This is of particular importance in the realm of water resource management in India, where there is a significant level of combination of old and new technologies. Water management suffers from this imposition of a dual, innately contradictory legal system.

IMPACT OF RESOURCES LAW ON CUSTOM...

The statute-centred modern legal system has had an adverse impact on customary modes of resource management.

Firstly, custom became subject to law. To uphold customary rights, these rights had to be proved according to criteria determined by the formal legal system: they have to be proved in each individual case, again and again. Formal law does not give recognition to a whole body of custom or customary law, but custom as proved in individual cases.

Secondly, customs relating to water use and management belonged to a complex and holistic system of local behaviour. Water use customs were included within customary practices relating to forest use, agriculture, and social interrelationships for a variety of reasons. But statutory laws were framed for each resource separately. Customary rights in forests were administered separately from rights to water and land, and all three were separated from family or personal laws. Thus, customs became fragmented by law.

Thirdly, customary rights were separated from duties. It was only the former which the executive regulated and the courts adjudicated upon. The associated duties which were enjoined upon users, for maintaining the systems and distributing benefits, were left to the local communities to enforce without the corresponding legal powers to regulate these rights.

... AND ITS IMPACT ON TRADITIONAL WATER SYSTEMS

British colonial administration referred to traditional water systems as "private" or "semi-public" to distinguish them from state-constructed, controlled or managed systems.

In North India, throughout the 19th century, there was no legislation specifically for traditional water harvesting systems. The first legislations in the water sector were irrigation laws, like the Northern India Canal and Drainage Act of 1873. These laws were only for canals constructed, controlled or managed by the government. Traditional irrigation systems were under revenue legislation which recorded rights, determined and collected revenue, and settled disputes through state-administered judicial institutions.

In the South, the jurisdiction of the Madras Irrigation Cess Act of 1865 extended to tanks also, but only for the purpose of collecting cess on irrigation water. The state did not interfere directly with the institutional arrangements among users of these traditional water systems, as long as mechanisms existed for the collection of revenue.

It was only in the early part of the 20th century that the question of legislation on "private" or "semi-public" systems was raised as a result of the work of the Indian Irrigation Commission of 1901-1903.

The result was the enactment of legislations such as the Punjab Minor Canals Act of 1905, UP Minor Irrigation Works Act of 1920, Bihar Private Irrigation Works Act of 1922 and Bengal Tanks Improvement Act of 1939. The main object of these laws was to give government power to exercise control over private canals and other waterbodies by interfering in their

management in cases of their neglect by users.

But these colonial legislations and the post-Independence laws, such as the Rajasthan Minor Irrigation Works Act 1953, have not been able to reverse the state neglect of traditional systems. The modern legislation has not provided support to the institutional framework of users — maintained informally to operate traditional systems.

Most traditional water systems continue to be regulated primarily by revenue laws. The post-Independence *panchayat* legislations have had provisions for the transfer of management of irrigation systems which had been taken over by the government from irrigators. However, these provisions have rarely been implemented.

DISABLING LAWS

Traditional water harvesting systems have not only been deprived of enabling legislation to strengthen, protect and promote their institutional mechanisms, they have also been assailed by a host of disabling legislations that have eroded and destroyed the arrangements that had sustained their institutions.

For instance, the state has through revenue, *panchayat* and forest legislations, taken control of catchment areas that feed and sustain traditional systems and has deprived rainwater harvesters access or control over this land.

Similarly, the law on *panchayati raj* institutions (PRIs), including the 73rd and 74th constitutional amendments, continues to make real decentralisation illusory. While state *panchayat* legislations have been amended to include the constitutional amendments, nowhere have real powers been delegated. This is primarily due to the fact that the constitutional amendment does not make it mandatory on the states to devolve powers to PRIs, but leaves it to their choice. State governments have taken full advantage of this intentional legal loophole, and have deliberately denied local bodies powers to make and enforce rules. As a result, while users are required to submit to collective discipline of maintaining the systems and distributing benefits, they are not given the corresponding legal powers to regulate these rights.

... the present system of governance in India is highly centralised. Laws emerging from the state leave no space for the exercise of self-governance by people

The government is now considering a policy of "users associations" and to transfer resource management responsibilities to these bodies. The question being discussed in policymaking circles is whether such associations should be registered or not and if they are to be registered, whether they should be under the societies registration act, cooperatives act or trusts act. None of these legislations can empower users over natural resources. Nor can this policy offer a decentralised system of governance under which local cultures of resource use and management can evolve and flourish.

TOWARDS AN ENABLING LEGISLATION

The question arises in this context as to what would be the modern equivalent of the *dharma*-royal order-custom trinity that provided the legal-institutional support to traditional water systems in earlier times.

Some common definitions of *dharma* highlight the concepts of sustainability, stability, self-restraint, self-governance and voluntary adoption of certain values, which when applied to environmental concerns, constitute the required approach.

Secondly, the characteristic feature of "custom" is that it permits localised law-making and law-enforcing norms and behaviour through localised institutions. The modern, democratic expression of this principle lies in the possibility of decentralised legislative and administrative functions. However, the present system of governance in India is highly centralised. Laws emerging from the state leave no space for the exercise of self-governance by people.

The recent constitutional amendments on *panchayati raj* remain a political gimmick as the listing of subjects for *panchayat* management have no significance unless law-making powers relating to these subjects are transferred to local bodies. The duty to prepare plans for development does not constitute decentralisation.

The principle of a unitary form of government has to be applied to define decentralisation in favour of PRIs. These institutions must be given law-making powers — in the shape of a *panchayat* list in the seventh schedule of the constitution. It is a matter of significance that, out of the 29 subjects listed in the Constitution as subjects on which PRIs may make plans, 17 relate to environment, that is, to natural resource use and management.

Unless natural resource legislations are amended simultaneously with *panchayat* legislations, to decentralise powers of control, access as well as management of natural resources to local bodies, the sustainability of traditional systems will not be possible. Under the political support of local bodies, local communities could develop their own informal institutions whose legal status need not be sanctioned by the state. Instead, the functioning of local bodies may emerge from two directions — one, from nature itself, which demands a community of interests in its interrelationship with it — and, the other, the state, which may choose to adopt a nurturing and protecting role, rather than an aggressive and antagonistic role that it plays at present. ■

Towards a Legal Framework

Traditional water harvesting systems have been victims of an indifferent executive. A revival of these systems and rights over water need enabling policies and laws

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Water harvesting is an instance of how traditional wisdom kept alive a system, which official mediocrity has now allowed to slip into near oblivion. Investigations have shown that people in South Asia evolved a water harvesting system based on the availability of a resource, its geophysical conditions and local needs. The system of water collection is ancient and was nurtured by religious edicts, prescription and social behaviour.[1] Why then did such a system, which survived for more than two thousand years, decay in a span of hundred and fifty years or so? Is it because of inherent design defects, some socioeconomic transition, population explosion, or neglect on the part of the state? As a student of law, this is a natural query of the author to find out to what extent law was responsible for the maintenance of the system, or indeed its failure.

At the outset it must be clarified that law in development is an important branch of study. The reason is simple: delinking law from development adversely affects both. Development, more than anything else, is aspiration, and when the law does not translate this aspiration into practical reality, the law slowly loses its social relevance. There are numerous examples to substantiate this viewpoint.[2] Therefore, when we deliberate upon the question of revival of a system connected with the livelihood of people, a brief examination on the role of law, in historical and present contexts, becomes relevant.

NATURAL RESOURCE MANAGEMENT DOWN THE AGES

Early and medieval period

The historical legal regime has shifted from the concept of trusteeship to the ownership of the state. The ancient laws of the Orient, like ancient Roman law, suggest that the concept of trusteeship governed the property law regime. Varuna, during the *Vedic* period, and kings in the *Vedantic* period were regarded trustees of resources like land, water and air, where their role during normal times was to promote and foster communal ownership and utilisation of resources.[3] At the same time, private use rights over resources including water was also recognised.[4] The duty of the king was to protect *dharma* which included *vyabahara* or long cherished customs of the communities. In the case of a water harvesting system, for which people donated land for the tank for common use, it was the duty of the king to protect and preserve such a system.[5]

In Hindu mythology, water was regarded as one of the holiest of all things — a sustainer and purifier. The construction and renovation of ponds and tanks was considered a religious activity. Similarly, in Islam, water was considered a perfect, indispensable and priceless element from which every living being was created.[6] The free access to and use of water was regarded as a birthright of everyone. This went against the commodification of water.[7] But with the Indian society being highly stratified along caste and communal lines, rules relating to the access and use of water were devised in favour of the higher strata of the social hierarchy.

Colonial era

The advent of the British rule in India brought a new legal regime which suited the colonial interest but was indifferent to local customs and practices. As far as the management of natural resource was concerned the emergent legal system meant:

a) *Subjugation of individual and collective rights of resource use to the unlimited power of the state*: This era marked the era of subjugation of rights. Most of the rights relating to resource management were customary rights. Under the colonial regime, these rights were possible only if they were not anachronistic to the exploitative design of the state and market.[8] The right over common lands and forest was derecognised and whatever was used as a right was now made a concession. The general legal supposition which came into being was that whatever was not recognised as private property belonged to the crown.[9]

This had a negative impact on water harvesting systems which were developed in communally-owned areas.

b) Commodification of resources in favour of the state and the social superstructure: The colonial legal regime favoured commodification of natural resources by the state. The Forest Act of 1927 transformed the right of the people to a concession and established the monopoly of the state to exploit this vast resource. Land and irrigation laws are other such examples. While, on the one hand, the law derecognised the right of the community on village commons and pastures, on the other, it emphasised privatisation of land. In the case of water, the right of the state was created to regulate the resource through legal measures. The Indian Easement Act of 1862 and various irrigation laws established the sole right of the state to regulate, collect, retain and distribute water.[10]

c) Continuous marginalisation and exclusion of a large number of people who directly depended on these resources: When the law favours the rich and the powerful, a large section of the people get marginalised. The Indian Easement Act limited rights only to those who owned land, leading to the exclusion of landless from access to water.[11] Similarly, the Land Acquisition Act of 1894 has been consistently used for acquiring land for a number of activities of entrepreneurial nature under the mask of 'public purpose'. Marginalisation and exclusion, thus, can be seen both as cause and effect for dislocation of the traditional resource management system.

Neglect of the traditional system of resource management was the combined effect of all the above.

Post-Independent India

In independent India, the legal regime of resource management is marked by various intrasystemic tensions. For instance, the general policies and principles of management of natural resources are in the preamble provisions of the Indian Constitution. The Constitution shuns any discrimination in the access to and use of water on the basis of caste, sex or religion.[12] The developmental concerns are addressed by making it a duty of the state to ensure that the exploitation of natural resources sub-serves public good, and does not result in the concentration of wealth in a few hands.[13] The Constitution also tries to strike a balance between ecological and economic interests by making it a duty of the state and the citizen to protect and improve the environment.[14]

The 73rd and 74th constitutional amendments empower the state to devolve powers to local self-government, to enable it to perform its functions and implement schemes for economic development and social justice.[15]

RICHARD MAHAPATRA / CSE

Necessity breeds ingenuity. Depending on the resources available and the ecology of the region a plethora of rain capturing systems were developed. In hilly regions of the Northeast and in Sikkim, a split bamboo often serves as a water 'channel'

However, despite this progressive framework of the Indian Constitution there exists a tension between it and specific legal prescriptions. The protection and improvement of environment would be possible only when both citizens and the state act under a defined legal space at local level, maintain effective communication, and launch coordinated actions. It is interesting to notice that despite the constitutional call, the states of the Indian federation have devolved only limited powers to the *panchayats*, and that too in varying degrees.[16]

NEED FOR A POLICY FRAMEWORK

The need for a policy framework for traditional water harvesting systems arises mainly because of the prevailing policy statements. The national water policy, national landuse policy, agriculture policy, national conservation strategies and policy statement on environment and development do not specifically touch upon the issue.

Water harvesting systems are diverse in their nature, size, number of users and ownership. For instance, there are open village tanks with or without a catchment, big reservoirs and lakes, partly dependent on rainwater and partly on spring or water sources that sprout in their bed. Some structures are privately owned but others are communally used, with or without ownership in the strict sense of the term. Then, there are tanks maintained by religious trusts. The diverse form of water harvesting systems demand a broad framework that encompasses most of the systems and is based on the premise that these systems need to be maintained with local strength and, where necessary, technological and financial support from the state.

The need for a policy framework for traditional water harvesting systems arises mainly because prevailing policy statements do not touch upon the issue

The policy framework should respect people's right to free and easy access to water. The policy should also respect the right of people to clean and unpolluted water and a healthy environment.

The policy should also incorporate the principle of equity and distributive justice in the utilisation of water and to do so, drinking water should get top priority followed by other domestic uses. As agriculture forms a key livelihood of a majority of the Indian populace, water for irrigation should get the third priority while industrial use of water should get the last priority. As water pollution is a major problem, the policy should outline stringent mechanisms against it. Recent court decisions propagating the 'precautionary principle' and the 'polluter pays' principle provide sufficient foundation for such action. The ownership of the water harvesting systems should be based on the public trust doctrine. For practical purposes, the ownership of village forests, pastures, tanks and other similar water harvesting systems traditionally used by the community should be vested with the *panchayats*. Where the ownership is private and the use is by the community, an attempt should be made to safeguard the interest of users.

In case the system is community managed, the stakeholders should be allowed to draw a work plan and to impose sanctions against violators. However, no management committee should be allowed to violate the principle of equitable distribution.

The policy should give voluntary agencies space to work with the community for the development, strengthening and revival of the water harvesting systems. Their role should be more focussed on capacity building of the stakeholders. The policy should limit the role of the state in providing funds for the revival, maintenance, and strengthening of the system and for technological assistance.[17] The state should not be allowed to acquire community systems without providing people an equally viable alternative.

The policy needs a law. A policy framework is a guideline for a possible law. Some suggestions for such a law are as follows:

Firstly, given the constitutional set up under which both land and water are state subjects, and where institutions of local self-government have been established, it would be important to improve the existing law and to empower the local institutions. In this regard, it would be necessary to ensure that these institutions and local communities work together for the maintenance, use and revival of traditional water harvesting systems.

Secondly, the proposed law should adopt a flexible framework for the management structure of water harvesting systems. There should be scope to constitute committees at different levels: a village cluster, *gram panchayat*, *taluka* and *zilla* levels.

Thirdly, the committees should be allowed to settle disputes among the users and also be given punitive powers to take up cases of frequent defaulters.

Fourthly, the committee should have its funds raised from the stakeholder and also from the contributions made by the state.

It is evident that there is a need to evolve a decentralised legal regime which empowers people and makes them real managers of the resources. And, furthermore, to assign the state a role which is facilitatory and not predatory. This is the challenge. ■

Policy Dimensions: Getting city-dwellers to do it

Facilitating Urban Water Harvesting

A policy for promoting urban water harvesting should include a mix of incentives and penalties

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Secretary to the Government of Tamil Nadu, Chennai, Tamil Nadu

The experience of Chennai shows that to promote widespread adoption of rainwater harvesting in urban areas, a number of measures need to be undertaken:

1. A single water authority or local body, as the case may be, should be vested with the control and regulation of all waterbodies, including rivers, canals, waterways and groundwater in urban areas.
2. Town planning requirements must provide a checklist of essentials in which the provision of rainwater harvesting / recharge of groundwater systems is a prerequisite for sanction of all new colonies / layouts.
3. Town planners / local authorities / municipal bodies must immediately provide for surface water percolation along roads / pavements and other open spaces.
4. All building plans must provide for rainwater harvesting structures before applications are accepted.
5. Provision of rainwater harvesting systems in plans should be followed up by enforcement, for example, at the time of grant of water / sewer connections / assessment of property tax.
6. No building / layout should be permitted to allow rainwater to flow into sewage drains or septic tank systems.
7. Builders / planners should be given clear technical guidelines on cautions to be observed in providing rainwater harvesting systems in a way that there is no contamination with septic tanks. Suitable punishments such as fines / disconnection of water supply should be provided for violation of such stipulations.
8. The local water authority or agency in charge of water supply should be held responsible for maintenance of riverways, canals / lakes / temple tanks / stormwater drains and all other waterbodies with the specific objective of ensuring that all these water carriers and bodies are used as water storages through rainwater harvesting systems.
9. Master plans for rainwater collection and use for all urban centres or groups of urban centres should be made a prerequisite for meeting the eligibility requirements of funding agencies, including Housing and Urban Development Corporation (HUDCO), state / Central government / World Bank / European Commission / Asian Development Bank and other bilateral and multilateral aid for urban improvement and urban development.
10. Misuse of waterways through discharge of sewage should be rigorously followed up with the provision of interceptory sewers / canals along waterways. This is an expensive proposition and can be taken up in a phased manner.
11. The use of waterways as water storages in urban areas, particularly where there are no other riparian or agricultural interests, should be encouraged as a source of :
    a) additional availability of water;
    b) recharge of groundwater along the waterway; and,
    c) prevention of encroachments of dry river / lakebeds during the non-monsoon seasons.
12. A large number of urban local authorities are both water-starved and cash-starved. A central rainwater harvesting fund can be set up by the Union water resources ministry offering funds on loan-cum-grant basis for the promotion of rainwater harvesting systems by urban communities, either through public, private or joint ventures of both agencies.
13. Community-based systems by residents' groups / temple authorities / non-governmental organisations (NGOs) and service organisations should be encouraged with grants / soft loans involving the local water authority and other agencies.
14. Rainwater harvesting systems must be promoted as a means of both provision of water and prevention of flooding of low-lying urban areas.

15. One of the most effective means of encouraging household and community participation is through financial instruments such as water tariffs and property tax assessments. A special rebate on property tax for setting up rainwater harvesting systems, particularly in old buildings, can be announced by urban local bodies. A water tariff structure that allows a progressive rate of incentives for effective use of rainwater harvesting systems and treated wastewater for domestic use should be considered.
16. An appropriate central authority should be nominated as the nodal agency for the dissemination of correct technical and engineering advice on structures and systems to be used, particularly in urban centres, where availability of non-paved space in residential areas is becoming a rarity. Best practices of cities and details of individual technical experts within and outside the country should be collected, collated and transmitted to urban water and planning / development agencies. The lack of a central storehouse of well-researched / documented know-how has been a serious stumbling for interested NGOs, government agencies and individuals.
17. A massive, well-designed media campaign should be taken up at the national level. A recognisable and identifiable message on rainwater harvesting schemes and incentives for the schemes require careful and immediate attention.
18. Rainwater harvesting systems and water conservation may be introduced as part of the curriculum in schools and taken up as projects under youth activities promoted by the National Cadet Corps (NCC).
19. In urban areas, industries and business houses must be encouraged both by incentives, town planning requirements and pollution control requirements to provide for:
    a) rainwater harvesting in their premises, and
    b) promoting and maintaining at least one community rainwater harvesting structure in an urban area.
20. The Central government should proclaim rainwater harvesting systems and conservation of water as a matter of national importance through significant and appropriate interventions in national programmes such as the technology mission on drinking water. The policy statement should be all-encompassing and not be confined to rural / urban areas or have any other restrictions.
21. Annual state and national awards should be announced on recognition of outstanding work. The award should be monetarily attractive with the stipulation that it may be used for water / sanitation projects.

REGULATING GROUNDWATER USE

The city of Chennai has resorted to legislative control to regulate groundwater use

The Chennai Metropolitan Area Groundwater (Regulation) Act 27 of 1987 envisages control, regulation, extraction and transportation of groundwater in the notified area through (i) registration of existing wells; (ii) regulation of sinking of new wells; (iii) issue of licences to extract water for non-domestic use; and, (iv) issue of licences for transportation by goods vehicles.

The term 'groundwater' mentioned in the act means the water which exists below the surface of the ground and the term 'scheduled area' means the whole of the city of Chennai and the villages specified in the schedule. The act, which came into force in February 1988, exempted from its purview wells used for agricultural purposes as on the date of notification and wells used for purely domestic purposes. Construction of wells for other uses was regulated by requiring a grant of permission. Extraction of water was, however, regulated on an annual basis.

The competent authority for the purpose of the Act:

- In the city of Chennai is the board (Metrowater); and,
- in relation to the villages specified in the schedule, the respective sub-collectors or revenue divisional officers of the *taluks* in which the villages fall.

In granting or refusing a licence, the competent authority has to take into account:

- Purpose or purposes for which groundwater is to be used;
- existence of competitive users;
- availability of groundwater;
- effects on sources of water supply;
- compatibility with existing water supply system; and,
- availability of factors controlling or preventing pollution.

The competent authority has full powers to withdraw or cancel the licence, if any of the provisions of the act, or the rules made under the act, or if any terms and conditions and restrictions, subject to which the permits or licences have been granted, are contravened, or otherwise not complied with.

Punishment for first offence is a fine which may extend to Rs 500, and for the second and subsequent offences with imprisonment for a term which may extend to six months or with a fine which may extend to Rs 1,000 or both. Any offence punishable under the act is a cognisable offence within the meaning of the code of criminal procedure.

A comprehensive approach is therefore necessary. The above policy initiatives can be further strengthened through legislation, legally compelling owners to build rainwater harvesting structures in all buildings. In addition, there is also the need to legally regulate groundwater use *(see Box: Regulating groundwater use)*. No amount of rainwater harvesting will be of help in a situation where there is no control on the amount of groundwater extracted. ■

Towards Community-based Rainwater Harvesting: Some Conceptual and Policy Issues

A mass movement for rainwater harvesting is the need of the hour

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India, in terms of quantum of precipitation, is a water-rich country, now facing acute water scarcity. In fact, all the 35 meteorological regions suffer from water scarcity of varying nature and dimension. Whether it is the Jaisalmer-Barmer region with an erratic precipitation of 100 millimetres (mm) a year or it is assured rainfall areas receiving annual rainfall of 1,000-2,500 mm, all are facing water scarcity. Thus, water scarcity has become an issue of great concern and consequence. Yet one can hardly notice any significant change in the overall average rainfall, though there are indications of a slight shift in distribution. Thus, it is not the precipitation pattern but changes in the hydrological cycle which appear to be a cause of the water scarcity. Neither the changes in the precipitation quantum nor the population explosion, as is commonly believed and often complained about, are the primary causes.

The process of urbanisation and industrialisation coupled with water-squandering systems of production and lifestyle have precipitated the crisis. In fact, one can already see its vocal manifestation in Kaveri, Krishna and Godavari basins. In addition, widespread wanton deforestation and loss of vegetative cover is causing very swift runoff and decreased recharge.

Effective water availability depends on the state of the various ecological entities such as soil, vegetative cover and temperature. Traditionally, the farming system was based on a sound ecological understanding of the interrelationship of the different ecological entities. But with the introduction of water-intensive cash crops, industrial production and other technological processes, the water usage pattern has undergone a tremendous change. The upshot of this is that even though long-term average rainfall is the same, the effective availability has declined.

NEED FOR PARADIGM SHIFT

In view of the serious situation we face, we must adopt an ecologically-sound approach to water resource development. The engineering methods of 'exploiting' water are most destructive of the resource. Legitimately one may ask: what is the appropriate approach? We have to begin by removing the conceptual cobwebs we have in respect to water resource planning and policy.

The central question is storage. True, there is need to store water. However, the key questions are: how much, where and in what form? The dominant model dictates the choice of building large surface storage systems. This has led to the disintegration of traditional rainwater harvesting systems and ingenious local methods of moisture conservation. The overwhelming global and Indian experience amply proves that large dams cannot cater to the needs of divergent ecosystems, terrain and topography.

MAHARASHTRA SCENARIO

Given the above backdrop, let us examine the water scenario in Maharashtra. Different agroclimatic regions of Maharashtra had location-specific systems of rainwater harvesting. Among them were the *phad* system in north Maharashtra (Nashik and Dhule), *malguzar* tanks in eastern Vidarbha, small *bandharas*, *tals* and channels in Konkan, and very effective soil profile moisture storage in Marathwada and all other vertisol areas. Through very skillful agronomic practices, very high levels of moisture utilisation and conservation was achieved. Mostly these were community-owned, managed and controlled systems of 'protective' irrigation and moisture conservation to ensure adequate biomass production and water resource renewal and replenishment. They may be called a critical life-saving irrigation system — suited to local conditions and the cropping pattern.

But these cheap, quick and safe methods of water harvesting have been deliberately neglected and allowed to fall in disuse. Currently, Maharashtra is reeling under a severe water scarcity. Nearly two-thirds of the state's 40,000 villages are suffering from acute scarcity of even drinking water. On the other hand, 76 per cent of the

state's irrigation water is used for growing sugarcane, which account for no more than 2.5-3 per cent of the total cropped area. Thus, almost one-half of the state's 100 million people and 85 per cent land is left high and dry.

Interestingly enough, Maharashtra has the dubious distinction of having one-half of the large dams of India, which itself accounts for one-half of the world's large dams, and yet we have this pervasive water shortage and scarcity. Surely, it is not due the to niggardliness of nature but the misdoing of people which is responsible for the current water chaos. The present government in its insatiable hunger for kickbacks has even played a smart trick of raising Rs 10,000 crore from the market through irrigation bonds.

THE WATERSHED

In the light of conceptual and operational issues as well as the pitfalls in our planning and policies, let us examine what is the meaning and message of the rainwater harvesting projects in Ralegan Siddhi, Adgaon and Vile in central Maharashtra, Marathwada and Konkan regions, respectively.

In the past 27 years more than Rs 6,000 crore have been spent under the EGS.... However, the objective of drought-proofing has not been fully achieved

Maharashtra's agroclimatic conditions are diverse and distinct. One important characteristic is the vast rainshadow area in central Maharashtra and recurrence of drought is common. During the early 1970s, almost the whole of Maharashtra experienced consecutive droughts. This paved the way for the initiation of the famous Employment Guarantee Scheme (EGS) in the state — the first instance of the state legally promising and actually providing employment at subsistence wages to all those who need and seek it. The basic operational framework has been that of soil and moisture conservation works for drought-proofing. This has been an attempt to do what individual farmers have been doing in their microwatersheds. Though soil conservation as a programme has been underway for a very long time, the emphasis here was on a watershed basis. It was a comprehensive approach to land, water and biomass conservation. The main provider for this programme in terms of financial and human resources was the EGS. In the past 27 years more than Rs 6000 crore have been spent under the EGS and nearly 200,000 works of land and water conservation and afforestation have been carried out. Employment of several million person-days has been provided. But, the objective of the drought-proofing has not been fully achieved. The main reason for this failure is lack of community participation. It was implemented as a bureaucratic programme of providing dole through public employment. As such, it did not become a people's programme for durable asset creation, which was its real purpose.

VESTED INTEREST

Governments dominated by the landed gentry and urban interests were not entirely willing to create a condition of stability, self-sufficiency and security of livelihood for landless labourers and small cultivators. The obvious reason is that they needed surplus farmhands as well as factory hands so that they could exploit them at low wages.

Not surprisingly, the EGS was not structured for durable asset creation through soil and water conservation, as it was conceptually designed. Operationally, it remained an adhoc 'scarcity works' programme. Hence, the EGS should be institutionally streamlined in such a manner that it becomes a task force to carry out soil and water conservation and rainwater harvesting programmes through watershed development.

In villages like Ralegan Siddhi and Adgaon, however, local leadership has acted as a catalyst and actively participated in carrying out soil and water conservation programmes in an integrated manner. Moreover, in these villages, water harvesting has been the main focus in addition to the usual soil conservation bunding works.

In this it is worth noting that the key to effective rainwater harvesting is scientific landuse planning. The *sine qua non* of alternative landuse planning is rainwater conservation. In this respect, the efforts of the Indian Council of Agricultural Research in piloting the national watershed project during the early 1980s and the Agroclimatic Zonal Planning Exercise undertaken by the Planning Commission were really landmark efforts. Regrettably, on account of the dominance of the mega-irrigation lobby, the watershed development strategy has not acquired centrestage in the policy planning process. The politics and economics of gigantism and kickbacks is solely responsible for sabotaging scientific landuse planning on a watershed basis.

As a broad policy and strategy, microwatershed development culminating in total river basin planning, seems to be the most appropriate *modus operandi*. It is an approach which can usher in rational water resource development. But for this we have to do effective networking through which successful projects from Adgaon, Kabal, Nala, Maheswar and Mittimari to Sukhomajri (and a whole lot of others which have been undertaken) move forward and become harbingers of a national movement for equitable and sustainable water resource development. This is the singlemost important national issue today, and will determine the destiny of India in the 21st century. ■

Wanted: People-oriented Research

Sustainable agricultural production needs a water bank, so that surplus water can be stored, only to be withdrawn when needed. It also needs research in which people are the prime concern

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Agricultural production strategies need a rethink. The twin challenges that need to be addressed simultaneously are: How to increase and achieve sustainable production while, at the same time, reduce natural resource degradation, given that agricultural production is a natural resource input-intensive activity?

A model has been proposed based on managing natural resources on a microwatershed (500-1,000 hectares) basis, wherein all stakeholders — research institutions, non-governmental organisations (NGOs) as well as people — work together to achieve this goal. This model is based on rainwater utilisation and conservation so that the surplus rainfall is conserved and used when needed, during dry periods, for instance.

With the present scientific knowledge and database that is available on water, it is difficult to quantify its availability or demand in various forms in an area on a temporal scale.

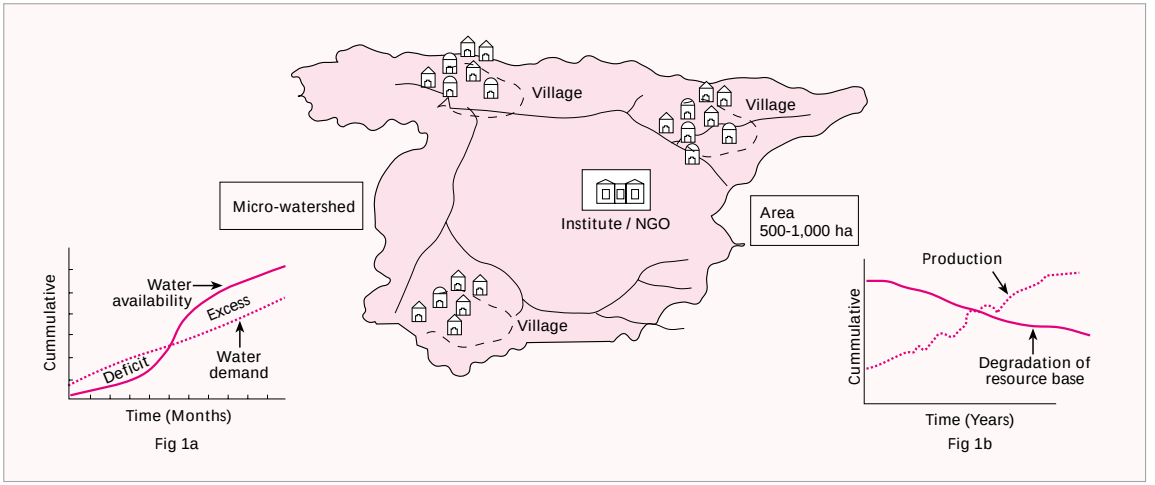
Rainwater management within a microwatershed through water harvesting or groundwater recharge and recycling of water for various uses is the key to success in watershed-based water management. This is a potential approach for rainfed areas which can lead to

ANIL SINGH

Sustainable agriculture involves water management, possible in a watershed that stores the excess water and releases it when required

Fig 1: People-centred model

Conceptual diagram for sustainable agricultural development through microwatershed management



ANIL SINGH

higher productivity and sustainability in production. Research inputs are, however, needed for the application of various production technologies and methods of implementation of agricultural development projects. Participation in developments programmes has been poor, as has been the adoption of appropriate technologies other than the use of high yielding varieties. This needs to be changed.

MODEL APPROACH

A model has been developed for watershed-based water management, wherein a single capsule approach involving research, extension and development has been conceived. The basic hypothesis of this approach is based on the following premise: research institutes / state agricultural universities or NGOs intending to work on sustainable agricultural production should adopt a mandate for holistic development of 500-1,000 hectare microwatersheds. They should work for overall development of the area with an in-built monitoring and database building mechanism, with the objective of achieving an increasing trend of overall biomass production with a decreasing trend in resource base degradation. A conceptual framework of this hypothesis is indicated in *Fig 1: People–centred model.*

To fulfill the mandate of this hypothesis, the water availability and demand scenario will have to be created as indicated in *Fig 1a.* To meet the water requirement of the water deficit period from the excess of the water surplus period, appropriate conservation technologies will have to be adopted. On the production front, the people will have to participate in order to increase production while reducing the extent of natural resource degradation *(see Fig 1b).* Systematic monitoring and analysis of the database will help in generating appropriate feedback for dynamic planning towards achieving sustainable agricultural production.

RESEARCH REQUIREMENTS

There is, therefore, a need to redirect research in the country so that people are its focus and the research is integrated with extension and development. Research institutions, agricultural universities and NGOs which deal with water-related issues need to work with this as a mandate.

Unfortunately the above mentioned approach has rarely been adopted in the country. There are a number of major research issues that need to be addressed for developing appropriate procedures and activity schedules for watershed-based development and water management. These include:

- Methodology for assessing biomass production through one index;
- appropriate tools for indexing the overall degradation of natural resource base;
- models and tools for assessment of temporal water availability in the watersheds and microwatersheds;
- analysis of existing farming systems and their development with reference to environmental sustainability;
- irrigation systems analysis with reference to water availability potential and its management;
- energy management through systems analysis approach and mechanisation; and,
- development of methods for indexing socioeconomic status of the inhabitants of the watersheds. ■

Health and Rainwater Potability

Rainwater mirrors human polluting activities, specially in urban areas. Treatment is often required before consumption

John Gould
Lincoln University, Christ Church, New Zealand

People have consumed rainwater since ancient times and in almost all regions and traditional cultures, rainwater is universally recognised as a pure and clean source of water. But today, there is growing concern regarding the quality of small-scale drinking water supplies.

Rainwater is used for potable purposes mainly by individual households or small scattered rural communities, and the issue of the safety of rainwater supplies has until recently been largely ignored. But there is no simple answer to the question "Is rainwater safe to drink?" No water supply is 100 per cent safe all the time and the issue is really one of what is an acceptable level of risk. The level of risk associated with drinking rainwater is a product of the concentration of pathogens/toxins present, the level of exposure and impact of the infective agent/toxin, and the vulnerability of the individual or population exposed.

Local circumstances and, in particular, environmental factors are also critical, such as the degree of atmospheric pollution; the type of construction materials used; and, level of maintenance of the rainwater catchment system. In rural areas where atmospheric pollution is generally not a problem, several simple

AMIT SHANKER / CSE

Pesticides get into the air and pollute rainwater

PESTICIDES IN THE AIR

Just as chemical pollution contaminates rivers and groundwater, it can also contaminate rainwater, especially if the pollutant can get into the air

A Swiss study published in 1999 reveals that much of the precipitation in Europe contains such high levels of dissolved pesticides that it would be illegal to supply it as drinking water. The study found that rain is laced with toxic levels of atrazine, alachlor and other commonly used crop sprays. "Drinking water standards are regularly exceeded in rain," says Stephan Muller, a chemist at the Swiss Federal Institute for Environmental Science and Technology in Dubendorf. The chemicals appear to have evaporated from fields and become part of the clouds. Both the European Union and Switzerland have set a limit of 100 nanogrammes for any particular pesticide in a litre of drinking water. *But, especially in the first minutes of a heavy storm, rain can contain much more than that.*

One sample of rainwater contained almost 4,000 nanogrammes per litre of 2,4 dinitrophenol, a widely used pesticide. Previously, the authors had shown that in rain samples taken from 41 storms, nine contained more than 100 nanogrammes of atrazine per litre, one of them around 900 nanogrammes.

In the latest study, the highest concentrations of pesticides turned up in the first rain after a long dry spell, particularly when local fields had recently been sprayed. Until now, scientists had assumed that the pesticides only infiltrated groundwater directly from fields.

Muller warns that the growing practice of using rainwater that falls onto roofs to recharge groundwater may be adding to the danger. This water often contains dissolved herbicides that had been added to roofing materials, such as bitumen sheets, to prevent vegetation growing. *He suggests that the first flush of rains should be diverted into sewers to minimise the pollution of drinking water, which is not usually treated to remove these herbicides and pesticides.*[1]

According to a Canadian study funded by the government, extremely high amounts of the herbicide 2,4-D were found in rainfall in southern Alberta. The herbicide was found in all 150 samples of rain collected during 1998. The highest amount of 2,4-D was found at the golf course where the herbicide registered 5.1 parts per billion (ppb). The Canadian aquatic guideline for 2,4-D is 4 ppb and the drinking guideline is 100 ppb.

Farmers in this region of Alberta are the biggest users of 2,4-D in the province, with more than 20,000 kilogrammes of the herbicide sold to the area's grain farmers each year. The herbicide, which is produced by several chemical companies, is also used by urban residents to rid their lawns of broad leaf weeds such as dandelions.

Scientists suspect the high level of 2,4-D is specific to this region due to the area's persistently hot, windy and dusty weather. The 2,4-D levels in the study were 10-50 times higher than herbicide levels reported at other Canadian locations, such as Manitoba and Ontario.[2]

Yet another study in California found that pesticides used in fields can cause smog in agricultural regions of the state. A report released by the Environmental Working Group (EWG) and Californians for Pesticide Reform found that after application, pesticides give off large quantities of reactive organic gases (ROGs, also known as volatile organic compounds). Approximately 40,690.28 tonnes of ROGs are emitted from pesticides each year in California — nearly four times the total ROG emissions from petroleum refining, and more than double the ROG emissions from all other industrial sources in the state.

For hours and even days after application, pesticide formulations can evaporate from the soil and vegetation, emitting more chemicals into the air and often leading to continued exposure for farmworkers and nearby residents. These evaporating chemicals can include the active ingredients, chemical products of the breakdown of those ingredients, and chemical additives — so-called "inert ingredients". Some pesticides, such as chlorpyrifos and methyl bromide, are so volatile they are considered ROGs themselves.

Two years of EWG's monitoring in counties around the state found that almost two-thirds of the air samples contained pesticides known to cause cancer, brain damage, birth defects, acute poisoning or other negative health effects.[3]

The answer to avoiding chemical contamination of rainwater is to go the source of the chemical pollution and control it at that point. There is no evidence as of now that chemical contamination of rainwater is any greater than that of surface or groundwaters in a polluted environment.

steps to reduce contamination of rainwater supplies can be undertaken. Most of these require little or no extra cost. In the absence of serious atmospheric pollution, while it is possible to protect the quality of water in roof catchment tanks, water collected as runoff from ground catchments can get easily contaminated and use of any such water is not recommended for drinking unless first treated.

SOURCES OF RAINWATER CONTAMINATION

In most industrialised urban areas, the atmosphere itself is so polluted that the rainwater is considered unsafe to drink. In the US, drinking rainwater within 48 kilometres of urban centres is not recommended unless no other source is available. Heavy metals such as lead are potential hazards especially in areas of high traffic density or in the vicinity of heavy industries. Organic chemicals such as organochlorines and organophosphates can also contaminate rainwater. Although serious atmospheric contamination of rainwater is normally limited to urban and industrial locations, studies in the northeastern United States have revealed the presence of pesticides and herbicides in rainwater *(see Box: Pesticides in the air)*. Most contamination of rainwater occurs after contact

with the catchment surface (roof or ground) and during subsequent delivery and storage.

Microbial Contamination

The issue of water quality is a complex and sometimes controversial one. In the 1980s several studies indicated that rainwater supplies often do not meet World Health Organisation (WHO) and other national drinking water standards especially with respect to bacteriological water quality. While these findings did not in themselves imply that water is unsafe to drink, they did prompt further investigations which focused on determining both the sources and implications of any contamination. They also led to the development of less stringent bacteriological water quality standards for potable rainwater. In a parallel development, drinking water quality guidelines more appropriate for rural conditions in developing countries were proposed. Both of these less strict sets of guidelines allowed for water with mean *E. coli* counts of up to 10 per 100 millilitres (ml) to be accepted for drinking. This compares to the WHO recommended limit of 0 per 100 ml. When the quality of stored rainwater samples are judged according to this more realistic criterion, the number of rainwater supplies with water deemed to be within acceptable limits for drinking is greatly increased.

A more direct source of evidence implicating a rainwater supply as a potential health risk comes from identifying the presence of specific pathogens. There are many references to pathogens including *Salmonella, Legionella-like spp., Clostridium perfringens, Aeromonas, Vibrio parahaemolyticus, Campylobacter, Cryptosporidium,* and *Giardia* having been isolated from rainwater samples. Proving direct causation between microbial contamination and health is, however, more difficult especially when contamination levels are low. The paucity of studies citing proven links between disease outbreaks and rainwater sources is perhaps not surprising given this difficulty and the fact that many individual cases go unreported or result in no further investigation. This is mainly due to the fact that most rainwater supplies are used by single families thus reducing the likelihood of large numbers of people being affected in any single outbreak *(see Box: Decentralised systems: less threatening).*

An exception to this and one of the best documented cases records an outbreak of gastrointestinal illness including diarrhoea, headaches, fever and vomiting amongst 63 individuals from a group of 83, mainly children 5-19 years of age, who attended a rural camp in Trinidad, West Indies. The probable cause for the outbreak was postulated as *Salmonella arechevalata* contained in animal or bird excrement on the camp roof and washed into the rainwater tank, from which water was used for drinking.

DECENTRALISED SYSTEMS: LESS THREATENING

Localised microbial contamination poses less risks as compared to contamination from distant water sources

All E. coli are not equal, says John Briscoe, currently a water expert with the World Bank and formerly a scientist at the London School of Hygiene and Tropical Medicine. Contamination in a contained water supply system like a household-based rainwater harvesting cistern will not have the same effect as contamination in a centralised water supply system. This is because infection in a household-based water supply system is most likely to be an infection that most members of the household have already been exposed to and have developed an immunity to it unlike an infection that reaches the household through a centralised water supply system. Therefore, microbial contamination in household-based rainwater harvesting systems, in most circumstances, should not be a matter of serious concern. Briscoe and James van der Slice studied faecal coliform levels in stored household water supplies and their effect on 2,355 Filipino infants and found that contamination of potable water stored at home did not pose as serious a risk as contamination of public water sources.[1]

Other studies that have established links between rainwater consumption and illness include outbreaks of:

- salmonellosis in New Zealand;
- campylobacteriosis in Australia; and,
- giardiasis and cryptosporidosis in Australia.

Chemical Contamination

Though several studies have found that stored rainwater generally meets WHO drinking water quality standards for various chemical constituents, for a broad range of parameters, slightly elevated levels of magnesium and zinc exceeding WHO guideline standards for drinking water have been detected in a few cases though these did not pose any serious health concern. Elevated levels of lead have been the most common cause for concern. A recent study of 25 potable household rainwater supplies around Auckland in New Zealand found lead exceeding national drinking water standards in 12 per cent of the tanks surveyed. Lead levels exceeding 3.5 times WHO drinking water standards have also been noted in Selangor, Malaysia.

Proving direct causation between microbial contamination of rainwater and health is more difficult especially when contamination levels are low

Potentially, the adverse health implications of the long-term consumption of rainwater containing elevated levels of heavy metals such as lead pose a serious health threat. For roof catchments several potential sources of lead contamination exist. These include the use of lead-headed nails, lead-based paints / primers for roof construction, and the deposition of lead particles on the catchment surface in regions subject to heavy industrial or traffic pollution (especially in countries still using leaded petrol).

When the pH is depressed, rainwater becomes more 'aggressive' and can leach out metals and other constituents from storage tanks, taps, fittings and sludge deposits on the tank floor

Where roof catchments are poorly maintained allowing for a build-up of leaf litter in the tank, stored water can become more acidic. When the pH is depressed, rainwater becomes more 'aggressive' and can leach out metals and other constituents from storage tanks, taps, fittings and sludge deposits on the tank floor. Evidence from Ohio, in an area with serious atmospheric pollution and acidic rainfall, suggested that elevated lead and cadmium levels in cistern sediment and water, posed a potentially serious health risk.

