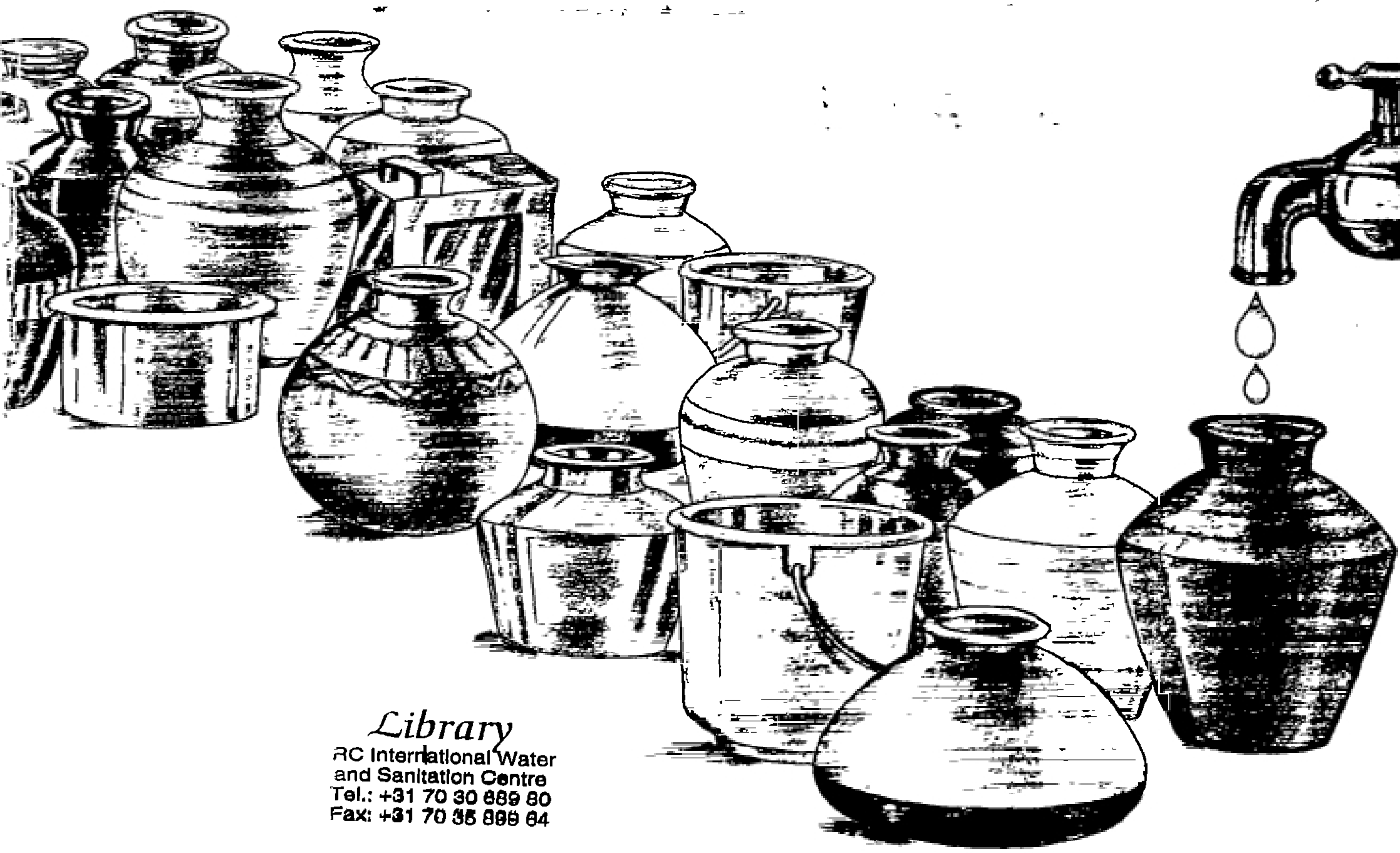
Fresh Water for India's Children and Nature



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WWF

FRESH WATER FOR INDIA'S CHILDREN AND NATURE
LEARNING FROM LOCAL-LEVEL APPROACHES

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A draft report based on local-level case studies prepared by:
Action for Agricultural Renewal in Maharashtra (AFARM)
Institute of Rural Management, Anand (IRMA)
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The views expressed in this synthesis report, in particular the interpretation of the case study findings and recommendations, are those of the authors and not necessarily of their respective institutions. Ashok Nigam is Policy Analyst, UNICEF, New York; Biksham Gujja is Head, Fresh Water Policy, WWF, Gland, Switzerland; Jayanta Bandyopadhyay was until recently Visiting Professor, International Academy for the Environment, Geneva; and Rupert Talbot is Chief, Water and Environmental Sanitation, UNICEF, New Delhi

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UNICEF-WWF PARTNERSHIP

These studies have been conducted in partnership between the United Nations Children's Fund (UNICEF) and the World Wide Fund for Nature (WWF). While addressing the basic needs of rural communities in India, UNICEF, with its concerns for children and women and their environment, concluded that environmental degradation and competition for fresh water resources was undermining the long-term sustainability of the country's ground water resources Children are among the first to suffer. Likewise, in addressing environmental degradation, WWF, which is primarily concerned with wildlife conservation and the promotion of sustainable use of natural resources, realized that unless people's basic needs are combined with the organization's work to protect nature and conserve biological diversity, the results will not be sustainable. Thus, a partnership between the two agencies, both of whom are concerned about the future – of children and nature – is only natural

The results are outlined in this synthesis report and in the individual detailed studies They provide insights into the local-level situation of the 'fresh water environment', trends and coping mechanisms that are being used by people to satisfy the basic needs of water for humans and animals. The future of children is linked to that of the environment Preserving that environment for children and nature is essential for meeting the concerns of both UNICEF and WWF.

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Preface

Water is perhaps the most precious asset on Earth. People in several parts of India face an immense challenge to meet the basic needs of water and protection of the natural environment. It is this challenge that has brought the United Nations Children's Fund and the World Wide Fund for Nature to join forces in India to conduct location-specific case studies to enhance our understanding of the fresh water scenario and engage others in a dialogue for action.

Water is a basic right. Access to adequate water supply is enshrined in the Convention on the Rights of the Child ratified by the Government of India. Management of water resources for biodiversity and fulfilment is a commitment made by governments including India, in Agenda 21 of the Earth Summit. India is no doubt making efforts to fulfill these commitments, but the progress is threatened as recent studies have shown.

Several million people in India still live under water scarcity and stress. Millions of women and children, particularly girls, still carry the immense burden of fetching water. Deforestation, soil erosion, water pollution, and lowering of watertables are undoubtedly the consequence of human actions. The studies have pointed to the inter-linking nature of the stress created by environmental degradation on women and children's health. The studies show how improvements in biodiversity can be made while meeting basic needs, and basic needs can be met only through environmental protection and enhancement.

The studies conducted by local institutions point to a set of actions which have been synthesized in this report. It is vital to create widespread awareness among the people on the need to preserve and protect the natural environment for both humans and animals. People must be involved in this enormous challenge. We hope that the recommendations contained in this report will contribute meaningfully in facing the fresh water challenges in India. UNICEF and WWF are pleased to have joined hands in this task for the good of India's children and nature.

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These studies have been conducted with the support of Gourisankar Ghosh, Kul Gautam, Jon Rohde and Jan Vandemoortele (UNICEF), and Claude Martin, Chris Hails and Samar Singh (WWF). Their encouragement has been the driving force in a lengthy process of designing and conducting them.

This synthesis report is based on local-level case studies carried out by five institutions in India: *Fresh Water Case Studies (1995-96) for Maharashtra Plateau Region,* Pune (1997), by Action for Agricultural Renewal in Maharashtra (AFARM); *Fresh Water Case Study in Garhwal Himalayas: Comparison and Analysis of Water and Women's Stress in Two Micro Areas (1997)* by J. Carr-Harris, A.S. Chawla, R Mohanty, A Singh, S. Mani, and S.T. Mammen, South-South Solidarity, New Delhi (1997); *Fresh Water Management in the Arid Region (Gujarat),* Institute for Rural Management, Anand (IRMA), Gujarat (1997), by R. Prabhakar, V. Vani, K. Tatu, and S. Patel; *Case Study of Gurrabbadu Watershed on the Management of Fresh Water,* Hyderabad (1997) by THINKSOFT, *Sustainable Fresh Water Supply for Madras City, India,* (1997), by Shri AMM Murugappa Chettiar Research Centre.

The authors of these studies along with their teams are the primary sources of the case study material. In particular, the findings in Chapter 3 of this report have been synthesized from these case studies.

The studies could not have been undertaken without the contribution of a number of persons. The authors of this synthesis report are particularly grateful to Claude Martin, Gourisankar Ghosh, Kul Gautam, Jorgen Randers, Samar Singh, Jon Rohde, Gordon Alexander, Henk van Norden, Jan Vandemoortele, Aung Chein, Vishwas Joshi, Paul Sochaczewski, Muriel Glasgow, J Gururaja, Hasan Moinuddin and Dipankar Gupta for their support and comments. Aung Chein was the focal person for the co-ordination of the studies, and David Stone provided editorial assistance on an earlier version of the report Our thanks and appreciation to all

The studies are an initial attempt to understand and develop effective responses to the water crisis facing India's children and nature They are by no means the first or the last word. Our hope is that they will contribute to the dialogue for action to meet the fresh water challenges facing India's children and nature.

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Acronyms/Abbreviations

AKRSP	Aga Khan Rural Support Programme
BCM	billion cubic meters
CRC	Convention on the Rights of the Child
GOI	Government of India
GWRDC	Gujarat Water Resources Development Corporation
ha	hectare
kharif	monsoon
kg	kilogramme
m^3	cubic metre
km^2	square kilometre
l	litre
lpcd	litres per capita per day
MCRC	Murugappa Chettiar Research Centre
Mld	million litres per day
MCM	million cubic metres
MMWSSB	Madras Metropolitan Water Supply and Sewage Board
ppm	parts per million
MSSRF	M. S. Swaminathan Research Foundation
NGO	non-governmental organization
ppm	parts per million
rabi	winter
Rs	Indian rupees
TDS	Total dissolved salts
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
VRTI	Shri Vivekanand Research and Training Institute
WWF	World Wide Fund For Nature

Rate of currency exchange. US$1=Rs 35

Executive Summary

A mammoth fresh water crisis awaits future generations of India's children and their natural environment. The crisis will not be due to the lack of fresh water as such, but the availability of adequate quality water at the right places and required times to meet basic needs. Many fresh water ecosystems are also fast degrading in quality and quantity The emerging global fresh water crisis is already visible in India, involving enormous social, political and environmental costs which are already affecting the economy and quality of life.

This crisis will undermine many of the successes achieved in securing the rights of children to enjoy the highest standards of health, provision of clean drinking water and environmental sanitation, and a safe natural environment. All these conditions are enshrined in the Convention on the Rights of the Child; commitments in Agenda 21 of the Rio Earth Summit, as well as in the attainment of economic and social prosperity of the country

In many parts of India, the fresh water crisis already exists, varying in scale and intensity at different times of the year There have been a number of predictions on water wars between neighbouring countries. But in India water already occupies centre stage in the economic and political agenda with plenty of reports in the media of disputes between and within states, districts, regions, and at the household level.

Nearly 44 million people are affected by water quality problems either due to pollution, or the prevalence of fluoride, and iron deposits, or due to the ingress of salt water or arsenic Millions do not have adequate quantity water, particularly during the summer months, and women and girls still have to walk long distances to fetch water The search for ground water progresses deeper and deeper and, in some instances, has led to tapping of fossil water

The fresh water crisis is not the result of natural factors such as drought, but has been caused by humans — by increased pollution of both surface and ground water, improper water resource management, and the shortcomings in the design and implementation of legislation and regulations which address these problems. The crisis has been accelerated in India by the increase in population and the aspirations of the people At the same time there is need for a better and wider understanding of the limits of the resource and for taking effective action to meet the challenges.

The objective of the studies in this document was to provide insights for policies and programmes on fresh water management in India through an analysis of the trends in water availability and its use at the local level The studies gathered primary data and information through participatory rural appraisals, surveys, testing of water quality and, in some cases, soil quality, and hydro-geological observations (soil and rock formation, ground water depths, precipitation, run-off and recharge of ground and surface water) over a one year cycle covering all seasons. The intention was to examine the water situation and approaches being used by people at the smallest level of habitation — villages in rural areas, and in urban areas, a large city — in five different ecological regions of the country, in order to achieve an assured supply of household water and utilize it for productive activities with related impacts on the ecosystem Data was gathered, for example, on the amount of water used for different types of crops and household use from all the sources available, as well as on alternatives available to the community The insights are used in this synthesis report to suggest a set of policy and programme recommendations aimed primarily at the state and national level, but with implications for the strategies and programmatic support provided by UNICEF and WWF in India .

These initial studies have intentionally not covered the cost and financing of alternative approaches and institutional issues in great detail in order to focus more on the dynamics of water availability and its use The studies also indicate that issues of social equity in the sharing of water resources are important These issues will be examined in subsequent extensions of the studies

The findings on the evolving fresh water situation in India suggest that there is not just one story but many different ones which provide both opportunities and challenges for action. Villages, such as Narsipur in Gujarat in a semi-arid region, have taken initiatives to secure their domestic water supply through the construction of a mini-piped water scheme. This has ensured adequate water for domestic purposes in spite of the pressure from cash cropping Though the community has responded by adopting a higher level of technology for domestic water supply, yet the increasing decline in the ground watertable due to increase in cash cropping will most likely lead to long-term difficulties in meeting basic needs Water consumption for domestic use in this village is as low as 2 per cent of the total ground water extracted, but this small amount too is threatened primarily by the uncontrolled use of water for irrigation of cash crops.

Another village, Pathoda, is in the 'dark zone', with a projected net extraction in five years being in excess of 85 per cent of the ground water resources utilizable for irrigation. The village is extracting 48 per cent more water from the ground than is being replenished from natural re-charge. Its hydro-geological situation is not suitable for cash cropping, but increasingly, it is moving into those crops because of the remunerative prices. Villages which currently do not themselves have a water problem because of their location atop an aquifer, such as Kubda, nevertheless impact on water quality and water availability further down the aquifer. If these regions do not manage the resource base, or if there is over-exploitation of ground water, there will be serious consequences for water availability for domestic purposes for those living further down the aquifer

In the drought-prone region of Gurrabbadu, Andhra Pradesh, there is a possibility of doubling the amount of fresh water for agriculture. To achieve this requires promotion of water recharge structures through rehabilitation and desilting of *kuntas* (surface storage systems or tanks) which have been in disuse, and afforestation. But improved water resource management should not lead to cash cropping — there are ecological limits to the quantity of water available. Ensuring a priority status for domestic water will require protecting it from pollution, and construction of storage facilities for water structures and mini-piped water systems. In this region, the cost of water in terms of the time women take to fetch it is ten times the cost of water delivered in cities.

The four villages in Maharashtra face different problems: conjunctive use of water for agriculture and industry, both of which impact on water availability for domestic purposes in Sanaswadi, with industry now occupying 50 per cent of the village, water deficit, even for drinking, in Adgaon as a result of sugarcane production in adjoining villages, water shortage in Lohom with little possibilities for traditional water harvesting systems, and resort to privately owned wells for domestic water in Jogwada-Sos In three of these villages, water has to be brought by truck during the summer months. Even so, a large number of women, as much as three-fourths of all the women in one village, have to travel long distances to fetch water since the water transported is not sufficient for the needs of the village The conflicts arising because of the conjunctive uses of water cannot be resolved simply at the village level

Danda and Chandrabhaga in Garhwal, Uttar Pradesh, have plenty of water, but Danda still suffers from severe water shortages in some months, and water quality is

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affected by faecal pollution The community has more water than it needs, but forest degradation and soil erosion are chiefly responsible for its inability to store water. Water stress contributes to many hardships for women in this region Because of the low availability of water, vegetation growth is low, which means there is less green fodder This, in turn, lowers the production of both *gobar* (cow dung) used for fuel and manure, and milk. Lower production of *gobar* reduces agricultural yields. Low agricultural yields affect food availability and nutrition of women There is, therefore, a vicious circle of water and ecological degradation impacting on the health of women causing 'eco-stress'. Low-cost community based solutions are available such as community management of the piped water supply scheme, protecting the forests and springs, and promotion of other low-cost technologies

The Chennai [Madras] basin theoretically receives sufficient rainfall to meet its needs. But two-thirds of the water is lost either through evapo-transpiration, or is not available because it is widely dispersed. Over 65-70 per cent of the water supply in Chennai is from ground water Despite this heavy dependence on it, there is inadequate effort to maintain this resource base Instead, the approach is to bring water from as far as 600 km from the city by pipeline. The efficiency of this method as well as its wetland environmental impact must be considered. Other measures consist of diverting water from nearby paddy fields to the city Despite adopting expensive high-cost approaches, there is no assurance that the water supply will be adequate for Chennai, even if projected supplies can be provided

The costs and benefits of a number of alternative approaches for Chennai such as recharging ground water through structures such as temple tanks, cleaning of waterways, adoption of low-cost rain water harvesting and storage systems, and water treatment of ground water at the domestic level have been examined The study suggests that some of these actions can be achieved at low cost while at the same time protecting the environment. These actions must be accompanied by sewage and waste disposal in an environmentally friendly manner, control of pollution, and removal of stagnant water bodies, water conservation and water reuse.

The studies show the close linkages between household water security, food security and environmental restoration Regeneration of traditional water sources and forest protection which benefits animals and birds at the same time improves water availability and water quality for humans When natural watersheds are protected for these purposes they are also being protected for children and vice versa. The common thread in the preservation of bio-diversity and meeting people's basic needs is water The examples of Rayalseema and Garhwal testify to this, but the situation is the same in other regions of the country.

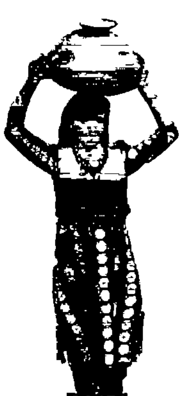
Water use and water regeneration has to be integrated effectively as was done in many traditional technologies. For example, renovation of forest tanks in a drought prone region such as Rayalseema will have a significant impact on the wildlife and forest cover. Similarly, renovation of temple tanks and effective water management with the regeneration and protection of ground water aquifers from pollution in the Chennai basin will contribute to other aspects of environmental protection such as reduction of salt water ingress The eco-stress in Garhwal is directly linked to the forest cover and degradation of soil. Water and soil is also being impacted by pollution from industry and agro-chemicals in Sanaswadi.

Women and girls still carry the bulk of the burden in providing water for households in rural areas With increasing opportunities for women to engage in productive employment activities, the opportunity cost of their time increasingly carries monetary value. In many instances, if this is included in the decision-making criteria of the choice of technology and strategies for household water security, it will be found that in the rural areas women and girls are paying far more for water supply than in urban areas, and would be willing to translate these costs into improved levels of services.

The National Water Policy (1987) clearly states that water is a prime natural resource, a basic human need and a precious national asset It gives primacy to drinking water for both humans and animals over its other uses

The policy also calls for controls on the exploitation of ground water through regulations and an integrated and coordinated development of surface and ground water. The Technology Mission on drinking water has also as far back as 1987 identified strategies for the short and long term for meeting drinking water needs and micro-watershed management, including conducting a number of pilot projects in a number of different types of regions in the country In short, a number of essential ingredients for water resource management have been examined in India, yet the country is faced with a water crisis. There are no easy solutions to the fresh water crisis in India. The root causes of the crisis are

- The system of 'water rights' under common law in India which has 'grandfathered' the ownership of water beneath one's land to the owner of the land despite the fact that ground water is a shared resource from common pool aquifers
- Uncontrolled use of the borewell technology which has allowed ground water extraction at phenomenal rates – far greater than the recharge possibilities – for the purposes of irrigation and growing of cash crops in water scarce regions. Subsidized electricity has been a major contributor to the uncontrolled extraction of ground water for irrigation Even water abundant regions are becoming water-scarce.
- Inadequate attention to: water conservation, water reuse, prevention of water pollution, efficiency in domestic water supply in urban areas, and ecosystem sustainability Watershed approaches do not adequately take account of the role of natural ecosystems — wetlands, rivers and traditional systems such as small tanks — in the regeneration of the fresh water resource. These must be integral to meeting the fresh water demands
- People are not in control of their water environment. Water is used as a political tool, controlled and cornered by the rich, who do not pay the price for this scarce resource.



The poverty of incomes, capabilities and opportunities of many is compounded by 'water poverty'. The challenge is to address 'water poverty' along with the improvement of the ecosystems

In the following recommendations, synthesized from the case studies (pitched primarily at the state and national level, but with implications for the strategies of UNICEF and WWF in India), the village or eco-region from whose experiences they are derived is indicated in each case The underlying strategy in the recommendations is to not only decentralize the management and regulation of water resources to the communities through institutions such as the Panchayat Raj, but to also provide them with the authority, responsibility and financial support to manage the water environment, and implement legislation for the protection of ground water resources.

Community awareness and management of fresh water resources should be enhanced

The awareness of communities of their fresh water situation should be enhanced through a more scientific approach to provide them the proper and required information and knowledge which will add to their practical understanding of the problems and possible responses (all study areas).

Communities should be vested with the authority, responsibility and accountability to be the caretakers and managers of their fresh water environment and empowered to take necessary actions Domestic water supply in rural areas should be owned and managed by the communities (Narsipur, Danda, Chandrabagha, Gurrabbadu, Jogwada-Sos)

It should not be assumed that homogeneous communities exist and that they are the only custodians of their immediate environment. Different interest groups and conflicting property interests suggest that in practice defining what constitutes a community is complex (Adgaon, Sanaswadi, Gurrabbadu, Danda, Kubda) The following actions are recommended for community management of the water environment in the Indian context.

- identify groups/communities and bring people together for management of their water environment through the Panchayat Raj institutions — Gram Panchayat, Pani Panchayat, or a municipal committee (Narsipur, Kheda, Pathoda, Gurrabbadu, Adgaon),
- give these groups/communities the responsibility, authority and accountability to manage their immediate water environment (Danda, Chandrabagha, Narsipur, Pathoda, Gurrabbadu, Adgaon, Sanaswadi),
- support communities to enter into contracts with each

other and develop public-private partnerships to share ground water resources giving primacy to drinking water, but within defined legal bounds and ecological and environmental standards (Gurrabbadu, Narsipur, Pathoda, Adgaon, Sanaswadi),

- build and support the capacity of communities to develop, design and implement alternative traditional water harvesting systems for domestic water supply (Gurrabbadu, Narsipur, Pathoda, Danda);
- promote ongoing monitoring, assessment and analysis of the fresh water situation through community participation (Pathoda, Danda, Chandrabagha, Gurrabbadu).

Only if communities are aware and participate in managing their water environment will they be able to protect it

Financial and capacity building support should be provided to communities to help them assess their fresh water situation, adopt alternate technologies, develop public-private partnerships, and enter into contractual arrangements among themselves within defined legal bounds and ecological and environmental standards. They should be empowered to enter into agreements with each other, backed by legislation, to ensure that domestic water supply is protected This includes the collection and management of any revenues raised at the local level (Narsipur, Pathoda, Kubda, Gurrabbadu, Danda, Chandrabagha, Adgaon, Sanaswadi)

There should be a technological re-orientation of water supply programmes and defining basic levels of services.

For eco-specific regions, affordable technological options such as recharging aquifers through tanks, rainwater harvesting, rehabilitation of traditional sources of water supply such as *kuntas* and bunds, check dams, afforestation, and the building of water storage facilities where, technically feasible and sustainable by the communities should be more actively supported by the government and external support agencies (Narsipur, Pathoda, Danda, Chandrabagha, Gurrabbadu, Chennai).

In the absence of effective legislative protection for ground water for domestic purposes, in some water stressed eco-regions construction of mini-piped water schemes with storage facilities or larger storage reservoirs will be needed, but with community level management and cost-recovery. This approach is needed to protect domestic water supply from competition from agriculture and industry, and ensure that adequate quality water is available throughout the year (Gurrabbadu, Pathoda, Adgaon, Lohom, Sanaswadi)

Basic levels of services in rural water supply should be defined in relation to adequate quantities of quality water that should be available for domestic purposes to households *throughout the year* at a reasonable distance rather than by the low-cost technology of a handpump This criterion should be used to define household water security

Alternative affordable financing mechanisms, including credit, will need to be examined in further studies and analyses to meet this basic level of service criterion (all study villages and Chennai)

Water quality should be a central consideration in designing and implementing programmes.

Ensuring adequate quality water for basic needs and ecosystem sustainability should be central to strategies for fresh water management In designing strategies and implementing programmes a long-term view should be taken on the implications for water quality Urgent measures are needed to address water pollution and environmental sanitation in both rural and urban areas (Pathoda, Sanaswadi, Danda, Chandrabhaga, Gurrabbadu, Chennai).

The government should implement effective ground water legislation and regulations through, *inter-alia*

self-regulation by communities and local-level institutions.

Ground water legislation and regulations should have the following components.

- control and/or regulation of water extraction in identified areas based on micro level analysis of underlying reasons for water scarcity and *defined standards* (Narsipur, Pathoda, Kubda, Adgaon, Sanaswadi),
- controlling types of crops grown in identified areas and economic incentives for dry-land cropping (Narsipur, Pathoda, Kubda, Gurrabbadu);
- mandatory construction of recharge structures in identified areas (Narsipur, Pathoda, Kubda, Gurrabbadu, Danda, Chennai),
- prohibition of withdrawal of water below certain depths for irrigation and industry (Narsipur, Pathoda, Gurrabbadu),
- provision for prevention of water logging and pollution (Adgaon, Lohom);
- devolving authority and responsibility to communities for management of water in its conjunctive uses and involving them in the implementation of legislation and regulations (all study villages)

Central to the success of legislation and regulations is the involvement of communities through local institutions in their design and implementation. Self-regulation by communities/ local institutions such as panchayats within defined legal bounds is likely to achieve greater success Previous efforts have failed because they have been top-down.

Water should be treated as an economic resource.

Treating water as an economic resource has two implications: it will ensure equity, and protection and conservation of fresh water ecosystems. As a scarce economic good, water has economic value and should carry a price as it already does in some instances (Narsipur, Pathoda, Kubda, Sanaswadi, Danda, Chandrabhaga, Gurrabbadu, Chennai).

But water as an economic resource also implies the need for national protection and equity in its allocation. While market forces may allocate water for agriculture and industry, the government has a role in ensuring equity and protection of water for domestic purposes and ecosystem sustainability Measures for water conservation, water reuse, and greater efficiency in water use for irrigation and in urban areas should also be promoted (all study villages and Chennai). Two specific actions are.

- *Water pricing should aid cost-recovery.* The cost of provision of water for its conjunctive uses, in particular for urban water supply and industry should be recovered Improving the efficiency of urban water supply through such measures as prevention of water loss, re-cycling and full cost-recovery should be implemented prior to alternative high-cost options for meeting urban demands. For urban water supply, alternate environmentally sustainable approaches for meeting water demands should be examined before water is transferred from long distances (Chennai) Pricing of water or, more appropriately, in the context of 'water rights' in India, water taxation in agricultural use, with revenue retention at the local level, should also be examined with the objective of protecting the resource base and the equitable distribution of both surface and ground water.

- *Water markets should be regulated.* Water markets have been suggested as one mechanism for water resource management in India Where such markets are promoted by the government for urban water supply (Chennai), and where they emerge in rural areas (Narsipur, Pathoda), they should be encouraged through community based actions (self-regulation) and government regulations where necessary and feasible, to ensure.
  - primacy for domestic water supply,
  - extraction rates which are commensurate with the rate of recharge either through natural or technological means; and
  - protection of the environment

External support agencies should support fresh water resource management.

Donor and multilateral agency support for rural and urban water supply should be placed within the wider context of water resource management and protection of the environment. Specific support, including pilot projects, should be provided by donors and multilateral agencies for local level analysis, assessment and implementation of sustainable actions. The case study approach adopted in these studies may be useful for other eco-regions and countries, and may be supported by donors and multilateral agencies as a catalyst to national efforts.

Environmental restoration should be promoted along with household water security.