Investigations in Halifax, Nova Scotia, also revealed high lead concentrations in runoff water collected from an old roof with considerable amounts of lead flashing from rainwater with pH 4. Evidence of the potential health dangers of excessive lead levels in stored rainwater also comes from a study in Port Pirie, an industrial port in South Australia and location of one of the world's biggest smelters. This study revealed a correlation between blood lead levels in children under seven and lead in tank waters, one source of which may have been highly-leaded roof paint. The effect of acidic (pH 3) water and presence of leaf litter in the tank was also shown to increase the rate of dissolution of lead from tank sludge by up to 50 times.

PROTECTING RAINWATER QUALITY

Methods to protect or improve rainwater quality include appropriate system design, sound operation and maintenance and the use of first flush devices and treatment. Treatment is mainly appropriate as a remedial action if contamination is suspected. First flush devices can be effective in reducing levels of contamination if properly maintained. Good system design, operation and maintenance are generally the simplest and most effective means of protecting water quality.

Appropriate system design

The best initial step to protecting water quality is to ensure good system design. Water quality will generally improve during storage provided light and living organisms are excluded from the tank, and fresh inflows do not stir up any sediment. The design should include:

- A clean impervious roof made from smooth, clean non-toxic material. Overhanging branches above the catchment surface should be removed.
- Taps or draw-off pipes on tanks should be at least five centimetres above the tank floor (more if debris accumulation rates are high). A tank floor sloping towards a sump can greatly aid tank cleaning as will a well fitting access manhole.
- Wire or nylon mesh should cover all inlets to prevent any insects, frogs, toads, snakes, small mammals or birds from entering the tank. The tank must be covered and all light excluded to prevent growth of algae and other organisms.
- A coarse filter and / or foul flush device should be fitted to intercept water before it enters the tank for removing leaves and other debris.

Operation and maintenance

Proper operation and maintenance of rainwater systems helps to protect water quality in several ways. Regular inspection and cleaning of the gutters and tank reduce the likelihood of contamination. The removal of leaves and other organic matter from the gutters and tank also helps to prevent the stored rainwater from becoming too acidic and potentially dissolving metals from the tank, tap fittings and sludge deposits.

- All system components should be cleaned / repaired when necessary.
- Water should not, if possible, be consumed directly from the tank without treatment for the first few days following major rainfall.
- Water from other sources should not be mixed with that in the tank.

First flush devices

Although not absolutely essential for the provision of potable water, foul flush and filter systems can significantly improve the quality of roof runoff. If poorly operated and maintained, however, such systems may result in the loss of rainwater runoff, through unnecessary diversion or overflow and even the contamination of the supply. A first flush (foul flush) device should be extremely simple, and should not require regular attention regarding its operation and maintenance. Examples of such devices include:

- self-cleaning gutter snipes;
- self-cleaning inlet mesh;
- sedimentation chambers requiring only occasional cleaning; and,
- movable downpipes for diverting the runoff from the season's first downpour.

In a 1989 study, water quality analysis was conducted on the initial "foul flush" runoff from both a tile and galvanised iron roof in which the first, second, third, fourth and fifth litre of runoff were sampled. This revealed high concentrations of most of the pollutants tested in the first litre with subsequent improvements in each of the following samples, with few exceptions. Faecal coliforms, for example, ranged from 4-41 per 100 ml in the first litre of runoff sampled but were absent entirely in samples of the fourth and fifth litres.

Numerous ingenious devices have been developed. Although widely cited in the literature on rainwater catchment systems, in reality, the use of foul flush devices is limited, specially in most developing countries, where finding working devices beyond the confines of appropriate technology demonstration projects is quite rare.

Treatment

Treatment of stored rainwater only makes sense if it is done properly and if hygienic collection and use of the water will ensure it does not suffer from re-contamination. There are several types of treatment possible, the most common being chlorination, boiling, filtration and exposure to ultraviolet or natural sunlight.

- Chlorination is most appropriately used to treat rainwater if contamination is suspected due to the rainwater being coloured or smelling bad. It should only be done if the rainwater is the sole source of supply and the tank should first be thoroughly inspected to try to ascertain the cause of any contamination.
- Boiling water thoroughly for at least one minute normally ensures it is free from harmful bacteria and pathogens. Since it is not practical to treat water regularly in this way, it is again only usually appropriate as an emergency measure.
- Filtration can be used to prevent material from entering the storage tank, during extraction of water from the tank or prior to consumption. Potentially, if properly maintained, filters will improve water quality.
- Direct sunlight can also be used to kill many of the harmful bacteria in water by exposing it in clear glass or plastic bottles for several hours. Although feasible in some circumstances, the water must be clear, the weather fine and the water cooled overnight before consumption.
- A solar-powered ultraviolet unit, able to process 1.5 litres of water per minute, was evaluated on a rainwater cistern water in Hawaii and found to be 99.9 per cent effective in removing indicator bacteria. But effective ultraviolet sterilisation may be too expensive for widespread use.

In conclusion, untreated roof runoff has been widely used for drinking purposes for many years with very few reports of serious health problems. While health risks may be small, recent findings suggest there is little room for complacency and every effort needs to be taken to minimise rainwater contamination. Compared with most unprotected traditional water sources, drinking rainwater from well-maintained roof catchments usually represents a considerable improvement and, even if it is untreated, it is generally safe to drink. Rainwater collected from ground catchment systems is generally subject to high levels of microbial contamination and its consumption without treatment is not recommended.

A number of pathogens harmful to health and disease outbreaks linked to rainwater sources have been documented. While serious, these outbreaks are all isolated and comparatively rare incidents. Nevertheless, they do provide an important warning regarding the potential hazards associated with drinking rainwater from sources which are poorly located, constructed or maintained.

Clearly, in certain circumstances such as in areas of severe air pollution or where lead flashing, lead-based paints or other potentially toxic building materials have been used, chemical contamination of rainwater can pose a health threat. Generally, serious chemical contamination of rainwater is rare. Nevertheless, extra vigilance may be advisable with respect to very old roof catchment systems, which may have been constructed at times when building codes and regulations relating to the use of lead-based paints, lead fittings and other hazardous materials were far more lax than today. Keeping leaves and organic material from accumulating in the tank and gutters will also help to prevent the stored rainwater from becoming too acidic and potentially leaching lead or other heavy metals from the tank walls, fittings or sludge deposits into the water. ■

While health risks may be small, recent findings suggest there is little room for complacency and every effort needs to be taken to minimise rainwater contamination

This is an edited version of a paper presented by the author at the 9th Conference of the International Rainwater Catchment Systems Association. The boxes have been added by the editors.

Recognising the Inevitable

Politicians and experts recognise the linkage between natural resource management, the role of the communities and the need to empower them

P A SANGMA

Had I not been addressing you today I would not have been able to give you the figures on what is the total availability of water over the world or what is the total availability of rainwater in the country. Only today I am able to tell you. If I had not been asked to come here, I would not have known these figures at all. The gravity of the situation when I go through your briefing paper is alarming.

The problem in our country is how to make political parties come together. I am not talking of governments working together but political parties coming together along with people who are specialised in the subject. I think this is going to be difficult. Tamil Nadu politicians will look at the Cauvery waters from the angle of Tamil Nadu while Karnataka politicians will look at it from the angle of Karnataka. We never think that people of Tamil Nadu and the people of Karnataka are the citizens of this one country. How to think that way is a challenge before us politicians.

When I was speaker of parliament, I tried a little by calling a special session to discuss serious issues before the country. I don't think that water was discussed in this special session. We never thought of it. We talked about corruption and criminalisation. Experts and politicians will have to come together at some forum to discuss this. Parliament is not a forum. I don't know how many years it will take the parliament to become a serious body again. The Central government, whenever there is any national issue, will only call state governments. These do not represent the entire country. We have seen in the Cauvery issue, four states, Kerala, Pondicherry, Tamil Nadu and Karnataka, agreed on a formula. But there was a political party that felt left out and did not accept it. Major political parties have to come together on certain basic issues, have a national consensus, and make them a programme of the people and not of the government.

Rainwater is a very important issue. Cherrapunji which has the heaviest rainfall in the world has become a desert today. There is no drinking water. Nothing grows in my state, Meghalaya. The entire soil has eroded and gone to Bangladesh. What is left is just rocks. When I was chief minister I took up a special programme for environmental protection in that area but it did not succeed. The trees that we grew there did not survive. I made a visit to Mizoram because I had heard that Mizoram had done an excellent job with harvesting rainwater. I found that they had indeed done a wonderful job. I tried to introduce this in Meghalaya and I succeeded to a great extent, specially in the towns. For some reason it did not succeed in the villages. It is a very easy method and doesn't involve much technology or investment and, therefore, if it can be made a people's programmes movement all the over India, I think you would have done a great job. It has to be a people's and not a government programme.

As A Vaidyanathan has said money is not the problem. We are spending a lot of money to supply drinking water in rural areas, but it goes down the drain and we do not even know which drain. If anything has to be done to get this done in this country, it has to be a people's programme and led by good non-governmental organisations (NGOs). Though we do have a lot of NGOs many of them are not better than

The Central government, whenever there is any national issue, will only call state governments. These do not represent the entire country

the government. So we have to be very selective. A number of ideas on rainwater harvesting have been discussed here. The issue remains how do we do it and how do we make it a people's movement.

P A Sangma *was the chief minister of Meghalaya and a former speaker of Lok Sabha.*

MANI SHANKAR AIYAR

I am here not because I know anything about water harvesting but to pay my personal tribute to the remarkable work that Anil Agarwal has been doing in this area. I was privileged to be present in a meeting where his book *Dying Wisdom* was released and it was a matter of immense pride to me as an Indian that we should have found answers, perhaps hundreds and thousands of years ago, to problems which western technology is still attempting to grapple.

I am most struck by a sentence in the briefing paper that has been given to all of us where you have said that the key to regenerating community-based water harvesting systems is regenerating community institutions and the community spirit. It is here that some things have happened in the recent past which give us hope that we can go back to community institutions and the community spirit that was destroyed by 200 years of British rule.

The state which has made most progress down the road of developing community institutions and community spirit is also the one that has recorded the most remarkable improvements in the area of water harvesting in the last few years, namely, the state of Madhya Pradesh. So, obviously, there is an intimate connection between this ancient method of collecting water for drinking purposes and possibly some irrigation as well, and the institutions through which we govern ourselves.

India amended the Constitution in a very significant manner in 1992 when we introduced a new part 9 of the Constitution providing for *panchayats* and municipalities, and it is because of these *panchayats* having actually come into existence, having been empowered with certain powers, responsibilities and finances that Madhya Pradesh has been able to return results in a short period of four years. I happened to be in Bhopal yesterday attending the first state-level *panchayati raj* convention and it is all over my mind. But I would like to concentrate instead on the larger issue of how a parliament which never discusses anything serious, sometimes, in an absence of mind, succeeds in passing legislation which is actually revolutionising the manner in which we govern ourselves.

The constitutional change has two essential aspects relevant to what we are discussing here. One is that it creates *panchayati raj* institutions which cannot be dissolved even if a given institution is for one reason or the other dismissed or an individual member of it is dismissed. The Constitution now provides that within six months bye-elections have to be held to ensure the *panchayat* in question is restituted or the individual who is dismissed has the opportunity to go before the people to determine whether he is rightfully or wrongfully dismissed.

And while it was possible after 50 years to secure a two-thirds majority in each the houses to get these institutions established, I doubt that for another 50 years at least, anybody will be able to acquire a two-thirds majority to abolish this system that has been brought into existence. Therefore, what the legislation has essentially attempted to do is to give constitutional sanctions and constitutional predictability to these institutions of self-governance at the local level and which was been done in a manner which is really irrevocable and cannot be changed. So these institutions exist today, but apart from Madhya Pradesh and one or two other states of the country, by and large, these are empty shells waiting to be filled with real authority, real responsibility, real powers, real finances and real technical and administrative personnel. But because these institutions exist, I think it is going to be inevitable that the shells will get filled.

The reason is that once elected grassroots representatives exist, even if in the first instance they have been brought into existence by legislators at higher levels, when it comes to elections to legislatures, candidates will be heavily dependent upon political activists who have secured the prior approval of the people by getting elected to these local body institutions.

And whereas, in Sangma's experience of several decades and mine own of a few years, it is clear that, as of today, an MP walking into his parliamentary constituency is clearly the one who is giving orders to the MLAs and, much worse, the MLAs are the ones who are giving orders to those down below, I think we are now set upon a course where over the long-term, there is

There is an intimate connection between the ancient method of harvesting water and the institutions through which we govern ourselves

going to be a definitive shift and legislators and parliamentarians are going to realise that their own longevity, there own re-electivity, will depend in a very large measure on how far they succeed in keeping these elected grassroots representatives happy. As in all human existence, where self-interest works successfully towards solving problems, over a period of time, it will become clear that it is in the self-interest of legislators and parliamentarians to strengthen institutions of local governance because stronger these institutions are, the more easy it will be for MLAs and MPs to get themselves re-elected.

This is not a revolution which is going to shape the world in ten days. This is a much more long lasting revolution which is going to take quite a long time. I would give it a minimum of 15-20 years, possibly even more, to work itself out but it has the great advantage of being an irreversible revolution. So I think we have grounds to take heart from the fact that there actually exist elected community institutions all over the country, that they exist at three key levels of decision-making and administration in our system — the village, the block and the district-level — and these can therefore be used in any manner that is seen by the community to be in its own interest. Its no longer a question of somebody from outside determining what is the community's interest, the villagers' interest, the family's interest or the individual's interest — that will be for the individual, the clan, the community and the village to decide itself.

And I cannot see that community water harvesting will be seen as the threat to the individual, the clan, the community or the family. This is not necessarily an area of social conflict. There could be a great element of community cooperation in this regard.

The other point I would like to make is that in the same legislation, there is a new schedule to the Constitution which bears number 11 in which 29 subjects have been identified for devolution to *panchayati raj* institutions. One of these is minor irrigation, and it is within this group will lie the subject of water harvesting. There is no real reason why there should be any conflict between the state legislature and the *panchayats* and the state government and the *panchayats* as to who should do this job of water harvesting. I doubt there are very many MLAs who would like to run around in tin cans collecting raindrops; there is not much in it for them. And, therefore, I would imagine that to collect drops of water that fall off roofs, there might not be any major political objection to it.

What you really need is a vast amount of conscientisation and there we are running into the problem of how do we get information out to a lot of people without bringing in the bureaucracy. NGOs, by definition work in a micro-process, and governments, by definition, work in a macro-process and there are simply not

It will be in the self interest of legislators and parliamentarians to strengthen institutions of local governance

an adequate number of NGOs which would constitute the strength of a bureaucracy, and if you did have it, then there are chances of them becoming a bureaucracy.

So you are faced with the problem of carrying a message not to a village or a *mohalla*, but to hundreds of thousands of villagers across the country, and that I am afraid will require a state mechanism and conscious efforts of the state to put the message out.

Here again, I don't see a conflict between what the state would wish to see happen and what it could do, for there is no reason to imagine that state interests are adversely affected by the collection of rainwater or any form of water harvesting. So again I should imagine, that in a benevolent way, it would be possible to bring the state into the business of conscientisation and awareness-raising and the provision of certain types of technical skills.

As far as money is concerned, it has been emphasised again and again here that the sum of money involved is so small compared to the total expenditure of the state or Union governments that it should not be difficult to devise ways and means of sending money out to the village *panchayats* to undertake such activity.

The only way we could really get to water harvesting is through money harvesting but instead of the money harvesting being done by politicians like Sangma and myself, perhaps the money harvesting would need to be done at the village-level in order to create the incentives required to take up this work. This is absolutely the right moment in time for us to attend to this problem and I would urge upon all of you here to take advantage of this opportunity.

The best thing this current government has done is the appointment of the 11th Finance Commission under a chairperson who is an expert in agricultural economics and who understands the issues, namely, A M Khusro. I am glad to see the that terms of reference of the 11th Finance Commission that specifically provide that the commission will look into the finances of the *panchayats* and *nagarpalikas* as mandated by the Constitution because the Constitution says that sound finances of the *panchayats* is a responsibility of the Constitution. One easy and straightforward way of doing this would be to direct Central government money directly into the coffers of the village, intermediate and district-level *panchayats* as also of the *nagarpalikas* instead of routing them through the state government, as is the practice now.

I would imagine that if earmarked money goes directly from Delhi to a village in Kerala where I was born, nobody will permit that money to be used for any

serious diversionary purpose. There is a tremendous misuse of Central government funds of this kind. But this idea is opposed saying that until it goes to the state, they won't put in its 20-50 per cent share before sending it to the villages.

We should all try to persuade the 11th Finance Commission to take this up as a specific example. Let us say that for water harvesting, if the central government were to provide funds which were to be extended by 20 per cent, say, by the state government, and the money were to go straight to the villages, it would immediately draw attention to the importance which we attach to this job. I can't see anybody suggesting that this is not the singlemost important job that needs to be undertaken at the village-level. Since the involvement of the block *panchayat* or the district *panchayat* in this matter would be relatively small, I think it would be fair to say that perhaps 80 per cent of the money that is destined for water harvesting should go directly from the Central government to the village *panchayat*, and the remaining 20 per cent would perhaps need to go to higher levels in order to secure the kind of technocratic assistance that the villages might need to make this collection of water a more scientific process.

I think that the availability of the money itself will create consciousness about the importance of undertaking this particular activity. The chances are that we will be able to get the whole village to utilise this money as a community activity in the community interest for the community as a whole. And, should this happen, I think perhaps we will be able to regenerate the community spirit that is talked of in the Centre for Science and Environment briefing paper.

So the possibilities are there and the institutions exist. We have the precedent of the Jawahar Rozgar Yojna and the Nehru Rozgar Yojna which started in 1989 where money was sent directly from Delhi to the accounts of *panchayats* and *nagarpalikas*. So I cannot see any Constitutional or administrative or legal objection.

I can hear a lot of state governments squawking, but will not be delightful to hear state governments squawking? They have singlehandedly contributed to the arrest of development in this country in very many spheres starting with primary education and primary health. If we can get this money straight out to the people, then there will be some misuse of it at the people's level, of that I have no doubt, but I can't imagine that the village politician has honed his skills in creaming the layer away as much as Sangma, I and others of our ilk have done. Therefore, the extent of corruption is likely to be somewhat less at the village level. Certainly cutting out the administrative cost will save money, which is really what takes up 85 paise of every rupee, as Rajiv Gandhi had pointed out, on the basis of a Planning Commission study and was misunderstood to say that 85 paise goes into corruption. So, there is money, there are the institutions, there is the constitutional system, there is the legal framework. They can all be used, its only a question of putting it all together.

Mani Shankar Aiyar *is a former MP and member of the Congress Party.*

DIGVIJAY SINGH

I am indebted to Anil Agarwal, who has given me the opportunity to speak at this important conference and to meet you all. I have not known Anil Agarwal very well, but we have heard and read about him. And, as Anil Agarwal himself has said, we, the simple people living in villages, used to hear about people in Delhi concerned about the rural environment. But Anil Agarwal has changed that thought process. He himself has agreed that the background he possessed was a city background and his education has also been urban but still he has understood the pain of the village and the associated problems, and he, in his own way, has tried to raise issues and show the correct path.

Today, water is becoming a major problem for the world and the president in his speech has mentioned this crisis in the form of a water shock. I think that it cannot be highlighted in a better form than that. Even former prime minister, Chandrasekhar, talked about it. He has said that all the violence and strikes of the future will be because of the issue of water. I realised the importance of water soon in my political career. In the villages we used to visit where there was a crisis, we used to dig handpumps. After two to three years, we realised that everything had dried up. In some places where a dam was built, there was excess water. When I became irrigation minister in the Madhya Pradesh government, I found that the problem before us was that the water which used to flow through the canals, raised the water table in some villages to such an extent, that people could not sleep on the ground. They would put their bed on the terrace and sleep there. *Chulhas* could not be dug in the ground because water used to enter there. Excess water was a problem out there.

Some 25 kilometres away from this village in the hills, there was a crisis of less water. So today the crisis of water is a crisis of excess water and also less water. In one place we have used various technologies, closed the

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flow of canals and constructed a few tubewells and so now again the people can sleep on the ground and also cook their food by constructing *chulhas* on the ground.

The importance of water is not new, even during the ancient days, it was said that a good king was one who built *talabs*, dugwells and *baoris*, and planted trees. In the Bundelkhand area of Madhya Pradesh today, by tragedy, one can see the highest poverty. The worst region of Bundelkhand is Tikamgarh. In its 1,100 villages there are 1,300 ponds.

The ponds from the Chandela era are spread across the whole region like a network but due to siltation and disuse, they have lost their importance. In the same way in Chattisgarh, you won't get any village where you won't come across a *nistar* pond. Whenever there was a famine in these places, people were employed to dig ponds and because of this reason, Chattisgarh never faced a water crisis.

Today there is a drinking water crisis. Groundwater usage has increased. Most people have installed motors and diesel pumps, there is overexploitation and no recharge is taking place, and whereas we have given schemes for million dugwells and tubewells, no major scheme has been provided for recharging of water. Because of this reason there is a groundwater crisis in the plateau regions of Madhya Pradesh.

When I took charge on 9th December 1993 as chief minister, the biggest challenge in front of us was the growing depletion of the groundwater and, to deal with it, a plan had to be made. We dealt with it in Rajiv Gandhi's mission mode approach. We started seven Rajiv Gandhi Missions but the watershed management mission was of utmost importance.

I have always had this in mind that no plan can be successful unless the plan provides employment opportunities for the people. The Central government had also started a watershed program in the agricultural sector. When I went to see it in a certain village, I asked the villagers about it and they said that they don't know what the officials are doing, they don't talk to us, sometimes they dig our fields, and sometimes they pick our stones. We have no idea of what they are doing.

As the people were not taken into account, this programme did not meet with success. There were strict guidelines and you could not move an inch from here to there. What sort of planning is this?

Even after many attempts, the people in the farming section did not pay heed to my words, saying that we have decided that there will only be vegetational bunding. The expenditure spent bore no fruits. In such a big country, we cannot bind any plan within definite borders.

Each village is different. Somewhere you have to make a check dam, somewhere a gully plug, in other places you have to make different structures. But we have in our mindset that by sitting in Delhi we can decide what is appropriate. This only creates a lot of hassles in our work.

Thus, we have decided that for the plans which we will make, we will provide only broad guidelines and will involve the people of the village. We have this misconception that rural people are not aware of these things and have no knowledge. We have this notion that to do this, one needs to be a soil conservation expert, have a master's degree or possess a certificate in soil sciences. From the old days, all this has been happening in the villages. Villagers possess a common sense which even well-educated people cannot match.

So we decided on two to three things together. On a large scale, we decided that we will provide broad guidelines for watershed development and water harvesting structures, but to implement this, we will involve the village community. We troubled Anna Hazare as we adopted his model of the Ralegan Siddhi village. And we said that water should be everybody's business, though as an aside, I must say I have reservations as to why water only, basically everything in this country should be everybody's business. Mahatma Gandhi talked about *gram swaraj* (village independence). We have already given authority to the village *panchayats* and we plan to give more authority to the *gram sabha* (village assembly) along with *gram swaraj,* so that village people have the authority to call back the elected people in the local bodies if the candidates are not performing properly. We plan to include this 'Right to recall' in our election manifesto for the coming elections.

We made a plan to decentralise watershed management and to set up village watershed committees. We decided that all watershed committee members would go to Ralegan Siddhi and see for themselves the transformation of that village. For this we got tremendous cooperation from Anna Hazare. When people would return from there, they not only would go in for water recharging but would return recharged themselves. This made them work even better. My experience has been that wherever people had a chance to work, there were no mistakes. The

The only mistakes were made by our implementation officers, when they tried to use their own wisdom and interfere. But where the common person made efforts to implement the plan, there was no mistake

only mistakes were made by our implementation officers, when they tried to use their own wisdom and interfere. But where the common person made efforts to implement the plan, there was no mistake. In Jhabua, when I spoke to the *sarpanches* (village council heads) and chairpersons of watershed committees, I found that 100 per cent water recharge was achieved. The handpumps which would go dry in November and December earlier, even with less rainfall would now supply water till June.

The main problem was where to get money for this programme and this is where the rural development funds helped us. We get considerable money for rural development. We reserved 50 per cent of this allocation from the Central government for watershed development in most places.

For any development plan it is important that people be utilised properly. I believe that even a badly planned scheme can turn into a success if it is handed over to committed people and any planned scheme can be a disaster if bad people take it over

For any development plan it is important that people be utilised properly. I believe that even a badly planned scheme can turn into a success if it is handed over to committed people and any planned scheme can be a disaster if bad people take it over. So in Madhya Pradesh, we got together people who were committed to the cause like R Gopalakrishnan, his team and many others, and we gave all responsibility to them. There was a time when Kalahandi and Jhabua were acknowledged as two regions having serious problems. I have great pleasure in informing you that the number of people who migrate as distress labour has declined. The self-confidence of the people has increased. Literacy has increased. Productivity has gone up. The same Jhabua region, where cereals used to be imported is now exporting wheat out of the region. Where livestock would die of starvation, now fodder is being exported. We have tried to go beyond watershed development and have tried to integrate, at the lowest level, all the schemes. Numerous schemes are being implemented. I myself am not aware of the number of schemes that are being implemented in my state. There are 9-10 insurance schemes being implemented. There is a need for their integration and a forum where this can happen. The village is an ideal forum where this can take place. This is why the watershed committees are also involved in healthcare, education, women and child programmes and liquor prohibition so that a mass movement can begin at the village-level and an effective leadership can emerge from there.

Women's thrift committees were also set up as part of the watershed development programme which are something like little piggy banks. In Jhabua itself, there are 850 such thrift committees, managed by the women themselves. The women have collected Rs 3.75 crore through these committees and have started internal lending as a result of which these poor tribals have been able to come out of the clutches of moneylenders who would charge an interest of 15 per cent per month. In banking terms, this would mean an interest of 180 per cent per annum. These women are now charging Rs 2 to Rs 5 per Rs 100 as interest per month. There is 100 per cent repayment and the respect for these women has gone up in their homes. I asked some of the women of these committees if their husbands still mistreat them after a bout of drinking. The reply was, "How can my husband beat me if he has to take money from me?" The women are also enforcing liquor prohibition. Internal lending has steadily improved their lot.

I have seen the development of sand dunes in the regions of Jhabua and Dhar. But the process has stopped now. The people have been made responsible for protecting forests. When I visited a village of the Bhil community on the Madhya Pradesh-Gujarat border, the people of the forest protection committee informed me that a forest was regenerated and wildlife has also come back. "About 15 days back people from Gujarat came to cut the jungle. We fought them off with arrows and firing took place from both sides," they said. these people have protected the forests so zealously that the forest has really regenerated with ample grasslands.

Today, the watershed development programme is spread over 7,800 villages and over 3.4 million hectares which account for approximately 11 per cent of the villages in Madhya Pradesh. Wherever I have gone, the impact has been favourable. We have started another programme in 400 identified villages which have the highest rate of distress outmigration, where every year there appears to be a situation of death due to starvation. These are regions bordering Orissa and some in Jhabua and Dhar. We have started another Rajiv Gandhi mission programme here: Mission for the removal of hunger. The objective is to give the people here employment up to 200 humandays and gradually we are introducing a Public Distribution System (PDS). In Jhabua we have introduced the concept of community grain banks so that the community pays in kind and withdraws in kind. The current government PDS system means the transportation of agricultural production from its place of production to granaries and then back to the distribution system. This involves crores of expenditure in subsidy for transportation and storage by the government and losses. Who avails of these subsidies? Not the consumer. This is only subsidising the Food Corporation of India, and its associated staff and organisations. There is

a need to revamp the current PDS system with the help of people's participation. This is possible through community grain banks as was traditionally done. People would deposit whatever they had in exchange of grain from the local community grain bank. We have forgotten this tradition of ours in our search for new solutions. There is a need to revive this system now.

In our state we have tried to implement all programmes with the participation of the people. We have tried to decentralise governance, give people rights and are also aiming at giving people the right to information. It is unfortunate that though we made the law nine months back, we have yet to get acceptance from the Centre. We even met the President but have yet to get his approval. This is the only way to fight corruption. More decentralised the decision-making, lesser will be the corruption. The more right to information that is given to the people, more will be the decline in corruption. The decision that is taken in the midst of the village itself has no chance of corruption. More the decisions are taken behind closed doors, more pressures are exerted. It gets difficult to withstand these pressures and we succumb. Today our problem is that we talk of *gram swaraj* but all decision are taken by members of the legislature and the state ministers. This problem came before me when I started talking of giving powers to the people. I was asked, "If we give all the rights to the *gram sabha* and the *gram panchayat*, what will we be left with us? What will the MLAs do?" I replied that we really have no option and I am glad to say that I finally got support of the MLAs as well as my ministers.

The only way to fight corruption is decentralised decision-making. More the right to information that is given to the people, more will be the decline in corruption

Today, our objective is to bring maximum people's involvement in every aspect of governance. Your slogan 'make water everybody's business' is absolutely right. Unless we involve every person, we will not be able to implement any government programme. People view most government programmes with scepticism and view them as avenues of corruption. Unless people are given rights over their natural resources — water, forests, land and minerals — and unless they are involved, and unless the government is made accountable to the people, we cannot realise Mahatma Gandhi's vision of *gram swaraj*. In Madhya Pradesh, we are aiming at *nagarpalika swaraj* also. I will try and move towards this objective.

Digvijay Singh *is presently the chief minister of Madhya Pradesh.*

ANNASAHEB HAZARE

Water harvesting and watershed development can become a revolutionary programme for this country. The dreams that Mahatma Gandhi had dreamt for this country have to be fulfilled now as we have gained Independence. We have to make India a flourishing land. The message that Gandhiji gave us was that we should go to villages and make our villages self-governing villages. Then only will the country progress.

But, after Independence, our path went in the opposite direction and instead of considering the village as the centrepoint, we started considering cities as the centrepoint. As a result villages became empty and cities started getting filled up. Slums have increased, leading to an increase in social pathogens, air and water pollution, land degradation and resource depletion. Today, we are extracting petrol, diesel, kerosene, coal and water all the time and are still dreaming of development.

This is not true progress, but a disease which has come to the body. If we have to go for true progress, then we shouldn't deplete our natural resources but make wise use of the gifts of nature and develop the individual, family, village and city accordingly.

In this context, the development of watersheds is a revolutionary concept. There is no destruction of nature. With people involved — in a place where there was once a problem of drinking water and where people slept hungry, with only 380-510 mm of rain — vegetables are now being exported. Where there was no water and they used to call water tankers to meet drinking needs, people are now growing crops, which are estimated at Rs 70-90 lakh a year. I am speaking of my village Ralegan Siddhi.

We have a question in front of us: If watershed development is a revolutionary concept, why has it not happened in the last 50 years? We spent a lot of money but we did not consider the village as the centrepoint. When developing a watershed, we should think from top to bottom. Many people thought that making check dams or stop dams was watershed development. But this is not correct. Top to bottom, we have to see everything, soil and water conservation, contour *bunds*, forage development, forest development, gully plugging, *nullah* bunding, underground *nullah* bunding, recharged *nullah* bunding, check dams and many more.

Our fault was that we did not think from top to bottom. Water harvesting structures were made, but the

We need to network and unite together for the progress of the country. Our strength is today a scattered strength. If we unite, then we will move ahead

water did not stay in them even for two months and leaked away, there were so many technical problems.

There was also no involvement of the people. The work which had to be achieved with the help of the people did not take place, and because of these lacunae, the work in the last 50 years could not reach the stage which it should have reached. In Maharashtra, in 12 years, Rs 3,500 crore have been spent on watershed development but today we read that 17,000 villages didn't have drinking water even two years back.

After watershed development, we have to think of water management. In water management, we have to think of the cropping pattern, and utilisation of water in drip irrigation. We also have to ask: If we are going to work on these things, what is our purpose? The purpose is that food and work is available in the village itself so that migration to cities is stopped. And this way, our country will move forward. To achieve this objective, we know there is no progress without water.

But there is another question in front of us: Does water bring in the right progress? In many places that water has arrived, sugarcane cultivation has increased, money has increased, but humanity has decreased. There has been an increase in alcohol, gambling and drugs. So if money increases and humanity decreases, then what is the use of progress. Right progress is when water comes not only to the cultivated land but also to the human body, and there are tears in the eyes of the rich for the poor.

In Ralegan Siddhi, where there were 40 country liquor shops 13 years back, now there are no shops for *bidis*, cigarettes or *khaini* (processed tobacco leaves). The *dalits* had to pay Rs 60,000 as their debts. The villagers sat down and decided to work in the land of the *dalits* for two years. They reaped crops and returned the debt to the bank. *Dalits, chamars* and others, all came under the same platform. Food is served together and there is no discrimination. Today, you will see that people have erected buildings worth Rs 45 lakh with their own contribution, as the village people don't want to take donations. Villagers don't take donations because Vinoba Bhave used to say that donations makes a person worthless, he becomes lazy and loses his pride. Taking is not a fault, villagers cannot progress without funds, but some factors should be kept in the mind. We make a toy vehicle and give it to a small child to learn to walk. But after the child learns to walk on its feet, then it leaves the vehicle. But those who start depending on vehicles for life, remain crippled forever. Taking is not bad but we have to first take control of ourselves.

Today, in Ralegan Siddhi, you will see a new building for a hostel where children study. Those are children who earlier indulged in vandalism. Those who failed twice, were given priority for admission. But even with this type of students, our results are 100 per cent pass and merit children are 83 per cent, in the high school.

We have to think about all these issues and this work has to be done by voluntary organisations and not the government. We have to be responsible for this change. Yet only a few days back we got a suggestion in the Council of People's Action and Rural Technology (CAPART) that money should not go to NGOs but instead go to the collector. Yet no one can deny the excellent work done today by voluntary organisations.

The government is not alien to us. It is important that government people, volunteers and other social workers should work together. In politics also, there is no reason to think that all people are bad. There are good people in politics also and that example is well set in Madhya Pradesh by chief minister, Digvijay Singh. From Andhra Pradesh and Madhya Pradesh, people who have come and stayed in Ralegan Siddhi for 1-3 days to see it work number 36,000. People with similar thinking must work together. We need to network and unite together for the progress of the country. Our strength is today a scattered strength. If we unite, then we will move ahead.

Annasaheb Hazare *is well-known for the transformation of his village, Ralegan Siddhi in Maharashtra*

CHHELBHAI J SHUKLA

I am going to talk about the barriers we are facing today. Gujarat has a tradition of diamond cutting work which is today a major occupation there and all the youth are working. The land we have can feed the whole of India with oil and cotton. Today, 50 per cent of India's cotton exports is from Gujarat. But we don't have water and our youth are migrating to Surat or Mumbai. My first suggestion is that we should have an Employment Guarantee Scheme, which provides 100 days employment projects for watershed development. Then water will accumulate and there will be 300 days of work instead of only 100 days.

Secondly, Kachch and Saurashtra, which are border areas, need special attention. The military is also posted there but very few people are harvesting water out there. Thirdly, I want to say, "Don't disturb us with your politics." I also say 'keep the bureaucracy out.'

Fourthly, small projects should be initiated. There should be no check dams built for Rs 1-2 lakh. No work worth more than Rs 50,000 should be supported. I request you to allow small farmers to work as independently as possible.

Chhelbhai J Shukla *has done work in drought-prone and semi-desert areas in 40 villages in Gujarat. He also worked with the Khadi and Village Industries Commission.*

R GOPALAKRISHNAN

The experience of environment management programmes is that they have not excited political or popular imagination in the past. This was mainly because a technocentric approach was adopted despite opportunities for doing it through a poverty alleviation route.

The effort of the Rajiv Gandhi Watershed Development Mission in Madhya Pradesh was to combine the twin objectives of poverty reduction and environment regeneration in a mutually supportive manner. It was part of the larger set of initiatives that the government of Madhya Pradesh undertook in 1994 of seeing people as a solution to many of our urgent concerns. Along with other important issues like basic education and community health, watershed management was identified as a major priority. The point to emphasise here is that watershed management in Madhya Pradesh is not a stand-alone initiative but part of a larger process of community empowerment, at the political level, through *panchayati raj* and, at the social level, through community-based organisations.

The mission moved away from the traditional technocentric approach and put in place a watershed management programme through peoples' watershed committees. Watersheds of 5,000-10,000 hectares in each district were used for this activity. Madhya Pradesh tried to earmark 50 per cent of the Employment Assurance Scheme (EAS) funds received for watershed management from the Central government.

In each district the watershed development mission is overseen by a district mission team headed by the collector. In terms of management, at the apex level, there is a society headed by the chief minister which has environmentalists, ministers and secretaries of related departments represented on it. The chief minister's office has a secretary to the chief minister who functions as the mission coordinator to oversee this and other missions. The executive committee of the society which fast-tracks the progamme and provides intersectoral support is headed by the chief secretary. There is a mission director for the mission supported by a small team which implements the programme.

Between 1994-98, the work has spread over 3.4 million hectares in nearly 8,000 villages, making it not only the country's but perhaps the world's largest watershed programme. By 1998, work had already been completed on 1.2 million hectares of land and, in some districts like Jhabua, the work has been measured using satellite imageries of 1993 and 1998 to show the difference. The fact that both the green cover and extent of waterbodies as well as productivity of land has increased proves that an environmental turnaround of some of the most degraded areas is possible through this kind of approach.

The experience of the programme can be summarised as follows:

- It is possible to combine the need of the people in the rural areas for employment with a natural resources regeneration programme, thereby using surplus labour to regenerate degraded land and water resources. This, in the short term, provides livelihood to the poor and, in the medium term, regenerates the natural resource base to be able to sustain people on the land, making it a win-win situation.
- Such a programme tends to become popular with both, the public and the politicians, who see the welfare implications of such a measure.
- The real constraint is the bureaucracy which is organised on turfs and finds it difficult to come together. Their compartmentalised working dissipates both energy and funds.
- In this context, an approach like that of having a mission with the political backing of the chief minister helped to some extent to dissolve the turf issue and institutionalise intersectoral action. More importantly, conceiving the programme from bottom upwards with people's structures in command has also, to

It is possible to combine the need of the people in the rural areas for employment with a natural resources regeneration programme, thereby using surplus labour to regenerate degraded land and water resources

some extent, helped to resolve the issue.

- The watershed management societies have existed in parallel with *panchayats* in Madhya Pradesh. This was consciously done as watershed management societies were seen to be complementing *panchayati raj* institutions as plural grassroot-level initiatives. The actions of the state government which brought into existence a large number of user-based organisations has meant that *panchayats* function in a contested environment and these institutions together sharpen the process towards community-based activity, the larger objective.
- Currently, the progamme is poised at a point in time where it needs to be evaluated. These evaluations will also need to make a paradigm shift and supplement external evaluations with community's own evaluations of what has happened to them in their everyday lives.
- The mission is currently engaged in assessing the impact of the programme on the basis of various technical, economic and social parameters.
- The larger issue that the mission confronts today is that of intra-watershed inequity. This can be resolved only through major poverty reduction programmes through land and water management. The mission proposes to develop a framework of community regulations which allows the villages which have gone in for watershed development to regulate the use of water also.

R Gopalkrishanan *heads the Rajiv Gandhi Mission for Watershed Development and is secretary to the chief minister of Madhya Pradesh.*

N C SAXENA

We have had excellent case studies of success in Chennai, in Madhya Pradesh, in Kozhikode and elsewhere. We have also had some papers which are policy-oriented. We need to know if these are the changes required, then how do we operationalise them and what kind of road map is needed to reach them? If we look at the water sector in the last 50 years, two significant changes have taken place. One is that the resource from which we use to draw water was either surface water or sub-soil water — tanks, ponds and wells — from that we have shifted to groundwater. That's one very big change that has taken place. The other is that the responsibility for providing water has shifted from communities or individuals to governments. Everyone thinks that government is going to provide water.

Recently we came out with an advertisement saying that 95 per cent of the villages have been provided drinking water but we all know that the figure is not more than 50-55 per cent

On paper, the government may have succeeded. Only recently, we came out with an advertisement saying that 95 per cent of the villages have been provided drinking water but we all know that the figure is not more than 50-55 per cent; there are many villages with a chronic problem. So why this gap between actual reality and the figures that we have in our record? The reason is that the sustainability of our investment today is very much in doubt. When we took up this programme 15 years back under the Rajiv Gandhi Drinking Water Mission, at that point of time we thought the number of problem villages is five per cent that is 10,000-30,000. Very easy, in every plan we said that all problem villages would be covered. This announcement was made during the Sixth Five Year Plan. We started with the figure of 50,000 but soon found that 50,000 minus 50,000 is not zero, it is 100,000 or 200,000. In the Eighth Plan, we started with the figure of 200,000 and we covered 200,000. Today again we are left with 200,000. So, if we start looking at what is the achievement and what is the balance that is left, two minus two is always two in our mathematics.

Now this is happening because the entire programme is pipe or handpump-oriented and dominated by government, while people's participation is missing. But for this we need two changes. When we talk about rainwater harvesting, we have to shift the responsibility from groundwater to surface or sub-soil water. Can that be done in 5-15 years? I am not very sure. We also require programmes which will recharge groundwater, and for that we have watershed development programmes, but my own hunch is that watershed development programmes, even if they succeed and bring wonders to agriculture and forestry, their impact on recharge of groundwater will perhaps not be as good. Therefore, we have to look at the technology which should go into watershed development.

Then there is the whole issue of institutions. Government as an institution has its own weaknesses. We do have *Panchayati Raj* but the limitations of *panchayats* is very well known. *Panchayats* tend to become political bodies and they look upon themselves as offices of patronage. The *panchayat* leaders think that we will get

money under the Jawahar Rozgar Yojana and this money, we will distribute it to our friends. Therefore, how do we turn *panchayats* into functional bodies which have people's participation, is an open question.

Then you have *panchayats* and water users committees. In many places, water user committees may be doing really good work but these are smaller groups and often there is hostility between the *panchayats* and the water users committees. How do we link water users committees with the *panchayats* is another very big issue. The division of responsibility between the government and these committees or *panchayats* is another important issue. Often it is claimed by government that because people are inactive, because people are indifferent, we have to step in.

I think there is a cause and effect relationship and it is on both sides. When government becomes active, people become indifferent. When people become indifferent, and resources become open access resources, the government feels that it has a role to play, and there must be more laws. Communities on their own will not be able to control because it is not only a question of one village, it is a question of many villages. Today, even within one village, collaboration is difficult. So when you have a watershed programme for many villages, then it becomes a very difficult job.

In the three states of Andhra Pradesh, Karnataka and Tamil Nadu, there are about 150,000 tanks and each tank, if it can be desilted, can lead to lot of irrigation and groundwater recharge, but problems of technology and inter-village collaboration will have to be dealt with. Here, not only one tank may be covering many villages but there are tanks which are interlinked. Therefore, we cannot look at the sustainability of just one tank, we have to look at many tanks in a row. There again we require collaboration between a very large number of villages.

Many programmes of our government and of our political development has led to a decline in social capital. The kind of cohesiveness which is required today in a village is today perhaps lacking. How do we regenerate this social capital? How do we get back the community spirit? This is a very important issue.

As regards funds, we know there are funds, but there is fragmentation, there is not enough coordination. In drinking water itself, funds have increased from Rs 400 crore to about Rs 1,600 crore from our ministry alone and, more than that, maybe Rs 2,000 crore is contributed by state governments. So we have this programme of Rs 4,000 crore. How to utilise this Rs 4,000 crore?

People have talked about inadequacy of laws and delegation but you may be aware of the Schedule V law has been passed by government recently under which complete control over minor waterbodies, dams and ponds, has been given to *gram panchayats* and *gram sabhas*. In the tribal areas in the Schedule V areas of eight states, Himachal Pradesh, Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, Orissa and Bihar, *gram sabhas* and *gram panchayats* have complete control by law and ownership over tanks and ponds. So the complaint that at one stage, tanks and ponds belonged to the people and now Public Works Department or irrigation department has taken them over, is no longer true. We have also authorised the *gram panchayats* and *gram sabhas* to spend money from Jawahar Rozgar Yojana and up to certain limits, which varies from state to state. In Madhya Pradesh, for instance, it is Rs 50,000, elsewhere it is Rs 20,000 or Rs 10,000. Up to Rs 50,000 expenditure in Madhya Pradesh, they do not have to go to any junior engineer or block officer. The *gram panchayat*, on the orders of the *gram sabha*, can spend this much amount. So, therefore, at least legislation is in place, funds have also been devolved, but are things really happening? Is it really leading to rejuvenation of tanks and ponds? I have my doubts.