The process for achieving both conservation and development should be pursued through a combination of approaches including reviving traditional techniques, but most importantly, supporting communities in this challenge Many of the recommendations above have a direct impact on environmental restoration. The case studies have shown that the 'right to water' for humans, and reduction of the work load of women and girls in getting food, fodder and firewood for the household can be met while at the same time preventing environmental degradation (Danda, Chandrabhaga, Gurrabbadu).

The emerging fresh water crisis should be addressed by re-designing conservation projects, watershed management and wetlands preservation. Similarly, the traditional water supply programmes should work for the regeneration of fresh water sources for their own longevity which will at the same time preserve bio-diversity The case studies suggest how the organic links between nature and human needs can be integrated not at the conceptual but at the operational and programmatic levels

Policy and programmatic implications cannot be developed without addressing ecosystem diversity and local issues. The key conclusion from these case studies is that specific strategies and approaches need to be adopted depending upon the local-level situation. The integration of the issues of fresh water balance (water availability and demand) – technology, institutions, legal, and socio-economic aspects at the local level – have to be reflected in the policies and programmes for water resource management

This report has concentrated on ground water since most of the study villages are almost exclusively dependent on it for household and irrigation needs, but it is recognized that issues related to surface water, in particular equity in any response mechanism to deal with ground water problems cannot be ignored. Conflicts over fresh water already exist at the local and regional level, but their resolution requires action at all levels, including legislation and institutional support *No single action, whether community based, legislation, techno-fix, including traditional water harvesting systems, or reliance on market forces will in itself alleviate the crisis in India.* A holistic approach and composite set of actions are needed.

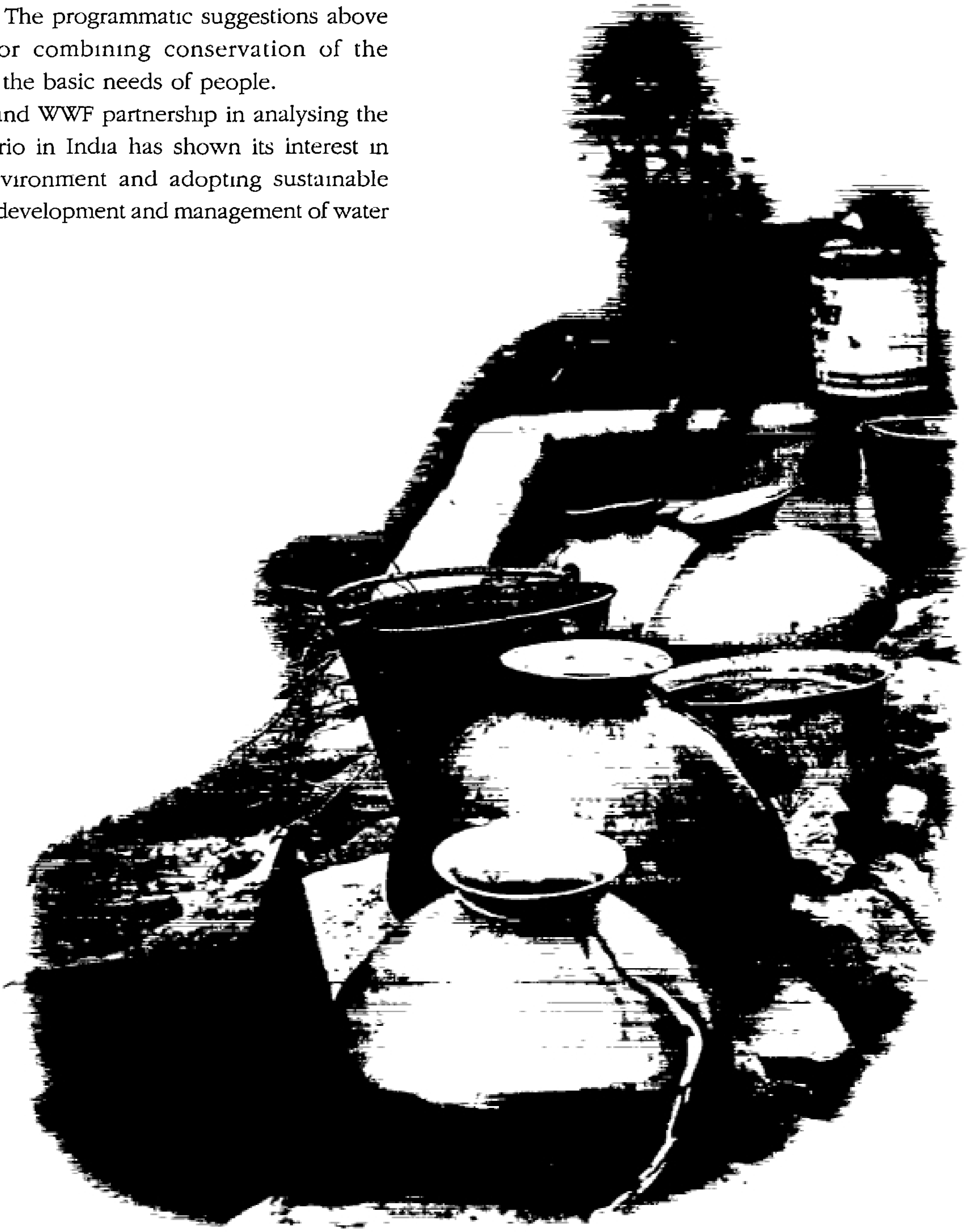
Programmatically, the recommendations for the two agencies suggest:

- Technical, financial and capacity building support to communities to manage their water environment, creating community awareness of the fresh water situation and advising measures to protect their environment, including those in the eco-regions covered in the present studies. Piloting projects of public-private partnerships, and contractual arrangements between communities to prioritize and share fresh water resources for domestic water supply and ecosystem needs
- Promotion of traditional water harvesting systems, afforestation in the catchment areas, regeneration of the resource base, and changes in agricultural practices in areas where they are appropriate and feasible.
- In regions with water stress and where the handpump technology is not able to ensure adequate quality domestic water throughout the year, advocacy and support for the construction of mini piped water supply schemes with community management. Various alternatives will need to be explored to finance such schemes, but on the principle of cost recovery
- Advocacy with the government at the national level for design and implementation of ground water legislation and regulations with the participation of local-level institutions
- Analysis and advocacy on water as an economic resource
- Continued assessment, analysis and actions of the local-level fresh water situation, including water quality, and working with the communities and government to address them with ecological sustainability. Undertaking further local-level studies to better understand the situation and address issues of cost and financing of alternative, institutional reforms, social equity and learning and building upon past experiences.
- Through analysis, actions, assessment, dialogue and

communications mobilize political will for policy changes in favour of integrated water management and environmental protection

The effective answer to the global fresh water crisis is to integrate conservation and development activities at the local level. Making communities aware and involving them fully is critical for success The case studies strengthen the dictum that what is good for nature is good for people. The programmatic suggestions above provide scope for combining conservation of the environment with the basic needs of people.

The UNICEF and WWF partnership in analysing the fresh water scenario in India has shown its interest in protecting the environment and adopting sustainable approaches in the development and management of water resources for future generations of children Children and nature go hand in hand — their futures cannot be separated, neither in the fresh water arena nor, for that matter, in other areas of the environment The plea for action must be taken up by the national and international community at large. The dialogue on the situation and policy response must be accompanied by action



Chapter 1

WATER FOR LIFE AND NATURE

1.1 INTRODUCTION

Water is life. This colourless, odourless and tasteless liquid is essential for all forms of growth and development – human, animal and plant. Water is a fundamental basic need for sustaining human economic activities. Not only does water support a wide range of activities, it also plays a central symbolic role in rituals throughout the world and is considered a divine gift by many religions

Providing water in the desired quantity and quality, and at the right time and place, has been a constant endeavour of all civilizations. No other natural resource has had such an overwhelming influence on human history. As the human population increases, as people express their desire for a better standard of living, and as economic activities continue to expand in scale and diversity, the demands on fresh water resources will continue to grow

While water is a renewable resource, its availability in space (at a specific location) and time (at different periods of the year) is limited, being largely determined by climatic, geographical and physical conditions, by affordable technological solutions which permit its exploitation, and by the efficiency with which water is conserved and used.

Though a renewable resource, water has limited availability in space and time as the demand for it grows

Much of the world's fresh water is consumed by the agricultural, industrial and domestic sectors Increasing water demands and the inadequacy of these sectors to effectively manage this resource, has meant that crises situations have arisen in many parts of the world – crises over the availability of adequate, quality water.

1.2 FRESH WATER: THE GLOBAL SCENARIO

Increasing knowledge of the ecological processes which constitute the global hydrological cycle has helped society to better understand the atmospheric and terrestrial movements of water, enabling people to improve and regulate its availability Such initiatives were initially guided by minor technical interventions, such as small-scale diversions, canals and shallow wells. In the past century, however, the level of technical interventions has greatly expanded, the result being that people are now

Pipelines help to move water long distance

capable of storing large volumes of water, of moving them over distances of hundreds of kilometres, and of using this resource several times before it is released back into the natural hydrological cycle. All of these features have resulted in a dramatic increase in the global consumption of fresh water over the past few centuries.

The limits of sustainable use in each climatic region are determined by local climate, hydrological and hydro geological conditions. In many parts of the world, the amount of water being consumed has exceeded the annual level of renewal, creating a non-sustainable situation. Many regions with scanty rainfall, particularly the Middle East, North Africa and Central Asia are already well advanced on the path to non-sustainable use of water resources. In other areas, particularly in industrialized countries, levels of utilization have already been so high that most possibilities to divert water away from the natural flow into storage facilities have been exhausted

Concerns

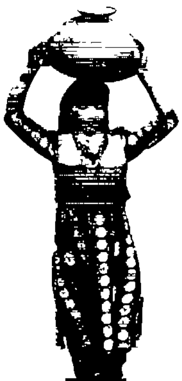
The situation regarding the status of drinking water supplies in particular, has caused a great deal of concern The United Nations, for example, declared the 1980s as the International Drinking Water Supply and Sanitation Decade. Other international declarations have also clearly recognized that access to water is a fundamental right of people (see, for example, the Montreal International Forum, 1990).

Fresh water lakes and rivers, which are the main sources of water consumed by people, contain an average of 90,000 cu km of water, or just 0.26 per cent of total global fresh water reserves (Shiklomanov 1993). This tiny fraction is distributed in a very uneven manner on Earth, creating a wide range of environments, from arid regions and deserts to humid areas which experience regular flooding In many parts of the world, the rainfall pattern is highly skewed and is characterized by small periods of intense precipitation followed by long, dry periods. Great disparities may even be seen on the same continent: about 20 per cent of the total global run-off flows in the Amazon River in South America, while the Atacama Desert has consistently received no annual rainfall.

Such variations become very important as human activities diversify geographically and in scale. In many water scarce parts of the world, human engineering initiatives have been geared towards balancing this spatial inequity In south-western USA, for example, engineering interventions in the form of extensive dams have already exhausted most possibilities for enhancing fresh water availability. In many other parts of the world, future options are becoming extremely complex and uncertain as the levels of total fresh water consumption approach the limits imposed by the annual renewal of fresh water resources

Increased availability, but exponential growth in utilization

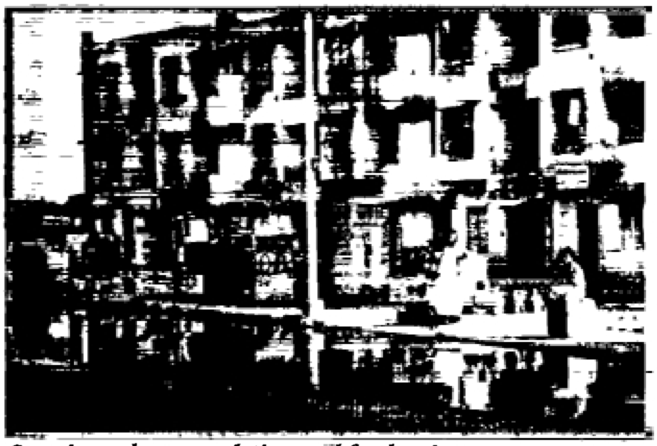
Advances in climatology and hydrology have contributed to improved, quantitative estimations of the processes which make up the global hydrological cycle. Though this knowledge has resulted in increased availability of water in some situations, an almost exponential growth in the level of utilization of this resource has balanced off the advantages so created In this way, in spite of advances made on the scientific front, human survival and well-being today are probably no less dependent on fresh water availability than in the early years of human civilization. Notwithstanding some impressive records in activities related to the UN Drinking Water and Sanitation Decade (WHO 1990), the provision of water at affordable cost and of acceptable quality is emerging as a major environmental challenge (Carman and Rangeley 1994) In particular, the close dependence of future food security on the availability of irrigation water, as well as growing awareness of water resources for conservation purposes has created widespread concern (Postel 1996).



Emerging situations

The emerging situation is one of water shortages, whether as a result of over-exploitation for limited, localized purposes, or because of inadequate and ill-informed management strategies. Past experience such as the situations in the Aral Sea or the Rhine basin, has established that water resources the world over are in urgent need of attention. Warning signals are there for all to see. About one-third of the world's population lives in countries experiencing moderate to high water stress Recently, the Committee on Natural Resources of the Economic and Social Council of the United Nations "noted with alarm that some 80 countries, comprising 40 per cent of the world's population, are already suffering from serious water shortages and that, in many cases, the scarcity of water resources has become the limiting factor to economic and social development" (United Nations 1997) The reasons given for this were greater demands on fresh water resources by burgeoning human populations, diminishing quality of water resources because of pollution, and the additional requirements of servicing spiralling industrial and agricultural growth.

In 1950, less than 100 cities had a population greater than one million. By 2025, it is expected that about 650



Growing urban population will further increase pressure on fresh water resource

About 80 countries, comprising 40 per cent of the world's population, already suffer from serious water shortages

cities will be in this situation. As urban populations grow, there will be greater demands for water, which may be supplied at the cost of irrigation needs, creating inter-sectoral conflicts In addition, pollution caused by increased human densities and irresponsible disposal of industrial wastes, has already started to reduce the limits of useable water resources

We are facing a global fresh water crisis with many regions where human demand is outstripping local water supplies There is, therefore, an immediate need to develop a better understanding of, and management system for fresh water resources to ensure the conservation and sustainable use of the world's water resources (see Falkenmark 1984)

There is immediate need for a better management system for fresh water resources

There is distinction between 'water scarcity', 'water shortage' and 'water stress' (Winpenney 1997a). Water scarcity is a relative concept intended to convey the imbalance between supply and demand under the prevailing legal, institutional, regulatory and, where applicable, price arrangements. Water shortage is an absolute concept indicating low levels of water supply relative to minimum levels necessary for basic needs. Water stress signifies acute water shortages for prolonged periods

In this respect, it is important to examine whether the emerging water scarcity in various parts of the world is absolute, needing drastic reductions in demand, or can be adequately addressed through new and holistic management strategies and restrained consumption patterns The need for a totally new perspective and the manner in which people use fresh water has been felt and the existing perceptions of engineers regarding water supplies has been questioned.