We have problems but we need concrete suggestions on what kind of laws and policies we need, how should this money be spent, what institutions are required, and how can we improve the social capital of our villages. Given the fact that we have these strong constraints of bureaucracy and politics, we need some good implementable suggestions.

Institutional changes are often the most difficult to achieve and specially from the government itself. We have been trying to give the responsibility of maintenance of water systems like handpumps to the *panchayat* or to the village. We have also been trying to train people in the village itself so that repairs and maintenance can be done within the village itself. We are also toying with the idea of charging for water, and we have some projects, especially a project in Uttar Pradesh, where people are to pay 100 per cent of maintenance charges and 10 per cent of capital costs because we feel that unless people pay for water, there will not be sufficient people's involvement and they will continue to look upon water as government's responsibility. But in order to make people pay, you have to build the capacity for management.

People living in a village do not often constitute a

Many programmes of our government and also our political development has led to a decline in social capital. The kind of cohesiveness which is required today in a village is today perhaps lacking. How do we regenerate this social capital?

Generally, what happens in a government project is that as soon as money is sanctioned, the implementing authority is in a great hurry to spend that money so that it can get the second installment

community in a sociological sense. Therefore, in order to build managerial capacity in the Uttar Pradesh project, a time of 22 months has been provided after a project is sanctioned for a village. For 22 months no purchase can be done. Generally, what happens in a government project is that as soon as money is sanctioned, the implementing authority is in a great hurry to spend that money so that it can get the second installment. But for the first time, a lead period of 22 months has been provided and we have also involved a large number of NGOs in both Bundelkhand and Uttar Pradesh hills.

So, therefore, there are these interesting examples of both governmental and non-governmental collaboration, trying to build social capital and trying to build communities, but these are still at a very small-scale. We have prepared a new policy, which is going to the Union cabinet soon where many of these elements are being taken care of.

N C Saxena *is member-secretary of the Planning Commission*

DUNGLENA

Apart from a water harvesting programme, we also have a rural programme. The situation in India today is such that the role of the government is so big that we cannot immediately shift to the people. What is required is a slow but steady effort to mobilise the people so that they can take over. In Mizoram, we have a programme of rainwater harvesting which is a Central and state government combined programme. Under this programme, we have already constructed over 6,000 rainwater harvesting tanks of varying sizes in 198 villages which is about 25 per cent of the total number of villages in the state. We have strong NGOs in Mizoram which are now planning to completely take over the maintenance of rural water supply from government and hand it over to the people. The maintenance will be the job of the village council.

It is not possible to take over this work immediately. At this time, the change over has to be slow as the people have to be prepared, because there is no will to pay and there is no political will, no individual will or social will. At the moment what is required is to change the minds of the people first.

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A VAIDYANATHAN

I have been requested to sum up these three days of deliberations. Obviously, I cannot do justice to many things that were said and inevitably one's own personal biases will creep in. But please bear with me.

The conference arose from the widespread realisation that water shortage for essential domestic use is a problem of crisis proportions in many urban areas and also a serious problem in rural India despite considerable investments taking place over the last 40-50 years.

The second concern is the low productivity of rainfed agriculture and much of the non-agricultural land which should be producing biomass. It is in such a degraded shape that it doesn't produce any of its potential. Both these have a direct bearing on the food and livelihood security of a vast majority of India's population. Lets not forget that 70 per cent of cultivated land is still rainfed. The central cause of this is the inadequate and the unreliable supply of water and its inefficient management. This is not a God-ordained situation but is entirely human-made.

There are basic sources of all water. Rainfall is abundant in many areas; properly harvested and utilised, is adequate to sustain a much higher level of biomass productivity of all kinds. The technology is available, we have ourselves had a long tradition of rainwater harvesting in rural India which is embodied to this day in something like three-quarters of a million small water control works, tanks, *bhandaras*, and others, spread all over the country. And their beauty is that they are, for the most part, products of local community effort and they have been maintained and managed by the user

communities for a very long time. But these have suffered from serious neglect in the post-Independence period and there are many reasons for this.

First, without getting into the question of whether large dams are good or bad, we can definitely say that there has been far too much emphasis on large storages and energised pumping of groundwater, to the neglect of even preserving whatever traditional water systems we have had. Much of these have suffered from neglect and decay. Not to speak of exploring new ways in which this tradition blended with modern technology could be made to play a much more extensive role in harnessing and utilisation of local rainfall.

There has been too little effort to conserve and make effective and efficient use of the available water. This is in part due to the defects in the way we have planned projects but, fundamentally, they reflect the fact that the pricing policies which the government has followed in respect of practically all sources of water, has served actively to encourage its wasteful and inefficient use. In other words, with the current pricing of water and electricity, no one has any incentive to use less water and use water for more productive purposes.

The other problem is that there is far too much statism in the development and management of water resources. Almost the entire investment in irrigation is by the government and, in fact, in large projects, right up to the field, as the government undertakes to build free channels and all the rest of it. A great bit of the investment in private well irrigation has been the result of very liberal financial assistance from the state and public financial institutions. In this process, the politics of populism applies not only to irrigation water supply but also to urban water supply. This has led to a fiscal problem and a serious problem of unsustainable and ineffective use of water resources.

The conference has been addressing the problem of restoring traditional, local community-managed systems to their full potential, rehabilitation, and modernisation by seeking to expand the scope of this systems, by constructing new small reservoirs, integrating them with large reservoirs, and, most important of all, integrated watershed development in rural areas; and, in the case of urban areas, the importance of both conservation and proper management of available water supplies and exploring less expensive and technologically-feasible ways of tapping rainwater. We have been impressed by the very many examples presented from all over the world, including the developed world, and we have also noted the very significant innovative initiatives which have been taken within the country, particularly in Chennai and in the Northeast.

Our general conclusion, first, is that there should be a drastic redressal of the balance of allocational resources and much more attention be given by policy-makers and planners to small, community-managed water control systems.

Second, in order to do this, the state must withdraw. We have noted that there are innumerable plans of integrated watershed development, mostly on the basis of NGO initiatives and significantly in recent times. The kind of experiments which are being done are remarkably striking in terms of their success in Madhya Pradesh.

Therefore, we emphasise that these systems cannot

...The politics of populism applies not only to irrigation water supply but also to urban water supply. This has led to a serious fiscal problem which is also a problem of unsustainable and ineffective use of water resources

be centrally planned for several reasons: one is that they are far too dispersed over vast areas and the conditions under which the techniques, the scales and the manner in which one would harvest water or use it will be critically dependent on local circumstances. Therefore, the state should withdraw; it should entrust the responsibility for planning, design and implementation of these works as well as continuing management to the elected *Panchayati Raj* bodies. The problem is not one of resources. The money available is quiet considerable but much of it goes down the drain. Therefore, with this money, two things can be done. Ideally, all this money should be transferred and earmarked for an unified integrated watershed development plan. It should be transferred to the village communities with appropriate external help to plan and design in consultation and full participation of the community representatives at all stages, along the lines being attempted in Jhabua, Madhya Pradesh, and in other places.

There is no question in our mind that this transfer of resources and responsibilities to the concerned communities is an important, essential prerequisite. Now this does not mean that the state abrogates all responsibility. It has several responsibilities, one of which is to create an enabling environment, legally and in terms of incentives. It is the responsibility of the state to provide a framework which defines the broad guidelines, and mechanisms by which these guidelines can be monitored. But otherwise there should be very little interference from the state.

A Vaidyanathan, *formerly a member of the Planning Commission, now leads a study on tank management of the Madras Institute of Development Studies (MIDS).* ■

CHAPTER 7

Drought of 1999-2000

- Though by October 1999, it was known that the monsoon was below average in several states, the media suddenly discovered drought in April 2000 and reports abounded in the press for the next few months. The government was forced to take action.

- States like Andhra Pradesh, Gujarat, Orissa and Rajasthan which had been declared drought-hit made their customary demands for Central government aid, which is generally used in the form of various short-term and highly unsustainable measures like digging deeper tubewells, ensuring tanker supply, providing fodder and employment generation. This is the predictable and typical knee-jerk damage-control exercise of a government that has woken up late. There was nothing unusual in this.

- What was unusual about this drought was the way in which state governments started thinking about long-term drought-proofing measures. The governments of Andhra Pradesh, Gujarat and Madhya Pradesh initiated several community-based water harvesting programmes. They were finally thinking of long-term measures to deal with monsoon failure.

- CSE researchers travelled extensively to Andhra Pradesh, Gujarat and Madhya Pradesh to assess the results of these efforts. Each state government had a different approach, as was the response by the people.

- Gujarat followed the same paradigm that civil society follows, of social mobilisation, raising awareness and involving the people. The people responded wholeheartedly. Other than non-governmental organisations who were already involved, religious movements and groups chipped in to mobilise people and promote water conservation programmes. Even the business community participated. Those who had made money outside the state were eager to mitigate the crisis in their homeland. It was a true representation of civil society.

- In Andhra Pradesh, a 100-day crash water conservation programme was announced as part of the Janmabhoomi programme. Non-governmental organisations were hardly involved. The approach was more top-down than actually participatory. But in places where awareness levels were high, communities capitalised on this programme. The government is, however, learning and plans to continue this work.

- In Madhya Pradesh, under the Ek Panch Ek Talab programme, every elected *panchayat* member was asked to restore a tank, thus setting into motion a kind of competitive populism amongst the political leaders. The response to the programme has been good. Grassroot level politicians recognised that this was a programme which could build up their vote bank and so willingly supported the programme, cutting across party lines. The villagers gave their labour, money and land.

- All these efforts indicate that it is possible for governments to effectively drought-proof their states if they set their minds to it. Not only does this make political sense, it also provides long-term solutions to effectively deal with drought.

Jolted into Action

State governments were forced to launch crash programmes for community-based water management in the drought of 1999-2000

Anil Agarwal
Centre for Science and Environment, New Delhi

It was election time: September 1999. The monsoon season was just coming to an end. India's home minister, L K Advani, was fighting for re-election from a constituency in Gujarat. Yet, at a time when there should have been sufficient water, newspapers were reporting slogans like '*Pehle Paani Phir Advani*' (first water, then Advani). This sounded quite ominous. If there was a shortage of water even before the monsoon had ended, how would people survive over the next nine months when there would be no rainfall. The next newspaper reports were indeed ominous.

On December 14, three people were shot and 20 injured in Falla village by the Gujarat police when villagers protested against the state government's decision to reserve the remaining water in the Kankavati dam for the nearby Jamnagar town. The summer was still three months away. Rainfall in the area was reported to be a mere 148 millimetres (mm) compared to the normal of 550 mm. "If there are no rains in early 2000, we will have to migrate from the village," said Veljibhai Dhamsania, vice president of the Falla gram panchayat. "This is the worst drought I have ever seen in my life," claimed 48 year old Lasan Bhilwad of Rentia village in Dahod district.

The state's ruling politicians themselves were busy sowing confusion. While one set wanted to reserve water for Jamnagar residents because of the forthcoming city corporation elections, another set wanted to keep it for the rural folk because of the upcoming *panchayat* elections. So everybody in power was busy fighting over the limited water available. Few were saying anything about how to solve the region's water crisis where groundwater resources had been seriously overexploited.

Because of its past work in rainwater harvesting, the Centre for Science and Environment (CSE) knew most people in the country involved in community-based water conservation using the age-old technology of water harvesting. We, therefore, decided to send a researcher to see how those communities were faring in this drought. Was rainwater harvesting helping them to meet this acid test?

Not far from Falla there were several villages in drought-affected Gujarat and western Madhya Pradesh which had been undertaking water harvesting or watershed development-cum-water harvesting work. The CSE researcher visited numerous villages and came back with a stunning and extremely inspiring report. All these villages were coping quite well even though neighbouring villages which had not harvested their rainwater endowment were in deep distress. The report published in *Down To Earth* (January 15, 2000) revealed the following:

- In Gelhar Choti in Jhabua (western Madhya Pradesh), which had benefitted from a Madhya Pradesh government watershed development-cum-water harvesting programme, though the rains were only 439 mm as compared to the normal of 980 mm, villagers were able to irrigate 91 hectares (ha) in 1999 *kharif* as compared to 13 ha in 1996. The *kharif* yield was about twice that of 1996. But the fate of the people of Umari panchayat, just 30 kilometres from Gelhar, who did not get a chance to participate in the watershed development programme, was not the same. "People are now demanding watershed management projects in their villages," said Mohan Singh, *sarpanch* of Umari panchayat.
- Just across the Madhya Pradesh-Gujarat border, in Dahod district, Sadguru Water and Development Foundation, a non-governmental organisation (NGO), had also been encouraging water harvesting. The foundation got the villagers of Thunthi Kankasiya, a village that was shunned by prospective brides, first to build a check dam on the seasonal *nullah* called Machhan and later take up intensive watershed development work. Today, the *nullah* flows round the year. And even in 1999-2000 when the rainfall was only 40 per cent of the normal, farmers were able to irrigate 135 ha and all the 23 wells in the village had enough water to meet drinking water needs.
- Nobody wanted to give their daughters to Raj Samadhiyala in Rajkot district either. This was 15 years ago. But since then its *sarpanch*, Hardevsinh

Balwantsinh Jadeja, had encouraged the villagers to build 12 check dams and undertake watershed development. The result: Farmers were able to sow cotton, wheat, groundnut and vegetables in 1999-2000 even though the rainfall was less than two-thirds of the normal. And the groundwater level in most wells was only about three metres.

- In Gandhigram village in Kachch district, the villagers were suffering from overextraction of groundwater leading to ingress of saline sea water into the aquifer making it undrinkable. The village has constructed several check dams and has even taken a bank loan to build more. Gandhigram was getting its drinking water from government pipelines. But the villagers were unsure that this water supply would last long. So they decided to strike off on their own. Despite the drought of 1999-2000, the villagers had irrigated 400 ha, a lot of which was earlier barren.
- In Mandlikpur in Rajkot district, the villagers had fought back their water crisis by recharging their borewells by harvesting their rainwater under the leadership of Saurashtra Lok Manch, an NGO headed by Shamjibhai Antala which has launched a movement to recharge dugwells and borewells.

All this was really inspiring. It showed that those who cared for their raindrops reaped a big harvest.[1]

For many months, as dry weather set in, there was no news about the drought and its impact on the drought-affected people. On April 19, 2000, *The Indian Express* suddenly had a banner headline 'Forget the Sensex (stock-market index) for a second, look what else is going down'.[2] The lead story of the national daily talked about a serious drought affecting Gujarat and Rajasthan and depleted groundwater tables making life miserable for water-short people. Soon the media was reporting a serious drought not just in Gujarat and Rajasthan but also western Madhya Pradesh, Andhra Pradesh and Orissa.

The only silver lining to this tragedy was that the efforts of the NGOs to promote community-based water management finally began to penetrate the mind-sets of the country's intelligentsia and political leaders. The media also strongly supported the concept of rainwater harvesting.

Faced by the violence that the water shortage had unleashed in Gujarat, the state government had already started a crash programme to build thousands of check dams to hold the monsoon runoff and recharge the groundwater in January 2000. Unlike other states. a powerful combination of NGOs, religious leaders and village entrepreneurs who had made it big in diamond trading and other forms of business had already been promoting rainwater harvesting to meet the state's near-permanent water crisis. The government needed a quick fix for the problem and immediately capitalised upon the efforts of its civil society to start its own Sardar Patel Participatory Water Conservation Programme.

By mid-May, Andhra Pradesh chief minister, N Chandrababu Naidu, was also announcing a crash 100 day rainwater harvesting and conservation programme across the state at a cost of Rs 140 crore.[3] District collectors had already apprised him of the benefits they had seen of contour trenching, check dams and various other water harvesting methods in late April.[4] Even the World Bank offered to provide Rs. 100 crore to fight the drought through water harvesting measures.[5]

Meanwhile, the Madhya Pradesh government which had started a pioneering and highly participatory watershed development programme way back in 1994, and which had helped to keep the state away from all those tragic pictures in the national media even though western Madhya Pradesh was equally badly affected by the 1999-2000 drought, was thinking of a yet another programme for water conservation: a village tank restored or built by every *panchayat* leader.

The following pages present reports on the experiences of these three state governments in the first year of their water harvesting programmes: Their successes and failures in launching a mass movement for rainwater conservation.

But the story has not ended here. Not only are these governments still learning from their initial foray into community-based water harvesting — a new paradigm for water management — nature has thrust upon them yet another serious drought in 2000-01. India is likely to re-invent its ancient paradigm of water management forced by a period of crisis. ■

AKHILESH / CSE

A facilitating government and a receptive community can reduce the drudgery involved in sourcing water. OPPOSITE PAGE: ***A government tanker supplies drinking water to a drought-stricken village in Saurashtra in April 2000*** (PIX: SHAILESH RAWAL / INDIA TODAY)

Drought of 1999-2000: Gujarat

Emulating Civil Society

In January 2000, the Gujarat government launched a massive drive for building check dams after the 1999 monsoon failed. The first initiative of its kind, based on the 'civil society paradigm', the programme left behind a trail of successes and lessons to be learnt

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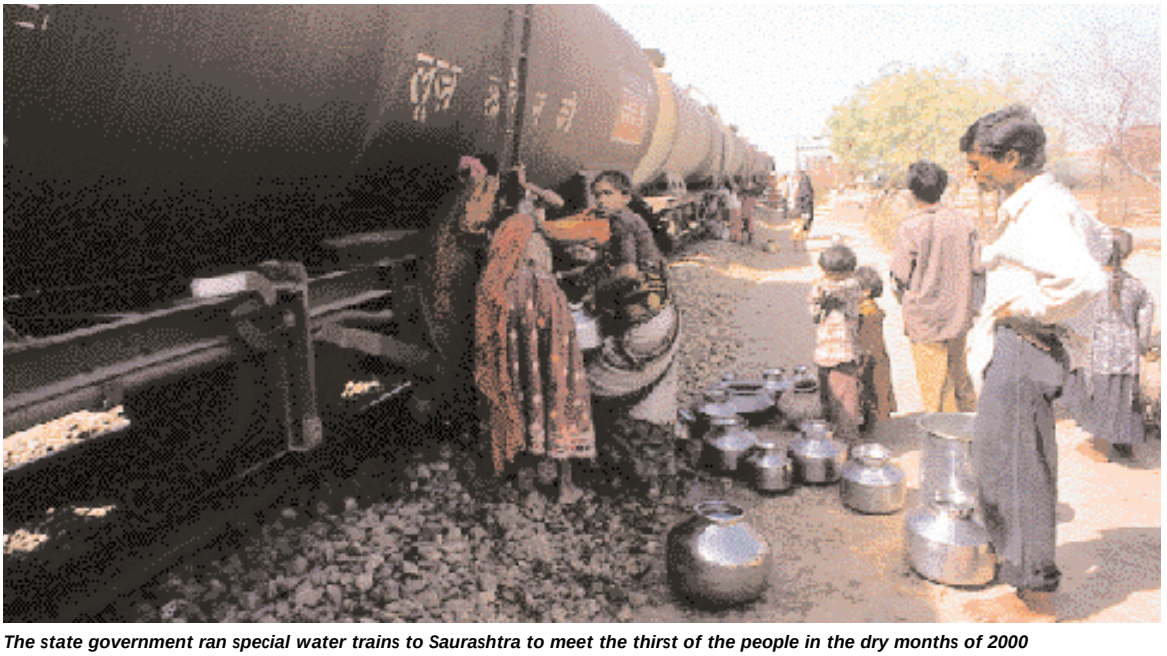
In January 2000, the Gujarat state government launched the Sardar Patel Participatory Water Conservation Programme (SPPWCP) with the objective of involving people in the construction of 2,500 check dams at an estimated cost of Rs 100 crore. The unprecedented response that the government received in response to its programme resulted in the construction of more than 10,000 check dams — more than four times the estimated number — at a projected cost of Rs 200 crore.

One of the most striking features of the programme was the implementation process that was adopted. Learning from its own experiences and the experiences and processes followed by various non-governmental organisations (NGOs) and religious groups in the state, the government attempted to adopt a similar process of raising awareness, social mobilisation, involving the people and getting them to contribute to the programme.

There were already several outstanding community-based efforts to manage local water resources using the technology of rainwater harvesting. These efforts were showing clear results that the drought of 1999-2000 was being easily managed by these communities *(see Box: A sarpanch scores)*. The results of SPPWCP have been encouraging, and, as can be expected from a programme of this scale, there are also several flaws and lessons that need to be learnt. Nonetheless, coming from a state government viewed as a strong proponent of large dams, this effort is indeed commendable.

However, success for the state government's programme would not have been possible if the people had not responded in the way they did. They filed applications by the thousands, which implied that they



SHAILESH RAWAL / INDIA TODAY

The state government ran special water trains to Saurashtra to meet the thirst of the people in the dry months of 2000

A *SARPANCH* SCORES

The drive of a village* sarpanch *brings water where there was none

About 20 kilometres away from the district headquarters of Rajkot, the village of Raj-Samadhiyala shows how environmental management can bring about a socioeconomic turnaround and beat the vagaries of nature. Around 15 years ago, people were unwilling to marry their daughters to grooms in this village due to water shortage. More than 75 per cent of the borewells in the village yielded no water, says 48-years old Hardevsinh Balwantsinh Jadeja, head of the village council *(sarpanch).*

About 10 years ago, the village was declared a desert area and put under the arid zone development programme of the state government. In the 1986–87 drought, residents undertook watershed management projects. Jadeja led the villagers to construct 12 check dams between 1986 and 1988. The villagers planted thousands of trees, and undertook stone-trenching, bunding and terracing in their fields. The district rural development agency (DRDA) allocated Rs 17 lakh. Since 1998, the villagers have implemented around 50 microwatershed projects (a microwatershed project is an area of about 500 hectares).

The credit for the turnaround in the village goes to Jadeja. He thinks that rainwater harvesting is the only solution to deal with the grave water crisis in Saurashtra. In 1985, Jadeja, a post-graduate in English literature, was selected for the post of deputy commandant in the Central Reserve Police Force. At the same time, Jadeja was also offered the post of *sarpanch* by the village development committee. He opted for the latter, a courageous decision as he was foreswearing the comfort and security of a government job. "If you are strong as a person prosperity comes to you. You do not need to run after it. Today I lead a life of comfort and luxury in my own village along with my neighbours," says Jadeja.

In 1986-88, Jadeja organised the village to take up 12 watershed management projects and initiated a drive to plant trees. Today, the village is one of the most prosperous ones in the area.

There is ample water. Farmers were able to sow cotton, wheat, groundnut and vegetables even during the drought of 1999–2000. Even though there was only 316 millimetres (mm) of rainfall this year — against an annual average of over 500 mm — the groundwater level could be found in most of the wells at a depth about three meters, and was only 1.5 meters in some wells. "All the 280 wells, 5 handpumps and 35 borewells have water. The surface water is available for at least 10 months now," says Jadeja. There are 51,000 trees in the village today, as against just 1,600 in 1988. The farmers are now developing their erstwhile wastelands.

Farmers' earnings have increased significantly. Villagers point out that they earn around Rs 2.5 crore more than the neighbouring villages of Aniyala, Pada, Hammatiya Goldia, Dhandiya and Shadan, which do not have water harvesting structures. Raj-Samadhiyala sells vegetables alone worth Rs 50 lakh every year. "In 1990, when water was scarce, my father used to earn Rs 1.5 lakh from his farms. Today, I earn around Rs 10 lakh from the same land," says Jadeja. Says Devsinhbhai Bhavanbhai Kakadia (60). "I used to earn Rs 5,000–10,000 per year from my 6.4 hectares. Today, my income is about Rs 1-1.5 lakh. I am confident of earning at least Rs 50,000 even during the present drought."

Water has brought about social well-being as well. Jadeja claims there is no crime in the village, no police case is registered at present against anyone from the village and that the people leave their houses open and unguarded.

Before 1988, most of the families used to migrate in search of livelihood. Migration for employment has ceased now. Today, there are just 50 families below the poverty line, as compared to 138 in 1988. Ashwini Kumar, sub-divisional magistrate of Rajkot, says Raj-Samadhiyala received the prize of Rs 25,000 as the best village *panchayat* in Gujarat.[1]

were ready to do their part. This readiness can be gauged from the fact that in some villages which have already been involved in water harvesting, people had even taken loans to build water harvesting structures *(see Box: Taking loans to harvest water).*

FRUITS OF LABOUR

The impact of the SPPWCP was visible in several districts of Gujarat, whether it was Rajkot, Junagadh or Jamnagar in Saurashtra, or Bhuj in Kachch. Villagers in these drought-prone regions looked much more confident in September 2000 about dealing with drought in the future. They now had water. Barely four months ago, in June, after the failure of the 1999 monsoon, they had appeared doomed and defeated. The reason for the change: check dams built by the thousands in the past few months, made possible only under the SPPWCP, launched by the state government in January 2000 in response to the drought. The response from the people was tremendous: a whopping 25,234 proposals were received. SPPWCP is based on the 60:40 concept, where the government bears 60 per cent of the cost, while the villagers contribute the remaining 40 per cent.

One such village is Padodar in Gharda tehsil of Bhavnagar district. For the past two years, no government water supply reached the village. Yet, in September 2000, there was ample water. Between March 17 and June 17, the villagers built 51 check dams. After the first showers of the 2000 monsoon, which is actually all they got in the season, all of them had water. Madhujibhai Dadojibhai, head of the village committee to make check dams, says, "During last year's drought, 20,000 litres of water was being brought in tankers every day. We are now optimistic that drinking water will be available even during summer."

In Dahisarda village of Rajkot district, a check dam had been built on Aji river 20 years ago. "Water would stay for only 10-15 days after the rains," informs Jagdanjibhai, member of the committee formed to raise

TAKING LOANS TO HARVEST WATER

Realising that the only way in which the water scarcity problem can be solved is by helping themselves, villagers of Gandhigram village in Mandvi taluka took loans to harvest water

Gandhigram village in Mandvi taluka of Kachch district has embarked on rainwater harvesting and water management only recently. For the past 10-12 years, the residents have been facing a drinking water crisis. "A few years ago even officials of the Geological Survey of India failed to get water from a borewell. They left the area, never to return. But we cannot leave. We have to live here and we have to find our own solutions," says Bhimji Premji Chaudhury, president of the Gram Vikas Mandal (GVM, the village development group) of Gandhigram.

The groundwater table has fallen below sea level due to overextraction. Seawater has now seeped into the underground aquifers, making them saline. At present, though Gandhigram is supplied drinking water through pipelines, the villagers do not know how long this water will last. They wanted to be on the safe side. So, in 1998, they took a bank loan to construct their own check dams. "We borrowed Rs 15 lakh from a local person and took an additional loan of Rs 5 lakh from a bank. We also contributed Rs 5 lakh to the project in the form of *shramdaan* (voluntary labour)," inform GVM members.

In mid-1999, the residents constructed a dam on the Khari river which flows nearby. There are about 400 people in the village, of which 25-30 people had migrated in late 1999 due to the drought. Faced with the drought, villagers decided to reserve whatever water was left in the dams for drinking purposes.

Apart from the dam, the people of Gandhigram have also undertaken a microwatershed project. The District Rural Development Agency is carrying out a watershed project in Gandhigram with the Shree Vivekanand Research and Training Institute, a non-governmental organisation as the implementing agency.

Says Lalji Vishram Chaudhury, the 68 year old chairperson of the watershed committee, "We received Rs 28 lakh from the government. With the help of this money we have constructed four large dams, 30 small dams and plugged 31 *nullah*s." He says the results are showing. "Gradually, we are getting more returns. From one hectare, we can now fetch Rs 2,500-5,000, which was impossible a few years ago. With the help of water harvesting structures, we have around 400 hectares of cultivable land, most of which was earlier barren." The drought of 1999-2000 thus became manageable for the people of Gandhigram.

the height of the check dam by one metre in May 2000. After the height was raised, 300 dugwells and 50 handpumps have been recharged in 40 per cent of the village land which is under agriculture, he points out. The dams now arrest enough water to facilitate lift irrigation, improving the lot of farmers.

The September 10, 2000 issue of *India Today* reported a number of villages where water availability increased dramatically after implementation of the SPPWCP.[1] The 2,000 odd residents of Vankia village in Jamnagar district survived on 40,000 litres of drinking water supplied daily by tankers. Thanks to their efforts in constructing 18 check dams on the rivulets and tributaries running into the Und river at a cost of Rs 42 lakh, when the rains came in July, the mere 150 millimetres was enough to raise the water table. Says Ashwinbhai Patel, a farmer who organised villagers from Vankia to avail of the scheme, "We have learnt to tackle the curse of drought." Bhurabhai Patel, another farmer who worked in a government-run relief camp during the drought along with other farmers from Vankia, is ecstatic. "What couldn't be achieved in 50 years has been achieved in just a few months," he exults. In Mudila village of Jamnagar district, the water situation was so bad that villagers had to buy water for the construction of the five check dams. Today, all the five dams are overflowing despite an unsatisfactory monsoon. The 100-odd wells in the village are full of water and the villagers expect the crop yield to double.

Fortunes also changed for the residents of Parapipalia village of Rajkot district after they got together and built nine dams on small rivulets at a cost of Rs 15 lakh. With the first downpour of just 110 millimetres (mm) all the dried up handpumps in the village revived. Munjka village of Rajkot district is happy with its 270 mm of rainfall against an average of about 500 mm. All the 90 handpumps and 50 wells have recharged following the construction of 11 check dams and farmers expect a good harvest.

Nitinbhai Patel, Gujarat's minister for minor irrigation programmes, who played an important role in promoting SPPWCP, says, "During the recent rains, water overflowed in about 8,000 (of the 10,500) check dams. Dugwells in the adjoining areas got recharged, improving water availability. While tankers were providing water to 2,500 villages during the drought, the figure went down to 1,400 after the first rains." According to Nitinbhai Patel, the most thrilling aspect of the entire programme was the execution work, which was accomplished by the people themselves. "There was no interference from anyone. The villagers were given a freehand to execute the programme according to their requirements", he claimed.[2]

M S Patel, secretary (water resources) of Narmada, water resources and water supply department, is confident that in villages with check dams, the problem of drinking water will now get deferred to the months of May or June instead of February. He says the SPPWCP is not merely a temporary measure to fight the drought but the reflection of a policy to deal with the water crisis in the long run.

COMMON SENSE PREVAILS

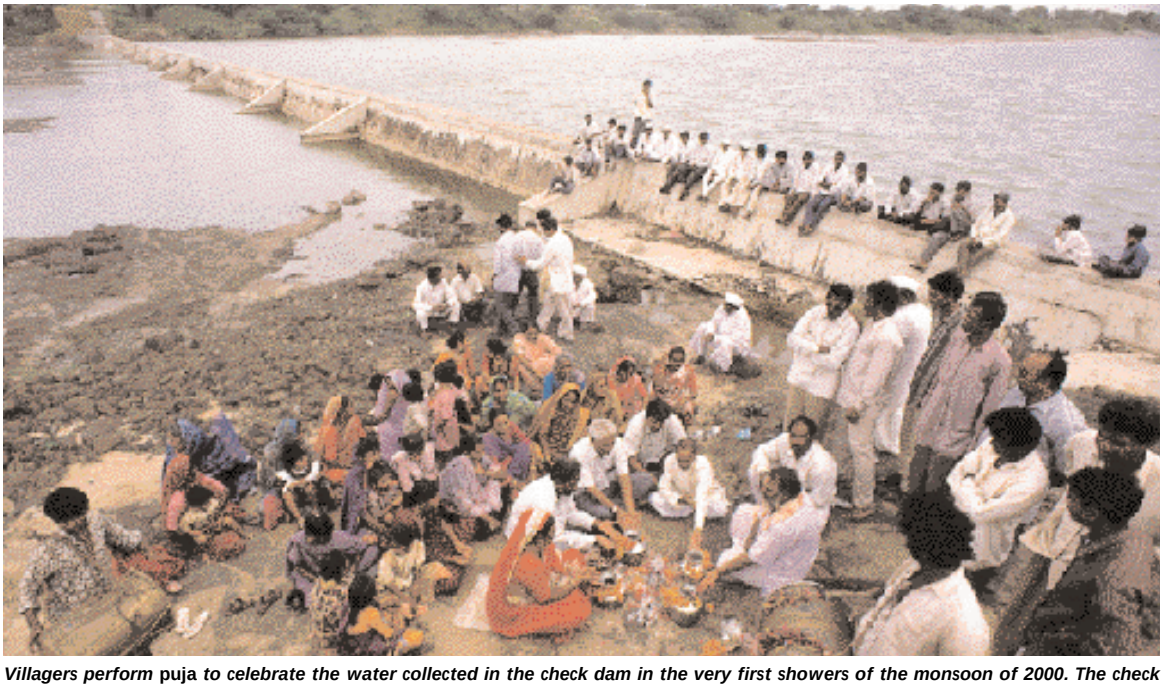
Genesis of SPPWCP

How did the state government come up with such a decentralised water management programme, especially in a state that is well known for its colossal affection for the Sardar Sarovar dam on the Narmada? The answer lies in the drought of past few years, which had created a compulsion for the government to look for additional strategies to deal with the water crisis. Apart from the drinking water crisis, agriculture, too, was in doldrums. "In Saurashtra, the main crop in the *kharif* season is groundnut," informs M S Patel, adding, "The total cropped area for kharif in Saurashtra is four million hectares (mha). At present, water for irrigation is being provided by 113 dams for 0.3 mha. Even after the Sardar Sarovar Project is implemented, only 0.4-0.5 mha will be irrigated. Therefore, 3.15 mha will still be dependent on rain. Therefore, even Narmada water cannot solve the problem. However, with small structures in Saurashtra, villages would have water both for irrigation and drinking."

In 1997 itself, the government had launched the 'Own your own check dam' programme, which was a disastrous failure. It yielded merely 62 check dams in three years despite the fact that the government was bearing 90 per cent of the cost. M S Patel acknowledges that the people stayed away from this programme due to complicated government procedures. It was obvious that a novel approach was needed.

While the need of the hour was evident, how did the government hit upon the idea of a large-scale, decentralised programme to build check dams? The answer lies in the success of community efforts, often led by civil society and religious organisation. "The government had seen the work of voluntary,religious and spiritual organisations in the state. They were interested in replicating the process across the state," says Sachin Oza of the Ahmedabad-based Development Support Centre (DSC), an NGO.

In fact, the government circular dated January 17, 2000, which announced the creation of SPPWCP, says, "Several active workers and service-oriented NGOs have taken up water conservation projects in these areas by collecting voluntary contributions from the people for preventing the rainwater from flowing out of their respective areas and to recharge the groundwater… and the results are overwhelmingly successful." The circular also mentions that the scheme is in response to the fact that "the people of these regions are determined to implement such projects" and also due to public demand as well as representations from members of the state legislative assembly and NGOs. The work done by Swadhyaya Parivar, a religious organisation, and the initiative taken by Mathurbhai Savani, a diamond merchant who belongs to Khopala village in Bhavnagar district, were a major source of inspiration *(see Box: Devotion in the time of drought* and *Box: Gem of an initiative)*.[3]



SHAILESH RAWAL / INDIA TODAY

Villagers perform* puja *to celebrate the water collected in the check dam in the very first showers of the monsoon of 2000. The check dam was constructed on river Und near Vankiya village of Jamnagar district by villagers during the preceding summer

AMIT SHANKER / CSE

The solution to the water crisis lies in capturing water and recharging wells, as shown by the message painted on the wall...

AMIT SHANKER / CSE

... as they do not know how long governments taps will give them water

DEVOTION IN THE TIME OF DROUGHT

Belief in* krutibhakti *or action-oriented devotion went a long way in persuading communities to harvest water

Swadhyaya, a popular religious movement in Gujarat believes *krutibhakti* (action-oriented devotion) and *shrambhakti* (devotion through labour) are the highest forms of devotion. In the field of water conservation this belief has translated into the construction of several *nirmal neers* (percolation tanks) and recharging of wells.

Started in 1958, the Swadhyaya movement aims to strengthen human relationships through volunteerism.[1] Pandurang Shastri Athavale, affectionately called as *Dada* (Marathi equivalent of elder brother) by the members of the Swadhyaya Parivar (family), is the main spirit behind the movement. His objective is to lift religion beyond mere rituals and blind faith and use the skills and intellect of the people to uplift the deprived: an act he equates with performing a *puja* (worship of God). [2]

The term *Swadhyaya* means the study of self and is extended by *Swadhyayees* to include self-development and enlightenment. The philosophy of Swadhyaya is derived from the *Bhagvad Gita* and focuses on *bhakti* (devotion) as an effective medium for a purposeful social existence. "For Swadhyaya the most effective form of *bhakti* is *krutibhakti* as opposed to blind faith or unwarranted rituals. *Bhakti* is considered as a social force for overcoming the existing social problems," explains Jagdishbhai Manubhai, a *Swadhyayee* living in Ahmedabad.[3] Whenever *Swadhyayees* are involved in manual labour, it is considered as *shrambhakti*.[4]

For groundwater conservation, the approach adopted by the Swadhyaya Parivar has been to construct n*irmal neers* (percolation tanks) and recharge wells. By 1998-99, the total number of *nirmal neers* constructed was 957. A total of 99,670 wells were recharged. The majority of them were constructed in Gujarat followed by Maharashtra and Andhra Pradesh.[5]

The process adopted by Swadhyaya for constructing *nirmal neers* — through volunteerism — is an ideal strategy to create a common property resource at the village level, according to C L Kotak, an ex-superintendent engineer with the government of Gujarat and an active member of Swadhyaya.[6]

Work on the *nirmal neer* at Chowkli village in Junagadh started in 1993 when Dada came to inaugurate the work. "Prior to construction, the youth of the village extensively discussed the pros and cons of the structure and mobilised people's support," recalls Jayantibhai Gajera, a Swadhyayee and resident of Chowkli.[7] The youth worked from 5 pm till 12 am continuously for one whole year. "Now, once the *nirmal neer* gets full, approximately 50 wells in the adjoining areas get recharged," informs Gajera. During the 2000 water crisis, villagers of Chowkli did not have to depend on tankers for drinking water. Though the water level definitely went down, water was still available.[8] Says Thakarshibhai Posia, another *Swadhyayee*, "We strongly believe in 100 per cent contribution by the villagers rather than getting support from outside."[9]

In Vavadi in Rajkot district, the Swadhyaya family briefed the villagers about the importance of percolation tanks. The villagers agreed to contribute to the construction work. The *Swadhyayees* then consulted the *panchayat* and obtained sanction for constructing the *nirmal neer* in the community pastureland. The villagers were involved in selecting the site.

Initially, only members of the Swadhyaya family came forward. Slowly, the rest of the villagers joined in the efforts. Keeping in mind the work schedule of the villagers, it was decided that construction would only take place from 8-11pm. "This arrangement was worked out to promote volunteerism," explains Kotak.[10] Soon people from the nearby villages also came and contributed towards the work. For them it was devotion to Dada. "The *nirmal neer* was constructed in 1997 but it had to be broken and constructed again because the adjoining agricultural lands were being affected," says Keshubhai of Vavadi.[11] The previous structure did not have a spillway and as a result the water was overflowing onto the adjoining fields. Apart from making water available, the other accomplishment of the *nirmal neer* project was that the entire village became one big family. When the water filled up for the first time, the entire village gathered to witness the impossible happening.[12]

Swadhyaya is also involved in the direct recharge of the wells. "There are approximately 500,000 wells in the seven districts of Saurashtra, out of which about 100,000 wells have been recharged by Swadhyaya. In some villages, 100 per cent wells have been recharged," informs Kotak.[13] The work of direct recharge has been accomplished through a concentrated effort rather than scattered one. "During the present drought, these wells still had water in them as a result of direct recharge," he claims.[14]

However, care needs to be taken while developing these water harvesting systems and the process has to be carefully adopted. Prior to implementation, villagers are made to understand that siltation has to be minimised. R N Athavale, a water harvesting expert, proposed measures to reduce the siltation. He suggested that a small pond should be excavated near the well in which water should be stored, so that water in this pond will percolate down and recharge the well on its own. This tank has to be made approximately 3-4 metres away from the wells," says Kotak.[15]

Other Swadhyaya projects like *Vruksh Mandir* (collective orchards), *Lokanath Amrutalyam* (community prayer sites) and *Shridarshanam* (collective farming by a group of about 20 neighbouring villages) also demonstrate how communities can raise economic resources for the poor. The *Vruksh Mandir* at Kankot in Rajkot was the first one of its kind to be started in 1979. There are approximately 2,000 plants in the *Vruksh Mandir,* all managed by using vermicomposting and avoiding chemical use. The wells and borewells used for the orchard are recharged through two *talavdis* (ponds) designed to ensure that rainwater from the adjoining areas is diverted into these structures. The produce is often bought by the *pujaris* (priests) themselves at the market rate. The money collected from the sale is recycled into the maintenance of the *Vruksh Mandir.*[16]

During the 2000 drought period, *Swadhyayee* members motivated those who were facing the crisis to take advantage of the government scheme. Today Swadhyaya has a vast network of functionaries at the village, district, area and region level. Through their efficient network, they are spreading the word amongst the Swadhyayees that they should apply and construct check dams in their respective villages.[17]

GEM OF AN INITIATIVE

When the concern of a Surat-based diamond dealer for his water-starved village translates into action with the village community, fortunes change. Then emerges a trust to spread the message to villages across the drought-prone region

Saurashtra Jaldhara Trust (SJT) was formed under the leadership of Mathurbhai Savani, a Surat-based diamond merchant from Khopala village, to spread the message of community water conservation across the water scarce villages of Saurashtra region. Savani is responsible for initiating rainwater harvesting in his village to minimise the intensity of the water crisis. SJT has been successful in generating awareness and motivating people to adopt rainwater harvesting at the local level in several villages across Saurashtra region.

The Saurashtra region of Gujarat has been facing an acute water crisis not only for irrigation but also for drinking purposes. The local people refer to it as *trikaal* (third year of consecutive drought). Traditionally, the *kaals* are classified as follows: In the first year, there is no water for irrigation; in the second, no water for livestock; in the third, no water to drink; and, in the fourth, no water for anything and famine. Into the third consecutive year of drought, an initiative was started in Khopala, a small village with a population of slightly more than 4,000, in Gharda tehsil of Bhavnagar district.[1]

Savani was concerned about the plight of the villagers in his native place due to paucity of water. He soon realised the two basic reasons for the crisis: overexploitation of groundwater and wastage of 90 per cent of the rainwater, which flowed into the sea without replenishing the underground aquifer. Just as quickly, he soon found the solution to both these problems: check dams. Not only did check dams store rainwater, but they also helped in groundwater recharge.