Biswas (1976) has stressed the need to adopt a systems approach to water management. Along with the various ecological linkages governing the flow of fresh water in the hydrological cycle, the need to understand the use of water in its many diverse roles and its economic implications is also being recognized, in particular in Delhi (1990) and Dublin (1992) (Box 1). The Earth Summit, Agenda 21, specifically calls for local and national level actions (Box 2).

Box 1. Delhi and Dublin Principles

Delhi "Some for all rather than more for some." Guiding principles:

- protection of environment and safeguarding of health through integrated management of water resources and liquid and solid waste;
- institutional reforms, integrated approach and full participation of women at all levels;
- community management and strengthening of local institutions in implementation,
- sound financial practices

Dublin: Emphasis on sustainability and the need to consider water as an economic good. Guiding principles:

- fresh water is a finite and vulnerable resource essential to sustain life, development and the environment;
- water development and management should be based on a participatory approach involving users, planners and policymakers at all levels;
- women play a central part in the provision, management and safeguarding of water;
- water has an economic value in all its competing uses and should be recognized as an economic good.

Source Global Consultation on Safe Water and Sanitation for the 1990s, Delhi, and International Conference on Water and the Environment, Dublin, 1992.

Box 2. Earth Summit, Agenda 21

- "At the lowest appropriate level, delegation of water resources management, generally, to that level, in accordance with national legislation, including decentralization of government services to local authorities, private enterprises and communities.
- At the national level, integrated water resources planning and management ....establishment of independent regulation and monitoring of freshwater, based on national legislation and economic measures.

Source. United Nations (1992), p 168

A more detailed analysis of the global water scenario is not possible within the constraints of this report There is, however, extensive literature on this subject Gleick (1993), Serageldin (1995) and Biswas (1992) are among many sources which describe and analyse water concerns at the global level. Such information can act as an important backdrop for examining the water resource situations at the level of individual regions or countries Strategies for managing water resources, however, are often made within the contexts of individual nations and, increasingly, within river basins, and watersheds. With this in mind, the following discussion will focus on the water scenario in India, providing a practical base for the analysis and understanding of the observations made in the various case studies conducted through this project

1.3 Fresh Water: The Indian Scenario

In a country where the first measurement of rainfall was made by Kautilya as early as AD 1200, it is surprising that estimates of the total availability of water in India are only quite recent. Khosla (1949) estimated the total average annual run-off of all river systems in India to be 1,674 billion cubic metres (BCM)

The National Water Policy estimates that total precipitation in India is around 400 million hectare metres, while surface water availability is 178 million hectare metres, of which 50 per cent can be put to beneficial use In addition, ground water potential is about 42 million hectare metres (GOI 1987). The first estimates of ground water resources on a scientific basis was made in 1979 by the Central Ground Water Board. Recent estimates based on a state-wise assessment have put the annual replenishable ground water resources of the country at 453 BCM With a provision of 15 per cent, 69.8 BCM for drinking, industrial and other uses, the utilizable ground water resources for irrigation is computed as 383 BCM (GOI/CGWB 1995).

In India, per capita availability of fresh water will be halved between 1947 and 2000

Chitale (1992) puts the amount of available aggregate annual utilizable water in India, surface and ground, at about 1,100 BCM. Population growth is expected to result in a decline in the per capita availability of fresh water In 1947, this was measured at 5,150m^3. By the year 2000, it is likely to be 2,200m^3

Such aggregate figures, however, are quite misleading, since there is considerable spatial and temporal variation in rainfall. Some areas receive slight rainfall, whereas others experience monsoon conditions which often result in flooding, loss of life and increased poverty. To better understand such variations and their consequences on people's lives, it is necessary to examine specific situations at the village or community levels under different ecological situations

Attention must, however, also be given to fast-growing urban centres, where water requirements are expected to double from 25 BCM in 1990 to 52 BCM in 2025 (Chitale 1992). The situation concerning industrial supplies is even more difficult to analyse. Meinzen-Dick and Mendoza (1996) have indicated that industrial water demand would increase from 34 BCM in 1990 to 191 BCM by the year 2025. Agriculture, the largest consumer of water resources in India, will probably require 770 BCM by the year 2025 to support food demand (Chitale 1992) The total estimated demand of 1013 BCM by the year 2025 would be close to the current available annual utilizable water resource of India.

With predicted demands such as these, the supply of rural drinking water and requirements for ecosystems conservation are sure to face an uncertain future unless anticipatory policy measures are taken It is evident that the politically and economically powerful urban-industrial sectors would obtain the water resources they need by organizing long distance transfers from surrounding rural areas or even by inter-basin transfers In such a scenario, alternative solutions of conservation and sustainable management of fresh water resources will find little support (Postel 1996) In view of this, much of the debate in this report will focus on the requirements of rural drinking water and ecosystem conservation, while at the same time suggesting alternative approaches for meeting urban demands

Can rural drinking water supply sustain itself and the urban sector?

In some situations, the intensification of irrigation, supported by electric pumps, has meant that uptake of ground water has often crossed the limit imposed by natural levels of renewal In the case of Junagadh district, Gujarat, Shah (1992) has described the implications of ground water overdraft which is now a common and growing problem throughout the state Barot (1993) has described the emerging alternatives in providing drinking water in Gujarat, while a similar initiative by the people towards water conservation and ground water recharge in the Saurashtra region of the state has been examined by Sangvi (1994)

Harvesting rainwater, which is a traditional practice in the Indian lifestyle, has received some active promotion

Box 3. Dying Wisdo[m] harvesting systems, wa[ter] communities

Traditional water harvesting techniques have been severely eroded. Modern attempts to restore them must reckon with the causes of their deci[ine] ... gies have often been imported from the West without due regard to local specificities. Some conclusions and recommendations.

- There is nothing backward about the technology of traditional water harvesting systems. They are not merely relevant; they are necessary and, in some cases, even vital.
- Modern water management systems have failed to integrate water management with care for the catchment areas.
- Choice between traditional and modern water systems should take account of intangible benefits such as soil and water conservation
- A scheme of water rights should be incorporated into the Constitution after extensive debate and discussion. Individuals and households ought to have the right to harvest all the precipitation that falls over their property. But they should not have the right to take any water from underground aquifers without permission of the community, or from a stream or any body of surface water that depends on inflows from catchments beyond the limits of privately owned property.
- The local community, represented by an appropriate institution, should have absolute right on all rainwater that falls over common land, local aquifers and other public properties.

Source: Agarwal and Narain (1997)

Waterfalls in the hilly region are a natural water supply source

from the Government of India (GOI 1989) In the case of an arid region, Rathore (1991-1992) described how conservation of surface run-off in Rajasthan was practised through the system of community water tanks Applied technologies are described in Mishra (1993). A comprehensive description of traditional water harvesting systems and recommendations for action has recently been provided (Agarwal and Narain 1997)

Such situations should be compared with conditions in uplands and mountains where there is substantial precipitation Here, basic water needs have been traditionally satisfied through collection from natural springs. Thus, while there is no significant competition for water, increased population size, contamination of water sources and deforestation have led to environmental degradation and increased effort on the part of women and girls to carry water up the mountains.

Rainwater harvesting has been developed in arid or semi-arid regions. As Paul (1989) described, rainwater and dew have been successfully used as a source of water, even in the moist eastern Indian state of Assam. Sengupta (1993) provides an account of locally developed water harvesting systems and irrigation practices in diverse agro-climatic conditions in India. These technologies have generally supported human well-being and agricultural growth within

Indigenous systems have systematically been replaced

the limits of sustainability.

Indigenous systems of water harvesting, storage and distribution, which evolved with built-in conditions for sustainability, have systematically been replaced throughout the country, especially where population density has increased and there is a higher intensity of agriculture. At the same time, however, people are, at least in some places, responding to the issue of water resource degradation. Thus, the water supply scenario is a dynamic one, caused by both human-induced scarcity and the human initiatives taken to avoid the problem This is a very positive signal for India and, as Narayan (1995) pointed out, the success of rural water supply projects can become more successful only with strong local participation in decision-making and operation

During the 1970s, there was a marked departure from sustainable utilization of water resources. Food scarcities of the 1960s encouraged government policies towards increased irrigation. In this way, the users of drinking water and irrigation, which had until then been a singular entity, started to be separated. This shift affected the management of common water resources in basic ways (Dhillon 1987). One of the most visible changes was the manner in which upper catchments were managed, leading to a degradation of water resources in tanks, lakes and rivers It also led to ground water being extracted from greater depths, making the shallow hand-dug wells, which until then had provided drinking water, redundant The situation has been described by Bandyopadhyay (1989) as human induced water scarcity, normally mistaken as being the result of natural drought What made the situation even worse was increased pollution of both surface and ground water resources In this perspective, unless pre-emotive measures in terms of new regulatory and policy instruments are adopted, the water situation in India is certain to become chaotic.

1.4 National Water Supply And Demand

The changing socio-economic situation in India is leading towards higher levels of ground water exploitation. With the increasing availability of more sophisticated drilling and pumping technology, the search for ground water is bound to increase. The results of excessive ground water use is already showing — small streams, are drying up due to insufficient catchments even during the monsoon season, and in both rural and urban areas people are drilling deeper and deeper borewells. In other situations, a significant amount of rain might fall, but it is not possible to store it for domestic needs In the hills, deforestation and reduced ground cover results in very little rainwater percolating into the soil to feed the springs Soil erosion further reduces the capacity of the ground to retain water. Cheerapunji in eastern India, for example, may receive 10.5m of rainfall in the short monsoon period, but it suffers from water scarcity

In India ground water sources provide 80% of rural domestic water supply

India is heavily dependent on ground water sources. It is estimated that this source provides about 80 to 90 per cent of domestic water supply in rural areas, 50 per cent of the urban and industrial demand, and 50 per cent of the irrigated area through over 17 million energized wells. In drought years, ground water represents the primary reliable source for irrigation (World Bank/GOI 1997a & 1997b) However, domestic water needs account for only about 5 per cent of the total water extracted from the ground.

A dramatic increase in ground water extraction took place in India from 1951 to 1990. The number of dug wells increased from 3.86 million to 9 49 million, shallow tubewells from 3,000 to 4.75 million, and public tubewells from 2,400 to 63,600. The number of electric and diesel pumps also increased during this period, from 21,000 to 8.22 million and from 65,700 to 4.36 million, respectively, electric pumps becoming more common as a result of rural electrification. In gross terms, however, the current level of ground water use is 32 per cent, suggesting that there is still vast potential for its further development, but there are significant variations with a number of blocks in the country classified as 'dark areas' or 'over-exploited' – more than 85 and 100 per cent of ground water development, respectively (GOI/Central Ground Water Board 1995).

With the heavy dependence of the country on ground water, the government's strategy has been based on using the dynamic component of ground water (i e. the amount available in the zone of water-level fluctuation), and temporary use of the static component (i.e the amount available in the permeable portion of the aquifer) to cope

Box 4. National Water Policy (1987)

- Water is a prime natural resource, a basic human need and a precious national asset.
- Periodic scientific assessment of the ground water potential, taking into consideration the quality of water and economic viability;
- Exploitation of ground water resources should be regulated so as not to exceed recharging possibilities and to ensure social equity with ground water recharge projects formulated and implemented for augmenting the available supplies.
- Integrated and co-ordinated development of surface water and ground water and their conjunctive uses planned right from the start of a project;
- Avoidance of over exploitation of ground water near the coast to prevent ingress of sea water into sweet aquifers.
- Drinking water needs of human beings and animals should be the first charge of any available water.

Source: Government of India (1987).

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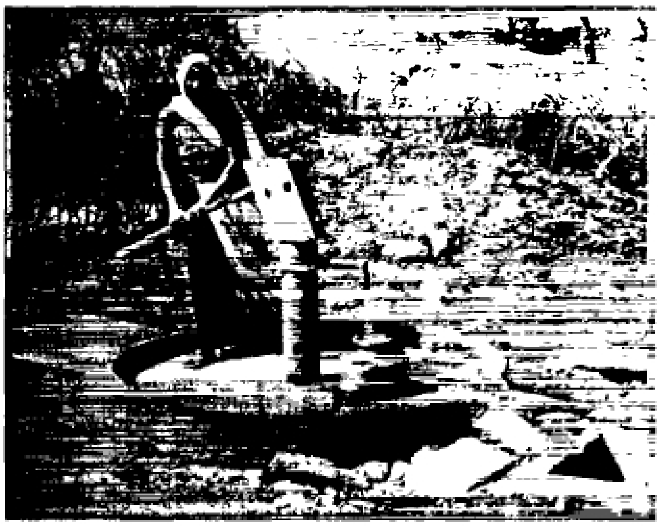
with drought situations[1] The National Water Policy (1987) sets out the framework for the implementation of this strategy (Box 4). Current legislation (common law) assigns property rights of surface (natural) water resources to the state, while rights to the extraction of ground water, which is the major source of drinking water in India, rest with those individuals who own the land above the aquifer. There is no limit on the quantity of ground water that a landowner can extract.