In order to get first hand information Savani visited Raj Samadhiyala village and interacted with *sarpanch* Hardevsinh B Jadeja, the person responsible for the transformation of this dry village into a prosperous one. Savani also visited Tarun Bharat Sangh to learn about the process of social mobilisation. This Alwar-based non-governmental organisation has been involved in motivating villagers to successfully undertake water harvesting in more than 650 villages. These visits convinced Savani that even small structures would help the villagers to counter the water scarcity problem.[2]

The Khopala Gram Vikas Samiti was meanwhile looking for an organisation that could assist them in benefitting from the government's earlier 'Own your own check dam' project. So Savani, approached Sardar Patel Gramin Vikas Mandal, a non-governmental organisation in Mallapura, to implement the project in his village.[3]

A total of 25 check dams were constructed in Khopala. However, several problems were faced in getting the government's share released. Technical reasons were cited for delayed payment for 23 check dams.[4]

Savani then realised that a different approach was needed for generating funds for widespread implementation of the project. He organised numerous village level meetings to motivate and sensitise

SAURASHTRA JALDHARA TRUST

Facing monsoon head on: villagers of Padodar in Bhavnagar district of Saurashtra rejoice in the water collected after the first rains from the check dam they built

the villagers regarding the project. Ironically, his own village was divided into various factions based on political ideologies, profession, class and even caste. Taking cue from Raj Samadhiyala and Alwar, he worked hard towards social mobilisation. Savani projected the water problem not as an individual crisis but as an issue affecting the entire village. The villagers of Khopala also visited Raj Samadhiyala. After the community got together, the entire plan for the project was formulated: some 200 check dams and 10 ponds were to be constructed.[5]

Before stepping out of the village boundary in search of funds, Savani started the process of fund collection from the village itself. His colleague, Babubhai Jhabalia, proudly recalls, "Everyone in the village contributed, even the small farmers. The share was kept at Rs 300 per *bigha* and *shramdaan.* A total of Rs 48 lakh was collected from the villagers themselves. The total amount collected was Rs 2 crore, the remaining amount being contributed by diamond dealers, settled in Mumbai, Baroda and Surat. "He capitalised on their sentiment for their native place and motivated them to contribute money towards the development of the village," informs Jhabalia.[6]

Work started in December 1998 and was completed in a record time of six months. During the first round of rains in 1999 (about 180 millimetres), all the check dams filled up. All existing wells were recharged.

Khopala has since then become a *teerath sthan* (pilgrimage spot). "People from approximately 1,500 villages have since visited Khopala. So have politicians, eminent personalities and bureaucrats," informs Ghanshyambhai, a local resident of Khopala.[7] In the very first year itself, the village earned a profit of Rs 7 crore from improved agriculture. People in the village normally grow cotton and groundnut. With water available in wells, the 1999 *kharif* season yielded a good crop. Khopala's produce was three times that of adjoining villages.The people were also able to take a second crop in the dry *rabi* season.[8]

Now that water was freely available and was in danger of being overutilised, Savani urged the villagers to adopt drip irrigation. The villagers agreed. Within four years, the entire village is expected to have drip irrigation.[9] "Savani was actively involved in popularising the new technology as well as getting a good bargain for the villagers," says Jhabalia. According to government rules, farmers who want to take up drip irrigation have to pay Rs 4,000 per *bigha.* The government pays the remaining amount. "When the villagers decided to install the system in 4,000 *bighas,* Savani called the drip irrigation company which was supplying the technology to the government and showed the quantum of work planned. Quick to realise the market potential and also the free publicity its activities in Khopala would generate, the company reduced the farmer's share to Rs 1,600 per *bigha,*" informs Jhabalia.[10]

After Khopala, Savani is involved in spreading the movement to other parts of Saurashtra. With the help of people from Saurashtra settled in Mumbai, Baroda and Surat, he set up SJT in October 1999. Immediately after its formation, the trust organised a *padyatra* from November 14-19, 1999 to spread awareness of water conservation in Bhavnagar and adjoining scarcity-hit areas.[11] The speaker of the Gujarat assembly, Dhirubhai Shah, flagged off the *padyatra*. Diamond merchants, social activists, eminent personalities, priests and village leaders took part in village meetings. Video recordings of Khopala were shown.[12]

Currently, apart from disseminating information in villages, SJT is actively involved in providing assistance to villages under the government's Sardar Patel Participatory Water Conservation Programme. SJT helped the villagers of Padodar by providing 2,000 bags of cement free of cost and the remaining cement requirement at a discounted rate of Rs 105 per bag instead of the market rate of Rs 130. The condition laid by SJT was that the village must act as a cohesive unit while constructing the check dams and the work has to be taken up at the village level. It also emphasised *shramdaan* by the people.[13]

"Constructing 51 check dams collectively in the village was a difficult task. After the euphoria of the *padyatra* subsided, villagers were reluctant to contribute money. A series of meetings were arranged.[14] But Mathurbhai was able to convince the villagers. The villagers also generated funds by collecting Rs 200 per bigha," says Natubhai, secretary of the Padodar village committee.[15]

On March 25, 2000, SJT organised a Jaljagruti Maha Sammelan (Water awareness congress) to disseminate information regarding the importance of water conservation at individual and community level. Gujarat chief minister, Keshubhai Patel, inaugurated the *sammelan*. Before organising the *sammelan*, SJT registered 300,000 workers in the diamond polishing industry as its members. The future plan of SJT is to develop Saurashtra as a water crisis-free zone. According to a member of SJT, "There are 78 rivers in the region carrying water into the sea. SJT is trying to develop a plan in which 5,600 villages of Saurashtra and Kachch construct check dams under the banner of SJT, or otherwise."[16]

SAURASHTRA JALDHARA TRUST

Villagers of Padodar, Bhavnagar, perform religious rites for the water they hope will see them through the 2000-2001 drought

The need of the hour was perhaps best summed up in the words of Swami Madhavpriyadas of the Swaminarayan sect in the June 12, 2000 issue of *India Today*:

''We have spent enough on extravagant temples of stone. Let us call a temporary stop to it and spend on *jal mandirs* (water temples like check dams). How will these temples of stone survive without water?"

Political wrangling

For the SPPWCP, the sailing was far from smooth. While Nitinbhai Patel was working out the details of the new, decentralised programme, the minister for Narmada and major irrigation projects, Jay Narain Vyas, was foul-mouthing it as merely a diversionary tactic of the anti-dam lobby. Without Patel claiming that water harvesting was an alternative to the Narmada dam, Vyas began to cry wolf. Rather than seeing the two issues separately, he took it upon himself to belittle the media attention that water harvesting was getting.

How then was the programme still successful? The irrigation minister says the chief minister Keshubhai Patel supported the programme, which led to the germination of a state-level initiative. Moreover, water has become one of the most important political issues in Gujarat, which meant the political will to tackle the water crisis was now stronger than ever before.

The political determination became all the more so after the water crisis started causing civic problems. Deaths had occurred when the police had fired on a rural mob protesting the government's decision to reserve the scarce waters left in a few dams for urban centres. Politicians started realising that their political survival depended on the availability of water. With the Narmada dam then a matter of controversy held up in court litigation, they began to look at an ignored area: water harvesting.

Not surprisingly, the government is getting kudos from civil society. "SPPWCP is a novel programme. It has provided the necessary impetus to the concept of water harvesting," says Anil C Shah of DSC. "It is popular because the government has been sensitive to people's problems. It has been formulated keeping the *antim insaan* (last person) in mind," says Ghanshyambhai Savani, head of the Gharda taluka panchayat in Bhavnagar district.

Social mobilisation: Generating Awareness

Once the political will started driving the water harvesting programme, things started moving. To mobilise the masses, the government relied on the method of civil society groups: *padyatras* (marches). The *padyatra* organised by Saurashtra Jaldhara Trust of Khopala in November 1999 had impressed the government *(see Box: Gem of an initiative).* The objective behind organising the *yatra* was to sensitise the people regarding water conservation at the village level. Taking cue from this *padyatra*, the state government organised a similar awareness campaign and named it *Jalyatra.* The *yatra* was organised in January 2000 in which social activists, NGOs and political parties were involved. As the Bharatiya Janata Party (BJP) is in the state government, all party workers, MLAs, MPs, government officers, *sarpanches* and *taluka*-level delegates, were involved in creating awareness about the programme.[4] The *yatra* moved in three streams. While Nitinbhai Patel led one *jalyatra*, the other two were led by Narottambhai Patel, minister of water supply, Anandiben Patel, minister of education, and Kaushikbhai Patel, minister of energy.

These *jalyatras* visited 6,000 villages in Saurashtra and Kachch. In each village, a *gram sabha* (village assembly) was organised. In the *sabha*, villagers were informed about the programme and the importance of stopping rainwater flowing out of their villages. Examples of successes by NGOs, religious organisations and people's own initiatives were shared with the villagers. In places, the villagers themselves had observed the outputs of such programmes. Through these *jalyatras*, villagers were made aware of the government programme and their participation was invited. The entire programme plan was put to the people in a way they could understand why it was important for them to contribute 40 per cent of the costs.[5] It was highlighted that the people would do the entire work and government officials would not be directly involved in the execution process. The small irrigation department had sanctioned 7-8 designs and the villagers were asked to pick and choose from them according to their requirement. The department also had a provision that if the villagers had their own design for the check dam, then after a technical assessment, the design would be approved. According to Nitinbhai Patel,"The department knew that in order to succeed, they had to earn support and faith of the people. To achieve this end, we adopted a transparent and accountable style of functioning."[6] Discussing the strategy of the state government in publicising the scheme, Oza said, "The state government launched the programme with a lot of fanfare and publicity. They had even strategically named the scheme as Sardar Patel Participatory Water Conservation Programme because of the popularity of Sardar Patel in Gujarat and especially in Saurashtra."[7] As it is, the people were quite eager to get rid of the water crisis. The situation was all prepared for what was to become a major ecopolitical initiative.

Implementation: learning from past mistakes

The government worked to develop a convenient and people-friendly implementation system for the project. The government had obviously learnt lessons from its previous scheme — the 'Own your own check dam'

Table 1: Intricacies of implementation

In the Own your own check dam programme, a mere 62 check dams were built in three years, though the villagers had to pay only 10 per cent of the cost. The decentralised approach, adopted in January 2000, resulted in 10,500 in six months. The difference is because of the implementation process adopted

Year	Number of check dams built	Villager's contribution to total cost (in per cent)
1997-2000	62	10
January –June 2000	10,500	40

Source: M S Patel 2000, secretary (water resources), department of Narmada, water resources and water supply, government of Gujarat, Gandhinagar, *personal communication*

programme — which, despite the government's contribution of 90 per cent had barely anything to show. The approach they followed this time worked *(see Table 1: Intricacies of implementation).* The achievements of SPP-WCP as of July 15, 2000 are given in *Table no 2: Report card.* Check dams were constructed in all districts of Saurashtra and Kachch region. Due to the geophysical conditions in the northern parts of Gujarat, deepening of existing ponds was more popular there.

"The state government followed an altogether different approach in executing the new programme," says M S Patel. Previously, the work was carried out by government departments under scheduled rates, in which contractors were involved. Tenders were either invited from interested parties or NGOs were involved in the execution process.[8]

"This approach of handing over the responsibility to the villagers was being implemented for the first time," says M S Patel. The programme was executed through a village committee of at least 11 members, which had to oversee the work. Each check dam had a committee to supervise the construction. In villages where more than one check dam was being constructed, a single committee was formed for all the check dams or a committee for each individual structure was formed. It was left up to the villagers to decide. Each committee had a *pramukh* (leader) who was responsible for the construction; purchasing materials; arranging for labour; ensuring 40 per cent contribution of the villagers; and, monitoring the progress.[9]

The villagers had the freedom to construct check dams in the village and in the adjoining areas as well. The only condition put forth by the department was that the minimum height of the stored water should be of two metres. Prior to construction, villagers were also told that the check dam should be considered as a medium to strengthen relationships within the village. The dams were promoted as social goods, which, if used properly as common property resources, would help to develop a cohesive community. In this way, a sense of sharing was inculcated in the villagers. Monitoring of water usage was left to the people themselves.[10]

After the committees were formed, villagers had to select an appropriate site for the check dams and choose its design. Once the site was selected and the design confirmed, villagers had to prepare the work estimate. The villagers were not restricted to estimates prepared by the minor irrigation department. They could approach

Table 2: Report card

Check dams constructed in the drought-prone region of Gujarat. Progress report of the check dams ending 15-7-2000 under Sardar Patel Participatory Water Conservation Programme

District	Applications received	Applications sanctioned	Estimated cost (Rs in lakhs)	Works completed	Works under progress	Total works	Allocated funds (Rs in lakhs)	Expenditure incurred (Rs in lakhs)
Amreli	2,935	1,425	3,117.24	732	255	987	820	690
Jamnagar	8,121	4,799	10,608.44	2,775	186	2,961	1,775	1,468.12
Rajkot	3,384	2,015	3,805.49	1,456	243	1,699	1,270	1,114.64
Bhavnagar	5,428	5,428	8,163.80	2,929	683	3,612	1,725	1370
Junagadh	3,411	2,875	7,119.19	700	133	833	445	230.19
Surendranagar	748	623	1,668.76	100	227	327	150	50
Porbander	269	269	1,089.24	112	88	200	150	49.91
Saurashtra	24,296	17,434	35,572.19	8,804	1,815	10,619	6,335	4,972.86
Kachch	745	710	3,114.12	232	252	484	625	405.50
Ahmedabad	51	51	221.5	26	18	44	105	42.07
Sabarkantha	142	120	256.52	50	60	110	80	17.15
TOTAL	**25,234**	**18,315**	**39,164.33**	**9,112**	**2,145**	**11,257**	**7,145**	**5,437.58**

Source: Anon 2000, Progress report of the check dams ending 15-7-2000 under Sardar Patel Participatory Water Conservation Programme, Narmada, Water Resources and Water Supply Department, Government of Gujarat, *mimeo*

anyone, including the department's engineers for assistance. The government put a ceiling on the sanctioning power of the executive engineers and chief engineers. District level engineers could sanction a project up to Rs 6 lakh. Estimates beyond that had to be sent to the secretary of the minor irrigation department in Gandhinagar for sanction. Once the villagers prepared the cost estimate, they had to fill a simple application form and submit it to the chief executive engineer. Once sanctioned, villagers could commence work immediately. After three weeks, the work accomplished by the villagers was inspected and the government's contribution was released. According to Nitinbhai Patel, "It was important for us to release our part of the contribution fast otherwise people would not have been able to complete the work and their faith in the system would have been shattered."[11]

The government had also set up its own monitoring system to ensure quality work was being executed. According to M S Patel, "Monitoring was being supervised by regular nodal officers, statutory auditors and chartered accountants, retired senior engineers, quality control chief engineers and by a check dam committee of politicians, farmers and social workers, appointed by the chief minister."[12]

PEOPLE'S' RESPONSE

Soon after the programme was initiated, the state government had to once again go back to the drawing board because of the tremendous response of the villagers. Initially, the state government planned to construct 2,500 check dams with an allocation of Rs 100 crore. But it was forced to allocate Rs 200 crore and increase the target to 10,000 check dams. "The government reacted in a positive manner. This was possible only because we had the killer instinct to achieve the new target," says M S Patel.[13] The increase in the budget from Rs 100 crore to Rs 200 crore and also the numbers of check dams to be constructed was on an *ad hoc* basis.[14]

The realisation of conserving waterbodies was not restricted to the rural population alone. Even in urban areas across the state, people were gearing up to clean up traditional water sources. The unreliability of state-supplied water supply as compared to decentralised traditional systems can be gauged from the fact that in the town of Dwarka, abounding with *tankas,* a meagre rainfall of 50 millimetres in a below average monsoon year was enough to meet the water requirements of the people for the whole year *(see Box: Dwarka: Nurturing an inheritance)*. In Jamnagar the people rallied together to clean up the Lakhota lake *(see Box: Lakhota lake comes alive)*.

After the first rains of 2000, the villagers realised the importance of harvesting rainwater at the local level. The water which was captured in these new structures

DWARKA: NURTURING AN INHERITANCE

The* tanka *system in Dwarka has been in existence for centuries. This traditional art of rainwater harvesting continues to be practiced and used in residential areas, temples,* dharamshalas *and hotels

Locating a *tanka* in Dwarka is as simple as locating stray cows in Indian cities. Reach Dwarka and go to a public telephone booth. The owner will give you all the information you need. Sureshjibhai Thakker, one such person, is witness to a *tanka* functioning in his house since his childhood, constructed by his forefathers, a hundred years back. Water in Dwarka is extremely salty, and to get sweet water, residents have no option but to harvest rainwater. The capacity of the *tanka* in Thakker's house is approximately 8,000 litres.

In Dwarka today, every two out of three houses have *tankas*. *Tanka* is like a room in the basement. The base of the *tanka* has a slight gradient. At the end of the gradient, there is a small *khadi* (sump) which is normally 0.6 metres (m) by 0.6 m in size, where the water accumulates. When the entire water from the *tanka* is utilised and utensils can no longer extract it, water is then drawn from these *khadis. Khadis* are constructed directly under the opening of the *tanka*. Pushkarbhai Gokhani, an engineer by profession and a multifaceted personality known for his literary works and a member of the Gujarat Itihas Samiti, has two *tankas* in his house of 2.44 m x 3.05 m x 2.44 m size.

Water during the first showers is not captured. After the first rain, the entire *agashi* (rooftop) is cleaned and locked. If the rain intensity is not high and lasts for just one hour, normally it is not collected because it has a lot of sand and dust. Water is collected only during heavy and continuous rainfall. In residential houses, clothes are not dried on the terrace during the monsoon to avoid contamination with the soap water.

To preserve the water, a small pot filled with lime is put inside as a disinfectant. Some people also colour the *tanka* walls with lime for the same reason. Gokhani relates a story pertaining to the quality of the stored rainwater: "A house nearby was sold as the owner never stayed there. After about ten years the house was reopened and so was the *tanka*. The water was tested and its quality was found to be good, except for the strong taste of lime, given that it had a pot full of it kept inside for the past ten years."

The size of the *tanka* is usually determined by the size of the family. A 4-5 member family consumes 4,000-5,000 litres every year. The stored water is used for drinking purposes only, and at times, for cooking. The stored water normally lasts for more than a year and there are instances where water is available for even two years.[1] According to Usad Kumar Thakker, a resident of the town, "Whenever people construct a house in Dwarka first priority is given to *tanka* construction. Even if they have to reduce the number of rooms in their house to accommodate a *tanka,* they will do so."[2]

In Dwarka, *tankas* are not only built in residential houses but also in temples, *dharamshalas* (community guest houses set up by religious or charitable institutions) and even hotels. At a hotel, an attendant is quite likely to ask you, "*Barish ka paani lenge ya bottle wala?*" meaning, "Do you want rainwater or bottled water?" Most hotels have their own *tankas*.

In temples, *tankas* abound. Dwarka is considered one of the Hindu *char dhams* (four key religious pilgrim spots). All temples in Dwarka and Bet (island) Dwarka have *tankas* in them. Donating money for their construction is considered a sacred act and temples have been

responsible for motivating people to construct them. The Dwarkadeesh temple deputy administrator, Harish Patel, informs, "The stored rainwater is used for making *prasad* (God's offering) and for the *rasoi/bhandar* (kitchen) of the temple."[3] The capacity of the tank in Dwarkadeesh temple is approximately 25,000 litres and it normally lasts for one year. The *tanka* is cleaned after every two years or whenever it gets empty. The present *tanka*, is recent by Dwarka's standards, about 50 years old. The original *tanka* was too small to cater to the increasing number of pilgrims. The capacity of the old *tanka* had to be increased and a new one was built. The *tanka* collects rain from the roof of the *bhandar*, entry to which is forbidden to prevent contamination. Patel is extremely confident about the quality of the water collected and stored.

In the Swami Narayan Mandir complex built approximately 150 years ago, there are five *tankas* in the complex with a total capacity of 0.6 million litres. The central *chowk* (courtyard) where vehicles are parked has a *tanka* of 250,000 litres capacity. Below the entire *mandir* there is another *tanka,* which is supported by huge columns and arches made of locally available sandstone. The outlet of all the roofs of the temple's residential complex have been connected by a pipe which ends in one *tanka*.

EKLAVYA PRASAD / CSE

The pilgrim town of Dwarka is home to a tradition that is being preserved. **Tankas *abound in residences, hotels and temples***

Bet Dwarka is an island with a population of 5,000 — 3,000 Muslims and 2,000 Hindus. While Muslims depend on fisheries, Hindus are directly or indirectly dependent on the temple. This temple is said to be the residential palace of Lord Krishna and his four queens. Thus, in Bet Dwarka, there are five temples. Says Jagdishchandra Bhatt, *mukhiya* (chief) of Radha temple, "Water in the 500 year old *tanka* is collected from the rooftop. The water lasts for about two years.[4] They draw about 180 litres daily for bathing the temple's deity and all other works. Water is also used for drinking.

Gokhani says that though pilgrims donate money to *pandas* (temple priests) to build *tankas,* unfortunately, the *pandas* don't make as many *tankas* for which they are given money." In order to convince the pilgrims that their money has been utilised, they show the same *tankas* to different pilgrims. They have made name plates of pilgrims and every time the pilgrim visits Dwarka, they put the name of the person in front of the *tanka."*

Drinking *tanka* water can be a fascinating experience: extremely sweet as though sugar was mixed into it. Says Gokhani, "Traditional rainwater harvesting technology has been prevalent since the past one thousand years. The technology is very old because it has a mention in the history of Gujarat. It also has been mentioned in the Jain illustrations because Navtang Acharya and Hemchandra Acharya have written about it."[5]

Dwarka did not suffer during the 2000 drought as there was enough drinking water stored in the *tankas*. Today, the situation in Dwarka is such that at least 60 per cent of the people are economically capable of constructing a *tanka* in all new constructions. To construct a *tanka* of 2.44 m x 3.05 m x 2.44 m size, the approximate expenditure would be Rs 20,000. Modern houses have installed electric motors to draw water from *tankas*.

Apart from salinity, a key reason for the prevalence of this traditional system in Dwarka is that there are no government schemes to provide regular water supply to the city. Supply from the recently constructed Saini dam approximately 100 kilometres away from Dwarka is highly erratic. People who do not have *tankas* have no option but to drink saline water. "Several cases of kidney stones are being reported from villages and urban areas because of drinking water contaminated with minerals, in the absence of *tankas*. No such cases are reported from areas where *tanka* water is consumed," informs Vinubhai J Bathiya, a medical practitioner, adding, "The efforts of our forefathers should be applauded because this wonderful system gives water of extremely good quality throughout the year."[6] He claims that the rainwater captured is hygienic and ideal for sterilising medical instruments.

Despite the technology being transferred over generations, Bathiya is concerned about the future, "With changing times, the living style is also changing. If following generations are not sensitised towards this system, it will slowly die away. Then Dwarka's condition will be similar to that of the rest of Saurashtra," warns Bathiya. Gokhani agrees, "With the coming up of multistorey buildings the tradition of *tankas* is slowly getting eroded. The terrace is not jointly owned by all the residential families. It happens to be the property of the person staying on the top floor. Even if it is co-owned, regulations and practices have to be put in place. This has to be thought from now onwards if *tankas* have to be sustained."

In Dwarka water harvesting thus remains a living tradition, supported both by need and religion.

LAKHOTA COMES BACK TO LIFE

The failure of the monsoon of 1999 saw the people of Jamnagar collectively clean up their urban waterbody, the Lakhota lake

Under the leadership of Sadhu Devi Prasad Maharaj of Ananda Baba Ashram, Jamnagar residents came forward to clean and deepen the city's derelict Lakhota Lake — another outstanding example of people's efforts during the crisis. The *ashram* has been in existence for 350 years and is considered a secular institution with its mission one of human service.

Jamnagar city, the abode of the Jadeja Rajput rulers of Nawanagar, was founded in 1540 on the banks of Rangamati river. Rangamati then used to flow through the heart of the town. Gradually its course changed and got amalgamated with the Nagmati river.[1] Between 1834-1838, when there was a great famine, as part of the rehabilitation and scarcity works strategy, ruler Ranmal employed people to develop the local lake, which was a natural depression. The slopes, main lake and a waste weir were developed, keeping the natural drainage pattern in mind. In the middle of the lake, the Lakhota Kotha (fort), a summer palace, was constructed.[2]

From Ranjitsagar dam, a feeder canal brings water into the Lakhota lake. "The feeder canal got silted up over time, decreasing the capacity of the lake as well as reducing the percolation from it," says Maharaj. As a result, the water crisis in Jamnagar became severe during the recent drought.[3]

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Swami Devi Prasad Maharaj who inspired Jamnagar residents to clean up their lake

While going from Jamnagar to Rajkot, Maharaj had once come across a pregnant lady struggling to carry a pot full of water on her head. Maharaj came to know that she daily travelled for five kilometres to fetch drinking water, as there was no water yielding source in her own village. Maharaj realised the intensity of the drinking water problem that existed in the region and therefore was keen to work on restoring the water sources of the woman's village. He got in touch with the village elders and got a borewell fixed.[4] "This experience exposed me to all the problems arising due to paucity of water and the urgency to work on water harvesting," says Maharaj.

In Jamnagar, there is a tradition to organise *bhandaras* (religious common meal) for the poor. Substantial money is spent on this. Maharaj appealed to the people to put a stop to the tradition of *bhandaras* and channelise the money towards water-related works instead. He chalked out two proposals: rainwater harvesting, which restricted the flow of water into the sea by damming it; and, desiltation and deepening of Lakhota lake.[5] A series of meetings were organised to chalk out a strategy to desilt the lake. "Several people voiced their reservation," says Maharaj and nothing substantial emerged. Finally, he appealed to those who had a negative approach to refrain from joining the campaign. A meeting was then organised in which people with a positive approach were welcomed and those with negative thinking were kept out.[6] In the meantime, Maharaj and his close associates got in touch with local chambers of commerce, the grain market association, factory owners' association, eminent personalities, and all those interested in generating funds for the initiative. Being the leader in the initiative, Maharaj contributed Rs 1.5 lakh. Other religious organisations followed suit and soon Rs 5 lakh were collected. Sanction was obtained from the district authorities to work on the lake.[7] A 25-member Lakhota Jal Sanchay Abhiyan Samiti was formed. There was resistance from some people who argued that professionals and not *mahants* (priests) should handle this work.[8] But Maharaj was keen to show them that even non-professionals could work in a systematic manner. Within a span of eight days, 2,000 tractors full of silt were taken out from the lake.[9] The silt taken out from the lake was used for construction of roads, railway platforms and graveyards. Work, which was pending for the past 5-10 years, was completed during this time. The people realised that by working on the lake it was not just that the lake that got cleaned, but many pending works were also completed.[10]

As word spread, apart from financial institutions and industrial associations, even individuals now came forward with contributions, which gave an enormous boost to the programme. There were instances where people gave their pension to the committee. People who could not contribute cash or kind contributed with their skills. Engineers and other professionals helped in conceptualising and implementing the project. Donation boxes were kept in various religious institutions and the maximum amount was collected from *masjids* (mosques). People crossed all social, economic, religious and political barriers to make the project a success.[11] In the entire project there was no dearth of money. When the rains came, the entire lake got filled up.[12] Labourers came from the adjoining villages where the impact of drought was severe. Thus, local villagers also benefitted from this *abhiyan* (campaign). If contractors

EKLAVYA PRASAD / CSE

The desilting of Lakhota lake brought Jamnagar residents to work together for a common cause

would have been hired, the money would have definitely gone out of the hands of these villagers.[13]

Along with the work on Lakhota lake, the committee also constructed a dam over Rangamati and Nagmati rivers at a cost of Rs 22 lakh. Waterbodies in the adjoining 70-odd hectares agricultural land got recharged. "The water in this river will last till Holi (a festival in March) and the water in the lake will last for at least for two years," claims Maharaj.[14]

According to P D Matalia, an active resident of Jamnagar, "The major accomplishment of this effort was that it united the residents of Jamnagar on a crucial issue of cultural and religious heritage." The involvement of a religious leader like Sadhu Devi Prasad Maharaj was a crucial aspect for the entire project. Heads of Kabir ashram, Anubhav ashram, Swaminarayan temple, Kijada Mandir, Pranami and others all came together on one platform. "Various people at different points of time took the initiative," says Matalia. Maharaj relates a story. "There is a lady who became a widow at the age of 28 and she manages her livelihood by making *papads*. She had collected Rs 45,000 in five months by selling *papads*. She came regularly to contribute from her savings." When asked, she replied, "*Maharaj, mere paise aur kahan kaam ayenge?*" (Maharaj where else can this money be utilised?).[15] "It was a wonderful mass movement," recalls Jaydev Nansey, an avid nature lover, sharing his enthusiasm.[16] "The saints attracted the maximum crowd. People came forth more out of devotion than the issue of water," says Maharaj.

But Nansey is not entirely happy. "The entire effort was to increase the capacity of the lake. The lake has a multifaceted personality. It is a historical monument, an ecological marvel and an ornithologist's paradise. All the other aspects of the lake were destroyed," he says.[17] "There were between 104-110 species of birds, both migratory and local, in the lake. The lake supports three different ecosystems of avifauna," he explains, "The deep water, where birds like divers, for instance, used to stay; the shallow water, where birds like ducks and flamingos were found; and, the floating leaf ecosystem. Huge leaves of lotus used to be the place where several birds lived. Chicks were born on those leaves. These leaves have a lot of stability for the chicks to walk. By desilting the lake, the mud and the lotus too were removed. Due to this, the third ecosystem was totally destroyed."[18]

"The cleaning should have been done in a more systematic manner," agrees Matalia. There should be a desilting pond in between the canal and the lake. "If silt keeps coming into the lake, the entire purpose of the exercise will be defeated," he adds.[19]

K D Vaishnav, a civil engineer from the Indian Institute of Technology in Mumbai, opines, "There is extremely little seepage of water right now. Movement of heavy machinery in the lake bed during the desilting process has affected the seepage process. The houses in the periphery of the lake are not getting water as claimed by the implementers of the project." Comments Nansey, "Leaders of such campaigns should be educated about the multifaceted personalities of waterbodies like the Lakhota lake."

Nansey says that it is the prime responsibility of the government to take up such works. But, indeed, where was the government when the *abhiyan* (drive) was being conducted?

percolated and recharged the groundwater. This was a typical scenario in the villages after the first spell of rains. Commenting on this phenomenon, Nafisa Barot of UTTHAN, an Ahmedabad-based NGO, said, "The positive effect of the programme has been that the villagers have come to realise that alternatives do work."[15] Over the past two decades, dependence on tubewells for water supply had increased. The villagers had stopped exploring sustainable options for water supply. Once these sources dried up, villagers had no option but to depend on the state for water supply.

During the crisis, voluntary organisations as well as government officials asked the villagers to think about water conservation. The initial response of the villagers was not a positive one. But persistent efforts to orient them with successful case studies did yield the desired result. In villages such as Arcot and Dahisarda in Rajkot, Nagedi in Jamnagar and Padodar in Bhavnagar districts, the structures stand testimony to the sincerity and dedication with which the villagers have worked. During the first phase of the scheme, there were a few fencesitters who were not convinced with the approach. After the first spell of rains and with the visible impact of the structures these villagers stood converted and were convinced about the reliability of this approach.

The other positive outcome of the project was assistance from governmental financial institutions like National Bank for Agriculture and Rural Development (NABARD). "It is for the first time that NABARD has given loan to a state government to a tune of Rs 57 crore for this kind of work. The officials of NABARD had come to see the work and they expressed their interest to further provide loans to the state government for such initiatives" says Nitinbhai Patel.[16] NABARD's assistance can motivate even other state governments to implement similar programmes.

NGO'S CONTRIBUTION

The SPPWCP owes its success to the response that it got from various groups across the state in informing the people about the programme and in undertaking check dam construction under the programme. In March 2000, Vivekanand Training and Research Institute (VRTI) and Shree Sahjanand Rural Development Trust (SSRDT) had together organised a Jal Mandir Yatra to inform the people about the need to respond positively to the programme *(see Box: The great water march*).

According to the government report of July 15, 2000, the maximum number of check dams have been constructed in Bhavnagar. This has been possible also because of the efforts by Saurashtra Jaldhara Trust (SJT). According to Babubhai Jhabalia, trustee of SJT, "The interest generated by the earlier *padyatra* organised by us amongst the villagers was evident when the state government launched the SPPWCP. In the entire state, Bhavnagar tops the list with the maximum number of proposals sanctioned under this scheme. In all, 5,428 application were received and all of them were sanctioned. Maximum check dams were sanctioned in Gharda tehsil. The *tehsil* has 75 villages in which 975 check dams were sanctioned. Some 650 have been completed."[17]

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Causeway-cum-check dam at Khopala in Bhavnagar district. This structure increased water availability in the adjoining agricultural fields

THE GREAT WATER MARCH

In March 2000, two non-governmental organisations jointly organised a Jal Mandir Yatra — march for water temples — to urge the people to participate in the state government's Sardar Patel Participatory Water Conservation Project

If the government was serious in involving communities to undertake water conservation programmes, so also were non-governmental organisations keen that this opportunity not be lost. In March 2000, the Bhuj-based Shree Sahjanand Rural Development Trust (SSRDT) and the Mandvi-based Shree Vivekanand Research and Training Institute (VRTI) organised a Jal Mandir Yatra (JMY) to exhort the people to take advantage of the Sardar Patel Participatory Water Conservation Programme (SPPWCP).

Development organisations in Kachch have realised the importance of raising awareness to popularise any activity. However, the normal procedure of information dissemination amongst villagers does not always work. Sometimes, the entire effort has to be given religious or spiritual sanctity. Keeping this in mind VRTI and SSRDT invited Madhav Priyadasji Maharaj, *sthapak* of Rajkot Swami Narayan Gurukul, to be involved in their awareness raising efforts. Maharaj is respected throughout Gujarat not only for his preaching but also for implementing what he preaches. Maharaj agreed to participate on the condition that he would not be involved in merely delivering speeches. It was decided that in the morning session, work would be undertaken on construction of check dams; during the afternoon, meetings would be organised with the elders and leaders of the village to devise strategies to promote this work at the village level; and, in the evening, a *gram sabha* would be organised where Maharaj would share his thoughts with the entire village community.

This strategy worked. As Kamlesh Solanki, project coordinator with VRTI puts it, "VRTI has been disseminating information about efforts which can minimise the intensity of drought for a long time now. But we did not get that sort of response as we got this time because religious leaders were also involved."[1]

According to Vinod D Kevariya, project director of SSRDT, ,the reasons for SSRDT being part of this campaign stems from the strong belief of Keshubhai Premji Bhudia, the Mombasa (Kenya)-based industrialist founder of the organisation, that water availability will only come about if small structures are constructed in large numbers.[2] A plan was conceptualised with organisations like VRTI and Akhil Bhartiya Kisan Sangh which took shape of the JMY between March 21-26, 2000.

Organising JMYs was not the ultimate. SSRDT also extended financial support (10 per cent of the villager's contribution to the SPPWCP programme) to the economically backward villages which were unable to afford the contribution demanded by SPPWCP. To procure these funds, the villagers would need to submit a proposal along with the design and details of the selected site.

Says Kevariya, "Initially the response from people was mild. But when they came to know Maharaj would be visiting and that SSRDT would also contribute 10 per cent of the peoples' contribution, the scene changed."

The first meeting was held in Bharasar village in Bhuj district. During the *yatra* villagers from adjoining areas would get together and be briefed about water conservation. Representatives of the District Rural Development Agency and the local *panchayat* leaders would inform the farmers about the extent of water shortage and benefits of water harvesting.

Every day about 7-8 people forward came with demands for constructing check dams in their villages. By the end of the JMY, foundation stones for 19 check dams had been laid and projects worth about Rs 1 crore were formulated. Later, the government gave sanction to 700 projects in Kachch indicating the success of this *yatra*. By July 15, 2000, 150-200 of these projects had been completed.

There were three reasons why the villagers undertook the construction work. Firstly, they had very few options to minimise the intensity of drought in the near future. Secondly, people had faith in VRTI because of its existence in the region for the past 25 years. Thirdly, traditional systems in the villages are deeply engraved in their minds and become stronger when reinforced by religious gurus.

SSRDT received 53 applications; it checked 52 sites. Some 27 projects were sanctioned for receiving the SSRDT grant. While executing the work, Kevariya realised that contractors were able to do the work without the actual 40 per cent share of the villager's contribution. SSRDT, however, continued to assist the groups with their 10 per cent because they could not go back on their word, and also because they wanted to encourage the villagers which had applied to satisfactorily accomplish their task.

Kevariya believes that though their project has definitely increased awareness of water harvesting, the involvement of the contractors in the SPPWCP went against its spirit.

Apart from the organisations mentioned above, several others like Kundla Taluka Gram Seva Mandal and Vraksha Prem Seva Trust also played a crucial role in sensitising and motivating people to construct check dams in their villages.

FLAWS AND FOLLIES

Despite all its success, the SPPWCP suffered from serious flaws. Says Anil Shah, "The programme could have achieved much more if the government had spent more time in planning the execution process."[18] Several other people agreed, including government officials, who felt that the department was not geared up for handling such a colossal programme and that the initial target of 2,500 would have been better. By increasing the number of check dams from 2,500 to 10,500, the work load on the existing staff increased substantially. There was tremendous pressure to sanction projects and then to verify and guide the villagers regarding the construction site. Out of 25,234 proposals received, 18,315 were sanctioned and a total of 9,112 check dams

EKLAVYA PRASAD / CSE

Water flows over the check dam in Dahisarda village of Rajkot district after the first showers of the monsoon rains in July 2000

were constructed by July 15, 2000. Work on 2,145 was still in progress *(see Table 2: Report card).* Because of the pressure to attain the magic figure of 10,500, the visits to the sites became perfunctory.[19] Ultimately, the scheme became target-oriented like any government programme rather than process-oriented, which took away its essence. According to a government engineer, "The government was in a hurry to implement the scheme. For a scheme of this size, a minimum of seven to eight engineers are required." The technical results would have been better if the sanctions had been given in a more pragmatic manner. In many cases, undesirable elements vitiated the process as monitoring was weak. Contractors got involved in the implementation work, confident that no review would be undertaken.

The correct procedure for implementation should have been for officials to visit the site and give the sanction. This way they would have come to know that contractors were getting involved in the process and who the members in the village-level committees were. It would have helped if engineers could have been brought from south Gujarat as additional helping hands.

Thus, the hurry to implement the programme affected the quality of construction and allowed contractors to get into the programme. Several contractors got involved in the construction of check dams in Junagadh, Kachch and Jamnagar. Elsewhere, their numbers were relatively less or next to negligible. As a result, there are reports of corrupt practices and rampant manipulation of accounts having taken place in these districts.

Contractors entered mainly because the approval process was too easy. Explaining the possible reasons for the influx of contractors a government engineer points out, "Contractors were scared that because of these small structures, the normal medium-size irrigation structures would no longer be in demand. To compensate for their hypothetical loss, they got involved with a mission of making money by hook or crook." But very few big contractors were involved. Most contractors were from the village community itself or from the *tehsil* level, many of them having functional relationships with the villagers. Usually, the villagers were approached after collaborating with the *pramukh* of the village-level committee. Unaware of the underlying objective of the contractor, the villagers got convinced and, rightly so, because they felt that they would be getting an important asset without doing much work. Secondly, they thought that they would now get employment in their own village. Contractors prepared the proposal on behalf of the villagers either with correct or fake names and with cost estimates that included an enhanced margin. In some cases, the head of the committee supervising procurement and other logistics turned out to be a fake name.

According to the field staff of SRDT in Bhuj, "There were instances when contractors lured people to hand over the responsibility of constructing the check dam by not asking them to contribute their 40 per cent share." The contractor was able to construct the check dam and make profit even, with just the government's 60 per cent contribution. The government rates were apparently high (Rs 1,500 per cubic metre). Moreover, many dams made were of inferior quality to maximise profits. M S Patel agrees that the quality of check dams built in Junagadh were specially bad.[20]

A researcher of the Centre for Science and

Environment (CSE) who visited several sites observed that most of the work which was hijacked by contractors was of inferior quality. In Khamdroad village in Junagadh tehsil, the structure had already started to crack, a few months after being built. Stones from the base of the check dam could be easily removed. A check dam in village Jodia, Joida taluka in Jamnagar had already broken into two though it was constructed only three months back. The problem in Junagadh was highlighted in the Gujarati media because of the large-scale misappropriation there in constructing check dams. A May 17 report in *The Times of India* mentioned that "irregularities have been reported from at least 90 per cent of the check dams in Junagadh district."[21] The government decided to suspend construction of nearly 800 check dams in 25 *talukas* of Saurashtra and Kachch after detecting poor construction and overestimation of cost, said a May 21 report in *The Indian Express.*[22] The district executive engineer was later transferred to Kachch by the government. According to an official document, the expenditure incurred in Junagadh was approximately Rs. 2.3 crore and it is estimated that 60 per cent of the work is of inferior quality. There were problems in Kachch too. Commenting on Kachch, Kevariya said, "The major fallout of the project has been the absence of the 40 per cent contribution by the villagers because it was not the villagers who had constructed the structures but professionals like contractors."[23] One contractor contacted in Bhuj admitted that he was able to accomplish the task within the contribution provided by the government. When questioned about the quality of the structure, he said "*Mera bahut saalon ka experience hai aur mein kam daam mein achcha kaam karta hoon* (I am an experienced person and I know how to do good quality construction at low cost)."

Site selection by contractors was often suspect. They often selected sites where big structures had to be made to increase their profits. It is understandable why contractors did this type of work — bigger the work, more the profit margin. But the people themselves could not supervise the work properly because of lack of proper guidance from government engineers or NGOs in monitoring the progress of the work.

The entire process of peoples' participation in Saurashtra was unique. Involvement of the people was not through *shramdaan* (voluntary labour) but through their money. Contractors exploited this aspect often in league with the government machinery.

The members of the Swadhyaya Parivar submitted about 250 proposals to the chief executive engineer but only 15 were approved. On the contrary contractors who had submitted proposals under different names either from the same village or different villages got these sanctioned within a day or two. It is said that a few engineers amassed a good amount.[24]

Another problem was the selection of the village-level committee members. Even in villages where villagers did the work themselves, the selection process was unclear. Accountability of the committee towards the *gram sabha* was vague. If the government wanted the programme to be taken up as a social movement, it should have given more thought to the process of formation of such committees. Often, the committee was formed on an *ad hoc* basis.

As Nafisa Barot of UTTHAN puts it, "The government has completely hijacked the entire process of the participatory model but has not been able to implement it in the right perspective. The government was too much in a hurry in implementing the programme because of which the process suffered."[25] Capacity building and training of the villagers too, was neglected. Moreover, coordination between village committees was virtually absent, which led to bad planning in the management of the catchment area and poor choice of check dam sites. In areas where NGOs were operating, there was just one committee which supervised the execution of the project. But in other areas, every check dam in the village had its own committee.

THE FUTURE

Despite its flaws, the effort of the state government to popularise rainwater conservation through constructing check dams for assured water availability at the village-level needs to be appreciated, unlike the neighbouring state of Rajasthan where in spite of severe drought, the state did not take any proactive steps to counter the menace.

The issue now is how to improve in the future because the government will continue with this scheme. The benefits derived by the people after construction of the check dams cannot be discounted. The first rains of the monsoon of 2000 have boosted the confidence of people as the water stored in the structures has regenerated the underground aquifers and the adjoining wells.

The government has stopped all payments in areas where there have been reports of corruption. This has created fear amongst the contractors who will think twice before involving themselves in this programme. Apart from dealing with corruption, the government also needs to incorporate certain modifications to ensure a long lasting impact. The life of a check dam is short if appropriate arrangements are not made upstream to arrest soil erosion. The rate of siltation is very high in parts of Saurashtra. Desilting has to be done at regular intervals and cannot be left to the villagers without proper orientation of how to manage a community asset. In the absence of prior preparation, the responsibility will be taken up by a few conscious members but whose interest might soon fade out if others do not show interest. Anil Shah emphasises,

AHMEDABAD'S NEGLECTED ARMOURY

It all started when scientists and engineers visited the walled city of Ahmedabad to look at traditional water harvesting systems. While they returned aghast at these systems not being put to use, they motivated the Khadia Ithihas Samiti to revive these systems

Tracking down the house of Ashutosh Bhatt, a banker by profession and an active member of Khadia Itihas Samiti (KIS), is a delightful experience. His house is situated in the lanes of Dhobi pol in the Khadia region of the walled city. There are 19 *pols* in the Khadia region with approximately 70,000 households.

While going through the lanes, it is difficult to imagine that these households encase a remarkable tradition — that of *tankas*. Even if ten per cent of houses have *tankas*, then the total number of *tankas* would be at least 7,000. But, even this appears to be a conservative estimate, according to Debashish Nayak of CRUTA Foundation (Foundation for Conservation and Research of Urban Traditional Architecture) and advisor to the Heritage Programme of the Ahmedabad Municipal Corporation (AMC), who feels that the number will be much more.[1]

Bhatt's own *tanka* is more than 400 years old. "This house is more than 300 years old. My ancestors purchased it in 1792," informs Bhatt.[2] It was constructed during the Mughal period. Rainwater in his house as well as in other old houses of the city's *pols,* is routed through a copper pipe from the rooftop to a chamber below the plinth level, where it is then stored in a *tanka*. The entire tank is roofed at the plinth level and serves as an open courtyard inside the house. A manhole cover acts as a lid service to draw water. The other side of the tank roof has an opening for the removal of the sludge. Stone or cast iron steps lead to a sump in a corner. The inside walls of the *tanka* are coated with lime. "Both copper and lime act as purifiers and so the water does not contain any impurities," claims Bhatt. His *tanka* is 6.28 metres (m) x 2.74 m x 4.75 m in size. Columns with arches support the ceiling of the *tanka*.

Tankas were used to conserve monsoon rains to be utilised till the onset of the next monsoon Unfortunately, as the city reels under a water crisis in the summer, this traditional system of *tankas* is dying.

Ashutosh Bhatt is now involved with reviving these traditional systems through the efforts of KIS founded by Neerubhai Desai in the pre-Independence period. In March 2000, KIS formed a committee headed by health minister Ashok Bhatt to survey *tankas* in the area with the help of the Ahmedabad Municipal Corporation (AMC). According to Ashutosh Bhatt, "A group of scientists and engineers had come down from all over the country to attend a conference. During their stay in Ahmedabad, they came to see the traditional rainwater harvesting structures in the walled city." The visitors were shocked that these systems were not being put to use. They motivated Bhatt to take up the work and requested the AMC to revive this dying wisdom.

In February-March 2000, a study was conducted in 19 *pols* of Khadia to generate information on the *tankas*. A questionnaire was circulated in 16 of the 19 *pols.* Some 75 forms were filled up, out of which 11 *tankas* were selected for a detailed study.

The 11-member committee came out with interesting findings. The average capacity of each *tanka* is 50,000-100,000 litres. Water sampled from 10 *tankas* matched WHO standards. The water sample from Ashutosh Bhatt's *tanka* was at least 65 years old. "I had never seen this *tanka* being used since my childhood. It has been opened for the first time. One of the reasons for the *tanka* not being used was the ban imposed by the British government which believed that the structures gave rise to malaria," Bhatt explains. Later, the ban was imposed to prevent freedom fighters from hiding in the *tankas*.

After the survey was completed, a meeting was organised to share the information. It was agreed that there was a need to revive this traditional system and strategies were recommended to the AMC and the state government. It has suggested that for restoring the age-old system, funds allocated to members of Parliament and state legislative assembly should be earmarked for this work. The AMC should prepare guidelines for the usage of *tankas*. Work on the selected 11 *tankas* has been completed but is yet to be adopted on a wider scale. But Ashutosh Bhatt is optimistic.

"More than anything else, the government has to ensure that the programme grows into a mass movement for the management of the entire watershed."

An appropriate strategy is now needed to maintain the structures already built at a cost of Rs 200 crore, even as the government maintains its own momentum to support the construction of new check dams.[26] The major concern is whether the government will look into such issues before initiating the same process again.

Discussing the future strategy for the programme, Nitinbhai Patel points out, "SPPWCP was not conceived for the drought period but as an integral programme which will also be implemented during the normal time."[27] In that case the programme can be greatly improved with the help of a good appraisal and appropriate changes.

There is a need to create village level institutions, accountable to the *gram sabha*, which would ensure sustainability of the assets created as well as safeguard the interests of the stakeholders. Monitoring too should be strengthened, something NGOs emphasise a lot in their work. Thus, if the government wants to follow the approach adopted by NGOs, then they it should adopt it in fuller measure.[28]

Looking beyond the programme, in addition to creating new water harvesting assets, there is a need to revive the existing ones which are not in use in spite of the severe water scarcity that the state faced. A step in the right direction has been undertaken by the Khadia Itihas Samiti, involved in reviving the *tankas* of Ahmedabad city *(see Box: Ahmedabad's neglected armoury).* ■

Drought of 1999-2000: Andhra Pradesh

Miles To Go

In May 2000, the Andhra Pradesh government launched its crash Neeru Meeru water conservation programme to deal with the water scarcity. Though a step in the right direction, the government and the people still have a lot of ground to cover

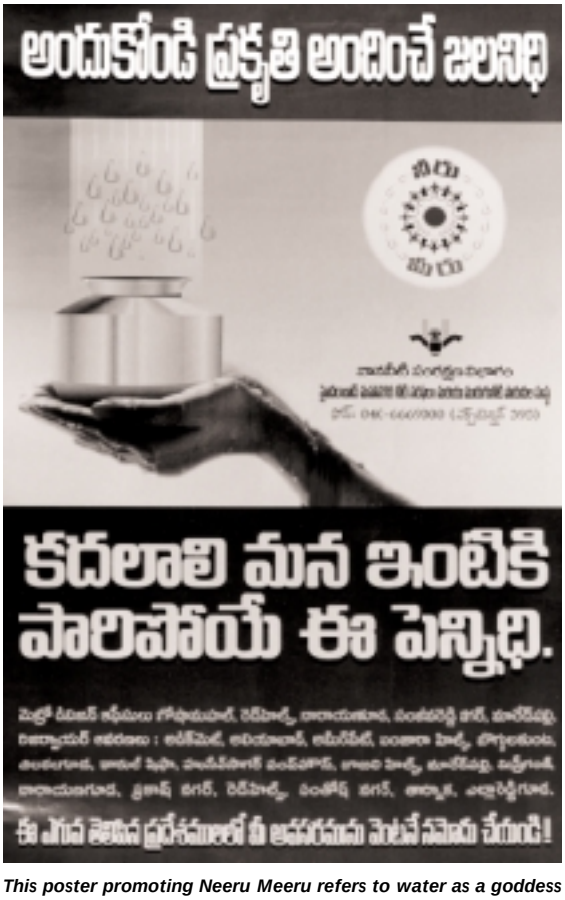
Binayak Das
Centre for Science and Environment, New Delhi

In May 2000, the government of Andhra Pradesh (AP) launched its water conservation programme termed as Neeru Meeru (water and you) under the Janmabhoomi (motherland) programme. The Janmabhoomi programme is being heavily promoted by chief minister Nara Chandrababu Naidu and is a package designed for encouraging communities to help themselves.

Under the Neeru Meeru programme a number of water conservation efforts were undertaken. This programme also combined all existing water conservation programmes under one umbrella in addition to initiating new ones. A crash programme that was implemented in a great hurry, there were a number of detractors. The issues of discontent were many: the people were not ready or informed, there were reports of corruption and the science component of the programme was weak and not holistic in approach. People felt that these efforts were aimed at increasing grassroot level political clout and that the programme was target-oriented and too bureaucratic in approach. However, for communities that were astute enough to capitalise on the programme, the programme came as a boon and not a moment too soon.

IMPACT

Achampet mandal in Mahabubnagar district was one area where Neeru Meeru fitted into their ongoing activities on water conservation *(see Box: Bore power)*. The *mandal* was in the grip of drought six years ago. But there has been a turnaround. "The groundwater table has risen four-fold between February 1994 and March 1998," says Ramesh Reddy, head of the department of civil engineering at Osmania University, Hyderabad. He is also the chairperson of the Centre for Rural Youth Development (CRYD), a non-governmental organisation (NGO) based in Achampet. In 1995, people of this region, along with CRYD, took up the AP Groundwater Borewell Irrigation Scheme (APWELL). This scheme was aimed at watershed development to improve groundwater resources and recharge borewells. It was made available in seven drought-affected districts of the state — the result of an agreement between the state government and the government of the Netherlands to fund watershed development. Under this programme, water harvesting structures like check dams, contour trenches and rainwater pits were constructed to ensure



This poster promoting Neeru Meeru refers to water as a goddess and urges the people to allow this goddess entry into their home

BORE POWER

The word borewell conjures up visions of electric and diesel pumps furiously overextracting groundwater. Villagers in Achampet and other* mandals *in Mahabubnagar district have helped change that image by their concerted water harvesting efforts to facilitate borewell recharge

Lambada men and women, the latter wearing silver ornaments and colourful clothes, pour water on each other, as part of the *Malkala* festival to pray for rain. If the rains do not arrive within the next 10 days, the rainfed crops will fail. But the Lambada villagers of Kotapalli, a village in the Nallamalai range, are a little relaxed. They have installed 43 borewells under the Andhra Pradesh groundwater borewell irrigation scheme (APWELL), which has made the cultivation of castor, paddy, *jowar*, *bajra*, *teel* and vegetables like chillies and tomatoes possible. They no longer travel to urban areas in search of livelihood.

These villagers however are aware that borewells can go dry over time and that there is a need to recharge groundwater sources. To do this, the villagers have made *indukanta* (rainwater pits) 3 metres (m) x 2 m in size, dug close to each borewell, as a part of Neeru Meeru (Water and You) programme. Explaining the proactive stance of the villagers, says Lakshmi, the septuagenarian leader of the women's self-help group, "We don't wait for government support. The social organisation, Centre for Rural Youth Development (CRYD) is helping us. But if the government provides funds, we accept it with grace."[1] The village watershed committee resolves all conflicts otherwise the villagers go to the CRYD general secretary, Mohammad Abdul Khader, a 45 year old professor of English in a local college in Achampet.[2] Under his able guidance, many villages in Achampet mandal are now managing their own resources with confidence.

APWELL started in 1995 when a bilateral agreement was signed between the government of Andhra Pradesh (AP) and the Dutch government for a grant of Rs 70.2 crore. The AP government provided another Rs 5.7 crore. Farmers contribution stood at Rs 3.7 crore. The purpose of the project was to improve the living conditions of small and marginal farmers. It provides groundwater irrigation facilities to increase crop production. It also ensures groundwater recharge through construction of water structures. Local NGOs have been involved as project implementation agencies (PIA).[3]

In Achampet, CRYD is the PIA. The region has an annual average rainfall of 700 millimetres. The project now covers 21 villages spread over four *mandals* of Achampet, Balmur, Amrabad and Lingal. The PIA decided that the villagers should also take up watershed activities simultaneously. "Satellite imagery of the Achampet in March 1988 shows an increase in the water table and green cover, as compared to February 1994," says Ramesh Reddy, head of the civil engineering department, Osmania University.[4]

Watershed activities have continued and check dams, contour trenches and other water harvesting structures have been constructed. Villagers are maintaining their tanks. The local economy has improved. P Ramulu, the local MLA endorses the project: "I trust the PIA and the local villagers to take up the work themselves."[5] S Raghavendrachary, assistant project director of the Drought Prone Area Programme says, "I did not allow contractors to participate. The government released the fund to the village committee."[6] The water users associations were formed under a resolution of the *gram panchayat* and after their formation, there has been no interference from the *panchayats* or *sarpanches*. The *sarpanch* of village Komat Kunta in Lingal mandal confirms, "I do not interfere in the affairs of the watershed committee." CRYD audits the village cash register. Watershed Support Services and Activities Network, a Hyderabad based NGO, evaluates the watershed activities.

Slowly, the villagers are beginning to manage their own affairs. Ramesh Reddy, chairperson of CRYD, says, "It is better if the villagers start taking decisions independently. They will learn to manage themselves without outside support." But as inter-village coordination is lacking, villagers now want to make a federation of farmers belonging to all the villages under the *mandal*.

On the foothills of the Nallamalai forest reserve in the Balmer mandal lie the villages of Billakal, Banala, Lakshmipalli, Konnangulari and Venkatgiri. The road to Billakal (26 kilometres from Achampet town) is inhospitable. Five years back, the Billakal watershed was a poor fallow village where people starved. In 1995, CRYD started to work in this harsh terrain, under the APWELL project. Borewells brought water to 325 hectares of agricultural land. Simultaneously, villagers also started impounding the runoff by building check dams and rock-filled dams within the catchment area, which reaches into deep forests. Yerraiya, a member of the Chengchu tribe, shows the deep thickets surrounding a check dam built in 1997. The check dam provides irrigation water to a land of 14-16 hectares and recharges the borewells. A second check dam was built in the vicinity of borewells. This check dam helps to recharge 10 borewells.[8]

In 2000, to implement Neeru Meeru, villagers started digging a rainwater recharge trench near one of the borewells. To their pleasant surprise, they struck water at just one metre depth because of the presence of the check dam in the vicinity. The president of the watershed committee, J Pedayya, says, "Earlier, we could only manage 0.75-1 tonne of crop per hectare, that too depending on the rain. But now we are producing 3-3.5 tonnes of crop per hectare."[9]

But not everything is to the satisfaction of the villagers. Different government departments have different priorities Rasoolcheruvu is just three kilometres away from this village. Pedayya says that the tank has been in existence from the days of his great grandfather and serves five villages on its periphery. The tank has not been desilted under Neeru Meeru because of a dispute — the tank area belongs to the forest department and it is not ready for desiltation yet.

Borewells can be used to turn arid land green and yet never run dry. The villagers from Mahabubnagar have shown how.

BINAYAK DAS / CSE

The Janmabhoomi programme aims at helping communities to help themselves through the formation of self-help groups

that borewells did not go dry. When the Neeru Meeru programme was launched in 2000, several villages in the *mandal* capitalised on it to augment borewell recharging efforts through the construction of recharge trenches

NEERU MEERU

Genesis

In his efforts to deal with the drought of 1999-2000 and the resulting water crisis in the state, Naidu decided to launch the Neeru Meeru programme on April 30, 2000. In April itself, Naidu had asked the Central government to release Rs 250 crore for drought relief particularly in the state's Telengana and Rayalaseema regions which were the worst-hit.[1] The status of the state's groundwater reserves was already quite bad. With a normal annual rainfall of 896 millimetres (mm), the state receives a total of 24,400 million cubic metres (mcum) of water every year. However, only an estimated nine per cent of this goes to recharge the groundwater whereas 40 per cent gets converted to surface runoff. Meanwhile, the state's well population is increasing by 50,000 per year.[2] A May 2000 report of the rural department of the Andhra Pradesh government had stated that in 1999-2000, after the state faced a severe drought, more than 17 per cent of the habitations in the state faced drinking water scarcity. But by mid-May, realising that drought-relief alone was not enough and a long-term drought mitigation plan was needed, Naidu announced a crash 100 day rainwater harvesting and conservation programme across the state at a cost of Rs 140 crore.[3] District collectors had already apprised him of the benefits they had seen of contour trenching, check dams and various other water harvesting methods in late April.[4] Newspapers reported that even the World Bank was prepared to provide Rs 100 crore to fight the drought through water harvesting measures.[5] In May 2000, a concerted effort called the Neeru Meeru (Water and You), which is the 12th part of the omnibus Janmabhoomi initiative of the AP state government.

The Neeru Meeru programme was one of the packages under the Janmabhoomi programme. The Janmabhoomi programme is a package of measures designed by the government to help communities to help themselves. An ongoing process, the objective is that communities manage their own resources and address problems and issues through the formation of self-help groups. These self-help groups include women's self-help groups, water users associations (WUAs), watershed committees and youth groups. For instance, *van sanrakshan samitis* (VSS) or forest protection committees are expected to look after forest areas and watershed activities; WUAs will manage surface waterbodies outside the jurisdiction of the forest department; and, *ayacut* development members promote the development of *ayacuts* (irrigation command areas). In Janmabhoomi, all concerned officials visit villages and explain the concept, create awareness and take up programmes in those villages. The entire concept under Janmabhoomi is explained

within seven days. The works are implemented at 50 per cent cost to the government.[6] Under Janmabhoomi many rounds have been undertaken. Some of these rounds are:

- Neeru Meeru: The 12th series of Janmabhoomi in which all development activities of water were taken up with the involvement of the people
- Mahila Janmabhoomi: Under the 13th Janmabhoomi, women's self-help groups were mobilised for their participation in developmental activities of the village and also development of women and children
- Deepam: Distribution of gas cylinders to the people
- Adarna: Hand tools distribution to farmers and other workers
- Yuva shakti: Youth groups formed to secure their future by providing jobs
- Chandra Kanthi: Distribution of solar lanterns and solar cookers to villagers

"All these water conservation activities were going on individually, but there was no impact analysis and individual decisions were giving poor deals to the people," says Chandrasekhar Reddy, special officer in charge of Neeru Meeru in the rural development department.[7] Neeru Meeru was thus conceived of as a multi-departmental but coordinated programme which would aim to increase groundwater and surface water resources through increased rainwater harvesting with the help of the people. The programme aimed to excavate 57.65 million cubic metres (mcum) of earth to capture the rain at a cost of Rs 189.22 crore. The stress was on desilting of old tanks and construction of contour trenches, check dams and percolation tanks followed by rock-fill dams and other recharge structures.

The stress on desilting of old tanks made sense in Andhra Pradesh because of its remarkable legacy of irrigation tanks, especially in the Deccan Plateau region. Even today there are more than 200,000 small and big tanks spread across the three south Indian states of Andhra Pradesh, Karnataka and Tamil Nadu, providing not less than 25 per cent of the total irrigation potential. In Andhra Pradesh alone, there are around 80,000 small and big irrigation tanks irrigating over a million hectares in the most drought-prone regions of the state. But the contribution of tank irrigation has been steadily declining because of neglect. Whereas it was around 40 per cent of the total irrigated area in the early 1950s, it came down to about 20 per cent in the 1990s. As much as one-third of the command area under these tanks has gone out of the total irrigation potential. The neglect of the tanks has also reduced groundwater recharge even as the area irrigated by dugwells and tubewells has gone up nearly six times[8] (*see Table 1: Troubled tanks of Andhra Pradesh*). This now leads to extreme water scarcity during drought periods when groundwater tables fall dramatically and there are few surface water sources around.

Table 1: Troubled tanks of Andhra Pradesh

Area irrigated by various sources in Andhra Pradesh (million hectares) reveals how the area under tank irrigation is declining over the years and the area irrigated by other sources, specially groundwater is increasing

Year	Canals	Tanks	Dugwells	Tubewells	Others	Total
1955-56	1.29	1.07	0.28	—	0.10	2.74
1965-66	1.23	1.19	0.42	0.03	0.11	2.98
1975-76	1.63	1.10	0.47	0.12	0.13	3.45
1985-86	1.78	0.79	0.66	0.19	0.11	3.53
1995-96	1.54	0.75	0.95	0.71	0.18	4.13

Source: Bureau of Economics and Statistics (1997), Hyderabad, quoted in Dhan Foundation 2000, Revival of Tank Systems in Cascades: Conservation and Development Approach in Tankfed Areas of Andhra Pradesh, *mimeo.*

Unfortunately, as the programme of desilting old tanks was being implemented, the heavy monsoon of 2000 caused breaching of tanks. The reasons for the breaching included neglect of the tank and poor quality of construction of the new tanks *(see Box: Breaching menace)*.

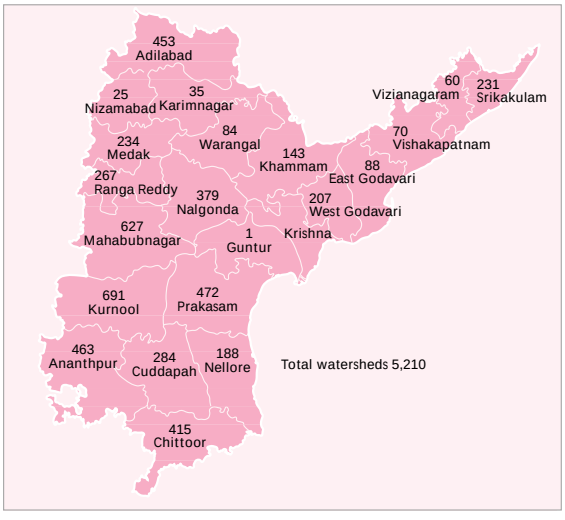
The government's guidelines for Neeru Meeru say, "It is being emphasised again and again that traditional, no cement, structures must gain prominence. Since these must be initiated by the community, there will be less temptation for cornering of efforts by contractors since these structures are most cost-effective and easier to maintain. This aspect needs to be repeatedly reiterated." The guidelines are very clear regarding the involvement of the community in the management of its own resources.[9]

Naidu says in support of the programme, "Neeru Meeru is a concept under which I want to increase the percentage of rainwater we are conserving. Rainwater is going to the sea as waste. So what I am doing is to conserve more water. We are building structures and recharging groundwater. We are working in many different ways. All over the country, whatever is the experiences of experts, I am borrowing from all of them."[10]

To oversee the work of Neeru Meeru, the AP government formed a water conservation mission (WCM) consisting of experts from various parts of the country under the chairpersonship of the chief minister himself. The objective of WCM is to finalise a policy framework and provide guidance for monitoring water programmes. The departments of panchayati raj and rural development were made responsible for implementing the programme. There are 5,210 watersheds under the rural development department *(see Map: Watersheds in Andhra Pradesh)*.[11] Under the joint forest management scheme, 6,620 VSSs have already been formed to green 1.8 million hectares (mha) of land, of which 0.55 mha has already been covered. District and *mandal*-level

Watersheds in Andhra Pradesh

There are 5,210 watersheds being developed in Andhra Pradesh under the rural development department



advisory bodies have been formed of officials belonging to various government departments (groundwater, rural development, forest, irrigation, horticulture and urban development), *zilla parishad* members, NGOs and experts. Village level committees have the village *sarpanch* as president and a village level officer as convenor. The stakeholders are the WUAs, self-help groups, women's groups, NGOs and research organisations. The mission includes provisions for training, funds and technological assistance to the villagers.

Implementation strategy

Naidu took a personal interest in the implementation of the programme. For the first 50 days, he took daily video conferences with district collectors and officials of all concerned departments and weekly reviews thereafter.[12] To implement the programme, officials were instructed to construct and revive water harvesting structures.

The ground realities were grim. Out of a total of 45,000 habitations, 7,700 faced a drinking water scarcity. About 16,000 borewells had gone dry while the number

BREACHING MENACE

Building tanks is just half the story. Maintaining them is the other half. In Andhra Pradesh, rain, humans and ants came together to breach tanks by the hundreds during the heavy monsoon of 2000

A heavy downpour can easily breach a tank. Tanks breach when a crack or hole develops in a tank *bund* and is left unattended. Heavy rains accelerate the process of breaching. Ants also make antholes in *bunds* and other earthen structures and, thus, weaken them. But whatever the cause, the underlying problem can be summed up in one word: neglect.

In Andhra Pradesh, many tanks breached during the torrential rains of 2000. Just a few months before, in May, the chief minister had instructed that the tanks be desilted under the Neeru Meeru programme when the state was experiencing water scarcity after the monsoon of 1999 had failed.

According to Rukmini Rao of Deccan Development Society a Hyderabad-based non-governmental organisation, Mahabubnagar district received very heavy rains in June 2000, and 244 tanks breached.[1]

Several reasons have been cited for the breaching of tanks. Their *bunds* had not been strengthened periodically. According to A Vaidyanathan, an expert on tanks with the Madras Institute of Development Studies, Chennai, "In a large number of cases, *bunds* have been weakened by neglect of regular maintenance and repair, as well as failure to attend to damages caused by earlier episodes of high rainfall and resulting flooding. Maintenance and upkeep being a management responsibility, its neglect does reflect managerial failure."[2]

According to Watershed Support Services and Activities Network another Hyderabad-based non-governmental organisation, in most of the cases where breaching occurred, poor quality material had been used for repair of old tanks as well as in the construction of new tanks.[3] In Ananthapur district of Andhra Pradesh, "90 per cent of the breached tanks are new constructions," informs Koda Ramakrishna Reddy, a minor irrigation expert from Krishnadevaraya university in Ananthapur.[4]

D Muralidharan, a scientist with the Hyderabad-based National Geophysical Research Institute, says that in new constructions there are limitations like site availability. "New tanks are often constructed not on the basis of volume but on the basis of who will benefit from them.[5]

Tanks which lack the capacity to store adequate water breach at the topmost section. Government pays Rs 3 per hectare under tank irrigation to maintain the tanks. For a tank with a command area of 120 hectares, about Rs 1,000 per annum is given to maintain the tank and that, too, in a cycle — first the government will take 100 tanks for repairs in a year and then the next 100 tanks in the next year. As a result, many tanks do not get repaired for years, which leads to breaching.

"It is not failure of technology, but neglect and mismanagement. Very little money has been allocated for the maintenance of tanks" explains Koda Ramakrishna Reddy.[6] Tanks often get damaged due to poorly constructed contour *bunds* on the upper slopes of a tank's catchment. Sometimes these contour *bunds* give way under the force of water and water gushes towards the tank to make a breach. It is important to fix the breach immediately, but tanks are often not repaired on time. Villagers, too, don't take much interest as tanks are under the panchayati raj department, which creates legal problems for villagers to act on their own. They can only report a breach to the department.

BINAYAK DAS / CSE

The Neeru Meeru programme encouraged communities to undertake water conservation exercises to harvest rain

of villages supplied by water tankers stood at 1,000. The panchayati raj department planned to build 67,748 water harvesting structures. Two types of trenches — continuous contour trenches and staggered trenches — were to be constructed in all watersheds. Efforts were also to be made to construct gabion structures and gully control works with a minimum amount of cement being used. The groundwater department and remote sensing application centres were to work together to analyse the groundwater scenario and status of green cover. Desiltation of old tanks was to be taken up in a big way. Manual labour and poclains (earth moving machinery) were to be used to desilt old and new tanks and percolation pits were to be constructed. Breached tanks were to be repaired. Ring *bund* construction was to be undertaken to stop breaching.

Desiltation was carried out at varying rates from Rs 9 per cubic metre (cum) in Krishna district, a delta area, to a maximum permissible rate of Rs 17.20 per cum. The other cost is the machinery cost. The contractor's poclains extract the silt and put it in a farmer's tractor who takes it to his fields to enrich the soil fertility. Desilting per hour needs the services of 20 tractors and every 2-3 minutes a tractor has to be present. "That is how mobilisation started and people were present with their tractors," informs Chandrashekhar Reddy. The government only paid for poclains on an hourly basis.

Funds for Neeru Meeru were provided both by Indian and foreign sources. Foreign donors included Department for International Development (DFID) of the British government, Kreditanstalt fur Wiederaufbau (KFW of Germany), Swiss Development Cooperation (SDC), Netherlands assistance projects and the World Bank. The World Bank sanctioned Rs 225.84 crore for the programme *(see Table 2: Water harvesting financing by the World Bank)*. From the Central government, funds

Table 2: Water harvesting financing by the World Bank

The World Bank financed water harvesting activities under the Neeru Meeru programme

Activity	Amount granted for implementation (Rs crore)
Recharge and desiltation of 6,000 tanks under the Panchayati Raj department	120.00
Construction of water harvesting structures and check dams	5.76
Watershed approach for water conservation in urban areas	24.20
Total for water harvesting related activities	**149.96**

Source: Anon 2000, Funds for water harvesting from World Bank, Water Conservation Mission: The Information Guidelines, Government of Andhra Pradesh, *mimeo*

Table 3: Increasing water recharging capacity

Groundwater recharge capacity created under Neeru Meeru works as on September 23, 2000

Type of work	Achievement (in number)	One time water impounding volume created (mcum)	Number of fillings till 20-9-2000	Percentage of recharge	Total recharge (mcum)	Number of fillings during the year	Total recharge during the year (mcum)
Desilting of tanks	7,452	22.86	2	50	22.86	2	22.86
Contour trenching (hectares)	160,002	18.81	18	70	237.02	30	395.00
Percolation tanks	1,903	9.52	3.5	50	16.65	5	23.79
Check Dams	4,960	12.37	3.5	50	21.65	5	30.93
Rock-fill dams	78,516	4.00	18	30	21.59	30	35.98
Recharge Structures	78,155	1.11	18	30	6.00	30	10.00
Total	—	**68.67**	—	—	**325.77**	—	**518.56**

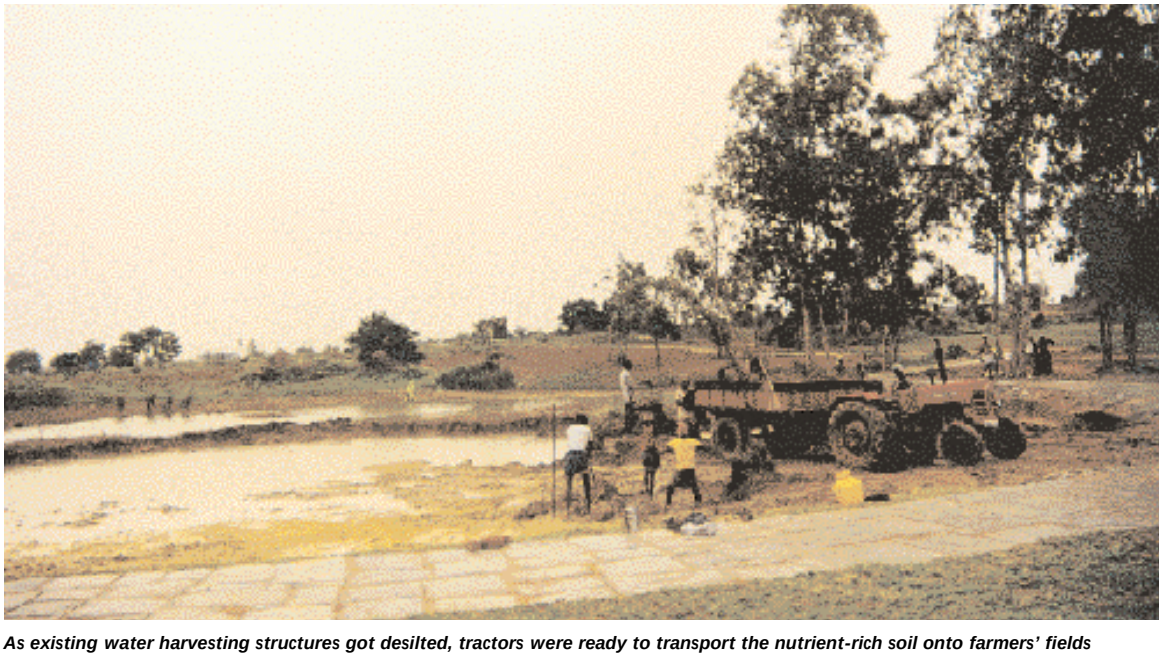
Note: *mcum: million cubic metres*

Source: Anon 2000, Status of Neeru Meeru 23-9-2000, Water Conservation Mission, Government of Andhra Pradesh, *mimeo*

under the Jawahar Gram Samridhi Yojana and Employment Assurance Scheme were used.[13]

Achievements

The Water Conservation Mission met for the second time in October 2000 to take stock of the progress under Neeru Meeru. The official report claims good results of the programme. Some 7,452 tanks had been desilted in four months; 1,903 new percolation tanks have been constructed with a total impounding capacity of 9.52 mcum. Overall, a one-time water impounding capacity of 68.67 mcum had been created *(see Table 3: Increasing water recharging capacity and Graph 1: Earth excavated)*. The total expenditure was estimated to be Rs 88.08 crore. It was found that dried up dugwells and borewells in the vicinity of these tanks were recharged after the 2000 monsoon and were working satisfactorily both for drinking and irrigation water needs. The government estimated that as it received higher than normal rainfall during 2000, the actual volume of water

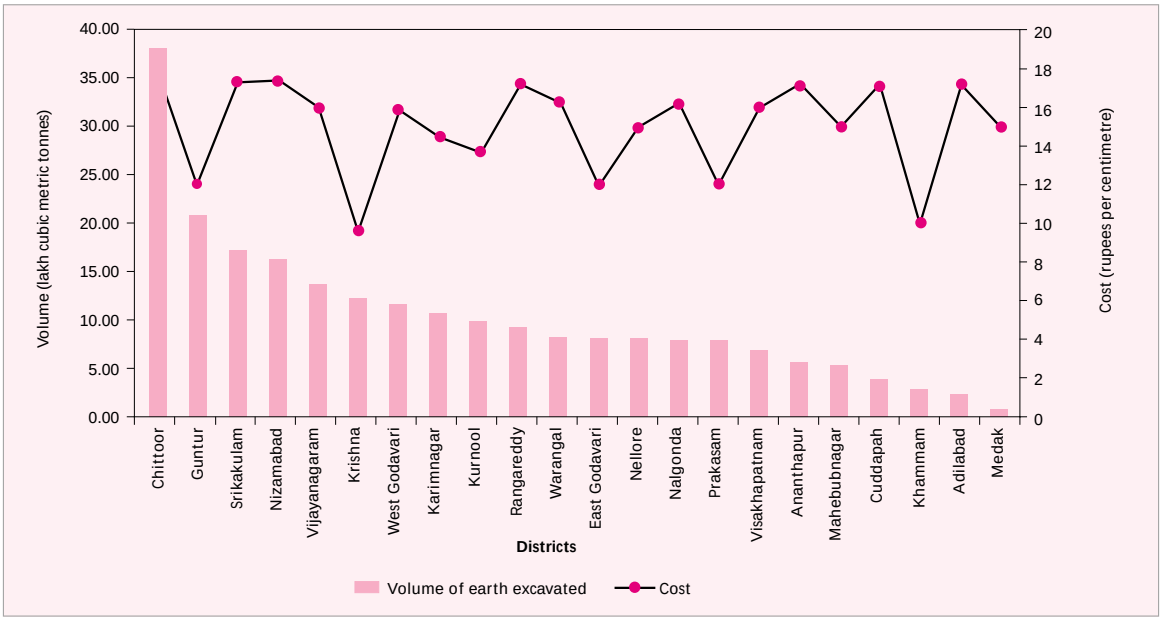


BINAYAK DAS / CSE

As existing water harvesting structures got desilted, tractors were ready to transport the nutrient-rich soil onto farmers' fields

Graph 1: Earth excavated

Several water harvesting structures were desilted to increased their efficiency under the Neeru Meeru programme



Source: Anon 2000, Status of Neeru Meeru 23-9-2000, Water Conservation Mission, Government of Andhra Pradesh, *mimeo*

recharged went up from the expected volume of 13,500 mcum to 17,100 mcum — about nine per cent of the rainwater received.[14]

Case studies were carried out in Krishna, Chittoor, Karimnagar, Guntur and Khammam districts and they all showed a rise in groundwater table varying between 0.21 metres to 9.126 metres.

The work efficiency varied from district to district and from one type of water harvesting structure to another. The cost of desilting one cubic metre of earth varied from Rs 10 in Krishna and Khammam districts to about Rs 18 in Chittoor, Srikakulam and Nizamabad districts. While the statewide average for removing one cubic metre of earth through desilting of tanks was Rs 14.84 it was Rs 20.5 for contour trenches *(see Table 4: Cost of water recharge)*. Contour trenches were found to be the most cost-effective for groundwater recharge — just one rupee to achieve one cubic metre of water recharge. In terms of groundwater recharge, they were found to be most effective when implemented as part of an overall watershed development programme.

ASSESSING PERFORMANCE

While project officials are very enthusiastic about the results of the programme, the programme drew flak on several fronts. Some of these include:

Poor social mobilisation: Critics say that very little time was spent in mobilising people for participation. The programme was implemented too much in a hurry. As a result, a people's programme became a programme of the government. A crash programme was also started for rainwater harvesting in urban areas which also had its detractors (*see Box: Cyberabad's travails*). Critics say that awareness pamphlets were printed a day before the

Table 4: Cost of water recharge

Cost efficiency of different types of water recharge structures (Rs)

Type of work	Cost per cubic metre of water impounding volume	Cost per cubic metre of water recharge during one year
Desilting of tanks	14.84	14.84
Contour trenching	20.5	1.36
Percolation tanks	11.93	4.77
Check dams	24.9	9.96
Rock-fill dams	48.18	4.81
Recharge structures	306.84	30.6
Others	74.99	7.5
Overall works	23	4.13

Source: Anon 2000, Status of Neeru Meeru 23-9-2000, Water Conservation Mission, Government of Andhra Pradesh, *mimeo*

CYBERABAD'S TRAVAILS

Urban water harvesting efforts in Hyderabad will succeed only if the people participate

Water tankers are a common sight in the twin cities of Hyderabad and Secunderabad. Groundwater has receded to low levels forcing residents to buy water at a high price of Rs 400 per tanker (10,000 litres) in some localities. Piped water reaches once, twice or thrice a week, depending on which locality one is living in.

Under the Neeru Meeru programme urban rainwater harvesting (RWH) was promoted to recharge the groundwater. The Hyderabad Water Supply and Sewerage Board (HWSSB) is implementing the programme in residential and commercial complexes, while the Hyderabad Urban Development Authority (HUDA) is responsible for promoting it in various institutes and open spaces of Hyderabad-Secunderabad.

Urban rainwater harvesting had already been initiated in 1998 through HWSSB, HUDA, road and buildings department and the municipal corporation of Hyderabad (MCH). In 1999, RWH was made compulsory in all multistorey buildings, and in all new constructions with an area of more than 300 square metres. A tentative deadline of June 2001 was set for following the guidelines. Private individuals were also encouraged to take the up work. Under the 12th round of Janmabhoomi, in 2000, the government revamped the programme by creating a RWH cell under J V Mukhedkar in HWSSB.[1]

The programme has received a poor response from the people. D Muralidharan, a scientist with the National Geophysical Research Institute based in Hyderabad, says, "There are two reasons: failure to motivate the public, and failure to conduct pilot projects to assess public needs."[2] Mukhedkar, however, counters, "The campaign has not been a failure. In 1998, an advertisement in the newspapers resulted in 60-70 people of Padmashali Nagar taking up the work by themselves and they are benefiting from these structures. The people are responding, though slowly."[3]

HWSSB and MCH plan to make 5,000 structures in the twin cities to harvest 1.20 million cubic metres of water at a total cost of Rs 1.5 crore. Water harvesting structures have been constructed in government buildings. In Osmania University, 18 water harvesting structures have been built. Some Rs 30 lakh were spent to create awareness through pamphlets and newspaper advertisements. From May 1-7, 2000, the HWSSB organised *basti sabhas* (meetings) in 308 slums and held discussions with residents welfare associations. "Some 4,900 people registered with the Metro Board by June 15, 2000, the last day for taking advantage of the government's subsidy," claims Mukhedkar. The HWSSB is giving a 50 per cent subsidy to residents who are implementing RWH. People have to deposit their contribution in a bank while the government buys the construction material through contractors appointed for making the structures. This is where the problem lies, according to C H Ramachandriah, a social scientist working with the Centre for Economic and Social Studies in Hyderabad. "This form of subsidy is discouraging people from coming forward as they believe that contractors will supply poor quality materials. Out of 5,000 applications, only 50 deposited money under the scheme," he informs. He feels that residents should pay for the materials to the contractors directly.[4]

J Rajendra Prashad with Peoples Research Organisation for Grassroots Environmental Scientific Service, an NGO, feels that the government is promoting rainwater harvesting without adequate information on how it should be done and what are the necessary precautions. "Water harvesting pits have been located near septic tanks and drainage outlets," he claims. He also warns against the policy of subsidy. "People expect the government to give a loan, a grant or a subsidy, especially in small towns. Even NGOs going to these places face a problem."[5]

Table: Restoring Durgamcheruvu

Several water harvesting structures were built by HUDA around Durgamcheruvu

Sector	Rock filled dams	Contour bunds with rubble stones	Stone bench terraces	Total
I	11	10	41	62
II	19	22	3	44
III	10	1	16	27
IV	17	20	1	38
Total	**57**	**53**	**61**	**171**

Source: Anon 2000, Details of rainwater harvesting structures executed by HUDA on watershed concept at Durgamcheruvu Hills and Appropriate Plantation Technique by Rainwater Harvesting, A presentation by HUDA, *mimeo*

Hyderabad and Secunderabad are dotted with many ancient tanks of which Osmansagar and Himayatsagar supply drinking water. HWSSB is desilting these tanks to increase their storage capacity and aims to remove 100,000 cubic metres of silt. In the hills surrounding Durgamcheruvu, HUDA has constructed rock-filled dams across gullies and *nullahs*, stone bench terraces and contour *bunds*. One-third of the upper reaches has been treated with contour bunds *(see Table: Restoring Durgamcheruvu)*. HUDA has taken restoration of other tanks also.[6]

Expressing satisfaction with the programme, K L Vyas, an active member of the city's environment movement, says, "There are cases of disputes of ownership in residential buildings and poor planning. Sometimes, there is not enough space for water harvesting. Elsewhere, people do not want to spend an amount of Rs 4,000-5,000 even after a 50 per cent subsidy. In some places, government agencies are making money by building cheap structures. But these are just initial teething troubles."[7]

Says Muralidharan, "Water harvesting has taken roots. The media is regularly focusing on it and people are becoming increasingly aware of the benefits. We should see an increase in the water table in 3-4 years." But the government alone cannot cope with the pressure and community participation is vital, he feels. M S Kodarkar, another environmental activist from Hyderabad, suggests, "Technologists from training institutes should be involved and certain areas can be assigned to students."[8] Many experts believe that water harvesting should be included in students' curricula, that the government should give an incentive or an award for the best water harvesting structure, and those buildings which do not install water harvesting structures should have their property tax increased.

implementation started. Redappa Reddy, professor of rural development in Sri Krishnadevaraya University, says, "The CM wants fast implementation of the programme. He does not like pilot projects. He wants to do things in a big way throughout the state."[15]

In smaller towns and municipalities too, work is moving at a lacklustre pace *(see Table 5: Little to declare)*. People are still not aware of rainwater harvesting in many small towns. Concerned municipal departments are not making any attempt to create awareness. The Chennai-based KRG Rainwater Harvesting Company was asked to conduct a feasibility study. It was able to achieve some results. The company implemented its ideas by building new water harvesting structures and identifying new sources in Kama Reddy, Nizamabad district. This company has been asked to work in 14 more municipalities.[16] Projects undertaken by the private sector are thus yielding better results as compared to the government.

"In Kurnool, the district received nearly Rs 10 lakh for urban water harvesting," says B N Chetty, who works with the Kurnool-based NGO, Jan Vikas Sangh, adding, "The government made a few 'showpiece structures' in its office premises at a cost of Rs 3.4 lakh. There is no public awareness, however." In a small town, Nandikotkul, in Kurnool district, outside the bus terminal is a placard that says: This is a rainwater harvesting pit. But the pit has now turned into a garbage dump.[17]

Several cynics in Ananthapur district say that there are many showcase watersheds like Wanjuvanka. Any person who wants to see the progress of the programme is taken for a *darshan* to these watersheds. The visitors' register speaks of the number of people taken to them.

Too many cooks: Another criticism is that innumerable committees have been formed. M S Kodarkar, a zoologist with the Vivek Vardhini College in Hyderabad and an activist for the protection of urban tanks, says, "Multiple government departments control water. There is the metro water supply department, irrigation department and now various WUAs sprouting all over the rural areas. The administrative structure is becoming vague."[18] The government has formed many village-level groups like WUAs. Their job is to harvest water, check runoff, desilt tanks, build water harvesting structures and regenerate watersheds to save AP from subsequent droughts. Project implementation agencies (PIAs), NGOs, contractors, all have come to play their part.