The water supply and sanitation sector, particularly in rural areas, has been given priority from the inception of the five year planning process in India In total, during the five year planning periods 1951-56 to 1992-97 Rs 336 billion or 3 3 per cent of the total government budget has been allocated to this sector, of which 60 per cent (Rs. 202 billion) was for rural areas. Government investment in rural water supplies and sanitation was Rs 143 billion up to 1996 From '1991 to 1995', total external support to the water supply and sanitation sector amounted to US$ 339 million or US $56.5 million per year which represents 2 per cent of total external disbursements in India. But it is also noted that the utilization rate of both multilateral and bilateral assistance in India is low; for example in 1992-1993 it was only 10 per cent of commitments (World Bank/GOI 1997b) Estimates of private investments are not available, but they are likely to far exceed that of the government if irrigation and domestic expenditures in water extractions are included

> ***Government investments for water and sanitation was Rs. 336 billion from 1951 to 1997***

1 *By March 1993, the Central Ground Water Board had established 15,947 National Hydrograph Network Stations which measure water levels four times a year in January, May, August, and November and collect water samples once a year in May Micro-level monitoring of water is carried out by various state ground water departments, through 30,000 network stations established for this purpose*

According to the Rajiv Gandhi National Drinking Water Mission (RGNDWM) a total of 520 million people have been provided access to public water supply since the launch of the first national water supply programme in 1954 During the period 1954-1955 to 1994-1995 it is estimated that 478 million rural people were covered with water supply. By 1994, 95 per cent of the rural population had access to a 'safe' source of water, with 52 per cent fully covered with 40 litres per capita per day (lpcd) or more, and 48 per cent partially covered with 10 to 40 lpcd Only about 5 per cent of the rural population were without access to safe water.



In terms of physical infrastructure, more than two million handpumps have been installed on drilled tube and borewells, 116,000 mini and regional piped schemes have been constructed supplying 1.5 million standposts and 4 3 million house connections Moreover, handpumps account for 95 per cent of the total number of publicly funded rural water supply schemes, serving almost 395 million people, or 75 per cent of the rural population.

A 1994 Government of India survey examined the status of handpumps It found that many schemes required repair (more than 33 per cent), or rehabilitation (22 per cent), or were completely defunct (12 per cent). In the case of piped water supply the situation was less serious with about 26 per cent requiring repair or rehabilitation Eighteen per cent of all standposts were found to be without taps (World Bank/GOI 1997b).

The RGNDWM Validation Survey has also reported significant problems with water quality. Approximately 82,000 habitations or about 44 million people are suffering from water quality problems as a result of excessive quantities of fluoride, iron, nitrate and arsenic or excessive salinity. The Ground Water Subgroup of the Water Resource Management Sector Study by the World Bank and Government of India reports that arsenic is a recognized problem in West Bengal (1,000 habitations or an approximate population of 500,000); fluoride levels are considered high in Andhra Pradesh, Gujarat, Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh (28,000 habitations or an approximate population of 14 million); high iron levels have been found in the north-east and eastern parts of the country (58,000 habitations or an approximate population of 29 million); and high salinity is prevalent in Gujarat, Haryana, Karnataka, Punjab, Rajasthan, and Tamil Nadu" (World Bank/GOI 1997b).

> ***Nearly 44 million people are affected by water quality problems such as excessive fluoride, iron, nitrates, salinity and arsenic***

With an area of 3,268,100 km², India has 33 meteorological sub-divisions. Almost one-third of the country — 99 districts in 13 states, covering 108 million hectares have been classified as drought-prone. As of March 1994, out of the 7024 Blocks, Mandals, Talukas and watersheds in the country, 537 Blocks and Mandals (102 Mandals in Andhra Pradesh, 32 in Haryana, 9 in Karnataka, 3 in Madhya Pradesh, 73 in Punjab, 68 in Rajasthan, 97 in Tamil Nadu, 65 in Uttar Pradesh, 2 in West Bengal), 45 Talukas in Gujarat, and 35 watersheds in Maharashtra were classified as 'dark' or critical where the projected net extraction in five years would be in excess of 85 per cent of the ground water resources utilizable for irrigation. Another 600 Blocks, Mandals, Talukas and watersheds are classified as 'grey' or 'semi-critical' with projected extractions in the 65-85 per cent range (GOI, Central Ground Water Board, 1995)

In response to the emerging problems of ground water, the RGNDWM has as far back as 1987 identified strategies for the short and long-term for meeting drinking water needs and micro-watershed management such as the conservation of water and recharging of ground water aquifers (Box 5), and a Model Bill has been proposed by the Central Government (Box 6).

Box 5. Technology Mission: Some approaches for the conservation of water and recharging of ground water aquifers

- collection of hydro geological and related data in problem areas;
- reconnaissance to verify the available data and to update micro level data base;
- chemical analysis of water for evaluating its suitability for drinking;
- construction of suitable structures for ground water exploration and periodical monitoring of their performance;
- designing and construction of suitable structures for rain water harvesting;
- artificial recharge of aquifers (wherever feasible);
- development and adoption of measures for reduction of evaporation losses from surface waterbodies;
- conservation of water through adoption of appropriate irrigation practices;
- identification of micro-watersheds in problem areas;
- assessment of hydro geological parameters of aquifers;
- estimation of recharge to ground water regime;
- assessment of total water potential in basins and micro-watersheds;
- scientific management of water resources using computerized mathematical modeling.

Source: Government of India (1987a)

Box 6. Key components of the Ground Water Model Bill

- Control and/or regulation of the extraction of ground water in any area deemed necessary and notified by a Ground Water Authority;
- Need to obtain a permit to extract and use ground water in the notified areas;
- Registration of existing and new users in the notified areas;
- Monitoring and enforcement of the controls and regulations by the Ground Water Authority.

Source: Government of India (1996)

In 1992, the Constitution Act (73rd Amendment) gave responsibility for drinking water and sanitation to the Panchyati Raj Institutions. The underlying rationale is that the public health engineering departments and Water Boards are centralized, monopolistic, overstaffed, and lacked accountability to users. The Gram Panchayats as the local-level tier are now expected to be responsible for choice of technology, recovering costs and operations, and maintenance of rural water supply and sanitation The assets would be owned by the community This process is, however, in a very early stage in most states, but Gram Panchayats are now almost entirely implementing development programmes that are handed down to them by the state and central governments However, because the governments continue to control the grants to the Panchayats, they continue to exercise control on the day-to-day functioning of the panchayats, and the state governments still continue to act as the providers of minimum coverage of free water supply in rural areas (Meenakshi Sunderam 1995, World Bank/GOI 1997b).

The broad picture of the demand and availability of fresh water has typically suggested certain generalized solutions such as the need for resource management rather than controlled resource extraction and improved environmental management in critical zones Alternative mechanisms for water allocation in such a complex situation have been studied by Meinzen-Dick and Mendoza (1996). Specific solutions have pointed to the promotion of water markets, reforming the tariff structure of electricity, prohibiting certain crops in water scarcity areas, creating legal and institutional frameworks, and re-orienting investments in the sector

The applicability of some suggested changes has often not taken into account the regional and ecological differences that prevail in the nature and assessment of the fresh water situation, including social and cultural factors. Policies and plans developed at the national level, and calculations of per capita fresh water needs based on national data have little meaning in a country of this size. The water issues in India must be analysed in a dynamic context — both over time and for specific locations

1.5 The Problem

The lives of women and children as well as the environment have been seriously threatened by water shortages in the country.

- As a result of excessive extraction of ground water, drinking water is not available during the critical summer months.
- 141,000 habitations or about 5 per cent of the rural population does not have access to regular safe drinking water and many more are threatened by less and less access to safe drinking water in the not so distant future Water shortages in cities and villages have led to large

> ***Shortage, pollution, unsuitability for drinking and irrigation purposes characterize the water crisis in India***

volumes of water being collected and transported over great distances by tankers and pipelines

- High levels of fluoride, arsenic and iron, lead to major environmental health problems and in the case of iron, people simply do not like to drink the water because of its smell.
- Ingress of sea water into coastal aquifers as a result of over-extraction of ground water has made water supplies more saline, unsuitable for drinking and irrigation
- Pollution of ground and surface waters from agro-chemicals (fertilizers and pesticides) and from industry poses a major environmental health hazard, with potentially significant costs to the country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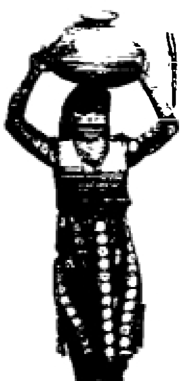
Pesticides being sprayed

- The World Bank has estimated that the total cost of environmental damage in India amounts to US$9.7 billion annually, or 4 5 per cent of the gross domestic product. Of this, 59 per cent results from the health impacts of water pollution (World Bank 1995)



- It has been recently estimated that by 2017 India will be 'water stressed' – per capita availability will decline to 1600 cu m. Cities generate 2000 crore litres of sewage but treat only 10 per cent of it. Poor drinking water and sanitation infrastructure will lead to high levels of water related diseases and death It is estimated that 60 per cent of irrigation water is wasted by seepage through unlined field channels and due to over-application (Tata Energy Research Institute 1997).

Evidence suggests that not only is there an emerging water crisis at the global scale, but that the crisis is already happening in many parts of India (World Bank 1995, Matzger and Moench 1994) Ground water is being over-exploited, surface water is utilized inefficiently, as is water used for irrigation and urban water supply, and water pollution is escalating at exponential rates, not least because of poor sanitation The poor in rural and urban areas, particularly women and children, continue to be hard hit by these emerging problems There is a fear that unless urgent measures are taken, present and future generations of children will have to bear immense health and economic costs. The government has recognized that there is a problem with availability of quality water (GOI, Rajiv Gandhi National Drinking Water Mission, Habitation Survey 1994).

India's National Water Policy recognizes the importance of providing safe drinking water to its people. It states. "Drinking water needs of human beings and animals should be the first charge on available resources " For children, specifically, this right is also enshrined in Article 24 of the Convention on the Rights of the Child (CRC) ratified by the Government of India It has been recommended that water be treated not as an 'economic good' but as an 'economic resource' which is essential for growth and development (Ghosh 1996) But many aspects of the National Water Policy, legislation and regulations and the rights of children under the CRC have not been implementable in the Indian context, because of a lack of political will and because water is used as a political tool.

> ***Water rights for children are enshrined in the CRC***

Water for irrigation is available as a 'free' resource apart from its extraction costs, and while industry may be paying for water through a metering system, water is not treated as an 'economic resource' whose price reflects its demand and supply in its competing uses. Ground water is considered a 'free good', despite the fact that it comes from common pool aquifers. Subsidized water is often cornered by rich farmers who also cause long-term aquifer damage due to excessive withdrawal by taking advantage of energy or water subsides intended for small farmers (Ghosh 1996). The greatest pressure and the most serious impact is on availability of water for domestic uses which faces competition from irrigation and industry. The selling of water through water markets for irrigation has developed in parts of the country There is, however, no effective regulatory mechanism to ensure ecological sustainability Sustainable domestic water supply cannot be assured without at the same time addressing the inter-linked issues of water for irrigation, industry and ecosystem sustainability.

Market and state regulatory mechanisms which allocate water resources to competing uses — agriculture, industry, domestic and ecosystem sustainability — respond to different signals The price of agricultural products, the major consumer of ground water, is a key determinant of the crops grown and the cropping pattern followed, along with the soil, climate and water situation. However, partly because legal rights have been conferred to water which lies below an individual's land, and there has been no pricing of water, the cropping pattern does not take account of the cost of over-extraction. The issues in the case of industry are water tariffs based on usage, water pollution and recycling. Without an effective pricing and regulatory mechanism, the cost of water supply and the environmental costs of water pollution may not be factored into the price of manufactured goods

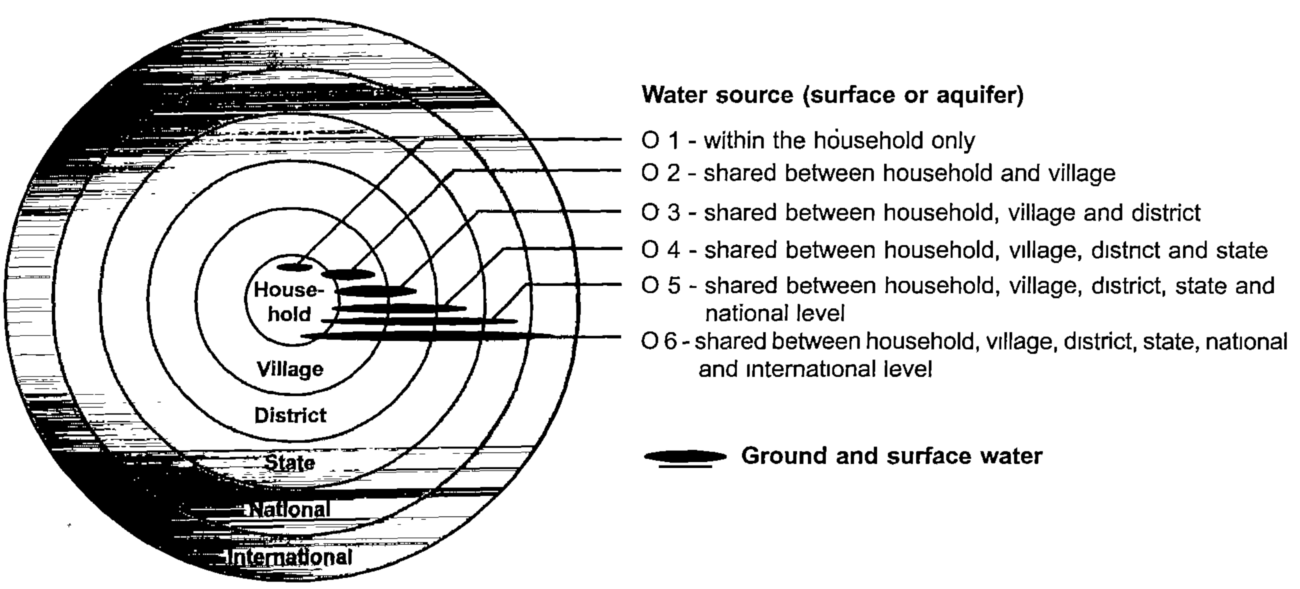
The fresh water problem in India, therefore, as suggested by existing analyses and policies, is that *adequate quality fresh water is not available at an affordable cost in the right place at the right time for basic needs and ecosystem sustainability.* This problem is conceptualized further in Figure 1

The figure shows the different levels at which water resources are shared, with the focus being the household or community level, and hence the different levels that have to be involved in their management. The fresh water resource from surface and ground water which is physically available to each of the levels — household/ community, district, state, national and international, is shown by the oval shaped figures At the lowest level, a household, village or community has access to a well or surface water within its own boundaries, which is not shared with other levels

Water may also be obtained from an aquifer or surface source which is shared with other levels, from the household to the village/community, district, state, national and international levels. In these cases, if a household or community is using water from a shared aquifer, then the rate of extraction at each level will affect the level of availability at the other levels Thus, concerns over water access may range from those of villagers in an isolated area, to people many thousands of kilometres away, or even other countries coursed by some of India's great rivers.