Gaining political mileage: Critics also say that most of the grassroot committees have been formed in a way

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Under the APWELL and Neeru Meeru programmes, borewells were recharged by excavating recharge pits and trenches

Table 5: Little to declare

In various municipalities, rainwater harvesting activities during the implementation of the Neeru Meeru programme (May to July 2000) were disappointing

District	Pits	Trenches	Wells	Check dams	Others	Total
Vizianagaram	85	6	—	—	—	91
Karimnagar	314	14	—	—	—	328
Warangal	372	14	—	—	—	386
Anantapur	53	164	1	123	2	343
West Godavari	484	809	7	—	—	1,300
Srikakulam	259	22	4	59	—	344
Chittoor	—	—	—	—	—	571*
Kurnool	8	16	2	—	—	26
Sangareddy	55	—	2	—	—	57
Visakapatnam	292	58	23	—	41	414
Nalgonda	6	—	—	—	—	6
Nizamabad	233	—	—	—	—	233
Nellore	170	3	—	—	—	173
Rangareddy	—	—	—	—	—	—
Total	**2,331**	**1,106**	**39**	**182**	**43**	**3,701**

Note: ** Chittoor was not taken in the total because the district could provide only the total structures, and not the break up*
Source: Anon 2000, Progress report of rainwater harvesting programme in municipalities of different districts in Andhra Pradesh during 2000-2001, Report of Groundwater Department, Hyderabad, *mimeo*

that representatives have been selected from the ruling party. "At the ground level, these bodies have been created to generate positions for the people of the ruling party. If one person is given chairpersonship of the party, then another is made the president of the WUA or the VSS," says Koda Ramakrishna Reddy, an expert on minor irrigation, with Sri Krishnadevaraya University in Ananthapur.[19]

Another major criticism is that property rights over water harvesting structures have not yet been worked out properly. Desiltation work has been undertaken in many tanks controlled by the panchayati raj and minor irrigation departments. Tanks under the programme were to be handed over to the WUAs but a court order said that the government has no right to hand over tanks to WUAs because these come constitutionally under the rights of the *gram panchayats*. "But in Andhra, *gram panchayats* in most places are controlled by the opposition party, the Congress. This is one main reason for the formation of WUAs," says Rukmini Rao, of the Hyderabad-based Deccan Development Society, who works on watershed projects in Rayalaseema.[20]

Corruption: Several people expressed unhappiness about levels of corruption and wonder if all the money allocated for the purpose of water conservation was actually spent on it. Money for desiltation projects is handled by WUAs. But there are doubts about the amounts sanctioned and the amounts received by the WUAs. A person who does not want to be revealed says, "I personally know a person who has received Rs 7,000. When I enquired, he replied that since he was the watershed committee president, he was getting this money because he had signed a cheque for Rs 28,000."[21] The WUA president is responsible for releasing money to contractors or PIAs. Half the work is done with the knowledge of the WUA president, but the contractors claim the money for the full work. Rao says, "A lot of corruption is going on. NGOs have to pay money to get money released." This is also a major reason for low public participation.

The programme was also hijacked in several places according to Rao. In a watershed in Mahabubnagar, a few elite farmers formed the watershed committee and then released all the money to their relatives. One beneficiary got Rs 72,000 for horticulture. But landless people, when asked as to what they received, said that most of them had not even been called for work. In several watersheds the scheduled rates (SR) of the government have not been followed. The rate of SR in Mahabubnagar is Rs 9 per cum for desilting but a few influential farmers of the watershed committee united to get it reduced to Rs 7 per cum, which went against the landless workers.

Scientific approaches: The science component in the programme should have been stronger. In the

BINAYAK DAS / CSE

A continuous contour trench helps capture rainwater cheaply

Banaparty taluk of Mahabubnagar district, 40 tanks have breached and there is no sign of immediate repair.[22] Poor management accelerates the process of breaching, say many tank experts *(see Box: Breaching menace).* "Because scientific aspects are bypassed, tanks breach. No location-specific study has either been undertaken to assess the causes of breaching," says M V Ramachandran of Watershed Support Services and Activities Network of Hyderabad.[23] Explains Uma Shankari, convenor of Neeti Sambhya, an NGO based in Chittoor district, "Tank *bunds* get weakened by neglect of regular maintenance and repair as well as failure to attend to damages caused by earlier episodes of high rainfall and resulting flooding. What is the point of desilting tanks, if the supply channels are not in order and water does not flow into the tank? Desiltation programme should include supply channel cleaning too."[24]

Check dams have been made on hard soils where water cannot percolate. In Kumaranpalli village in the Amrabad mandal of Mahabubnagar, villagers in their enthusiasm to implement Neeru Meeru dug about 130 rainwater harvesting pits, but they also connected their house wastewater drains to them. No government official educated them about the risks of groundwater pollution. Studies being conducted by the Hyderabad-based National Geophysical Research Institute (NGRI) suggest that some of the silt being extracted may be toxic due to industrial effluents flowing in from the catchment area. "The study is still nascent but the government should be cautious before it allows the silt to be taken to agricultural fields," cautions D Muralidharan, a scientist with NGRI.[25]

Commenting on the urban water harvesting efforts, Muralidharan said, "RWH for artificial recharge is not suitable in Hyderabad because of its impermeable terrain. Instead, rainwater should be conserved and used directly with proper chlorination."

According to Shashidhar Reddy, a leader of one of the opposition parties and a former state minister of environment and forests, "The programme of water conservation implemented by the government is an incomplete one, as there was no forethought or systematic approach to the work," he claims.[26]

Entry of contractors: There is resentment over the involvement of contractors. "Money has been more involved than the people. There is a vast humanpower in the villages which could have gained employment if private contractors were not involved," says Chetty and argues that this would have helped to reduce distress migration from the villages.[27] Poclains have been used on a grand scale to desilt tanks. Some say that these poclain contractors are people who belong to favoured political parties. "Contractors work for a few hours or a few days and then send their bill for a lot more," says Koda Ramakrishna Reddy.

THE FINAL ANALYSIS

One cannot blame the government alone, people have become used to being spoonfed. For instance, M Niranjan, secretary of the B K Uppantala village watershed committee flatly says that his village is not equipped to manage watersheds by itself. It needs funds and motivation from the government. The committee's chairperson, Nayak Sadiq, disagrees. He claims that it is possible to motivate the people and cites the example of Lambada tribal village Kottapalli, about 30 kilometres away in the the Nallamalai hills. The women's self-help group here is confident of helping themselves.[28]

NGOs have been able to do better work than the government because of the time they take to work with the village community. The problems are case-specific, which demand both the commitment of implementing agency and the willingness of the villagers to solve them. The villagers of Maradgu in Amrabad mandal of Mahabubnagar district were

divided into two political camps and had pitched against each other during the last elections. They even had a case registered against them. They soon realised their folly and the need to work together when they sought the help of CRYD in setting up a Neeru Meeru committee. The CRYD staff explained to them that the villagers will have to take complete responsibility with CRYD acting as a support organisation. The villagers agreed and a Neeru Meeru committee has been set up without political infighting.[29]

Choice of villages to undertake Neeru Meeru work also appears to be faulty. It has been reported in AP newspapers that massive desiltation work is going on in Nizamabad district with the participation of farmers. The village of Gaur, however, tells a different story. The two village tanks cover 53 hectares but they have not been desilted. M Yella Reddy, village *up-sarpanch* expresses his anguish, "We have appealed to the irrigation department two times last year to take up desiltation as these tanks are our sole source of agriculture, but the department people told us that there is no money." Silt has accumulated in the feeder channel of the upper tank which is stopping the flow of water to the lower tank. The result is flooding of the *kuccha* (temporary) village roads. Yella Reddy says that if the tanks were under the *panchayat* instead of the government, the village *panchayat* could have taken responsibility, but they cannot do so now as it would be illegal. This is after Neeru Meeru has been implemented in 2000.[30]

Just a few kilometres from Gaur, Ballamamatary village is desilting a canal after Rs 9 lakh was granted. The department handed Rs 6 lakh to the village committee and said that the rest will be given after the work is complete. The rains arrived and work got stopped. Now the department refuses to release the remaining Rs 3 lakh saying that work is incomplete. The villagers have invested their money and are now waiting for their reimbursement.

When a researcher from the Centre for Science and Environment travelled through villages in Andhra Pradesh to assess the implementation of the Neeru Meeru programme, he found a diverse range of experiences *(see Box: Village variances)*. In village Mallya of Kurnool district, for instance, the villagers capitalised on this programme to clean up the Krishnia tank, their source of water. Unfortunately, the programme got under way too late with the result that barely 20 per cent of the tank was cleaned by the time the monsoon arrived.

On the other hand, watershed activities in the villages of Achampet stand testimony to the efforts of the people who took up the task of developing their watersheds *(see Box: Bore power)*. The village of B Tandrapadu in Kurnool district has a *cheruvu*. The *cheruvu* was desilted under Neeru Meeru by the government. About 15 metres of the tank was desilted, which is a good figure compared to the work done in other areas. Villagers worked day and night along with the poclain contractors for two months. The silt was taken to the fields in tractors. The villagers prefer the PIA, Jan Vikas Sangh an NGO, to the government. The village is slowly moving towards rebuilding its own watershed.

Rajendra Singh, of the Alwar-based non-governmental organisation, Tarun Bharat Sangh, which has transformed the ecology of over 650 villages in Rajasthan through water harvesting, visited some parts of the state. "AP waterworks are not in accordance with the people's vision," he points out. "It is technocratic and work has been done at a very fast pace."[31]

The biggest problem is that bureaucracy still drives the entire programme. This top down approach pursued by the state government has given rise to resentment amongst the stakeholders. But Naidu disagrees. He says he will wait for three years before judging the results. "Results take time," he says.

In its urban programmes the Hyderabad Urban Development Authority did a good job developing and protecting the catchment and hence the waterbody Durgamcheruvu in the Jubilee Hills area near Hitech city in Hyderabad *(see Box: Cyberabad's travails)*.

THE FUTURE

The second meeting of the Water Conservation Mission of the AP government was told that "while the initial phase of Neeru Meeru brought in focus the need for water conservation and recharge, the campaign has highlighted the need to continue the efforts." Between October 2000 and March 2001, water harvesting works will be further carried out to create another 67.5 million cubic metres of one time water impounding volume at a cost of Rs. 139.25 crore, to achieve a recharge of 648.75 mcum. A number of decisions were taken to improve on the future performance of the programme.[33]

- To improve public participation and selection of watersheds, all villages located in watersheds designated as very high priority watersheds will be offered the opportunity to use existing rural employment funds and their own voluntary labour to undertake groundwater recharge by restoring one waterbody, protection from fire or regeneration of a nearby hillock. After a year, any village which has carried on these activities can ask to be sanctioned a full watershed development programme.
- High problem areas will be earmarked. Out of 1,130 *mandals* in the state, there are 15 fully covered dark *mandals* (zones with more than 85 per cent of available groundwater exploited) and 51 partially

VILLAGE VARIANCES

Travelling through the villages of Andhra Pradesh throws up diverse experiences with the implementation of the Neeru Meeru programme

While travelling from Nandikotkul town in Kurnool district to rural areas, one can see the ruins of old wells and *baoris* built during the Kakatiya and Vijaynagar rulers. The Rayalaseema region is dotted with ruins of such structures which at one time used to store rainwater. The people have now forgotten the importance of these structures and have started exploiting the groundwater. The end result is that Rayalaseema is now facing extreme drought conditions and villagers are once again looking at rainwater harvesting as an option.

Seven kilometres from Nandikotkul, in the village of Mallya, where drinking water scarcity started in 1988, tube-wells and handpumps were the source of drinking water. As groundwater continued to be overexploited, the water table declined to 120 metres. Rainfall was erratic. "Our drinking water pumps were going dry," remembers P Moulali, farmer and member of the village water users association.[1] Near their village is the confluence of Tunghabadra-Sangameshwaram rivers flowing to the Krishna. The Krishna waters are used for irrigation.

In 1991, to alleviate the problem, Madur Subba Reddy, an ex-MLA of the constituency, constructed a 5.5 hectare tank in the village through a government grant. Apart from the rainwater, water is diverted from the Krishna to the tank by a 0.6 kilometre long canal. The tank, known as Krishniakunta was a percolation pit to recharge the drinking water points. The tank was used by animals too.

Unfortunately, as the water scarcity got alleviated, the villagers forgot all about the tank and that it needed to be nurtured and maintained. Gradually, silt accumulated in the tank. This resulted in the gradual depletion of the groundwater table in 1998-99. In 2000, when the government launched the Neeru Meeru programme, a programme for desiltation of this tank was started. Unfortunately, desiltation was never completed. "The rains came and the work had to be stopped. Only 20 per cent of the tank had been desilted by then," says Moulali.

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This signboard of the panchayati raj department informs of the desilting operations of Krishniakunta by the villagers of Mallya at an estimated cost of Rs 2.35 lakh, an action to 'fight for water'

But many of the villagers do not blame the rain. "The work started late. The order to desilt the tank came in late May but work commenced only in July-end, when the monsoon sets in," complain villagers like Chandra Basha and D Suban. Suban is also the president of the WUA.[2] After this, no programme was undertaken. The villagers say that they are willing to carry on the desiltation themselves provided the government gives the grant. Meanwhile, the 4,000 strong population is hoping that their handpumps don't go dry.

On the fringe of the Gargiyapuram reserve forest, 15 kilometres from Kurnool town, are the villages of Bopalnagar and Gargiyapuram. There is a tank that separates the two villages. In both these villages, as part of the joint forest management programme, *van sanrakshan samitis* were formed to protect the forest and the watershed. Implementation of the programme in Gargiyapuram was done through the forest department while an NGO, Jan Vikas Sangh, implemented the programme in Bopalnagar. The forest area is rich in medicinal plants and the villagers pitched in to conserve the rare flora. The project was funded by the World Bank. Under this programme, many water harvesting structures have been constructed to arrest the runoff. This arrested water flows down to the tank and also recharges the groundwater table.

Unfortunately, under the joint forest programme, no money was allocated for tank maintenance and renovation. Some 80 per cent of the tank was silted. The *bund* of the tank was also continuously breaching. The water arrested upstream in its watershed was thus going waste. Though the tank belonged to the forest, it was responsible for irrigation of a massive *ayacut*. Then the government programme of Neeru Meeru came along, ordering desiltation of the tank.

The VSS was given the responsibility of desilting the tank. The work commenced in June 2000, and by August about 30 metres of the 75 metre deep tank was desilted. The *bund* was repaired.

What is interesting to note is the way in which the Neeru Meeru programme was implemented in these two villages. "We did not use poclains for desiltation," informs Nagmani, president of the VSS in Bopalnagar.[3] The villagers got their tractors to move the silt with tractors to strengthen the *bund*. This gave employment to many villagers. In village Gargiyapuram, the forest department used poclains for desiltation. They did not allow villagers to participate as most of the watershed was under forest land. There was no income generation for the villagers as contractors were responsible. So, in one village the people benefited in the form of employment, while in the other, they did not.

BINAYAK DAS / CSE

Urban tanks like Safilguda are facing several threats including encroachment

covered *mandals.* Some 615 villages are covered by these *mandals*. In addition, there are 35 *mandals* in the grey zone (with 65-85 per cent of available groundwater exploited). Work will be given high priority in these areas.

- Some 200,000 hectares of continuous contour trenches will be constructed between November 1, 2000 and March 31, 2001 at a cost of Rs 50 crore.
- Desilting of old tanks will be carried out with two objectives in mind — to create water storage space in non-drought prone-areas like Nizamabad, Karimnagar and various coastal areas, and to increase groundwater recharge in drought-prone areas.
- Restoration of feeder channels and repair of weirs will be undertaken in all the 7,452 tanks desilted during the first phase.
- Dhan Foundation, a Tamil Nadu-based NGO, will be asked to help in the restoration of 500 tanks located in cascades (tanks in which the overflow of one feeds the other) over the next four years.
- A draft law has been prepared on trees and water by the state's environment and forest department. Some of the key factors of the proposed law is to:

a) Set up water authorities;
b) make it compulsory for all public and private places to have rainwater harvesting structures and in case of existing buildings, a deadline of six months to have such structure in place;
c) instruct all group housing schemes to have the required rainwater housing infrastructure;
d) regulate the exploitation of groundwater; and,
e) provide for a Memorandum of Understanding to be signed with village communities which take up watershed projects. While the district authorities will involve them in the planning and execution of the project, village committees will also agree not to go in for water-intensive crops and socially fence the regenerating vegetation in the watershed, failing which the communities will have to pay back the entire money spent on the watershed.

All the criticism notwithstanding, it would not be fair to ignore successful works in several districts — for instance, Bokachalla in Ananthapur and Gaur in Nizamabad where check dams, continuous contour trenches and rock-filled dams, staggered trenches were constructed, as claimed by the government; and, Tamrapali in Kurnool where tanks were desilted and new percolation tanks constructed, as claimed by JVS. It will be interesting to watch the future of the statewide water harvesting programme of Andhra Pradesh, especially to see how it overcomes its initial weaknesses and fares during future droughts.[34] ■

Second Generation Mission

The Ek Panch Ek Talab programme launched by the Madhya Pradesh government is considered as a second generation water conservation effort. It aims at drought-proofing the state now and forever through competitive populism

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In March 2000, Madhya Pradesh chief minister (CM) Digvijay Singh was invited by the Centre for Science and Environment to inaugurate a one day workshop on community-based water management during the World Water Forum in The Hague, The Netherlands. During his inaugural address the chief minister informed about the Ek Panch Ek Talab scheme, which was launched in mid-1999, wherein every *panchayat* member would be responsible for reviving or constructing a *talab* or tank. In January 2001, three researchers travelled through various districts of the state to get first hand information about the implementation of the programme *(see Map: Trailing tanks)*.

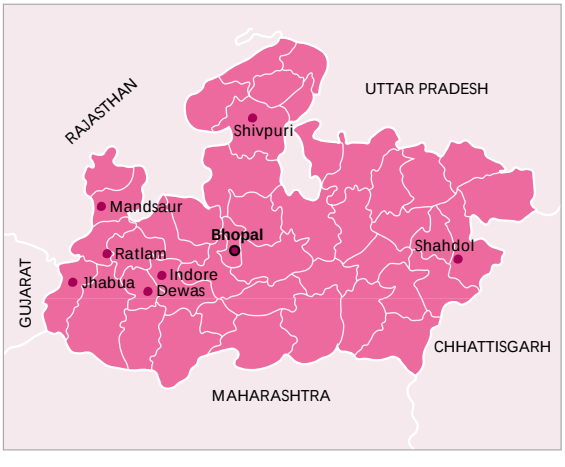
Expectations were high. A *Down to Earth* report of how villages like Gelhar Choti which had undertaken watershed development or water harvesting were faring during the 1999-2000 drought had revealed that they were doing well *(see Box: Participation pays)*.

The researchers came back with fascinating reports. Politicians were competing with each other to contribute to the programme. They understood that the future of their political career lay in implementing the programme. People contributed more than *shramdaan* (voluntary labour). They willingly parted with their hard-earned money. Some even gave up their land. Bureaucrats were doing their best to ensure the smooth implementation of the programme.

Though not implemented in all the districts, the results are impressive. In Shahdol, the earliest district to adopt the programme, the results are already visible. When the chief minister was flying down to Shahdol to attend a public meeting, he could see thousands of tanks reflecting the bright sunlight. Since then he has been speaking about his Shahdol experience in each and every public meeting. Shahdol means 'a thousand tanks.' The district is living up to its name (see *Box: Shahdol: Land of a thousand tanks*).

Trailing tanks

The map indicates the districts where the CSE researchers travelled



IMPACT

Didawali is a village in Shivpuri district of Madhya Pradesh (MP). Navigating one's way into the village needs enormous patience. Expansive but congested rock formations block the landscape. Some 60 kilometres (km) away from the district headquarters, this remote village presents an amazing picture in more ways than one.

For the first time the village is having a rich harvest of wheat, beyond imagination a few years ago, because of the Rajiv Gandhi Mission for Watershed Development (RGMWD). A web of check dams has been built to harvest rainwater. Lala Singh, a *panchayat* member (*panch*), nonetheless, grumbles, "We still waste rainwater." So now he wants *talabs* (tanks) in the hills. He, along with some other residents, have even volunteered land for these tanks. This is just one example. Several such examples could be found in the districts which were implementing the programme.

Water means 'to circulate', feels Lala Singh. This is precisely what the state government is presently doing,

PARTICIPATION PAYS

For the villagers of Gelhar Choti, their participation in watershed development paid rich dividends

A microwatershed management project was launched under the Rajiv Gandhi Mission for Watershed Development in Ghelhar Choti village of Jhabua district in 1996. Since then, a lot has been changed. The underground aquifers have been recharged. "All the eight handpumps in the village yield water throughout the year," says Bhurji Bhawar of the village's watershed committee.

According to R K Gupta, additional chief executive officer of the *zilla panchayat* (district council) of Jhabua: "This change has only been possible because of people's participation. Most people who used to migrate from this village do not leave now. They have found employment here itself." Even in the face of the 1999 drought — it only rained about 439 millimetres (mm) against the annual average of 980 mm — they were doing quite well. The villagers showed confidence that their handpumps would not dry up very fast. "In the past four years, we have been able to catch enough rainwater through the microwatershed projects in this area," says Kasani Bai, president of the villager's *Bairani kuldi*, a women's self-help group. Earlier, even normal years proved to be difficult as there was no water in the area. "Today, not only has the cultivable area increased due to water availability but their yield per hectare has also doubled," says Gupta.

Mohan Singh, *sarpanch* of Umari *panchayat* which is about 30 kilometres from Ghelhar, told *Down To Earth* that after facing severe crop damages and a drinking water crisis, people in Umari have realised the importance watershed management projects. "They are now demanding watershed management projects in their villages. They know plenty of water is available in areas under watershed management," he says.[1]

AMIT SHANKER / CSE

People getting together for a watershed committee meet. Their participation in watershed programmes improved water levels

AMIT SHANKER / CSE

What used to be barren is now clothed in greenery. The village has found the answer to poverty in soil-water conservation

facing the decade's worst drought. Having implementing probably the world's largest watershed development programme in a mission mode, the state has now taken the second step to launch its Ek Panch Ek Talab programme.[1] In this programme, each representative (*panch*) of the *zilla* (district), block and *gram* (village) *panchayats* is expected to build or renovate a tank in his/her tenure. This translates into at least 350,000 tanks, to be built or renovated by the state's 350,000 *panches* in the state's 51,000 villages.[2] The programme serves two purposes: strategically, as a long-term drought management solution; and, socially, to make water conservation a social movement.

For the primarily agrarian economy and the large population of livestock, these waterbodies would guarantee water availability in the dry post-monsoon period. The state's water scarcity is so serious that in the drought-affected dry winter of 2001 only 30 per cent of the agricultural area has been sown with *rabi* (winter) crops. The state government has put a ban on using water in the existing tanks for irrigation. In October 2000, the entire state was declared water-scarce.[3]

But the Central government's Scarcity Relief Committee has found that the 2000-2001 drought is manageable in those areas where extensive watershed development has been taken up.[4] "If we go for another extensive water conservation initiative in areas not covered under the RGMWD, we will have more waterbodies after the 2001 monsoon. We will then be able to drought-proof other areas against drought in the future," says Sudha Chaudhury, deputy secretary (panchayat and rural employment), who monitors the Ek Panch Ek Talab programme *(see Jhabua: A Green Miracle on p 107)*. Currently, the state catches 8-10 per cent of its rainfall informs, K G Vyas, a senior official of the rural development department and advisor to the RGMWD. "With the Ek Panch Ek Talab programme, we can easily capture 15-20 per cent of the rainfall. That would be enough to sustain the state's irrigation needs for five years."

SHAHDOL: LAND OF THOUSAND TANKS

Villagers in this district realise the value of water, which is why they did not wait for funds from the government

January 1, 2001, the first day of the first year of a new millennium. For the citizens of Shahdol district, it was a celebration of a different kind. The drought-affected district got its first shower after August 2000.

Narendra Yadav, a district *panchayat* member, wants to visit some villages to check whether the tanks renovated under the programme have water. In Bichia village, there is an early morning rush to the nearby tank renovated just a few weeks back. "The renovation was meant for creating some employment but now it has given us water," says Pritam Lal Kewat, deputy *sarpanch*. The villagers contributed 40 per cent of the renovation cost. "While the landless got jobs, the village will now have water till May 2001," says Kewat.

Shahdol literally means a thousand tanks. The district is living up to its name. Out of its 2,772 tanks, 584 have been renovated in the last 15 months and now carry water that can irrigate 3,000 hectares of land or can quench the thirst of 400 villages and their large livestock population.[1] Shahdol took up an extensive tank renovation programme to fight water scarcity. The district had its own programme called Apna Talab before the Ek Panch Ek Talab programme, under which 137 tanks had been restored under its previous programme.

The district has been witnessing a gradual increase in the use of groundwater, resulting in water scarcity. In the post-monsoon period, people used to migrate to urban areas in search of jobs. What added to their woes was the gradual collapse of their traditional water harvesting structures. "It resulted in less recharge of the groundwater," says Nagendra Mishra, additional chief executive officer (CEO) of the District Rural Development Agency (DRDA). The district, though covered under the Rajiv Gandhi Mission for Watershed Development (RGMWD), was still left with 88 per cent of its area without any water conservation activities. The district needed to be rescued from the crisis.

In May 1999, the district adopted the Apna Talab programme under which old tanks were taken up for renovation with the community contributing 50 per cent of the cost. It set a target of 10 tanks in each block during May and June 1999 so that water could be stored. "The presence of RGMWD helped us in convincing people about the benefits," says Sanjay Dubey, CEO, DRDA. The rural engineering department identified the traditional tanks and helped the community to estimate the cost. By June, some 137 tanks were renovated and a final quality test was done on them. "Surprisingly, we didn't find a single structure with any major fault. This convinced our officials that if the community is involved then the job is going to be up to the mark," says Dubey. The result of this programme was amazing: After the monsoon, though an erratic and below average one, most of the tanks got filled with water.

For the district, it was smooth sailing to launch the Ek Panch Ek Talab programme in April 2000. "The message of Apna Talab had already spread and people were hearing the horror stories of drought from Rajasthan and Gujarat," says Dubey. The Apna Talab programme transformed into the Ek Panch Ek Talab programme.

During April and May 2000, the programme was taken up to cover 586 tanks. "People came out in full support for the programme as by June 2000 it was clear that the monsoon was not going to be a normal one," says Yadav. When the monsoon failed, the district authorities changed their strategy a bit: Instead of the 50:50 sharing arrangement it lowered the community's participation to 20 per cent. "In a drought year, we can't burden the villagers who are in need of livelihood," says Dubey. So the *panchayats* decided to limit community participation to people who don't depend on wages. As of November 2000, Rs 2.8 crore have been spent on the programme of which 40 per cent is still the community's contribution. "Community participation continues to remain high because in many *panchayats* participation is up to 70-80 per cent," he explains. To compensate the loss of community participation in terms of money the district authorities have written to the local members of parliament and legislative assembly for monetary help from their local area development funds.

For the villages, it is a dream come true. In Pakaria village, *sarpanch* Buthia Bai is confident that the village will not go without water in the summer. Taking a round of the renovated tank, she says, "For years we asked our member of parliament for renovating the tank but it never materialised. But the moment the *panchayat* approved it, the villagers volunteered Rs 40,000 in terms of labour to renovate the generation-old tank. In the *gram sabha* I told the villagers: The government is not going to drink water from the *talab*, we will."

To maintain the water level in the tank and to regulate its use, the *gram sabha* has imposed a ban on agricultural use of the water. The district has created 40 million cubic metres of water storage through these tanks. Says Ram Lal Rothela, a resident of Jhateri and a member of the district *panchayat*, "We might not have the *rabi* (winter) crop due to this ban on use of water for irrigation, but we don't need to die of thirst in the summer. We have enough water."

In Bakoa block where coal mining has led to a serious depletion of groundwater, the programme has been accepted as the 'last effort to survive the water scarcity'. Whenever a *panchayat* leader visits the block the constant demand is water. Says Kewat, "We can survive without roads but not without water." His village didn't wait till the *panchayat* money was allocated: a site was selected and a new tank was dug. Babia Bai, 65, a resident of the village, questions, "Why wait for the official money when we can work ourselves for a tank?" She is the first one to have benefited from the tank as her land is just downstream of it.

Water availability in a drought year has triggered off a chain reaction. By December 2000, all 670 *panchayats* decided to renovate tanks in their areas.[2] "Tank renovation is a one-time investment but with long-term benefits. So *panchayats* are not hesitating to spend all their money on this one-time expenditure," says Rothela.

So impressed was chief minister Digvijay Singh at the aerial view of these tanks glittering in the sun that he is speaking about this experience in all his water conservation campaigns.

It is not only the people residing in villages that have been involved in capturing rain. In Indore city, fast running out of its groundwater resources, efforts are being undertaken by the local administration, academics and a newspaper publishing group to involve the people to harvest rain *(see Box: Indore's intelligent moves)*.

THE EK PANCH EK TALAB PROGRAMME

Genesis

The programme has its epicentre in Mandsaur. In mid-June 1999, when western MP, famous for its water-intensive opium cultivation, was writhing under an acute water shortage due to extensive use of groundwater and reduced recharge, local leaders took the first step towards creating awareness about the water shortage and possible ways to curb it.

"There was a panic-like situation in the Malwa plateau region as groundwater was depleting very fast," says Narendra Nahata, industries minister, who belongs to Mandsaur district. Though one-third of the district remains submerged in the Gandhisagar reservoir, the rest of the district does not even get a drop of water as it is at a higher elevation. Some 23 per cent of the district's agricultural land is irrigated but only two per cent of this comes from government canals while the rest comes through private wells.[5] The result: The groundwater level has dipped from 9-12 meters (m) in 1975 to 18-23 m in 1999.

It was in this background that the first Malwa Jal Sammelan was organised on June 10, 1999 to which people's representatives from all the *panchayats* of the district were invited. Digvijay Singh presided over the meeting. The elected representatives cited groundwater scarcity as the most challenging problem of the district. The CM called upon the *panchayat* representatives to build or renovate a tank during their tenure. The Ek Panch Ek Talab programme was born.

The chief minister's appeal was based on his earlier efforts to involve elected representatives in reviving degraded traditional water harvesting structures. In January 1999, he had written to all the collectors to take up cleaning of the state's tanks and rivers. He had requested community participation along with financial contribution from MLAs and MPs from their local area development funds. Immediately after this, he called upon elected representatives and district authorities for a *jan abhiyan* (people's movement) for restoration of waterbodies during the dry months of April and May, 1999. Though this drive got mixed reactions from different districts, there was a general appreciation of the effort within the political leadership.

Then came the failure of the 1999 monsoon and a drought in western MP, Gujarat and Rajasthan. "This drought came as a blessing in disguise for us," recalls Nagendra Yadav, member of Shahdol zilla panchayat. "People realised the importance of water and there was an immediate acceptance of the programme with people contributing more and more to it. "

Shahdol was the first district to react and started its own Apna Talab (Our tank) programme. By the time the monsoon of 2000 arrived, there were five districts, including Mandsaur, that were working on the revival of tanks in a participatory way. "This laid the foundation for a more extensive programme in which the community and their representatives could participate in the creation of water resources," says R Gopalakrishnan, secretary to the CM and director of Rajiv Gandhi Missions.

"Drought is an opportunity," feels Gopalakrishnan. As the media was flooded with drought-related reports, a cabinet decision was taken to drought-proof the state in February 2000 and the government made Ek Panch Ek Talab the state's highest priority programme.

In 2001, the state faces a bad drought again having received just 50 per cent of its average monsoon rainfall, leaving 32 of the state's 45 districts with rainfall below normal.[6] As a result, the Ek Panch Ek Talab initiative has been transformed into the state's key strategy to combat the drought. The strategy is to intensify water conservation efforts till the monsoon comes in June 2001 so that maximum water can be stored and recharged. "We hope it will totally drought-proof the state in coming years," says Digvijay Singh.

In just 15 months, since June 1999 when the CM made his first appeal, out of the state's 21,319 existing tanks, 3,412 have been renovated and some 500 new ones have been built with an investment of Rs 16.1 crore from rural development funds allocated to the *panchayati raj* institutions. The community voluntary labour was worked out to be Rs 4.85 crore *(see Table 1: Tank achievements)*. [7] In the coming five years, the state government has set a target to revive all existing tanks.[8] "There is a mad rush among *panchayat* leaders for building or renovating tanks in their respective villages," says Nahata, who was instrumental in organising the Malwa Jal Sammelan in 1999.

Thus, though it is not a well-defined programme like the RGMWD, the initiative has acquired top priority for state administration.

Strategy for implementation

The approach is simple: Revive traditional water harvesting structures to recharge groundwater. As the RGMWD is limited to select areas due to its funding pattern, other parts of the state need other programmes for water conservation. The Ek Panch Ek Talab is one such programme. Efforts are made to make the programme a popular mass movement for water conservation, to be initiated by grassroot-level leaders

INDORE'S INTELLIGENT MOVES

The local administration and various groups in Indore are raising awareness and implementing rainwater harvesting to deal with the rapidly depleting groundwater resources

When it comes to overexploitation of groundwater, the story of Indore is no different from other big and small towns across India. What is different is the effort of the people to harvest rains. The Nai Duniya newspaper group; the mayor of the city, Kailash Vijayvargiya; the Indore Municipal Corporation (IMC); and, Deepak Khare, professor of civil engineering and applied mechanics at the Shri Govindram Sekseria Institute of Technology and Science (SGSITS) are just some of the people involved in raising awareness and implementing rainwater harvesting.

The water supply to the town is 168 million litres per day as against the daily requirement of 320 million litres.[1] A declining rainfall and the growing population has resulted in the gap increasing between demand and supply. This gap between demand and supply is met through tapping groundwater. As a result, the groundwater table is rapidly declining. "Energised pumps are working overtime to meet water needs," informs Khare.

But rather than just complain, residents of the town are taking the matter into their own hands and are trying to alleviate the problem. Efforts to raise the groundwater level in the area have started through rainwater harvesting programmes.

On the occasion of the 50th anniversary of the Nai Duniya newspaper group, a Nai Duniya Seva Trust was set up. The proprietors agreed to deposit a sum of five paise for each of the 1,30,000 newspaper copies sold everyday. The scheme was launched on 23rd June, 2000. So far, about Rs 75 lakh have been collected and will be used for various development projects. Informs Ravindra Shukla, senior assistant editor of the newspaper, "This fund is currently being used to finance organisations working to promote rainwater harvesting in rural and urban areas. So far, we have involved 12 organisations, six each in rural and urban areas. We have also sponsored satellite imagery of groundwater resources in Indore so that rainwater harvesting efforts can be more effective."[2]

A lot of effort is going into raising awareness. The newspaper group is spreading the message through advertisements and articles in their newspaper. The mayor is appealing to the citizens to adopt rainwater harvesting methods to raise the groundwater level in the city. He is raising funds from the public to clean the Pipliahana tank and other tanks. He informs, "I am planning a *padyatra* (water march) for water harvesting before the next monsoon. This *yatra* will include a door-to-door campaign, public meetings, on the spot construction and exhibition of models."[3] Says Khare, "For the last few months, I have been trying to encourage the masses through working models. We have to motivate the people and convince them that it is possible to recharge their tubewell through rooftop water harvesting. I have also interacted with principals of some schools for conducting essay, painting and debating competitions for children on water conservation issues."[4]

The IMC launched its activities on 6th May, 2000 with the theme, 'If you protect water, water protects you'. An exhibition was arranged at Rajwada, the palace of the Holkar kings, where models of different water harvesting methods, posters and filters samples were displayed and leaflets distributed.[5] Bulletins on *Warsha Jal Sanghrah* (Rainwater conservation) and *Shahar ka Pani Shahar Me* (The water of a city should stay in the city) was released.[6] A meeting was arranged with various NGOs and individuals and a decision taken to observe a Jal Chetna Diwas or water awareness day on May 20, 2000. On this day, leaflets were distributed at different junctions with the help of NGOs to create awareness amongst the masses. An exhibition at seven different places in Indore was arranged and information pertaining to water harvesting was provided. Techniques of groundwater recharge through pile, recharge shaft, swale technique (a swale is a shallow saucer like bed which allows percolation of water into the deeper layers of soil where the soil is compacted) and tubewell recharging through rooftop rainwater harvesting were demonstrated in and around Ahilya garden and the IMC office, Malhar ashram and the mayor's house.[7]

Going beyond raising awareness, several of these groups have implemented water harvesting. Khare had implemented rooftop rainwater harvesting at the SGSITS campus. The institute has 10 tubewells and three openwells. "The rooftop rainwater from the Electronic Instrumentation and Computer building and staff quarters is harvested and diverted to the openwells. Efforts are on to adopt rainwater harvesting in the 22,000 square metres roof area present in the campus in the coming year," he informs. In Choithram Hospital and School, 110-120 piles (bores) with depths varying from 4-6 metres were put in and around an abandoned well. With the help of these piles, the surface runoff will be used for recharging the groundwater as well as revival of the well. The three storey building of the Shri Indore Cloth Market Hospital and Nursing Training School Hostel has installed a rooftop water harvesting system to recharge the tubewell in use after filtration. The security of the hostel informs, "After harvesting the rain, we have not faced any water shortage."[8]

Rainwater harvesting is being implemented in residential colonies, institutes, clubs and gardens. Records of the IMC indicate that more than 2,000 houses in Indore have water harvesting structures. Says Sanjay Shukla, "I am planning to present a paper on water harvesting for the Indian Administrative Services training programme so that trainees can implement rainwater harvesting wherever they are posted."[9]

The Nai Duniya office complex has a water harvesting structure that harvests rooftop rainwater from half of the roof area and recharges an old dugwell. Arrangements to harvest the water from the rest of the campus will be complete before the 2001 monsoon.

A rebate of six per cent on property tax is being proposed for those who install rainwater harvesting in their house, bungalow or building. Three committees — technical, education and execution committees were set up by the IMC for this purpose — the first of its kind in the country.[10] For construction of new buildings on areas more than 250 square metres in size, rainwater harvesting is now compulsory. The corporation has proposed to make rainwater harvesting mandatory for the existing buildings also.

Table 1: **Tank achievements**

The results at the end of 15 months of the programme are impressive in terms of tanks restored and money spent

Districts	Total *talabs*	*Talabs*		How many *talabs* have been benefited from:		Total money spent (lakh rupees)		Community contribution (lakh humandays)	
		In use	Can be renovated	Rural development funds	Other schemes	From rural development funds	Other schemes	For rural development tanks	For other scheme tanks
Balaghat	1,250	1,097	710	76	–	62.78	–	–	–
Badwani	–	–	–	–	–	–	–	–	–
Betul	128	100	128	25	–	32.77	–	–	–
Bhind	467	353	114	74	–	27.44	–	–	–
Bhopal	149	91	58	12	–	10.70	–	0.12	–
Chattarpur	760	477	422	62	–	31.04	–	–	–
Chhindwara	223	212	211	2	–	4.20	–	–	–
Damoh	718	467	288	131	–	23.03	–	–	–
Datia	289	174	199	61	–	20.68	–	–	–
Dewas	255	253	241	11	–	8.34	–	–	–
Dhar	259	169	95	93	–	78.07	–	–	–
Dindori	–	–	–	–	–	–	–	–	–
Guna	305	156	143	29	–	8.71	–	–	–
Gwalior	137	31	106	3	–	30.00	–	–	–
Harda	–	–	–	–	–	–	–	–	–
Hosangabad	122	56	100	16	–	8.35	–	–	–
Indore	346	98	248	14	–	4.52	–	–	–
Jabalpur	546	546	546	1	–	0.15	–	–	–
Jhabua	782	782	477	127	–	5.62	–	0.36	–
Katni	–	–	–	–	–	–	–	–	–
Khandwa	153	153	136	52	53	6.00	9.30	0.04	0.18
Khargaon	237	–	–	–	–	–	–	–	–
Mandla	978	840	851	49	–	11.61	–	–	–
Mandsaur	210	135	122	80	–	32.50	–	0.60	–
Morena	384	79	305	–	–	–	–	–	–
Narsinghpur	98	10	88	–	–	–	–	–	–
Neemuch	–	–	–	–	–	–	–	–	–
Panna	904	869	436	130	–	28.68	–	–	–
Raisen	166	53	113	11	–	6.69	–	–	–
Rajgarh	595	593	377	232	–	59.23	–	–	–
Ratlam	536	105	198	180	–	101.63	–	–	–
Riva	2066	1,226	840	–	–	–	–	–	–
Sagar	305	42	98	165	–	126.65	–	0.75	–
Satna	1,320	228	383	40	–	125.13	–	–	–
Sehore	285	285	187	1	34	0.70	7.24	–	0.09
Shivni	1,059	909	584	35	–	70.35	–	–	–
Shahdol	2,772	2,333	1,799	586	–	280.00	–	–	–
Rajapur	259	77	182	117	–	55.36	–	–	–
Seopur	–	–	–	–	–	–	–	–	–
Shivpuri	486	98	369	369	–	159.14	–	–	–
Siddhi	646	330	411	316	–	112.25	–	0.67	–
Tikamgarh	588	297	214	186	–	21.27	–	–	–
Ujjain	262	120	248	38	–	40.85	–	–	–
Umeria	–	–	–	–	–	–	–	–	–
Vidisha	274	–	274	1	–	0.49	–	–	–
TOTAL	**21,319**	**13,844**	**12,301**	**3,325**	**87**	**1,594.93**	**16.54**	**2.54**	**0.27**

Source: Anon 2000, Statistics provided by rural development and panchayat department, Ek Panch Ek Talab, Government of Madhya Pradesh, Bhopal, December, *mimeo.*

without extra funds. *Panchayats* have to spend money on water conservation from the funds available with them.

The programme is a strategic decision to combat the current drought. Once the structures are ready, by the next monsoon, the state will have more water storage facilities to capture the monsoon rain, thus effectively curbing water scarcity.

Targetting the base

Priority was given to the programme at a time when the state's *panchayat* bodies were getting a new leadership

after the elections of December 1999-January 2000. "It was assumed that the new leadership would be more positive towards this programme," says an aide to the CM. The Madhya Pradesh government has also adopted a policy of decentralised planning and has allocated a major portion of its planned expenditure to *gram panchayats*. So the programme is designed to be implemented by *panchayats* with community participation.

The *gram panchayat* is the nodal body that plans and implements the programme with funds at its disposal. It is not binding on a *gram panchayat* to spend money on water conservation as a priority. *Panchayats* are just reacting to the CM's appeal for taking up renovation of tanks and the current water scarcity has pushed the process. Later on, as part of its drought relief operations, the state government directed district rural development agencies (DRDAs) to spend a part of their money for water conservation. So now it is an official order for *panchayats* to spend money on water conservation.

The *gram sabha* (village assembly) selects tanks to be renovated or sites for new tanks to be built, and decides the community contribution for it. No uniform model of community participation has been evolved and it is up to the *panchayats* to decide on the extent of community participation. In districts like Shahdol and Shivpuri, *panchayats* have taken a decision that the community will contribute 40 per cent of the cost (25 per cent in poorer tribal-dominated *panchayats*).[9] "It is a very decentralised programme and is dependent on the *panchayat's* decision. As there are no extra funds available, communities have volunteered to fill the gap between the cost and funds available," says Anupam Rajan, chief executive officer (CEO) of Shivpuri DRDA.

District authorities help in estimating the cost of the job for each and every *panchayat*. An engineer is given charge of a cluster of *gram panchayats* who besides making the estimate, also gives technical assistance if needed. No contractor is involved and the village landless are recruited for the job. In some districts, a programme committee of *gram sabha* members has been formed to monitor the performance.

Funding the programme

The programme mobilises its funds from different schemes. According to the guidelines of the state government issued in February 2000, the programme should get priority funding from the rural development budget of the districts and from the funds of the *gram panchayats*. Besides, MLAs and MPs are now giving money from their local area development funds. As mostly old tanks are being renovated, the cost is small, ranging from Rs 15,000 to Rs 70,000 per tank.[10]

The use of different funds for water conservation is decided at three different levels: state, district and the *gram panchayat*. To start with, the state government facilitates fund use by giving priority to the programme. This has enabled the state government to spend all its drought relief money on water conservation. In 2000-01 alone the state government would be spending Rs 15.5 crore of drought relief money on water conservation. This money is routed through the district authorities to *panchayats* for water conservation activities. Similarly, under the state's Jan Sahoyog Nidhi Niti (a state government programme implemented by district authorities), the Ek Panch Ek Talab programme is getting priority. According to state government officials, the annual budget of Rs 30 lakh of every district under this scheme is being used for water conservation.

At the second stage, district authorities find funds through the Centrally-sponsored Employment Assurance Scheme (EAS) and the Jawahar Gram Samrudhi Yojana (JGSY) schemes. Under these schemes, the state government contributes 50 per cent of the cost while the rest is contributed by the Central government. The district and block *panchayats* that implement the EAS and JGSY schemes make provision for water conservation works.