The interlocking nature of the oval figures within the concentric circles across different levels also depicts the legal, institutional and economic issues which must be taken into account While a household/ community has control over a water resource wholly within its land, its ability to manage the resource varies as it is shared at

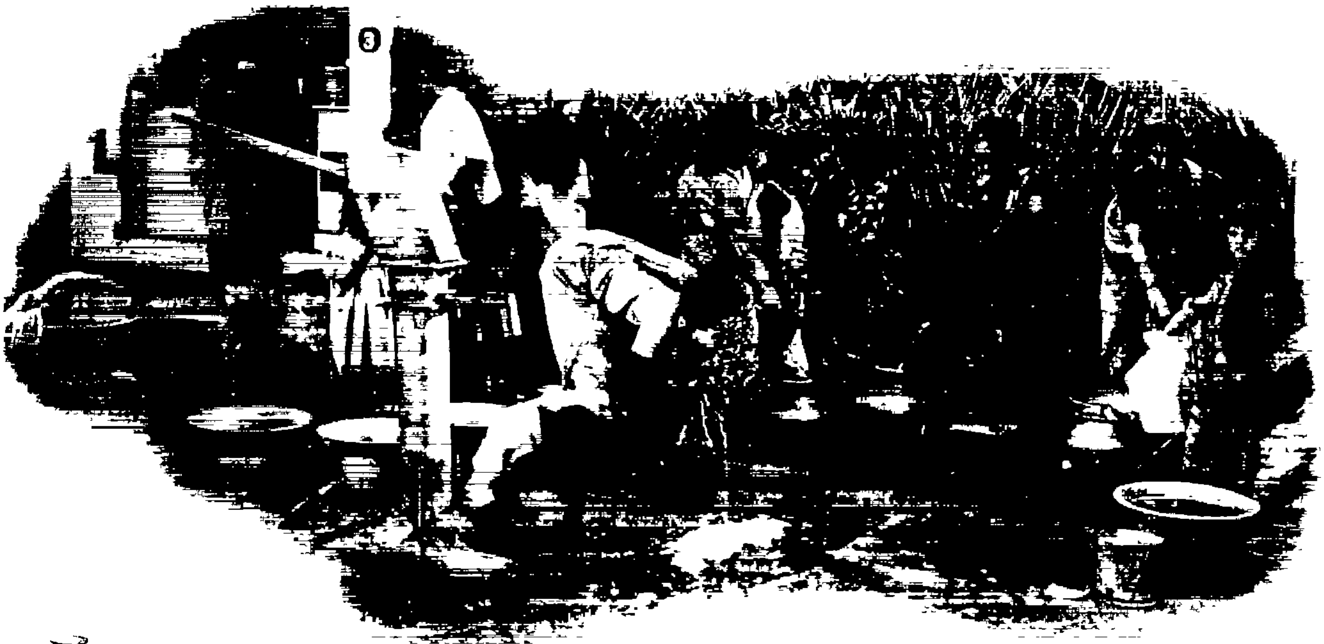
Figure 1: Conceptual Framework for Analysis of the Fresh Water Environment

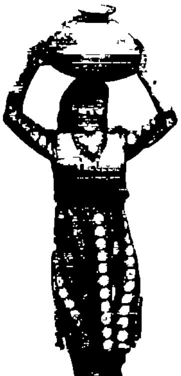


The ability of communities to manage water resources varies as it is shared with successively higher levels

successively higher levels This has implications, for instance, for community management of water resources.

Conceptually, this also suggests that when designing actions, the shared nature of the resource must be taken into account. Although this would suggest that ground water should be regarded as a public good, the existing system of 'water rights' and the grandfathering of these rights prevents the design of policies and programmes along these lines alone The fact that these rights have been conferred, and millions of ground water extraction structures created, that there is heavy reliance on ground water for both food and household water security and water is a political tool in India, all mean that the economics of water resource management in India will be quite complex. The conceptual framework itself suggests that actions will be required at different levels — household, village/community, district, state, national and international.





Chapter 2

Why Local-Level Studies?

2.1 Rationale And Objectives Of Local-Level Studies

The integration of the issues of fresh water supply and demand and the water balance, technology, institutions, and the legal and socio-economic aspects at the local level have to be reflected in policies for water resource management

Typically, policy making starts from the upper levels of government, but addresses local concerns *The objective of the studies was to provide insights for policies and programmes on fresh water management in India through an analysis of trends in water availability and its use at the local level.* The design of the studies recognized that unlike the forces of economics, the processes of ecology vary considerably from one eco-region to another. Government policies and local responses need to evolve from dependable local knowledge and information.

The studies were conducted by local institutions and non-governmental organizations (NGOs) working in close collaboration with local communities, collecting baseline data on available fresh water, its use and its management Data was collected over a one year period between 1995-96 covering all the four seasons, and perspectives were provided by respective communities through participatory rural appraisals

Specific data was gathered on the following:

- water supply and demand, including the hydro geological situation;
- water quality,
- socio-economic, political and cultural factors influencing water management,
- agriculture and cropping patterns,
- agricultural and industrial pollution;
- ecosystem impacts, and
- alternatives available to communities which would enable them to meet their needs in an environmentally sustainable manner.

The studies sought to determine how communities responded to local fresh water problems and develop appropriate actions which would permit improved fresh water utilization in respective regions The need for examining actions from a local level analysis have been well recognized (UNICEF 1995, Agarwal & Narain 1997, GOI 1995) Individual investigations in these case studies focused on the following priorities:

- satisfaction of basic fresh water needs for drinking and sanitation in an equitable manner, ensuring adequate supplies to water scarce regions and to poor households;
- recognition of the ecological imperatives in water resource management towards ecosystem conservation and protection of bio-diversity;
- conservation and protection of fresh water resources of the eco-region in all available forms, such as ground water, streams, ponds, tanks, etc,
- amicable and equitable allocation of water among competing users, and demands, including direct or indirect originating outside the study areas,
- innovation and strengthening of local low-cost technologies, social institutions, and legal instruments for managing fresh water resources on a sustainable basis,
- encouragement of technological innovations that enhance local initiatives and build upon local competence in conservation, resource enhancement, protection and allocation of fresh water resources

2.2 Selection Of Study Areas

To understand the regional and ecologically specific status of fresh water availability and the coping mechanisms that people have adopted to address the issue of drinking water in situations of water scarcity, these studies were targetted at the lowest level of human habitation — the village or community. While selecting regions which suffer water scarcity, shortages or stress at some time during the year, the following have been identified as the main parameters which should be considered

- Precipitation and topography
- Hydrological characteristics
- Geo-hydrological characteristics
- Level of industrialization
- Intensity of irrigation
- Level of urbanization

While combinations of these parameters can generate a wide range of situations, the scope of this report does not allow such detail. Accordingly, recourse to some broad regionalization must be taken. For this purpose, India can be divided into several eco-regions which represent a broad range of situations where water resources are a major concern. These are

- Arid and semi-arid regions in the west
- Rain shadow of the Western Ghats
- Drought-prone regions
- Coastal regions
- Mountains and highlands
- Plains of the Ganges river
- Deserts
- Urban and metropolitan areas

A typical scenario in an arid region (Gujarat)

In each of these regions, the availability of water and the possibility of transportation/lifting need to be understood in the local context. The five micro-level regions selected in this case study, each of which faces water scarcity at some periods during the year, represented a broad range of environmental conditions (see Map1). Included were an arid region (Gujarat), a plateau region (Maharashtra), drought-prone areas (Andhra Pradesh), hills (Uttar Pradesh, Himalayas), an urban area (Chennai, formerly Madras). Coastal, flood prone areas and deserts are intended to be covered in an extension of this project in the future

2.3 Methodology and Limitations of the Studies

Baseline data was gathered in four eco-regions – Gujarat, Maharashtra, Andhra Pradesh and Uttar Pradesh – by multi-disciplinary study teams. The system established included

An everyday chore for women in the hills

monitoring, sample surveys, participatory rural appraisals, and visits over a one year period. Issues addressed covered the hydro-geology of the region – soil and rock formation, ground water depths, precipitation, run-off, and the recharge of ground water and surface water – other sources of water such as tanker supplies, water quality, water pollution, water use, and the socio-economic profile of the study area. This, along with other available data, was used to compile a trend profile of water availability and use, institutional mechanisms, and technological and community-based options in the management of water resources within and outside the micro watersheds. Similar data was collected in Chennai from a sample of 10,000 households and 2,500 industrial establishments.

Baseline data on the evolving fresh water scenario was gathered by multi-disciplinary teams

While the studies have attempted to cover water resource management issues at the local level, and develop policy and programme recommendations from the lowest level upwards, there are obvious limitations to this approach. First, only five eco-regions have been covered. Second, data was only gathered during a one year period, which is not sufficient time in which to study the water balance or the responses of people to fluctuations in water availability. Third, financial and institutional issues could not be addressed during this phase. These aspects will, however, be considered in the extension phase of this project

Map 1: Study Sites within the States of India

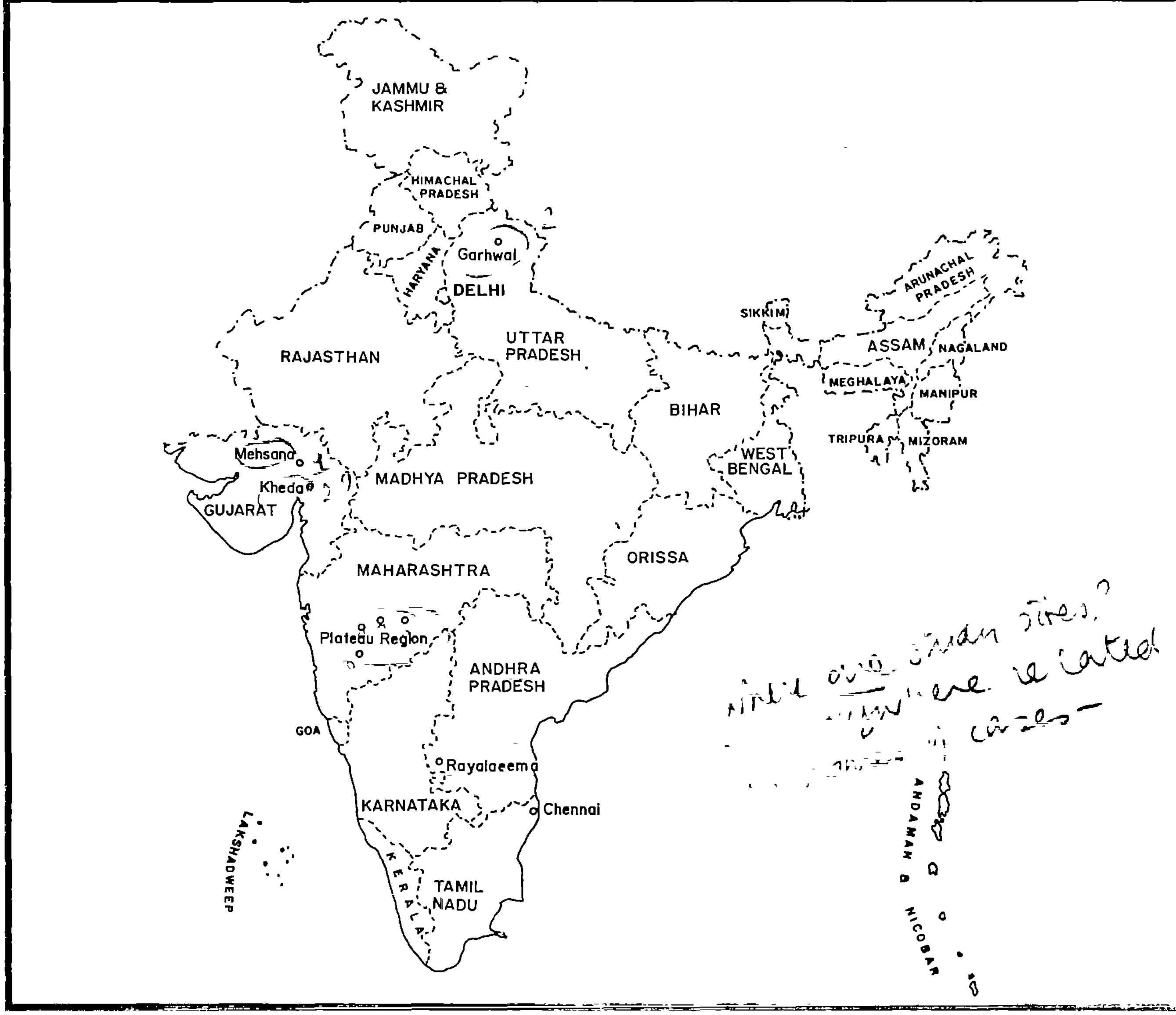


Table 1. Eco-regions and villages targetted during this study

Eco-region	State	District	Village/city
Arid and semi-arid	Gujarat	KhedaNarsıpur	
		Mehsana	Kubda
		Kheda	Pathoda
Drought-prone	Andhra Pradesh	Anantapur	Gurrabbadu, Rayalseema
Plateau and rain shadow of the Western Ghats	Maharashtra	Ahmadnagar	Adgaon
		Shatara	Lohom
		Parbhanı	Jogwada - Sos
		Pune	Sanaswadi
Mountain and highlands	Uttar Pradesh	Tehri	Danda
		Tehrı	Chandrabhaga
Urban - city	Tamil Nadu	Chennai	Chennai city

Chapter 3

What Are The Insights?

3.1 Status Of Water Balance

Narsipur: A declining trend in the ground water table

Narsipur village, population 2,547, is spread over 486 hectares of land in a semi-arid region with average annual rainfall of 801mm. It has faced droughts in 13 of the last 25 years. Surface water sources are limited to a few seasonal streams near the village and a shallow tank. Two seasonal rivers flowing at a distance of 2-4 km do not benefit the village, but their shallow alluvial tract helps to recharge the ground water.