At the *panchayat* level, the *gram sabha* decides on the community's contribution after taking into account available funds. In the state, *gram panchayat* gets around Rs 1-1.5 lakh a year and under the current guidelines, at least 50 per cent of it can be spent on water conservation. As most of the above schemes are meant for generating employment by creating infrastructure like roads and schools, no contractor is involved in the execution of the work under the Ek Panch Ek Talab programme. Landless residents of the village are employed for manual work. For protecting their rights over the common resources created like water, landless residents are given fishing rights in the tanks.

Second generation water conservation

The programme is now regarded as the extension of the RGMWD. "It is a second generation mission," explains Gopalakrishnan. "Water conservation should be a mass movement and should be powered by local initiative." The spread of watershed activities has already created awareness about water conservation among the people. In some districts, as part of community mobilisation for the new programme, watershed institutions were used. "Watershed activities and their benefits definitely helped in convincing people about the benefit of water conservation," says Sanjay Dubey, CEO of Shahdol DRDA. The other reason for this second generation mission are the limitations of the present watershed development mission. The watershed mission's reach is limited as it is funded by specific schemes like the Drought Prone Area programme, EAS and Integrated Watershed Development Programme. These schemes are implemented in specific blocks with limited funds. Under this programme, only 12 per cent of the state's area is covered. In

the last two years there has been no extension of the programme to new areas as no extra funding has come. "So we had to embark on a programme which reaches each and every village of the state and which uses internal resources," says Sudha Chaudhury, deputy secretary, department of panchayats and rural employment.

"Villages need not depend on one mission forever. That is where we realised the need for this programme," explains Gopalakrishnan. Going by the target set by the chief minister, the state will have enough water for use round the year within five years without any extra funding.

The programme has got an unusual response from the political leadership. Says Nahata, "It is an opportunity for politicians to restore their credibility with the people whom they represent." The state's cabinet is unanimously supporting the programme, and ministers are taking a personal interest in the programme as the drought situation worsens. "There is a kind of competition among MLAs to support tank restoration in their respective constituencies," says a high level official of the CM's secretariat. "Success breeds success and one district getting attention for good works means more and more districts emulating it," says Sabnam Mausi, MLA of Sohagpur and probably India's first eunuch to become an MLA. According to a preliminary estimate, all MLAs have contributed from their local area development fund for water conservation in the last two years.

The failure of the 2000 monsoon also played a role in popularising the programme. As the *rabi* (winter) crop has failed in 2000-01 and the water scarcity in the dry months of 2001 could spell doom for the state's large livestock population, the success stories of Shahdol, Shivpuri and Mandsaur in water conservation have spread like wildfire. "*Panchayat* members first said yes to the programme in adherence to the government order for sanctioning money for tanks. But now as these waterbodies carry water and livestock survives on them, there is another rush for digging these tanks deeper," says Devindra Singh, vice-chairperson of Shahdol's Amraha gram panchayat.

Social mobilisation

"The programme's success is dependent on the district leadership," says Gopalakrishnan. The more successful districts like Shahdol, Shivpuri and Mandsaur boast of dynamic leadership at the district level. Statistics indicate that some 11 out of the 45 districts have not taken up the programmes even though the panchayat department says that these districts have taken it up using drought-relief money.

"It is early to evaluate the programme on the basis of its physical achievements but I think its most important achievement is that it has helped us in a big way to make water a people's movement," says Chaudhury. In the districts where it is successful, the physical achievement is already visible. "In a drought year, we have enough water to last till May," says Prabhu Dayal Chaudhury, ex-*sarpanch* of Balpurba. Officials say that the villages are now ready with the infrastructure to capture water in the next monsoon. So the net rise in water storage would be its key achievement. "The structures created would definitely raise the surface water storage capacity and at the micro-level it would help in recharging the groundwater," says Deepak Sujalpurkar, a geologist and additional CEO of the Shahdol DRDA.

For the CM the change in the focus of development at the grassroots level is the real achievement. Admits Badal Kumar Das, principal secretary, rural development, "*Panchayati raj* had become *sarpanch raj* (rule of the village council head). There was no development. This effort to empower communities for water management is a real achievement."

CASE STUDIES

CSE researchers visited several districts in Madhya Pradesh to see and understand how the Ek Panch Ek Talab programme was being implemented. Some of these districts included Shivpuri, Shahdol, Ratlam and Dewas.

Shivpuri: Reliving history

Time has taken a magical twist for the villages of Shivpuri district, the summer capital of the Scindia rulers. All of the 369 silted up tanks have been desilted and now have water.[11] Migratory birds on their way to the nearby Dahela Lake take a break in them. As a group of children scare the *bideshi pakhi* (foreign birds) near a tank in Danger village, Doji Adivasi, a resident and president of the village forest protection committee which oversees the regeneration of the village's degraded forest, says, "For the first time we have water in this tank during winter and also these migratory birds."

Like Doji, the village's 800 Gujjar residents also have reason to be happy. No more do they have to herd their 600 strong livestock population to a stream three kilometres away for water during winter and summer. "In a drought year what you need to protect the most is livestock which complements our livelihood in the absence of a good crop," says Baijnanth Gujjar.

Shivpuri was one of the first districts to adopt the programme immediately after the CM's call. The district administration launched the Talab Bachao Abhiyan (Save tanks campaign) in August 1999.

The water history of Shivpuri is an inspiration. Situated in an undulating topography, Shivpuri's tradition was to build tanks. During the famine of 1899, the Scindia rulers exchanged digging of tanks with food for their subjects.[12] There are 486 tanks in the 1,265 villages of the district. After Independence, these tanks were

transferred to the revenue department and with the development of *panchayati raj* institutions, *gram panchayats* are now controlling them.

"But most of them were heavily silted up and not in use," says Anupam Rajan, CEO of the DRDA. In the face of a drought, tank restoration was the cheapest and most sustainable way out. Influential farmers had encroached upon most of these tanks, as these lands are fertile because of the topsoil swept away from the catchment areas. In September, farmers would breach the embankment for releasing the water so that they could cultivate the tank bed. "The village would then remain without water till the next monsoon," says Krishna Rawat, a former *sarpanch* of Kanker. This practice further alienated the residents from their tanks and, in case of a monsoon failure, the only option left for the residents was to migrate along with their livestock to other villages with waterbodies.

When the programme started, the district authorities made a list of such tanks and put a blanket ban on encroachment. To spread awareness about restoration of these tanks, meetings were held with *panchayat* leaders and watershed committees formed under the RGMWD. "This helped us in instilling a sense of positive leadership among the *panchayat* leaders," says Rajan. The drought in Rajasthan and Gujarat at that time also worked as a reminder to the leadership. This was followed by the drought 2000. Though the district has not been declared drought-affected, it has reported 25 per cent less rainfall and sowing for *rabi* is only around 60 per cent of normal.

Out of the district's 486 tanks, the *panchayats* chose 369 for renovation. By February 2000, the *panchayats* prepared their plans and the district authorities helped them to estimate the cost of renovation. In March, *panchayat* leaders called *gram sabha* meetings to decide community participation in the renovation works. It was decided that the community will fill the gap between the cost and the funds available with the *panchayat*. According to the DRDA, communities have contributed an average of 35 per cent of the total cost of the project till now. There are instances where villagers have also contributed money besides voluntary labour. "In villages where there were no tanks, some villagers gave lands for new tanks as it would benefit their lands downstream of the tank," says Sujalpurkar. In Didawali, village residents donated 4.5 hectares (ha) of private land. "This tank will not only irrigate my land but during summer my cows will also use the water," says Bhikam Singh, a resident who has also contributed some land for the tank.

The programme had already made considerable headway by July-end 2000. All existing old tanks were surveyed in February 2000 under the Talab Bachao Abhiyan, as a result of which we could initially identify 247 old tanks for renovation in the district. One to one meetings were held with the newly elected *sarpanches* at every *janpad panchayat* level so as to make them realise the importance and to garner their active support for the campaign. The identified 247 tanks were divided into 27 clusters. A talab suraksha samiti (tank protection committee) was constituted for every tank. The renovation work was executed by the *gram panchayat* with the funds available at the *gram panchayat* level. "It was heartening to see the local population coming forward to offer their labour voluntarily at many places since the fund availability was not much at the village level. The momentum created was so much that when the actual renovation work started, many more tanks were identified making the total tally 305," informs Rajan. Some 256 tanks have already been renovated. "The most significant aspect of the *abhiyan* (campaign) has been the realisation of the importance of old rural tanks in the minds of the rural population," he adds.

The monsoon failed in 2000 as if to test the programme. For villagers who have cleaned their tanks, the summer is not going to be that harsh. The renovation created 6.75 million cubic metres (mcum) of water storage and despite the shortfall in rainfall, villagers cultivated 1,200 ha of land for the first time.[13] The 388 new tanks built under the RGMWD supplemented this effort.

In Manaya village, for the first time, residents celebrated their Bhajuria festival (a local festival in which rituals are carried out in a tank) in the renovated tank. "Till now the festival was incomplete without a tank," says Shabu Bai. More than that, she no longer has to walk two kilometres in the summer heat for a bucket of water.

The availability of water has now convinced the *panchayat* leaders that in future too, they have to spend money on tanks. Says Ram Raja Parmer, president of the Manaya watershed development committee, "There were always conflicts over such programmes because of the ownership of lands. But the benefits have overshadowed this." In fact, when the district administration put a ban on the use of tank water for irrigation, there was widespread protest by farmers who were using the tank water. Later on, the district authority made a concession under which if a *gram sabha* asks for an exception to the directive then it would be considered on merits. However, there are very few such requests from *gram sabhas*. "I could not take a *rabi* crop but I have sufficient water for my livestock," says Shivraj Gujjar of Danger. Last year two hundred cattle had died due to water shortage.

With these structures in place, local residents now worry about the continuity of the programme. There is a growing demand from villages for more tanks but also there is a practical hurdle: *panchayats* have to take up other works like roads and school buildings too. In future, less money will be available for water conservation. "For the newly renovated tanks you need maintenance as deforestation is causing siltation," says Rakesh Jain, a local social worker involved in watershed activities.

Mandsaur: Competitive populism

It is claimed to be the district that has responded the best. "Nowhere in India have we seen such a massive response to fight drought, " says a beaming Sashi Bhusan Singh, sub-divisional magistrate of (SDM) of Mandsaur district.[14] Anywhere one goes, the land is full of successful stories of community participation. People have made new *talabs*, desilted old ones, and contributed the bulk of the money. They have not stopped: they are holding *sabhas* to make more *talabs*. The politicians, MPs and local MLAs have donated money for water conservation. The enthusiasm has reached such heights that politicians are in competition with each other in giving funds. Villagers are competing to build more and more *talabs* and *panchayats* are trying to surpass each other in making new *talabs* so that they can receive awards. Money is flowing from all quarters *(see Box: Friendly competition)*. The egos of politicians, villagers, *sarpanches*, and government officials seem to be at stake. Behind all the razzmatazz, the purpose is drought-proofing the opium-growing district. The 2001 monsoon will show the results of these efforts. "It looks like healthy competition but there is a fear of this being done to gain political mileage in the next elections," says Ajay Kumar, a resident of Mandsaur and a medical representative who keeps travelling in the district.[15]

Farmers have overused the available groundwater in this district, as opium is a water-intensive crop. The groundwater table has receded to a depth ranging from 250-280 m. The district has a total of 250,000 wells. The *tehsils* of Mandsaur and Sitamuh has been declared as dark zones. Even the drinking water situation is bleak. After the first Malwa Jal Sammelan organised in June 1999, district authorities formed a mission for groundwater recharge, which was inaugurated by the CM on January 12, 2000.

The district authorities considered the seriousness of the matter. The zilla yojna samiti (district planning committee) decided to organise a block-level *jal sammelan* (water conference) in every development block. During these *sammelans*, district administration and public representatives provided training to farmers and *sarpanches*. They were given training for recharging wells, tubewells and handpumps, making tanks in agricultural fields and proper drainage around the fields. "We emphasised on public participation during these training programmes," says K S Khare**,** project officer and engineer.[16] They organised campaigns in villages to create awareness and motivate people to participate in the programme. A nodal officer in every village was appointed after full training. Zonal officers were also appointed for supervising and directing the villagers. Technical knowledge and guidance was provided. Khare personally went and guided the villagers. A technical document was prepared on the recommendations of the Malwa Jal Sammelan and given to villages.

The agriculture department also participated in generating groundwater recharge awareness. It was done during the regular campaign of K*harif* 2000 Agricultural Fortnight. The nodal officers reviewed the progress on every Friday. The deputy commissioner (DC) also took a report of the programme at the district level every Monday. The *panchayati raj* institutions provided funds through the JGSY. They gave a first installment of Rs 1.22 crore and a second installment of Rs 1.03 crore for water recharging. Apart from this, for the project, an additional Rs 93.77 lakh was given. The total amount was Rs 3.19 crore for all village *panchayats*. If a village achieves 100 per cent success, then Rs 1 lakh will be given further as incentive to the village for other development works. During the works, new tanks have been created, the depth of existing tanks has been increased, and the ill-maintained tanks and check dams have been restored. The people contributed Rs 2.73 crore out of a total expenditure of Rs 3.13 crore.[17] The villagers still continue to donate huge sums of money (*see Table 2: Money for a cause*).

Table 2: Money for a cause

The people of Mandsaur were not found wanting when it came to donating huge sums of money for the Ek Panch Panch Ek Talab programme

Development block	Recharge wells	*Pokhar* (farm pond) construction	Hand-pump recharge	Tubewell recharge	*Nullah* surrounding agricultural fields (metres)	New tanks	Desiltation of old tanks	Stop dam construction	People's contribution received (lakh rupees)	People's contribution expected (lakh rupees)	Total (lakh rupees)
Mandsaur	599	607	318	115	61,540	7	25	5	51.31	10.74	62.05
Sitamuh	428	1,787	533	53	115,545	10	44	—	49.02	19.03	68.05
Malhargarh	570	726	167	4	2,150	6	19	—	33.81	7.27	41.08
Garoth	175	239	299	52	8,970	—	53	—	43.40	3.90	47.30
Bhanpura	105	88	95	3	2,260	—	25	—	53.37	1.46	54.83
Total	**1,877**	**3,447**	**1,412**	**227**	**190,465**	**23**	**166**	**5**	**230.91**	**42.40**	**273.31**

Source: Anon 2000, Karyoan ki pragati, in *Malwa Jalabhishek, zilla panchayat*, Mandsaur district, Madhya Pradesh, p.13.

FRIENDLY COMPETITION

As the response to the Ek Panch Ek Talab reached new highs, politicians and villagers tried to outdo each other. The result of this competition was the creation of water storage assets

In several villages in Mandsaur, in an attempt to be one up on other politicians, funds flowed into the Ek Panch Ek Talab programme. People also worked hard to build big tanks and several of them even donated land.

In Mandsaur, the Ek Panch Ek Talab movement soon acquired the festive atmosphere of competition. In one of the gatherings for the mobilisation of funds for one of the largest tanks at Katlar, the local member of the legislative assembly (MLA) said that he would give Rs 1 lakh if the local member of parliament (MP) gives Rs 3 lakh. He also announced that he would give Rs 3 lakh if the MP donated Rs 5 lakh. Interestingly, the MP and MLA belonged to different political parties.

The fever of competition could also be observed in many other places like Babrecha, where the leader of the *zilla panchayat* belongs to a particular political party. He was given the responsibility for *talab* construction in the village. The leader of the opposition party in that village did not like the idea. He went ahead and formed another committee for a new *talab* and donated Rs 50,000. The construction work for the new *talab* has also started. To continue the competition, the leader of the *zilla panchayat* contributed Rs 1 lakh for the first *talab.* In the village of Palarimam, the person elected for the *samiti* was not supported by a section of the village, which had a different political affinity. It went ahead and formed another *samiti.* Now, in the village, two *talabs* are being made.[1]

Competition is not restricted to politicians alone. Anurag Jain, the collector of the district announced that the *panchayat* with the largest *talab* would be given an award of Rs 1 lakh. In the village of Barban lies the second largest *talab,* after Rithal, which comes first. The tank is 200 years old. The tank's *bund* had been breached. The villagers decided to repair the *bund*. Of all villagers, Giridhari was the most enthusiastic. After the tank was repaired, Giridhari went to the collector and claimed the award. He had the notion that theirs was the largest *talab.* The collector informed him that the tank at Rithal was the largest, that villagers there had also reconstructed the breached tank, and that they deserved the prize. Giridhari returned hurt. Back in his village, he motivated the villagers to build new *talabs.* Some Rs 2.5 lakh were collected from the villagers. Even the MLA of the constituency donated Rs 1 lakh, when he came to know about what the villagers wished to undertake. Giridhari and the villagers worked hard and constructed two new tanks. Giridhari again went to the collector and demanded the award. The collector came to the village and acknowledged the effort. "I came, saw the work and appreciated the effort. But I told Giridhari that Rithal still deserves the award," says the collector. Giridhari, in his enthusiasm, constructed four more *talabs*. In this effort, the villagers pitched in again. A total of six *talabs* have thus been made in the village. He is still waiting for his award. "I will make more *talabs* if needed but I cannot let Rithal take the prize," says a determined Giridhari.[2,3]

As the programme gathered momentum all across the district, Patela village of Sitamuh tehsil approached the deputy commissioner (DC) to make a *talab.* The village received only 430 millimetres (mm) of rainfall in 2000 compared to 760 mm in 1999. After the first round of deliberations between the villagers, DC, sub-divisional magistrate and the local MLA, Bharat Singh Jawara, it was decided that the villagers would donate their land which would get submerged. In return, the government would give land to the villagers. For all agricultural land donated for the purpose, the government would give fallow land double the size of the donated agricultural land.

A massive gathering of farmers with the DC was organised on December 30, 2000. Leaders from the two main opposition parties stood on the same platform and addressed the gathering. Villagers expressed a willingness to give the rest of the money if the government provided Rs 1 lakh. The project cost stood at Rs 4 lakh. The villagers decided to give their tractor and provide diesel for it. They said that they could accumulate about Rs 2.8 lakh. Jagdish, a farmer, gave his agricultural land to the tank and donated Rs 10,000 for the cause. Apart from the *talab*, the collector appealed to the villagers to go in for well recharging and construct *pokhars* (farm ponds) in agricultural fields. The collector motivated the villagers by saying, "We think the amount of rain has reduced, but we do not think of capturing the amount which we are getting." Bhabanlal and Nanu Bauri are farmers who recharged their wells in 2000. As the village is facing a drinking water crisis, both of them decided to provide drinking water to the other villagers till they overcome the scarcity.[4]

Farmers who lose their lands to tank submergence have a problem. But experience in Mandsaur shows that this problem can be sorted out through dialogue. In Patela, seven villagers were going to lose their agricultural land. One farmer, Lakhni Chain had a problem. Lakhni said, "I am giving 0.6 hectares (ha) of my agricultural land with wells. In return, I am getting 1.2 ha of fallow land. What do I gain in the process?" He wanted a better deal. The collector intervened with a suggestion, "We will give you a different land of 0.6 ha and also give you the right to sell off the land and recover the amount. In your old submerged land, you can also do cultivation when the water recedes in the tank." But Lakhini was unsure. "Who will buy the fallow land?" he questioned. "The problem is that the cost of the new land, as settled by the government, is lower than the land I am offering, in spite of being double in area. According to the present market rate for land, my land of 0.6 ha costs Rs 3 lakh and the new land of 1.2 ha will fetch only Rs 2.8 lakh. I am willing to accept your offer provided you raise the price of the offered land," he argued. The DC had to come up with a solution. "Forget the new land, you can sell your old land at Rs 3 lakh and take the money," he said. But Lakhini would not give up easily. "If you find someone willing to buy the land now, I am ready," he replied. A murmur broke out among the crowd. The DC raised his voice, "Is there anyone willing to buy his land?" From the back of the gathered crowd, Parshuram came forward. "I am willing to buy his land." The DC then told Lakhni, "You can sell your land to Parshuram and abstain from any activities in this land forever." The solution was unanimously accepted and the deal was finalised.

DRDA, SHIVPURI

Villagers in Shivpuri were serious about their participation in restoring tanks in the district. Their participation went beyond their physical labour. Several villagers contributed to the funds and even donated land

Resurrection of Ratlam

Spread across the Vindhya mountains and the Malwa plateau lies the drought-prone district of Ratlam. The hills are barren without vegetation in villages like Palsauri, while, in others, there is a sparse growth of date palm, dry zone shrubs and sick-looking cotton plants. All of Ratlam is not arid. There are places like Bibrod village where water is flowing in a *khal* (a narrow canal) and is surrounded by green hillocks. "Water is present in the *khal* because of a *kachhe borie bund* (stop dam) made during the last drought," says Suraj Bai from the village.[18]

Ratlam district has participated in various activities to drought-proof itself. "RGMWD had covered only 15 per cent of all watersheds in Ratlam, so there was a need for another programme," says district collector, Manoj Jhalani (*see Table 3: Need for more)*.[19] Due to the 2000 drought, farmers have to face a major crop failure. Habji in his blue turban from village Palsauri points out to his cotton crop, "The crops are dying and I am in debt."[20] Now villages have the Jal Sanchayan Samwardhan (Water conservation and recharge) programme initiated by the government. Ratlam district has 1,077 villages of which 761 are drought-affected. The government has implemented Jal Sanchayan Samwardhan in three stages in all the six *tehsils* of the district.[21]

For the desiltation of old tanks and construction of new ones, a *sukha rahat* (drought-relief) programme has been undertaken. Desiltation work has been taken up in 170 odd tanks. New tanks are also being constructed. The old tanks were not useful due to siltation, breaches in the surrounding *bunds*, and bad maintenance. The waterholding capacity of these tanks was reduced. By repairing the embankments and maintaining and deepening these tanks through public participation, a people's movement got initiated. A total of 230 new *talabs* have already been constructed. Firstly, the *talabs* were identified and demarcated by the village engineering welfare department. According to the survey, around 243 *talabs* required renovation. The department calculated the cost at Rs 2.73 crore. The district authorities assured the people that it would provide funds from its various programmes to those people who will share 25 per cent of the cost.

Some 11,438 wells and handpumps have been recharged. Handpumps are demarcated with colours. High water-yielding pumps are coloured blue, low water-yielding pumps yellow and dry ones are red.

A Salil Sanchay Abhiyan (water collection campaign) was launched. In this movement, rainwater is conserved. While village water is conserved in the village itself, farm water is conserved in the farm itself. Generally, a stop dam's height is two metres (m), base is of three metres and upper width is 0.9 m. About 1,380

Table 3: Need for more

To effectively drought-proof Ratlam district, there is a need for more water conservation programmes

Name of scheme	Area (ha)	New tanks constructed (*talab*)	Farm ponds (*pokhar*)	Old tanks desilted	Water capacity created (mcum)	Amount (lakh rupees)		Total (lakh rupees)
						State	People	
Rajiv Gandhi Drinking Water Mission	48,257	101	82	27	917	91.7	26.59	118.29
National Watershed Development Programme	9,733	43	—	5	218	24.54	1.97	26.51
DANIDA programme	3,118	3	358	—	15	16.31	0.45	16.76
Ek Panch Ek Talab	595	57	222	138	697	9.65	161.69	171.34
Pokhar in the field	1,518	—	727	—	—	—	5.45	5.45
Micro/minor irrigation project	3,041	26	—	—	130	59.10	0.50	59.60
Total	**64,745**	**230**	**1,389**	**170**	**1,977**	**201.3**	**196.65**	**397.95**

Note: *ha: hectares mcum: million cubic metres*

Source: Anon 2000, Zilla mein jal samvardhan hetu kiye gaye karyoan ki jankari, in *Jal Sanchay Samwardhan, Zilla panchayat*, Ratlam district, Madhya Pradesh, p.27.

stop dams have been constructed all over the district by filling locally available black soil in cement or urea bags (*see Table 4: Stop dam benefits*). "We have asked the government to construct a permanent check dam as these makeshift dams collapse in two months," says Suraj Ban of Bibrod village. Jhalani, however, says, "I prefer the black soil-filled urea or cement bag stop dam as the materials are locally available and cheap and it is easy to construct. A new construction every two to three months will make the villagers busy and responsible." He also says that capital will flow out of the district if they had to acquire cement and other construction materials from outside through contractors. In certain places like Sailana tehsil, a stop dam has lost many of its urea/cement bags. All this has happened because animals dislodge the bags into the water or people steal the bags to sell them. No villager or official guard these dams thus leading to their damage.[22]

Table 4: Stop dam benefits

Some districts are irrigating their land using water conserved through stop dams

Name of the *janpad panchayat*	Benefits accrued (hectares of area irrigated)
Bajana	233
Sailana	282
Piplouda	72
Jawara	142
Aalot	184
Ratlam	467
Total	**1,380**

Source: Anon 2000, Statistics of accrual benefits, in *Jal Sanchay Samwardhan, zilla panchayat*, Ratlam district, Madhya Pradesh, p.16.

But the method is very cheap. The cost of irrigating one hectare (ha) of land using stop dams is Rs 3,000 as compared to the cost of irrigation by water from *talabs*, which is Rs 90,000 per ha according to irrigation department guidelines.

To implement the programme, *jal sanrakshan samitis* (water conservation committees) have been formed in the villages. The committee is responsible for the implementation of all the programmes that includes handling the funds for the *talab*, managing labour force and providing technical guidance. They have to prepare a weekly report and present to the sub-divisional magistrate.

Training sessions are being conducted for government officials, village *sarpanches* and villagers. Both the technical and institutional management scenarios are covered in the training programmes. The committee is responsible for the implementation of all the programmes that includes handling the funds for the *talab*, managing labour force and providing technical guidance. They have to prepare a weekly report and present to the sub-divisional magistrate.

For providing drinking water to problem villages, a community-led water plan named Bhagirathi Yojana has been initiated. Under the scheme, communities facing a drinking water crisis can participate by contributing 25 per cent of the total cost. These villages can divert water from any waterbody, which is in their area or within a radius of 1-1.5 km of their village. For this purpose, 20 villages deposited Rs 6.89 lakh with the *zilla panchayat*, and an estimate of Rs 40.70 lakh was made for execution.

Villagers are using this opportunity to resolve several water-related issues *(see Box: Compromise formula)*. "We have realised the value of water," says Kani Ram,

COMPROMISE FORMULA

Across Ratlam, examples where communities resolved their water-related conflicts abounded

While restoring and building water conservation structures, the Ek Panch Ek Talab programme also served as an opportunity to settle conflicts and resolve sharing issues.

In the village of Mathuri lies the massive Surajmal Jain talab, over 100 years old, built during the Scindia rule. This tank is capable of irrigating 118 hectares (ha) of land in the command area and 60 ha by lift irrigation, covering four villages of Titri, Mathuri, Karmadi and Lakkhangarh. The villagers are well-to-do farmers. They own long stretches of vineyards where grapes are grown. Strawberry is also a major product of this region. Other crops grown are cotton, maize, and various kinds of vegetables.

Over time, these farmers started using wells as a source of irrigation. The tank lay forgotten, buried in silt. Not only did this tank provide water for irrigation, it also recharged the groundwater. As a result of overuse and inadequate recharge, the water table started receding. In 1988, drought-like conditions set in. Many handpumps went dry and the farmers started realising their precarious situation. They approached the collector and it was decided in 1990 that the Surajmal Jain talab would be desilted.[1]

The cost of desilting and strengthening the *bund* was estimated at Rs 77 lakh. Many chemical industries had been set up near the vicinity of the tank, which also needed water. The government spent Rs 36 lakh and desilted 24 per cent of the tank. Progress was slow and as nearly a decade had passed, the cost escalated to Rs 1.13 crore. Under an agreement with the National Bank for Agriculture and Rural Development (NABARD) and the industries department, it was decided that NABARD would provide Rs 73 lakh while the industries department would contribute Rs 40 lakh. However, the industries department later backed out, claiming that the industries did not need water. Most of the units were shutting down as these had been declared sick units. The project came to a grinding halt due to lack of funds. Meanwhile, drought loomed large over the region.

Not to be disheartened, the villagers told the collector that they would contribute Rs 60 lakh if the government would provide Rs 60 lakh. Keshav, a farmer who is contributing money for the project says, "If the tank can be used again, we can use the water for irrigation. In addition, our wells and handpumps will be recharged."[2] Villagers and government officials claim that this is the largest tank in Madhya Pradesh.

On December 19, 2000, the chief minister came to Mathuri to inaugurate the project. A *jan sahbhagita samiti* (people's participation committee) has been formed which will take care of the fund flow and implementation. The government will provide technical guidance. Farmers whose land falls under the direct command of the tank will contribute Rs 20,000 per hectare. A total of Rs 22 lakh has been collected from these farmers. Farmers residing further downstream are donating Rs 6,250 per ha. A total of Rs 20 lakh has been collected from them. Upstream farmers who have no direct access to the tank water but will use lift irrigation, are providing Rs 30,000 per ha. Some Rs 18 lakh has come from upstream farmers. Work has started and villagers are hoping that the monsoon of 2001 will feed the parched tank. "We will do our part, the rest depends on rain. If there is no rain, then our efforts will be futile but this the only option left to save our villages," says Lakhiram, a landless farmer of the village. If rain comes, then villagers hope to recover more money than what they have invested.

In the *tehsil* of Jawara, the public decision to pay compensation to villagers whose land was submerged due to the building of a check dam was unanimous. Khorana *talab* is a 145 ha tank built by the government in 1910 during the Scindia rule. It lies at the border of Mandsaur and Ratlam districts. This tank helped in recharging the groundwater of drought-prone villages downstream. Most of the water of the Khorana talab used to flow out to a *nullah*. The downstream villages decided to construct a check dam to stop the water of the *talab* from flowing out.. But, this is where they ran into opposition due to vested interests.[3]

During the months of November and December, the water would be drained out by upstream villagers to the *nullah* so that the tank bed of 145 ha could be used for sowing *rabi* (wheat) crop. However, the area that was irrigated within the tank bed did not adhere to government guidelines. These guidelines state that if 10 ha are submerged, then the area to be irrigated from the tank should be 100 ha. But, in this case, 145 ha was submerged and the water was drained out to irrigate only 145 ha and not 1,450 ha. "We people living downstream felt that if the tank retained water round the year than it could facilitate water supply for irrigation purposes to 30 villages. It would increase the water level in the wells and handpumps too," says Ram Lal, a downstream villager.[4] The upstream farmers were not supportive as they stood to lose one crop.

To resolve the conflict, upstream and downstream villagers went to the collector. Thousands of villagers came to a temple near Khorana talab. It was decided in the presence of everybody that the villages which benefited from permanent check dam would compensate those villages that face submergence of their fields. The compensation cost that had to be paid to farmers for aquiring the tank was calculated as Rs 2.35 crore. The villagers took a unanimous decision to pay Rs 500 per hectare to the *zilla panchayat* office. The total from the downstream villagers came to Rs 90 lakh. The government agreed to contribute the rest. Well deepening activities would also provide a part of the contribution — about Rs 10-20 per trolley by selling the excavated earth from the wells. Other members of the *zilla panchayat* contributed Rs 51,000. The *janpad* (district) president of Mandsaur, along with others, gave Rs 11,000. The amount collected from other sources stood at Rs 10 lakh. The government is preparing a brief to present to the state cabinet so that the full compensation can be availed of.

At the moment, villagers upstream are waiting for the compensation and villagers downstream are waiting to construct the dam. But, at least, a settlement has been reached.[5]

These examples indicate how water serves a platform to resolve issues involving conflicting interests.

SHAHDOL DISTRICT PUBLIC RELATIONS OFFICE

Shahdol district earns its name from the thousands of tanks that existed here. The first district to adopt the Ek Panch Ek Talab programme, village communities worked hard to restore the district to its past glory

a farmer from village Maurbani.[23] Village landless are renovating many tanks. It is a sight to observe village males wearing fluorescent green, orange, pink and yellow turbans digging away the silt, while village women in bright yellow, blue and green *sarees* carry them to the *bund*. Work on two percolation pits started on December 13, 2000 — one in the upper catchment area while the other lies below. Both landless and land-holding farmers are providing labour at a rate of Rs 35 per hour. "All farmers are participating because we have no crop to reap due to the drought," says Ganesh, a farmer who is working as a labourer.[24] Women's participation is high and children too are spending their time at the construction site. Villagers provide 35 per cent of the cost in the form of tractors, labour and diesel.

Dewas: Making amends

Dewas receives an annual average rainfall of 1,000 mm. But the 2000 monsoon was very poor. "However, the water situation is under control at present — thanks to the water conservation programmes carried out in recent years. We are expecting problems only after February 2001," says Rashmi Shammi, CEO, *zilla panchayat*, Dewas district.[25]

Rainwater harvesting was not a new concept for the district as there were already 19 ongoing watershed programmes. But these programmes had covered only 69 villages of the district out of 1,958 villages — a mere 3.5 per cent. Since the water crisis affected the entire district, it was felt that rainwater harvesting efforts had to be spread to the rest of the villages too.[26]

The district administration, under its former collector M Mohan Rao had implemented conservation programmes on a war-footing. "When I took over as the district collector in 1997, I declared Dewas a water-crisis district and banned the drilling of tube-wells. Permits for new tubewells were to be given only by the SDMs. Between 1999-2000, only 20 tubewell applications were passed," says Rao.[27] During the summer of 1998, Rao felt the need to undertake a study on the water situation in the district. "I was shocked and alarmed at the findings of the district officers of different departments," says Rao, explaining, "Farmers of the district depended largely on tubewells and wells for irrigation. The number of tubewells had risen enormously from 3,887 in 1990 to 14,172 in 1998. The

number of tubewells owned by inhabitants of the city rose from 350 to 1,486 during the same period. Dewas has 330 village tanks. Ninety per cent of the tanks were drying up by January or February because they were silted up while villagers depended on dugwells and tubewells for their domestic use. As a result, the groundwater table was depleting alarmingly," writes Rao in the monograph Jal Raakshati Raakshitah (Save water).[28] People who used to get water at 60 m depth in the 1980s were getting water at 100-120 m depth in the 1990s.

The slogan for the water conservation mission of the district was *Akash paani rokenge, patal paani badaayenge* (We will save the rainfall and recharge the groundwater) and the people of the district participated wholeheartedly.[29]

In the rural areas, the Bhujal Samwardhan Mission (Groundwater Conservation Mission) was started in May 1999 which lasted till January 2001. Some 309 old tanks have been deepened while 23 new tanks were created, along with *nullah* bunding, cleaning of dugwells and digging of percolation pits. The cost of the total work carried under the water conservation programme is approximately Rs 5.375 crore out of which the public contributed Rs 4.92 crore, about 92 per cent.[30] Because of the increased water storage capacity, the total quantum of increased artificial recharge was estimated to be 21.41 mcum *(see Table 5: Recharge rewards).*[31]

The task was executed at two levels — the administrative level and the social level. At the social level, primarily a mass awareness programme was conducted during the summer of 1999 which was carried out through press releases and workshops at district level (blocks and *panchayat* level).[32] Says Shammi, "From the very beginning we made sure that water conservation was a public programme. Even the timing for the meetings, during the peak summer, was selected carefully."[33]

The response was overwhelming with people from every walk of life wholeheartedly participating in *shramdaan* for the renovation and building of tanks. Farmers voluntarily gave their tractors for the repair and deepening of old waterbodies. "The black cotton topsoil was dug and used for the *bunds* around the tanks," informs Shammi.[34] In urban areas, it was decided to use college students, especially girls, and senior citizens to motivate the people.[35]

RICHARD MAHAPATRA

A restored* talab *in Bhamaraha village in Shahdol district provides succour to animals even as it recharges the groundwater

Table 5: Recharge rewards

Through the Bhujal Samwardhan Mission it was possible to create a significant water storage capacity in Dewas

Project	Total area (hectares)	Total number of constructions	Total water recharge capacity (mcum)	Total funds from the government (lakh rupees)	Total funds through public contributions (lakh rupees)	Total funds (lakh rupees)
Deepening of old tanks	1,947.18	—	1,807.72	25.36	288.88	314.24
Government tanks	4.35	9	0.05	—	26.74	26.74
Farm tanks	5.49	14	0.05	—	41.29	41.29
Deepening of wells and *baolis* (stepwells)	2.06	244	0.06	5.20	5.86	11.06
Percolation pits	20.60	3,115	0.22	7.70	54.58	62.28
Nullah bunding	600.50	1,050	2.79	2.70	41.34	44.04
Roofwater harvesting	27.20	1,021	0.16	4.77	33.02	37.79
Total	**2,607.38**	**5,453**	**21.41**	**45.73**	**491.71**	**537.44**

Note: *mcum: million cubic metres*

Source: R B Tripathi *et al* 2000, *Jal Raakshati Raakshitah*, zilla panchayat, Dewas, Madhya Pradesh, p 51

The positive effects of the RGMWD can be seen in Tonkhurd block's Mohamdekhra microwatershed. When the mission started operating here water scarcity was at its peak. There were only 12 wells belonging to individual villagers and no tubewell. But only two to three years after the mission started operating, there has been a dramatic turnaround. Now the microwatershed has 22 wells and five tubewells. There is an increase in agricultural production and the total sown area. The total sown area for *kharif* crops increased from 210 ha to 290 ha and the production from 52.5 tonnes to 90 tonnes. Likewise, for *rabi*, the total sown area increased from 175 ha to 280 ha and production from 130 tonnes to 240 tonnes. Today, there is very little migration whereas earlier almost 35-40 families used to migrate for work. The total fodder production has also increased which has led to an increase in the number of cattle.[36]

AMIT SHANKER / CSE

The Dewas filter is used to clean up rooftop harvested water before use

Says Brij Lal, a farmer in the Kishanpura microwatershed, "The effects of watershed missions have also been very dramatic. In 1999, we thought we would have to leave because there was very little water left. But after the water conservation work started, in the first year itself, the wells are almost full. If we get a little more rain in 2001, then we can grow another crop."

Social auditing has also become an important part of the watershed activities after the Nirakh Parekh programme was launched. Under this programme, the map of the watershed area is drawn on a wall at a public place such as a *panchayat bhavan* (village council hall). On that map, all the structures built are mentioned. This audit has been implemented in all microwatersheds that have completed three years. The idea behind the programme is to evaluate the achievements of the programme in a transparent manner.[37]

Dewas has not only conducted water harvesting programmes in villages but also in the towns. "We started our campaign from the Karamchari (workers) Colony in Dewas that had 32 tubewells. There are 600 pending applications for filters and technical help from the public health engineering department," says Shammi.[38]

Almost 1,000 rooftop rainwater harvesting systems have been installed.[39] A filter system called the Dewas filter, made by Rao and engineers of the rural engineering services is provided to users for Rs 600. The filter has since then been patented. The filter is a polyvinyl chloride (PVS) pipe 140 millimetres (mm) in diameter and 1.2 m in length. There are three chambers. The first purification chamber has pebbles of size varying between 2-6 mm in size, the second chamber has pebbles of size 6-12 mm and the third chamber has 12-20 mm size pebbles. There is a mesh at the outflow side through which clean water flows out after passing through the three chambers *(see Fig 1: Designed in Dewas)*.

One of the first residents of Dewas to install a rooftop rainwater harvesting system, A Lunavat, says, "Most of the residents in Dewas have wells in their houses. They were only extracting groundwater but not recharging it. So when the collector took this initiative we were more than happy to help him. There were also new converts after they saw their neighbours installing the pipes and filters."

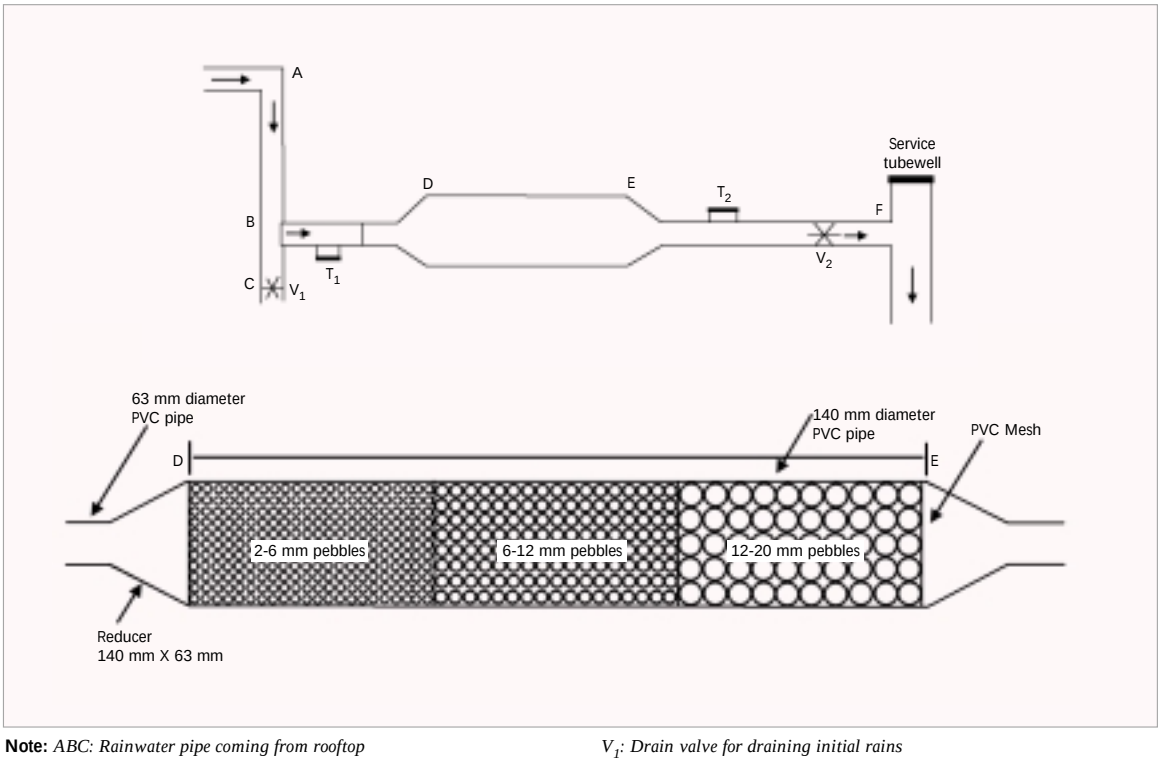
THE FUTURE

After a preliminary evaluation based on the feedback received from the districts, the state government has decided to make water conservation as the theme of the state's annual Gram Sampark Abhiyan (a one month programme during which the CM and his cabinet colleagues travel throughout the state extensively for evaluation of its programmes and to ascertain the future course of actions). Named Pani Roko Abhiyan (Catch water campaign) the campaign will start in February 2001. "After the success of our watershed mission and the tank renovation programme, we are using this as an opportunity to involve the people in water conservation even more extensively," says Gopalakrishnan who is also coordinating the programme. This is in line with the government's strategy to fight drought in the long-term.

The programme has the objective of making water harvesting a household affair. Its plans include rainwater harvesting starting from the premises of a house to a farmer's own land to revival of old tanks. When state

Fig 1: Designed in Dewas

The Dewas filter is a simply designed filter used to filter rooftop rainwater



Note: *ABC: Rainwater pipe coming from rooftop*
V_2: Valve for backwash
DE: Filter
T_2: T for inspection, introduction of chemical and backwash mm: millimetres
V_1: Drain valve for draining initial rains
BD: Inflow pipe to the filter
EF: Outflow pipe
PVC: polyvinyl chloride

Aware village communities know that their village will only prosper if there is water for all. The banner reads: "Villages will develop only when everyone has water"

officials will visit villages in February, they will be circulating manuals on water harvesting. Through a questionnaire, they will ask people about their mode of water harvesting. "In one way we will educate them technically and, on other hand, we will get a feedback from them," says Vyas.

This *abhiyan* comes at a time when the government is planning two major decentralised laws that would transfer and legalise people's rights over water and other local resources. On January 26, 2001, the state will adopt the *gram swaraj* (village independence) programme under which the *gram sabha* will become the nodal decision-making body. It will also have the right over water management besides management of other resources. The other legislation the government has initiated is empowering watershed committees formed under the RGMWD to manage the water resources created under the mission. This legislation will also empower them to manage other resources in a watershed.

According to officials involved in the formulation of these laws, this is a move is to put in place a system under which the people no longer have to depend on anybody for their needs. In a recent seminar in Bhopal, the government admitted that there have been intra-watershed conflicts over resources, particularly conflicts which involved community interests versus individual interests. "The maturity of community organisations created under the watershed mission is not very high," warns Amit Agrawal, a former director of the watershed mission. "This led the chief minister to think about this problem and to adopt a very planned way of empowering the community," says an aide to the CM. The Ek Panch Ek Talab programme has laid the foundation, the Pani Roko Abhiyan will strengthen it further, the *gram swaraj* programme will provide the overall framework, and the legislation empowering the village watershed institutions will ensure people's rights at a micro-level.

But the multiplicity of institutions at the village-level may create problems feel a few experts. "How many institutions can we have in a village? What would be their roles? Most important, what would be the role of the *panchayats*?" asks M N Buch , director of the Bhopal-based National Centre for Human Settlement and Environment, a non-governmental organisation, who participated in the seminar on these legislative initiatives. Says the principal secretary (rural development), "The existing laws can be amended suitably to give supremacy to the *gram sabha* (village assembly) and not the *gram panchayat* (elected village council). But before that we have to go for a massive public awareness campaign." That is where the Pani Roko Abhiyan is expected to help. ■

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Box: FRIENDLY COMPETITION

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Box: COMPROMISING FORMULA

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Glossary

AFRICA

baobab or ***tebeldi*** : trees native to tropical Africa; they possess digitate leaflets (which look like hand or feet of primates) which are as used as fishing nets

INDIA

Bengali

dada: elder brother
pukur: village pond

Gujarati

agashi: rooftop
khadi: sump
pallar pani: excellent quality rainwater
talavdi: pond
vav or ***vavadi:*** richly ornamented stepwell of Gujarat
virda: hand-dug pits in dry shallow ponds or river beds in Gujarat, used for drinking water

Hindi

aam sabha: public meeting
ahar: a rectangular catchment basin which has embankments on three sides; the beds of the *ahars* are not dug out
akash paani rokenge, patal paani badaayenge: we will save the rainfall and recharge the groundwater
anna: currency of India, 1 rupee is equal to 16 *annas*
antim insaan: last person
apna talab: our tank
Aravalli bachao yatra: Save Aravalli March
bandhi or ***haveli bandhi:*** *bunds* which confine rainwater in fields for irrigation purpose
banjar: fallow
banjara: migratory community
baori or ***ber:*** stepwell, usually used for drinking purposes
begari: forced labour
bhakti: devotion
bhandar / rasoi: kitchen
Bharat yatra: Tour of India
bideshi pakhi: foreign bird
bigha: unit of area which is less than one acre
bund: earthen dam
chabootra: platform
chapcha: small, *pucca* (permanent) storage structure
chappaniyan kaal: a great famine
char dham: four key religious places visited by Hindu piligrims
chauka: rectangular plot of land which stores rainwater in a dyked pasture
chetna yatra: awareness raising journey
darshan: a ceremonial visit to a religious monument
dhani: hamlet
dharna: protest
dhenkli: a basket with ropes on each end, used for lifting water
dhobi ghat: washerfolk's place
diwali: festival of lights to celebrate the homecoming of the Hindu god Rama
durgah: holy place dedicated to a Muslim saint
ghat: constructed approach to the water in a tank or a river bank
gram: village
gram kosh: village fund
gram sabha: assembly of all village adults
gram sewa mandal: village welfare society
holi: an Indian festival of colours
jal sammelan: water conference
jal sanchay abhiyan: water conservation movement
jal yatra: a journey for creating awareness about water
jan sahabhagita samiti: people's participatory committee
jheel: reservoir; spring; lake
jheel sanrakshan samiti: lake conservation committee
jinda kua: well having water
johad: basin bounded on three sides by natural hills and

an artificial dyke on another side to store the monsoon runoff

jowar: sorghum

kachhe borie bund: temporary stop dam

kalyani: system of excavating farm ponds based on traditional methods where structures are dug at strategic locations

kamalghatta: fruit of lotus plant

kanhar mati: hard soil with good waterholding capacity

kankar bani, rakhat bani, dev bani and ***rundh bani:*** types of forests categorised for specific community uses and protected accordingly

kari: highly acidic

khal: narrow canal

kharif: monsoon / summer crop

khus: aromatic grass whose straws are used in the making of mats which act as coolers during summer when water is sprayed on them

kothi: pavilion or house

krutibhakti: action-oriented devotion

kuchcha: temporary

kund: traditional tank

kundi: stone tanks

kunwan: well

***lok jan jagriti abhiyan*:** mass awareness campaign

lokanath amrutalyam: community prayer site

mahal: palace

malguzar: landowner

malmal: fine muslin cloth

mukhia: chief

murar: type of fish

naali or ***kuccha:*** earthen channels

naada or ***bandha:*** a stone check dam across a stream or gully that is constructed to capture runoff on a stretch of fertile land which is submerged in water during the rainy season

nadi: river

nirmali: a plant whose seeds are used for purifying muddy water

nirmal neer: percolation tank

nistar: rules laid down under the British regarding the rights of the local people over common property rights

nullah: stream

panchayat: a council of five members elected in an Indian village

parishad: special meeting of elected or nominated members

pokhar: farm pond

poonam sabha: full moon day meeting

pramukh: leader

prasad: God's offering

pucca: permanent, cemented

puskharini: stone-riveted sacred pond located near temples

pyne: a channel constructed to utilise water flowing through the numerous hilly rivers of Bihar

rabi: winter crop

rakhi: an Indian tradition in which a sister ties a string on her brother's wrist with the hope that he will protect her

rangdari: extortion

sagar or ***samand:*** big lake

salil sanchayan abhiyan: water conservation campaign

sansad: parliament

sardar: landlord

sarpanch: head of the village *panchayat*

sarvodaya yojna: plan to help everybody; state government scheme for overcoming the water crisis in Gujarat

satyagraha: a form of non-violent protest on the lines of Gandhian principles

shakkar: sugar

shrambhakti: devotion through labour

shramdaan: collective, voluntary work by villagers to remove silt from tanks and repair embankments

sukha rahat: drought relief

swadhyaya: study of self

tal: small tank

***talab*:** humanmade reservoir, permanent pond

talai: small lake

talaiya: small pond

tali/dhar: patches of low ground between sand hills

taluka: sub-district level

tanka: covered underground sump

teerath sthan: piligrimage spot

teharka: small traditional tank of the Chandela dynasty

terai: Sub-Himalayan plains at the foothills of the Siwalik range

trikaal: third year of drought

urad: a variety of pulse

usar: saline or alkaline lands

vikasana rekha: A line signifying progress and development

vruksh mandir: orchard temple

yatra: journey

zamindar: landlord; landowner

zilla parishad: elected council at the district level

Kannada

surangam: tunnel dug through a laterite hillock from the periphery of which moisture or water seeps out

Malayalam

surangam: tunnel dug through a laterite hillock from

the periphery of which moisture or water seeps out
taka kulam: valley-head ponds

Marathi

bandhara: small dam
bori: very small tank
dachcha: a hole on the two sides of a *monghad,* which is a stair-like structure built over a tank embankment
dada: elder brother
malguzar: a person who allots forest lands for establishing habitation and cultivation to migrating families and villagers; this is an age old practice in certain parts of Maharastra
monghad: stair-like structure built over a tank embankment
morand: type of soil suitable for cultivation of *rabi* crop
murrum: laterite pebbles; red sand gravel
pakan: silt dug out of a tank bed
pankar: a person appointed to release water to farmers and who ensures that decisions taken by the water users' committee are being implemented properly
patil : a person who allots forest lands for establishing habitation and cultivation to migrating families and villagers; this is an age old practice in certain parts of Maharastra
sihar: type of soil which is suitable for rice cultivation; locally called *sihar* in parts of Maharastra
tudum or ***monga:*** traditional mechanisms employed to draw water from reservoirs for irrigation
wada: residence

Mewari

arji-parji **:** swapping of labour in villages of Udaipur district of Rajasthan
chak: a big plot of land
charnot: village pastureland
halma**:** swapping of labour in villages of Udaipur district of Rajasthan
harva: a person having special skills in groundwater detection
heejara or ***adha-batta:*** crop-sharing arrangements amongst the *hembar* (small dam over a seasonal stream) members
heerma/seerma: refers to the practice of growing crops in the *rabi* season on residual moisture
hembar: a small, temporary seasonal dam constructed with stones, twigs and mud over a seasonal stream
kot: a stone boundary wall which encloses the *chak*
mautbir: the informal leader of a hamlet
medbandi: a stone embankment built on the lower side of an agricultural field on a hill slope to conserve soil and moisture and help create a level field for cultivation; it encourages controlled erosion
rehat: traditional water-lifting device which requires a circular platform
saza: partner
saza kuva: open dugwell with multiple owners

Oriya

bheda or ***bandhua:*** waterlogged areas separated from rivers and major surface waterbodies by large *bunds*
dhoiya or ***juaria:*** waterlogged areas situated along river banks which is often flooded by river waters
jantasaja: traditional water lifting device used to bring water to individual fields
jhola: lowland where terrace cultivation is undertaken
jore**:** narrow, long waterbodies
luna: saline land situated on river and creek banks that is flooded by saline water; it also means salt
madhura: land located in the tidal zone but not affected by tides due to artificial water harvesting structures that prevent the tide from coming in
pakhala: slightly fermented water rice, which is a part of the diet in villages of Orissa
palem: local territory

Sanskrit

samudram: sea
samuh lagnotsav: traditional community marriage ceremony in which several couples get married at one time and thousands of people participate
shridarshanam: collective farming by a group of about 20 neighbouring villages

Tamil

anicut**:** dyke or embankment; diversion dam
ayacut: command area of a tank
ayacutdar: farmers living in the command area
eri: traditional tank in south India
eru: rivulet found in south India which is seasonal and has a sandy bed
kudimaramath: community voluntary labour
madava: blocking a canal so as to allow water flow through another canal
manyam: land given to a *neerukatti* (water-tender) in lieu of the service rendered by him
neerukatti: water-tender
oorani: traditional ponds
poota: refers to 24 hours (or 12 hours in some places) and indicates cycle of turns of water release
thamarai oorani: surface pond

Telegu

adda madava: blocking the main canal in the middle so that the water level is raised
adugulu vese ayana: person who allocates shares of

excavation work to each farmer

alugu or ***marva*** or ***kalju:*** flood weir

amuji: voluntary community labour

anakatta: temporary *bund* or masonry structure

ayacut: command area of a tank

ayacutdar: farmers living in the command area

badava: narrow short passage on a hill; can even be marshes on wastelands

bandili or ***thoti:*** a watchperson to drive away stray cattle

beedu jamu: extra time given for the first release of water in a season into a field

bode: series of broad furrows made in a garden field

bogi katta: diversionary structure

bokkena: metal drum

bondalu or ***selalu:*** shallow natural pits

bookenagauntha: small depression in a well

botta bavulu: dugwell in a tank bed

bugga: natural fountain

chelama: naturally formed spring in the foothills or in ravines

cheruvu: irrigation tank in south India; it is a huge earthen dam built across a stream

dala: a tiny, slender *bund* made on the field to prevent percolation

dompu: a small parcel of land which is about 1-1.5 hectare in area

dompu kalava: branch of *pilla kalava* that supplies water to a *dompu*, which is a small parcel of land; a *pilla kalava* is a canal which is used to irrigate several plots of land simultaneously

dona: small natural pool of water usually located in hills or rocky places

doruvu: small *guntha* (pit) dug beside a stream passing through lowlands from which water is manually lifted

gooti madava: a process wherein a branch of the main canal is blocked in order to raise the height of water

guda: swing basket used for lifting water

guda gunta: a small pit in a high gradient

gunjana: stream or rivulet, full of pebbles and boulders

guntha: water harvesting structure, located in a deep slant depression and without any sluices or weirs; hollow pit

gunti kalava: furrow or passage on a gentle slope; *kalava* means canal

idagolu: a period of 12 hours used to calculate duration of irrigation needed in each *dompu* which is a small parcel of land or a *narava* which is a patch of land on a gentle slope taking off from a certain level on a hillock

indukanta: rainwater pit

irupakala kalava: twin canals running parallel to each other

jamu pedda: a person who monitors the duration of flow of water to the fields

javukulu: oozing hummock

jedu gaddalu: hummock which is located in marshy lands at a high gradient

kalava: a canal that has branches which supply water to the *ayacut* or the command area irrigated by a tank

kalava jamu: extra time given for the first release of water from a canal into a field

kalava pedda: a person who supervises overall work

kalavapina pedda: a person who monitors the opening and closing of canals according to turns

kanju: type of artificial check dam constructed across a stream flowing in the lower slopes or base levels

kapili: bullock-drawn lift to draw water out of wells and tanks

kappu kalava or ***vanagalava:*** deep furrow at the edge of a field that draws out percolated water

kasim: naturally formed spring, artificially deepened or widened

kattu kalava or ***katuva kalava*** or ***varava:*** channel that brings water to a tank

kattu kommu: barrier across the flow of water

keedu or ***keetu kalava:*** wide, short canal from the tank sluice before it bifurcates into the main canals

kesev: dugwell in a river bed

kona: big stream running for several kilometres

kondamu: water level in a wide canal is raised at a certain point by means of mud. This is known as *kondamu* or *vubbu* in Kalahasthi area, or *oddu* in Akepadu

koneur: pond

kunjara: large-sized pool in a river which is a habitat for elephants

kunta: small tank; water storage structure

kunta kalava: channel drawn from a pit or a puddle dug in the field to supply water

madugu: a naturally formed, perennial wide well or pond of great depth

Malkala: Lambada (name of a tribe) festival where the tribals pray for rain

medi madava or ***ubbeda:*** a narrow passage allowing water to flow from the upper field to the lower field

mera: customary annual/seasonal payment

mitta kalava: canal beginning at a higher gradient to irrigate high gradient fields

mitta thoomu: sluice at a high gradient

morava kalava: stream or canal

mota: masonry work involving stone beds

narava: a patch of gentle slope taking off from a certain level on a hillock

nattu: one or more contiguous zones

nattu kalava: a branched canal that supplies water to

the *ayacut* or the command area of a tank
neeru: water
neeru meeru: water and you
neeti viniyogadarulu sangam: water users' association
oddu: water level in a wide canal is raised at a certain point by means of mud; this is known as *kondamu* or *vubbu* in Kalahasthi area, or *oddu* in Akepadu
padi: small, shallow pit five square metres in size
panta kalava: branch of a *pedda kalava* (main canal), which brings water nearer to the fields
pathulu or ***pathi gunthalu*** or ***kopu gunthalu:*** excavated pit in a tank bed
pedda kalava or ***pradhana kalava:*** main canal taking off from the sluice of a tank
peddarikamu: guardianship to oversee proper distribution of water and cleaning of the water system; the person may be the *sarpanch* (head of a village council) of the village
pilla bavi: a tiny well sunk within a dugwell
pilla kalava: channel branching from the main canal used to irrigate several plots of land simultaneously
sanna kalava: narrow channel
savu madava: firmly blocking water flow in a canal by putting stones and grass
sela: puddle in a rocky place
soodi rallu, pooti maanu rollu and ***done banda:*** layers of stone beds
theerava: sharing of water between two canals in accordance with customary practices
thoomu: sluice
vagu or ***vaka:*** natural drainage channel
vanka: streamlet
vanthu or ***poota:*** order of turns of water release to each *ayacut*, the command area of a tank, or to a *nattu*, meaning zone
voorugalava or ***vootugalava:*** drainage passage made by cutting the field *bund*, used to drain water during harvesting
voota: similar to *jedu gaddalu* (a hummock located in marshy lands) but occurs at base-levels or plain lands
voota kalava: naturally formed canal which acts as a passage for percolated water from the hills
vubbu: water level in a wide canal is raised at a certain point by means of mud. This is known as *kondamu* or *vubbu* in Kalahasthi area, or *oddu* in Akepadu
vuddi: raised platform or passage
yatam: manually operated counterpoise lift
yathamu: a water-lifting device
yeda: blocking the flow of water in a canal to divert the direction of water flow
yeda kalava: passage of water traversing between two fields
yetikalava: canal dug at certain places on the banks so that water can enter into it

Urdu

boodhe nawab: title given to an aged head of a community
hammam: public bath
imam: Muslim clergy
malik: village notable; owner
pakhi: long well of rough, unfinished stones

ISRAEL

wadi: dry river bed

NEPAL

balesiko pani thapne: rooftop water harvesting
chautara: stone platform built on the roadside for travellers to rest
dhunge dhara: traditional stone spouts
kharka: pastureland
pokhari: pond
pokhariyan: *talab* or reservoir
raj kulo: canals of Kathmandu valley constructed by the rulers

PAKISTAN

dahar: saline alluvial soil in Cholistan desert, Pakistan
damni: huge wasteland
gandi/sad: *bund* constructed across the bed of a torrent
khad: ravine
khula: a term used for a shallow channel in Dera Ismail Khan
kulyat and ***riwajat-i-abpashi:*** rules and regulations for irrigation
pat: flat areas between sand dunes in a desert
playa: beds of ephemeral dry lakes in Cholistan, Pakistan
rod kohi: hill torrent system of irrigation
tarai: pond that collects rainwater in Thar desert
zam: major hill torrent

PHILIPPINES

barangay: village-level officials

SRI LANKA

cadjan: dried coconut leaves
walawe: big mansion of the Kandian dynasty

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Statement of Shared Concern

Taking note of the Statement of Shared Concern issued by the participants of CSE's Conference on Traditional Water Harvesting Systems (New Delhi, October 9-11, 1990) and published in the Citizens' Fourth Report on the State of India's Environment entitled Dying Wisdom: Rise, fall and potential of traditional water harvesting systems, *we the participants of the CSE Conference on* Potential of Water Harvesting: Traditions, Policies and Social Mobilisation *(New Delhi, October 3-5, 1998) conclude the following:*

THE CHALLENGE AHEAD: WATER, FOOD AND LIVELIHOOD SECURITY

India's ancient tradition of community-based water harvesting is declining. The role of the state in water management has increased, while that of communities and individual households has decreased. Simultaneously, there has been a growing reliance on river water and deeper layers of groundwater aquifers, as compared to the earlier dependence on rainwater, local runoff, floodwaters and the top layers of the groundwater aquifers. The modern paradigm has resulted in mismanagement of both groundwater sources and river water, and also in water use behaviour, which does not reflect concern for the growing scarcity of water. Subsidised water service by the state has further encouraged this behaviour and put limited water sources under stress.

There are still thousands of villages in India which do not get adequate or clean drinking water. Hardly any town of India gets round-the-clock water supply. In addition to the problems of quantity, there are growing problems with quality. Not only surface water resources, but groundwater resources are also being polluted, especially in urban and industrial areas and in areas where agricultural modernisation has led to increased use of agrochemicals. The growing threat of fluorosis and the latest dangers of arsenic in groundwater used for drinking indicates geochemical changes in the groundwater environment that are already having extremely serious effects on public health. Further, coastal aquifers and some of the inland aquifers are increasingly becoming brackish, which further degrades drinking water quality and makes its availability scarcer.

Improving the soil moisture status and providing for supplemental irrigation from local water resources is crucial for raising productivity of rainfed lands and in restoring degraded lands to their full potential.

We believe that it is essential to promote community and household involvement in water management and give greater importance to extending and improving local water harvesting systems — through techniques like rooftop water harvesting, storage of local runoff and recharging of groundwater aquifers in a framework of integrated land-water development, on a watershed basis. Community action backed by an appropriate decentralised legislative framework can play a key role in preventing overexploitation of groundwater resources. This can play a critical role in meeting the country's growing water needs in a sustainable way, and, thus, improve water supply, food and livelihood security and animal care, reduce dependence on the state, and involve people in protecting and making sustainable use of their water resources.

We believe that a new paradigm is needed to manage water that can be built both, on past traditions and the current practices of numerous communities in India and other parts of the world, which still remain outside the fold of state-managed water supply systems. These traditional systems should be further improved through appropriate adaptation and integration of modern systems, where possible.

This does not mean that we believe that the state has no role to play in water management or there is no role for centralised water supply systems. But there is clearly an urgent need today to restore a balance between the role of the state and that of communities and individual households. There is a need to give much greater importance to harnessing local rainfall and local runoff to meet water needs, thereby achieving a better balance and complementarity between large and small systems, and between surface and groundwater use.

THE STRUGGLE FOR A NEW PARADIGM

Emerging paradigm

A new paradigm in water management is already emerging due to the efforts of both government and non-governmental agencies.

Growing interest in water harvesting

A survey of developments within India and abroad, in the past decade, shows that numerous projects have been undertaken to promote local water harvesting, both in urban and rural areas. There have been some outstanding efforts to promote water harvesting in countries of South Asia and industrial countries such as Japan and Germany. Water harvesting can no longer be labelled a technology of the past and fit only for the poor and rural areas. Water harvesting is as relevant today for the rich as it is for the poor and it is as relevant for urban areas as it is for rural areas. Equally, it is as relevant for arid areas as it is for high rainfall, humid regions. It is a universal technology which is relevant to all with location-specific applications.

Rural water harvesting efforts

Local water harvesting projects are being increasingly taken up by government agencies and civil society institutions in rural areas. These projects aim to:

- Provide drinking water;
- provide water for irrigation, especially for supplemental and life-saving irrigation; and,
- increase groundwater recharge to ensure sustainability of water sources.

Experience shows that water harvesting projects in rural areas have slowly led to overall village ecosystem management (that is, land-water-biomass management at the village level) with substantial economic returns through improved agricultural productivity and an increase in animal products. Indian experiences in villages like Sukhomajri near Chandigarh, Ralegan Siddhi in Ahmednagar district in Maharashtra, the numerous villages of Alwar district in Rajasthan and the villages of Palamu district in Bihar, show that water harvesting can start off a chain of highly synergistic, substantial ecological and economic changes which uphold the adage that water is wealth.

These examples have inspired some state governments to undertake watershed management on an integrated basis by communities. Water harvesting to increase groundwater recharge is also being successfully attempted by several village communities in the arid parts of Gujarat. At the same time, several institutions even in a high rainfall state like Kerala are beginning to advocate the importance of local water harvesting to meet community water needs.

Urban water harvesting efforts

In urban areas, water harvesting can be undertaken for a variety of purposes:

- To increase water supply for potable water needs;
- to increase water supply for low-quality household uses like gardening, washing clothes and for sanitary needs;
- to provide water for institutional needs;
- to increase groundwater recharge to improve the quantity and quality of groundwater; and,
- to reduce stormwater runoff and thus avoid flooding of urban areas and overloading of urban drainage and sewage treatment plants.

A variety of measures have been undertaken by governments to promote water harvesting by urban households. In the city of Chennai, urban authorities have made it mandatory under the city's building regulations for all new buildings to have water harvesting mechanisms primarily to recharge the groundwater aquifers. In Bonn, a fiscal incentive is provided to households through a municipal tax that forces households to pay for runoff producing areas like paved areas and the roof area, unless they unpave the paved areas or collect the rainwater from rooftops and paved areas for domestic use. The primary objective in Bonn is to reduce urban flooding and overloading of sewage treatment plants and to increase groundwater recharge locally. Sumida city, a ward of Tokyo, provides a subsidy to all households interested in developing water harvesting systems. The main objective here is to promote the use of rainwater for low quality household uses, for drinking in emergency situations and to reduce urban flooding. If any subsidies are provided to promote urban water harvesting, it must be ensured that only the poor and lower middle classes benefit from them.

Water conservation and demand management

All these efforts show that we can never overemphasise the fact that water conservation and demand management are just as important as efforts to augment water supplies and this brings out the critical importance of water pricing and other fiscal incentives.

THE POTENTIAL

Rural potential

Water harvesting should be combined with village ecosystem management or watershed development as an important strategy. This will alleviate scarcity in the short run, sustain the growth of income and employment from rainfed agriculture and reclaim degraded lands in the long run.

Given the synergy that exists between population density and rainfall levels, there is really no village in India and in many parts of the developing world that cannot meet its drinking and cooking water needs through water harvesting. In areas which have less rainfall, population density is usually low and land availability for water harvesting is high. In areas which have high rainfall, population density is high and thus land requirement for water harvesting is low. In such villages efforts can be made to promote rooftop water harvesting.

Urban potential

In urban areas too, rooftop water harvesting has an enormous potential to reduce the demand on river and groundwater systems, many of which are getting increasingly overexploited and polluted.

Mass movement potential

The best thing about water harvesting is that households and communities can get involved in increasing and managing their water supply. Thus, water harvesting has the potential to become a mass movement. Individuals and local NGOs can easily take up the work of increasing awareness, educating people and mobilising local action. The aim is that community self-reliance is increased while dependence on the state is reduced.

Human security

Water harvesting can play a significant role in providing water security and since water is wealth, it can thus provide food and livelihood security.

THE AGENDA FOR ACTION

For the new water management paradigm to take roots, state agencies and international development agencies should work together with institutions of the civil society to promote:

Water literacy

A national campaign for water literacy is required to spread the message that water is a very precious natural resource, with a value system that makes water everybody's business, and which inspires people by disseminating information about success stories. The campaign should also make water professionals and policymakers aware of the social and ecological contexts, the realities of water management and the relationship between water use and total biomass production within a village ecosystem. The campaign must not only make people aware of what works but also make them conscious of the ecological and economic changes that pose a threat to future water availability in terms of quantity and its quality.

It is important to realise that investments in creating this water literacy are going to be critical for undertaking a major shift in the water management paradigm and for success in moving towards a nationwide programme for people-managed water supply systems. Without mass consciousness and people's cooperation, crores of rupees can be spent on projects without adequate results. Everyone needs to comprehend the role of water in improving the quality of life.

Water harvesting is already a component of government watershed development and rural drinking water supply programmes. However, there is a need to increase the awareness and understanding of the potential of water harvesting among officials dealing with rural and urban development on a nationwide basis, and to strengthen the water harvesting component in rural and urban development programmes.

Communication channels between engineers and environmentalists need to be improved and strengthened to obtain better results.

It is equally important to educate political leaders and officials about the potential of community and household-based water harvesting. They are generally of the view that only large water supply projects are necessary.

Given the new and welcome emphasis on local institutions, following the 73rd and 74th Amendments to the Indian Constitution, it is important to educate village and urban leaders in the country also about the importance of water harvesting.

Water harvesting should be included in the curricula of schools, colleges and universities. It should be made a compulsory subject for engineers and town planners. Mass awareness should be created by the media, by NGOs and the government. The electronic media, especially of the government, should provide free time for such messages.

National and state awards should be given to persons and communities in recognition for their outstanding efforts.

Social mobilisation

A process of social mobilisation is needed to involve and encourage communities and households to undertake water management to meet their water needs.

This process will demand a fresh look at the role of the government, institutional and financial mechanisms, legal rights and technical needs.

The government must not see itself in the role of a constructor of water projects, their maintainer or a distributor of water. It should play the part of a social facilitator/mobiliser. This means that the government must be prepared to hand over several powers to local actors and in doing so, it must not be niggardly. In other words, it must not tie the community in knots by giving it limited powers, while retaining most of them with itself. The government needs to delineate water rights on an equitable basis through community organisation for socio-economic development of the poor. Further, at the local level, NGOs should act as social mobilisers and encourage the communities to undertake water harvesting activities.

The government should also be prepared to provide free access to water-related information available with its various agencies, including access to information about the government's own programmes which are being planned.

The state should work towards creating an enabling environment in which community institutions can function. It means both dismantling restrictive laws and regulations, and enunciating a framework of general principles to serve as guidelines for community institutions. It has to take the responsibility to define both the principles and mechanisms by which intra- and inter-community disputes can be resolved through mutual negotiations and other informal methods. This also requires the state to ensure that these processes are institutionalised and insulated from external influences.

The state should provide the necessary technical and financial support without creating overdependence on its various agencies.

Financial assistance

The government should come forward to provide financial assistance to communities and households in addition to their contribution. Everybody has something to contribute. The rich have money to pay and the poor have labour to contribute, though the landless and the very poor will have to be provided wages to build water harvesting structures. People must be urged to save and contribute money and labour for maintenance. As much as possible, people must be allowed to undertake construction themselves; at the least they must be involved in the supervision of the construction. The people must be involved in the decision on what to construct. It is equally vital that people must know what money has been given to their community and for what purpose.

All these are ingredients of a system of incentives meant to encourage community institutions to function effectively and take decisions.

Priority regions

The priority regions for water harvesting should be areas those which have a high intensity of land degradation and low productivity of rainfed agriculture. Water harvesting should be taken up together with measures for good land and biomass management.

Water harvesting should be taken up on a priority basis in all regions where groundwater is the main source of drinking water but is saline or contaminated by industrial waste. Water harvesting for groundwater recharge could also be considered in such areas to reduce the concentration of groundwater contaminants. Such an approach would lead to greater investments in the village community itself and in improving its standard of living, rather than investments in high technology devices which later lie unused in construction projects. An appropriate selection of technology is required that incorporates local features and its economics. Rooftop water harvesting programmes in such areas will not just provide clean drinking water, but, depending on the need, such programmes could also help to invest in improvements in rural housing. These programmes assume great importance as most poor households have thatched roofs. Rural housing programmes should also include a component of rooftop water harvesting where necessary.

Water harvesting should also be given priority in towns and settlements dependent on drinking water from lakes which are getting increasingly polluted.

Urban water harvesting

In order to promote water harvesting in urban buildings, development byelaws need to be suitably formulated or modified. The following steps need to be taken:

- Every urban area should have a master plan, wherein water catchment areas are clearly demarcated and should be left undisturbed. Municipal corporations should demarcate such land and utilise them as water catchment areas. These catchments can be used for afforestation by the forest department or can be transferred to the forest department as an urban sanctuary, so that its landuse cannot be changed without government approval.
- Prior clearance before land acquisition to ensure that water catchment areas are not disturbed.
- A single water authority or local body, as the case may be, should be vested with the control and regulation of all waterbodies including rivers/canals/waterways/groundwater aquifers in urban areas.
- Town planners/local authorities should provide for surface water percolation along roads, pavements and other open spaces.
- All building plans must provide for water harvesting structures (WH) before applications are accepted, though provisions for exemptions should exist for those who cannot build water harvesting structures for genuine reasons like lack of space. A beginning can be made with statutory provisions for public buildings and large structures and making water audits essential.
- Provision of WH systems in plans should be followed up by enforcement at the time of grant of water and/or sewer connections/assessment of property tax, etc.
- Builders and planners should be given clear technical guidelines on precautions to be observed in providing WH systems so that there is no contamination with septic tanks. The local authority in charge of water supply should be responsible for the maintenance of rivers and other waterbodies with the specific aim to use them for water storage through WH systems. More efforts are needed to simplify approval procedures to reduce the overload on the existing administration.
- Master plans for rainwater collection and use for all urban centres should be made a prerequisite for

meeting eligibility requirements of funding agencies like Housing and Urban Development Corporation (HUDCO), the World Bank and others.

- The misuse of waterbodies and waterways through sewage discharges should be restricted with provisions made for interceptory sewers and canals along waterways. This is an expensive proposition but can be taken up in a phased manner. At the same time, no new housing/commercial/industrial/construction activity by private or government agencies, should be allowed till a proper sewer system is laid and commissioned.
- A large number of urban local authorities are both water- and cash-starved. A WH fund can be promoted by the government in the form of loans or grants.
- WH systems should be promoted as a means of both providing water and preventing floods so that the message and the need is permanent.
- Individual and community participation can be encouraged by offering subsidies, rebates or a progressive water tariff.
- A central nodal agency should provide technical and engineering advice on structures and systems to be used particularly in urban areas where the availability of non-paved areas is increasingly getting limited.
- Industrial houses should be encouraged, through incentives as well as town planning requirements, to provide for water harvesting on their premises and to maintain at least one WH community structure in an urban area.
- It should be made mandatory for airports to utilise the runoff water on their land to recharge groundwater and meet their requirements. Similarly, all highways and roads should construct structures to collect rainwater in order to sustain green strips on both sides.

Protection of waterbodies

It is not just important to promote water harvesting projects. It is equally important to protect and revive, to their full potential, existing water harvesting structures in both urban and rural India. The traditional water harvesting systems need to be respected as they are simple and sustainable and farmers execute them with little assistance. Given India's traditions in water harvesting, these structures constitute a rich heritage which, despite their dilapidated condition, continue to play an important ecological and economic role in the local environment. Citizen groups, who are trying to protect these urban water harvesting structures from further erosion and prevent the degradation of their catchment areas, need to be fully supported. Urban waterbodies are under severe pressure from polluting activities in their watersheds and encroachment by construction lobbies. Full costs need to be recovered from offenders. Many cities, which once had numerous water harvesting structures, have hardly any left today.

There is a need to develop a data bank on the environmental status of both urban and rural watersheds. Moreover, the waterspread area of both urban and rural waterbodies should be identified on the ground and demarcated on maps. Outside this periphery, a buffer zone of 200 metres width around a waterbody, especially in the upstream areas, should be delineated as a 'no construction zone'. All land within this 'no construction zone' could be acquired and handed over to the forest department. While waterbodies can be identified for private and government ownership, monitoring of water quality (especially in urban areas) should be entrusted to independent, competent bodies or universities to ensure proper maintenance of the waterbody and credibility of the water quality reports.

Fiscal incentives and regulatory mechanisms

There is clearly a need to study the possibility and feasibility of various fiscal incentives and regulatory mechanisms for promotion of water harvesting. Without appropriate pricing of water and electricity, households and institutions will have little economic interest to meet a significant part of their water needs through local water harvesting, and, thus, reduce the pressure on municipal water supply systems. The efforts made by Frankfurt Airport managers to meet a large part of their water needs is a case in point. The system set in place was able to save them unnecessary expenses.

There should be differential pricing of water for industry, domestic use, irrigation and landless communities. This will require research, for example, on how the water should be priced. For effective utilisation of water resources, research is also needed on pricing and legal rights of water while respecting social equity.

One option is for government agencies to concentrate on the provision of clean water supply for drinking and cooking, leaving households and communities to develop their own water harvesting structures to meet other lower quality water uses. The project can be supported with appropriate fiscal incentives. Currently in urban areas, all household activities utilise potable water, regardless of its use. In Rajasthan, while the traditional *kundis* met potable water supply, tanks and other structures met other household needs.

Another option is to provide a certain minimum level of potable water at low prices which can be used for drinking and cooking while the price of the remaining water use by households can be sufficiently increased to discourage indiscriminate use and wastage.

In rural areas, water pricing should be left to user committees and *panchayati raj* institutions to decide and implement.

Legal empowerment

Several states have legal provisions that prevent rural and urban communities from undertaking water harvesting activities. There is a need to study and document these legal provisions and replace them with provisions that support community and household efforts for water harvesting. There is an equally pressing need to develop and/or strengthen legal provisions that help to prevent destruction of existing water harvesting structures.

Institutional mechanisms

There is a clear need to think about the institutional mechanisms that are needed to promote water harvesting at all the following levels of Indian society:

- User level;
- village level;
- urban *mohalla* level;
- district level;
- municipality level;
- state level; and,
- central level;

Each level should have a clear and defined role which helps to strengthen the role of other levels.

The 73rd and 74th amendments to the Constitution need to be implemented effectively. State governments should constitute committees stipulated in the 74th amendment even though there is political opposition to their formation.

For the kind of integrated development mentioned above, it is necessary that the Centre and the states recognise and accept the need to rationalise planning and administration under a unified authority at central, state and local levels. This authority should have representatives from the civil society, members of *panchayats* and urban institutions, and officials from relevant ministries, such as those dealing with planning, urban development, rural development, health and environment. This authority should function under the prime minister at the Central level, the chief minister at the state level and the *zilla parishad* chairperson at the district level.

The purpose of these authorities should not only be to promote water harvesting in different ecological regions of the country but also to promote efforts to protect existing water harvesting structures. There is no institution today which deals with the protection of these waterbodies. The National River Conservation Authority, for example, deals only with river pollution. These authorities could be empowered under the Environment Protection Act of the Central government to issue appropriate directives to relevant authorities for the protection of lakes and other urban waterbodies. Otherwise a separate National Urban Lake and Waterbody Authority should be created to protect urban tanks and various other waterbodies. The Environment Protection Act has provisions to protect waterbodies and the catchment areas from encroachment or any activity which would pollute, impair, disturb or destroy them. It is now vital that this law be applied effectively.

Legal support should be provided to the public to help fight cases where these bodies are being destroyed. An apex committee or arbitrator should be appointed for the rapid settlement of disputes relating to waterbodies. In each district, a tribunal should be constituted to deal with water-related cases.

Water harvesting and protection of waterbodies should become an important part of the country's water policy. The country's water policy should be evolved through a national-level public debate with the involvement of village communities, NGOs and all stakeholders concerned.

Scientific and technological research

It is necessary to promote scientific and technological research on water harvesting. Though our traditions have already given us an enormous wealth of technologies, there is a need to fuse them with modern knowledge and improve their efficiency. For example, techniques to improve runoff and reduce evaporation could greatly increase the efficiency of small-scale water harvesting structures. There is also a need to find cheap and effective water treatment technologies that can be used at the household and community level.

Following is a list of areas which need attention:

- Methods or models for quantification/evaluation of the effects of water harvesting and watershed projects. There is a need to involve universities for research in refining the design of water harvesting structures and determining their efficiency. Viable research and development (R&D) projects can be funded by agencies like National Bank for Agriculture and Rural Development (NABARD) and Council of People's Action and Rural Technology (CAPART).
- Artificial recharge of water harvesting from rooftop water or percolation ponds is being done without any quantification studies. There is need for R&D on the quantity and quality of water which is retrievable.
- Methods for assessing the cost-effectiveness of water harvesting structures.
- Inventories of existing and traditional water harvesting structures should be prepared and should form the basis for planning in a district. It is essential that scientists and technicians work with local artisans to gain knowledge.
- Optimal scale of watershed planning.
- Benchmark surveys of virgin watersheds.
- Effect of percolation tanks on command areas.

- Water balance models which are appropriate to Indian conditions.
- Research on how technological devices can be used to bring rainfall prediction information to the village level, and how that information can be effectively utilised.
- Model of water conservation in which an individual farmer can practice with the farm as the unit.
- Quantification of the amount of surface and groundwater endowment of a watershed/village/community.
- Watershed information systems should be developed. All the existing data required for water harvesting should be digitised and put in an information support system.
- There is a need to bridge the information gap between research community, scientists, NGOs, government agencies and others, by undertaking a water harvesting project in each agroclimatic zone and also in specific locations where groundwater is brackish or has high arsenic or fluoride content.
- Research institutes or NGOs intending to work on sustainable agriculture should adopt the mandate of holistic development of 500 hectares (ha) to 1,000 ha microwatersheds located and work for overall development of the area with inbuilt monitoring and data-building mechanisms with a view to achieving an increasing trend in overall biomass production.
- Technology should be developed for wastewater recycling that is cost-effective and environmentally safe. This will not only safeguard water sources but also reduce the problem of wastewater disposal.

Research on health effects

There is also a need to undertake research on the health effects of small water harvesting systems used for drinking purposes. While rainwater is initially chemically and microbiologically clean, it may not remain microbiologically clean during the storage phase. This concern is often used to criticise the concept of water harvesting. The role of preventive and social medicine should be actively encouraged. But the ecology of disease spread in contained, small water supply systems is not the same as in centralised, large water supply systems. Cholera, for example, is unlikely to assume epidemic proportions through contained, small water supply systems. Disease organisms contaminating contained water supply systems will normally already be circulating in the household and its members will already be exposed to them.

Groundwater recharge using urban runoff could lead to a slow buildup of heavy metals and persistent organic pollutants in the groundwater as they are important contaminants of urban soils. Dumping of wastes, particularly toxic wastes, is already a punishable act. In rural areas, it is necessary to study the impact of agricultural pollutants on water harvesting structures.

There is, therefore, an urgent need to assess the health effects of small, contained water supply systems and urban groundwater recharge so that unnecessary concerns do not militate against the concept of water harvesting. And where health concerns are valid, appropriate regulatory and/or technological solutions will have to be found through research programmes.

There is also a need to produce home kits for testing water quality.

Role of social science community

The social science community must be encouraged to study the economic and social dimensions of water harvesting systems, including the documentation of property rights, management practices, and their effect on the lifestyle and traditions of the people.

State governments should support the study and documentation of the traditional methods of water harvesting, their history, viability and associated religious beliefs. Inventories of existing and traditional water harvesting structures should be prepared and should form the basis for water resource planning for the district.

Research is needed on conflict resolution methods, institutionalisation of water management practices, how people manage their resources, the scientific basis, if any, of rituals and dictums associated with traditional water harvesting methods, and studies of the social impact of watershed projects.

It is also important for social scientists to study the success and failure of water harvesting projects and their economic viability, so that the management of these projects can gradually improve.

Wastewater management

Urban water management must go hand in hand with urban wastewater management, including appropriate water tariffs to encourage the use of treated wastewater, because these wastewaters can pollute the available water sources, including water harvesting tanks and rivers.

Ecoregional specificity

It must be emphasised that the water harvesting approach must be ecoregion specific**.** Technologies and management systems must be specific to the local environmental conditions and constraints.

Building a national movement

Even as we address a number of recommendations to the state and other agencies, it is most important for all of us, as academics or other members of the civil society, to remember that the paradigm change we want to pro-

mote in water management will only come about if we can work together and form a powerful network of people who want to learn from each other and support each other in both their individual and collective tasks and objectives. The key objectives of the network should be to raise awareness about the potential of water harvesting, advocate policy changes and research programmes that support household and community-based water harvesting, and provide 'strategic assistance' to the members of the network in the form of information about best practices and experience, legal experts, or technical expertise, financial sources and technological options. There is, therefore, a need to build a nationwide network of water harvesters with appropriate regional and international links.

The ultimate purpose of the network should be to build a mass movement for household and community-based water harvesting. ■

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Publications on water harvesting produced by the Centre for Science and Environment

Dying Wisdom: Rise, fall and potential of India's traditional water harvesting systems (edited by Anil Agarwal and Sunita Narain)

Published in 1997, this book provides a comprehensive overview of Indian water harvesting traditions. The book breaks up India into 15 ecological regions and provides a survey of the traditions in water technology and management systems in all these different ecoregions. It took about seven years to produce this book because of the extremely scattered character of the knowledge that existed in this field. The book made people to realise that the water harvesting paradigm is relevant even today. (Price: Rs 290 paperback; Rs 490 hardback)

Water Links

This is a directory which presents information about water harvesters and the work they are doing in different parts of India and abroad. First published in 1999, this publication is updated periodically. It keeps people informed about water harvesting activities and experiences in different regions. It is a platform in print that helps experts and activists to get in touch with each other. (Price: Rs 140)

A Water Harvesting Manual for Urban Areas: Case Studies from Delhi

Published in 2000, this manual is built out of CSE's experience in providing technical advice to schools, residential colonies, individual households and factories to implement rainwater harvesting in the urban context. It provides basic information on the need and potential of rainwater harvesting. (Price: Rs 90)

Drought? Try Capturing The Rain (by Anil Agarwal)

Published in 2000 this publication presents the potential of rainwater harvesting for drought-proofing India's villages. It urges members of parliament and state legislative assemblies to ensure that the governments take up rainwater harvesting on a large scale to improve local food security. There is enough rainwater in every village of India to meet its drinking water needs and leave enough water to meet critical needs of agriculture. This strategy would complement India's current water management and agricultural strategy which aims at ensuring national food security rather than local food security. Whereas local food security means that every single farm in India would try to have as high and stable agricultural production as possible, national food security aims at creating pockets of rich agricultural areas which then feed the rest of the country through various food distribution programmes. (Free)

Catch Water

This is a bimonthly interactive newsletter which provides information on various activities undertaken by water harvesters in India and abroad. It is published as part of CSE's activities as the central secretariat of the National Water Harvesters' Network. It covers campaigns, initiatives, technology, news, policy reports and book reviews. (Free)