Cultivable land occupies 82 per cent of the village land area and is irrigated by ground water stored in three water bearing layers at 15-19 5m, 21.6-22.5m, and 25.5-27m The yield and reliability of ground water is highest in the 21 6-27m, which serves as the major source of all the water for the village. The uppermost layer of the ground water bearing layer has become non-productive

Energization of borewells changes the pattern of crop production in a short-sighted manner

Prior to 1962 there were only three wells in Narsipur, but with the advent of water extracting machinery (WEMs) the number of borewells increased rapidly to 101, of which 80 per cent are energized The energization of the borewells altered the pattern of crop production — from castor as a cash crop and *bajra* as subsistence to *saunf* (fennel seeds), wheat and chillies. *Saunf* is highly water intensive requiring 30 waterings over a five month period Farmers make a rational but often short-sighted decision on which crops to grow

Records show that the ground water table had declined at a rate of 0.11 to 1m per year from 1963 to 1975, during which 20 wells with a depth of 10m went dry. In response, farmers are using powerful and efficient submersible WEMs to pump water from deeper aquifers. A 1995-96 well survey showed that although water levels during the monsoons and winter are largely unchanged, thus giving farmers the perception that adequate quantities of fresh water are available for cash crops, there is an appreciable drop in the summer months and there is an annual decline in the water table All dug wells ranging from a depth of 7 5 to 10 5m are currently non-functional in the summer months due to over-extraction

Farmers dig deeper and deeper for water but find it non-potable

Farmers have started exploring the bottom of the hard rock strata even as deep as 100m for water, but without success Water below the hard rock strata is known to be non-potable in the semi-arid tracts of Gujarat Water scarcity is not confined to single years, but has become a common phenomenon as the water table steadily declines (Box 8).

An energized borewell

Pathoda: Extraction of water is vastly in excess of recharge

Pathoda (population 934, predominantly comprising a poor caste of Rajputs), has an average annual rainfall of 801mm. Hard rock covers 56 per cent of the village area This geological formation means that there is limited ground water storage potential as evidenced by the rapid

Village I, Gujarat.

WWF

Box 7. Narsipur: community initiatives for ensuring drinking water supply

With a population of 2,547, Narsipur village has taken steps to resolve the public/private conflicts over management of fresh water resources, responding to the changing pattern of fresh water availability and its uses. Before energized borewells were introduced, Narsipur produced traditional crops of groundnut and castor as cash crops, and *bajra* as a subsistence crop. Ground water use was confined to protective irrigation and livestock. A village pond, which used to provide water, is no longer used and has silted up. During the monsoon it refills and helps in recharging ground water sources on which the village is now fully dependent for agriculture and domestic purposes.

With the advent of water extracting machinery, the number of borewells has rapidly increased to 101. Over-extraction, however, has led to 18 per cent drying up.. There are now 82 energized borewells, including 40 submersible pumps which are more efficient in pumping water from deeper aquifers. The depth of boreholes has increased steadily to 25m, with 50 per cent of the borewells reaching this depth.

The energized borewell and green revolution have changed the cropping patterns to more water intensive and remunerative cash crops such as *saunf* (fennel seeds), castor, wheat, cotton, vegetables, and *rajko* (a fodder crop).

The village has developed an elaborate system for sharing water with the formation of joint ownership of a well by a kin group. The other mechanism for access to water is to have a partnership between well owners and the irrigators. The two share the produce of the land, with one-third of the produce going to the well owner, the remainder to the cultivator. But this involves an element of risk. Water selling is also practised at a rate of Rs 8 per hour but this is not a primary motive of the well owners.

Domestic water supply is completely dependent on ground water resources. Despite the fact that the ground water table has declined over the years, it has not yet affected drinking and domestic water demands. Domestic water consumption is only 1.5 to 2 per cent of the total estimated water extracted from the aquifers. Public open wells were located in the village and were originally used for domestic water supply. However, with the overuse of the ground water for irrigation, the community wells went dry. In 1970s a waterworks with a 30m borewell, a storage tank with a capacity of 85,000 litres, a pump house and distribution pipelines were built by the Panchayat. Water is presently being supplied by pipeline to individual homesteads. Villagers get water for two hours twice a day, which serves the domestic and livestock demands. The average consumption of water is 123 lpcd, 165 lpcd and 97 lpcd in winter, summer and monsoon seasons, respectively (including 15 lpcd, 24 lpcd and 18 lpcd for livestock), which is much higher than the government norms of 40 lpcd.

Community initiatives in Narsipur have allowed the village to meet their drinking water needs. However, increased community awareness of the depletion of ground water sources and efforts to recharge the ground water base and regulate the quantity of water abstracted are needed to ensure that drinking water is protected and that sustainable agriculture is pursued.

Box 8. Narsipur: managing fresh water at the community level, but need for additional measures

Of the total ground water extracted in Narsipur, 98 per cent is for intensive agriculture and only 1.5 to 2 per cent for domestic purposes. The community has taken initiatives to meet its drinking water needs (Box 7) but the water tank which once took two hours to fill, now takes seven.

- Contrary to expectations, the village does not as yet experience a drinking water problem. In part, this is because the community has taken steps to protect its drinking water supply.
- There is some scope for improving the ground water situation in the village by rehabilitation of the pond and other domestic or community water harvesting structures. Cost-effectiveness of other re-charge technologies should also be examined.
- Observations and perceptions of farmers on water availability and the prices of crops has led to cash cropping, more remunerative but also water intensive. But these trends do not take account of the long-term sustainable rates of extraction of ground water and are not reflected in the allocation-mechanism (user-based, market, public and private) across the various households.
- Alternative more water-efficient methods of irrigation and their affordability such as sprinklers and drip irrigation need to be explored.
- An assessment should be made of what is the maximum productivity and remuneration (type of crop and yield) that can be achieved in this village under long-term sustainable rates of extraction of ground water and alternate water allocation mechanisms.
- Community based management and regulations implemented by the community are needed to arrest the trends in water extraction for irrigation.

Source: Government of India (1996)

decline of water in the wells just after pumping.

The 483 hectares of the village are on the edge of a seasonal river which flows into the Waghas reservoir, about 2 km downstream Because of its seasonality, the river does not serve the water needs of the community for either irrigation or drinking, but is used for washing At the peak of the monsoon, the river and reservoir experience frequent flooding which has caused submergence of village land The village has a 2 hectare pond, with a capacity of 350,000m^3 that can store water up to 1.5m for three months. Surplus water from the pond flows into the reservoir The pond itself has little direct utility for the village because of its seasonality, but even with a 10-15 per cent infiltration into the hard rock, it serves to improve the ground water table.

Despite these factors, surface water development is limited in Pathoda A check dam was constructed on the river from 1970 to 1972, which has helped to stem the excess water flow to the village. Subsequently, a canal has helped divert water to the village reservoir which was created in the 1970s by deepening and enlarging the pond. Because of its limited storage capacity, the dam serves more to divert rather than store water. The Waghas reservoir is below the village and the check dam is meant to divert the flood waters. As a result, the villagers do not benefit from it and have no rights over the canal water

In spite of a hard rock area, not promising for ground water, cash cropping is being done at unsustainable rates

Even though the village has significant surface and ground water endowments at periods during the year, there is a large seasonal fluctuation in the ground water level in the functioning wells, with 50 per cent being seasonal. Although the hard rock area of Pathoda is geologically not promising for ground water and there is considerable uncertainty because of the limited storage capacity in these rocks, water intensive cash cropping is still practised. Traditional dry land crops such as groundnut, castor, and *bajra* have been replaced by water intensive crops such as *saunf* (fennel seeds), cotton, wheat and fodder. Increase in livestock farming has also intensified the fodder crops grown in the village Water is traded to a certain extent but the water sellers and water buyers claim the same share of the resource over the annual cycle (Box 9).

Pathoda village is withdrawing 48% more water than is available from rainfall and recharge within the annual cycle

Pathoda has scarce and erratic rainfall with unreliable surface water sources but the villagers still rely mainly on irrigated agriculture and cooperative dairying. Analysis of the water balance in Pathoda (see Box 10) shows that the village is withdrawing 48 per cent more water than is available from rainfall and recharge within the annual cycle This means that unless specific measures are taken to either conserve water or reduce utilization, ground water extraction in Pathoda is not sustainable The extraction rates in this village, like many others in Gujarat, are alarmingly high. Ground water recharge combined with improving the local ecosystem have to be initiated on a local and regional level

The ground water table in Pathoda has declined over the years Until 1982, the maximum depth for ground water was 15m, but has now increased to 22 5 m The quality of water is also deteriorating, with fluorides and dissolved salts making it unsuitable for drinking Tests at various times during the year showed that water quality varies from one well to another Only the pH and sulphate concentrations were within the desirable limits in all samples taken. Other parameters such as total dissolved salts (TDS), total hardness (TH), and total alkalinity (TA) and chloride exist in undesirable concentrations The quality of irrigation water was also found to vary· the greater the depth from which water was extracted, the less suitable for irrigation because of increased sodium levels (Box 11)

Kubda – no water scarcity yet, but implications for those downstream

Kubda (population 510), is situated in the foothills of the Aravallis, the recharge zone for Mehsana district where there is intensive ground water exploitation with very deep borewells Average annual rainfall is 675mm but the village is well endowed with several micro-watersheds. Of the total village area of 452 hectares, 46 per cent is cultivated At one time the village was in the

Box 9. Water partnerships or water markets in Pathoda?

Water partnerships between well owners and non-well owners are a common phenomena in Pathoda village. Well owners share more than 50 per cent of the total volume of water extracted during any month, but the proportion was reversed in the post monsoon season of September to December 1996 (i.e water buyers shared more than 50% of the total quantity of water extracted) But the well owners provide less water to water buyers and partners from winter to summer because during this period cash crops such as *saunf* and wheat are grown. The well owners extracted the maximum quantity of water to irrigate *saunf* followed by wheat. Also, the ground water quantity extracted by well owners was only 1 2 times higher than the quantity sold. This means that water buyers claimed nearly the same share of the village's ground water in 1996 as the well owners.

Water is traded to a certain extent in Pathoda. When laying a pipeline between two fields located away from each other, a well-owning farmer is often compelled to lay pipes across the fields of other farmers. In such cases, water is provided to the farmers whose land is crossed at a cost of Rs. 15 per hour (charge rates are based on energy and pumping costs, not the quantity of ground water pumped). Water trading is, however, of secondary importance compared with the intention of providing water to one's own field Water partnership is a much more popular mode of water distribution in the village. This may be because the village is mainly composed of a single caste — Rajputs — and partnership transactions based on social ties and kinship groups play a more significant role than market mediated buying and selling of water. Water trading is, therefore, basically of secondary importance compared to the intention of supplying water to one's own fields.

Pathoda: Cash cropping creates a greater burden on ground water resources

Box 10. Water balance in Pathoda

Pathoda, with an area of 483 hectares and an average rainfall of 818mm, receives about 3.9 billion litres of water each year. Recharge potential of the soils around the village is estimated to be about 10 to 15 per cent, which is about 489,000m³ of water. Actual water withdrawals, however, come to 795,000m³. In other words, the village is withdrawing 48 per cent more than its entitlement.

Some of the important data is summarized below:

Total rain over the village land	3,914
Potential ground water recharge	489
Usable ground water	416
Water extracted from the ground	795
Excess withdrawal	379
Percentage of withdrawal over entitlement	48%
Drinking water requirement	44
Percentage of drinking water over usable ground water	10%
Percentage of extracted ground water	55%
Per capita ground water extracted in the village	0.851

(Measurements are in 000m³ unless otherwise stated)

Box 11. Pathoda: limitations of traditional low-cost methods and water quality concerns

- Transition from dry land crops to cash crops as a result of higher remuneration has led to rates of water extraction which are much higher than recharge
- There is some scope for traditional low-cost methods for improving water resources, but the hard rock geology may not necessarily improve the productivity of the aquifers enough to meet the increasing demands for irrigation
- Drinking water needs to be protected in either the wells that do not have deteriorating water quality or other structures such as in Narsipur.
- Water quality fluctuates from well to well Communities must be made aware of safe and unsafe sources
- Community awareness of the unsustainable patterns of water utilization and alternatives, thereof, needs to be increased.
- The close kinship within the community provides opportunities for promoting community based management and implementation of regulations for ground water management.

forested tracts, but with their degradation, water quality in the seasonal streams and around the village has declined

Water is not a limiting factor in Kubda with the functioning wells (40% of all wells) showing levels of 1 2-1.5 m But the water demands in Kubda have changed

Pathoda: Children quench their thirst at a handpump

in recent decades, largely as a result of agricultural growth. In the 1950s, the crops were *til* (sesame) as the major cash crop, a variety of pulses such as *urad, guvar, chowli* and *math*, and local food crops such as *banti* and *kuri* (varieties of *bajra*) These crops were entirely monsoon dependent. Since the 1970s, villagers claim that because of decreased rainfall and irregular monsoons, cropping patterns have changed, with the discontinuation of *til* and food grain crops, although agriculture continued to be dependent on monsoon rains In the 1980s, with the advent of new technologies, improved seeds, and use of fertilizers and pesticides, cropping patterns became more oriented towards markets, with crops like groundnut, castor, cotton, *jowar* and maize being increasingly grown. Electricity provided further opportunities to extract water for irrigating these crops

Availability of drinking water is not a problem at Kubda Unlike the situation further down the aquifer in Mehsana district, there has been no appreciable depletion of the water table over the years Water quality, however, is a serious problem on account of high levels of fluoride, which vary from one well to another Although, the Taluka has been classified as degraded, with ground water development already at more than 85 per cent, Kubda itself is well endowed at present rates of water utilization

Communities need to be better informed of this situation and precautionary measures taken to protect safe drinking water. Although Kubda itself does not face a water shortage problem — it is located over an aquifer supplying water to the Mehsana district — management of water resources in Kubda is critical for the entire region (Box 12)

Box 12. Kubda: though in the 'dark area', it has no fresh water problems, but agricultural growth affects those relying on the common aquifer

- Though in a 'dark area' and contrary to macro level expectations, Kubda does not face a fresh water problem.
- The village has transitioned from monsoon fed to ground water dependent crops and within that, water Intensive crops
- With only 46% of land under cultivation, there is scope for an increase in area under agriculture But this will also have implications on water availability for those further down the aquifer.
- While there is plenty of water, water quality has deteriorated, with high levels of fluoride in part due to the degradation of the forests. Promotion of community awareness and participation for the protection of the forests and safe water sources is an area for action.

The changing pattern of water use in the village suggests that with increasing commercialization, water use may intensify and deplete the ground water table. The strategic location of the village, which is in the upper catchment of the Sabarmati River — which has large demands from towns like Ahmedabad and areas of intensive agriculture and ground water exploitation in Mehsana — suggests that what happens in water management in Kubda will be crucial to the entire region

Gurrabbadu: Potential for greater water extraction in a drought-prone region

The Rayalseema region is known as one of the most drought-affected regions of the country This is a rain shadow region with an average rainfall of 516 mm. Six of the last ten years witnessed deficient rainfall The study area, Gurrabbadu, is where the average rainfall (250mm) is only half the district average It covers an area of 1,831 ha with a population of 1,592 The watershed has three traditional water storage systems called *kuntas* —Brahmanapalli, Shabavikunta and Venkatachalakunta The surface area of these three tanks is 0.14 sq km (14 ha or about 0.8 per cent of the total surface area of the watershed)

The village has extensive dryland cultivation, particularly groundnut. The percentage of sown area in the watershed is 48 per cent (880 ha) relatively less than the district's average of 69 per cent The watershed has 587.5 ha (32 per cent) degraded forest and 262 ha (14 per cent) with some sort of scrub cover. Barren rock and fallow area constitute one per cent each of the watershed. About 856 ha (46 per cent) is nearly flat area, whereas 81 25 ha (4 per cent) has very steep slopes

About 46 per cent of the area (847 ha) is cultivated, and less than 2 per cent of the area (33 ha) has some sort of irrigation potential Yet, more that 70 per cent of available fresh water is used for irrigation (Table 2). Compared to the total rainfall of 7.398 MCM (1995-96), the fresh water consumption is only 2 per cent. In other words, the average annual fresh water consumption which is as low as 97 cubic metres per capita, consumes only a fraction of the rainwater of 4,645 cu m per capita that falls on the basin

Compared to the average fresh water consumption in India (610 cu m per capita) the consumption of 97 cubic metres in Gurrabbadu is less than 15 per cent. Per capita domestic consumption — 35 lpcd, rising to 44 lpcd in summer — is less than the national average. Livestock accounts for about 10 per cent of the total water consumption in the watershed

Table 2. Fresh water consumption in the Gurrabbadu watershed (1995-96)

Category	Total volume (mcm)	Per capita basis (lpcd)	Consumption various purposes (%)
Irrigation	0.122	210	77
Drinking	0.02	36	13
Cattle	0.015	26	10
Total	**0.158**	**72**	**100**

In 1995-96, the ground water withdrawal based on actual measurements was about 0.158 MCM. The water withdrawn for irrigation was about 0.122 MCM, and the rest was for domestic consumption. The water withdrawal for domestic consumption has been physically measured in the two villages. Two observation wells indicated that the ground water fluctuations during the year varied from 3-5 metres. With a fresh water withdrawal of 0 158MCM, the water balance over the basin is as follows: total precipitation: 7 398 MCM, run-off into *kuntas*: 0.452 MCM, fresh water withdrawal (ground water extraction): 0.158 MCM If fresh water withdrawal is equal to total ground water recharge, the transpo-evaporation amounts to 92 per cent of rainfall (6.838 MCM).

Detailed water consumption analysis indicated that rice cultivation uses five times more water than groundnuts An area of 1 hectare of rice uses 10,000m^3 of water, compared with 2,000m^3 of water for a similar area of groundnuts. On average, 1 ha of irrigated land produces about 1 2 tonnes of groundnuts In other words, to produce 1 kg of groundnuts requires about 2m^3 of water. Based on the prices of groundnut, this means that each cubic metre of water provides an income of Rs. 13.60 (1996 prices of Rs 15,000/tonne) to the farmers By comparison, one cubic metre of water for rice production provides an income of only Rs. 0 9 (1996 prices of Rs 4500/tonne) However, several other factors determine the cultivation of rice. larger fluctuations in the price of groundnuts, while the price of rice is fixed by the government procurement price; changes in government policy of importing edible oils; and lack of credit facilities for promoting dryland crops.

Ground water recharge is estimated at around 549,000m^3 during an average rainfall year. It is possible to increase ground water utilization from the present level of 144,000m^3 to at least 400,000m^3 if appropriate local, low-cost methods are applied Six small forest *kuntas,* and desilting the existing two *kuntas* in the revenue lands will considerably improve fresh water availability. Villagers have also suggested a joint forest management and tree planting programme to improve the ecology of these forests. Rehabilitation and management of this watershed offers a unique opportunity for these communities to improve local fresh water resources.

The chemical quality of the water was good but the fluoride level in drinking water was slightly above the desirable limit. Farmers in the watershed, however, have used about Rs. 1 million worth of fertilizers, the residues of which must be contributing to increased nitrate levels in the water Outbreaks of malaria, diahorrea and jaundice are frequent Mortality of livestock has also increased through disease Years of high rainfall appear to coincide with high levels of mortality among shepherds.

The hardship faced due to water scarcity by the villagers in the Gurrabbadu watershed is immense, particularly in the summer months. Coping mechanisms with minimum levels of water consumption have also reached their limits. Encouragingly, the community has some options for improving both fresh water availability and agricultural production. But more water availability which results in more water intensive cash cropping will not ensure sustainable water resource management (Box 13)

Box 13. Gurrabbadu: potential for increasing fresh water availability and agricultural production within ecological limits

- Opportunities for increasing the fresh water potential in the watershed exist through traditional low-cost methods.
- Increasing fresh water availability alone is not a solution. More water for more cash cropping will not improve the fresh water situation The ecological limits must be established and understood
- Mechanisms for ensuring priority for drinking water through community actions to regulate water use for agriculture, identification and protecting of wells and/or storage of water in structures and mini-piped water schemes are needed

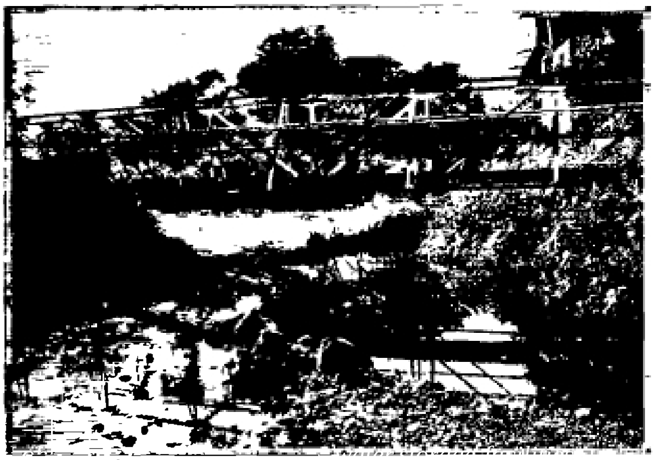
Lohom: Water stress and poverty

Lohom, population 1,105 (222 households), with an average annual rainfall of 505mm, is in a drought-prone region, lying in the rain shadow area adjoining the Western Ghats With an average per capita income of Rs 4,423, most of the people live well below the poverty line

Almost 77 per cent of the village area of 399 hectares is taken up by agricultural land on which *bajra* is produced in the Kharif (monsoon) season, and groundnut, paddy, sorghum, wheat, gram and other pulses, sunflower and vegetables in the Rabi (winter) season. Higher yielding hybrid varieties are being produced in some areas. In such cases, farmers employ irrigation, consuming more water than situations where local crop varieties are grown. The remaining land area is waste land (18 per cent), cultivable waste land (5 per cent), and grazing land (7 per cent) The latter is insufficient for livestock, hence there is dependence on agricultural fodder production and grass on the waste land The silty soil formation of the land allows infiltration of water at a rate of 12.5-25mm/hr, with a water holding capacity of 235mm/hr.

Industries are encroaching on agricultural areas with impact on water availability and pollution

There are no surface water storage facilities for either agriculture, drinking or recharge. The average distance from the



Lohom: There are no surface water storage facilities

source is 87 metres and the time required of 78 minutes is well within the national norms, if there is water in the wells In summer, however, people are dependent on drinking water supplied by tanker

Sanaswadi: Competition between industry and drinking water

Sanaswadi village, Pune district, is situated along the state highway between Pune and Ahmadnagar. Almost 50 per cent of the village is occupied by an industrial belt. Agriculture accounts for another 34 per cent and forest 9 per cent. Industrialization near the village has resulted in a dual economy — one based on industrial wages, the other on agricultural production The socio-economic issues, however, go beyond that of a dual economy, extending to the negative impacts resulting from uncontrolled and unregulated industrial waste discharge and pollution of the air, soil and fresh water resources Air pollution, in particular, has had an impact on agricultural productivity because it has been found to hamper the growth of crops

The 4,407 people in Sanaswadi have seen their incomes increase as a result of industrial development, and the village is increasingly becoming peri-urban. Increased value of land has led many people to sell their agricultural land for cash, turning agricultural landowners into wage labourers. The participatory rural appraisal revealed that these people now have little interest in village development activities which are left primarily to the women.

Annual rainfall in the village is 507mm Water is provided from three functioning handpumps, one piped water scheme, 30 wells and three borewells Ground water is the main source of water supply for agriculture, industry and human consumption The main crops in the village are cereals and vegetables.

Industrialization has provided opportunities for full-time work but at the same time it has not eased the water demand situation. Substitution in demand has taken place from agriculture to industry which now consumes about 87 per cent of the total ground water available in the summer season The village had never suffered from water scarcity in the past. But now tankers are needed to supply water in the summer months, but even this satisfies only 25 per cent of the demand because the village is large. The rest continue to walk long distances to fetch water

Industrial pollution is having a significant impact on the water sources as a result of raw effluents being released. A chemical analysis indicated high TDS, phosphates and chlorides Fluoride levels were within acceptable limits High sodium and potassium levels indicated the presence of fertilizer run-off

Sanaswadi: Piped water supply schemes are comparatively new

Adgaon: Impact on the villagers as a result of cash cropping in adjoining villages

Adgaon village, Ahmadnagar district, is in a water scarce situation for eight months of the year. Annual rainfall is around 800mm Adgaon itself receives only 549mm of rainfall, mainly between July and September Its population of 870, comprising 162 households, has an annual per capita income of Rs.2,058, making it a poverty-stricken village. Agriculture is the mainstay of the population, with 91 per cent of the total village area (418 ha) under cultivation.

The area around Adgaon village is known for its commercial production of sugarcane, but Adgaon village relies on cereals *(bajra)*, pulses *(moong, urad* and *toor* dals*)*, oilseed (sunflower and groundnut), cash crops (cotton) and vegetables for its income Sugarcane factories are found on both sides of the village, but the village is in a dry zone and does not have the potential for sugarcane production, although people do think about growing it in a good monsoon In most years though, the inequitable distribution of the ground water around the village precludes this. Adgaon is entirely dependent on ground water for agriculture and domestic water But, because of the high rate of ground water extraction in the village and its surroundings for cash cropping, wells in Adgaon are dry, and tanker supplies are required for drinking water in summer. Thus, while Adgaon itself does not produce sugarcane, its ground water availability even for drinking water is affected by the production of this cash crop around the village.

Surrounding sugarcane production has impoverished Adgaon

All the villagers depend on a single energized borewell for drinking water But it now has reduced yields because of other borewells in the region. Women have to walk an average of 223 metres and spend 71 minutes to fetch water. Apart from the women having to wait for their turn to collect water from the village borewell which is operated day and night, they suffer other stresses also. Some of them cannot sleep at night because their turn may come at that time and they have to leave their children at home alone to fetch water

Jogwada and Sos: Private initiatives to ensure drinking water

Jogwada and Sos are two sister villages which receive a regular rainfall of about 909mm each year Ninety-five per cent of the land of 1,004 hectares is under agricultural production with only 3 ha set aside as pasture and grazing land for livestock — an inadequate area for their needs Cultivable waste land is 32 hectares. The soil formation is similar to that of Lohom with a water retention capacity of 235mm/hr. Sos and Jogwada villages are relatively better endowed with fresh water resources and have been able

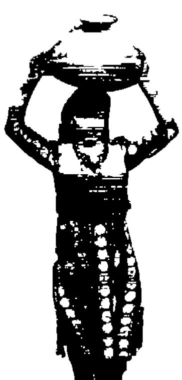
Private, not public water sources are more reliable

to develop and provide sufficient water for domestic purposes from privately owned sources.

Main crops sown in the villages are cotton and sorghum, inter-cropped with pulses in the Kharif season, and wheat and sorghum in the Rabi season Sugarcane is grown in summer. The villages have a non-functioning piped water scheme so the villagers have to manage on their own through privately owned ground water sources The average distance to the water source is 65 metres and the time required is 78 minutes 99 per cent of the women have to fetch water from privately owned ground water sources

Maharashtra villages: Competition for drinking water

The water consumption pattern in each of the Maharashtra villages — Lohom, Sanaswadi, Adgaon, and Jogwada and Sos is shown in Table 3 It is seen that drinking water requirement is only 1 5 per cent of the total annual water consumption, yet there is a shortage of drinking water even at below minimum levels of consumption.



In the Maharashtra study areas the resolution of issues surrounding the conjunctive use of water for different purposes is unlikely to come about through market forces alone While the market can address allocation mechanisms between agriculture and industry, it will not necessarily guarantee protection of water required for household purposes.

The complexity of the problem has led to the villagers being helpless about what can be done In the participatory rural appraisals most people did not have an idea of the causes of water scarcity or arrive at any suggestions for solutions (Box 14)

The Garhwal, Himalayas: Plenty of water, yet shortages

With an area of 30,089km^2 and a population of 2 98 million, the Garhwal region has a population density of 82 8 people per km^2 Rainfall is generally governed by the monsoon climate, but the local topography has a strong impact creating many micro-climates.

Danda watershed, with a maximum altitude of 1650m, receives less rainfall (856 mm) than Chandrabhaga at 1,850m, which receives 1052 mm each year Danda and Chandrabhaga consist of several small settlements with 24 springs and four streams. The villages have a total population of about 3,100 and need 125m^3 of water/day at the minimum requirement of 40 lpcd. There are 13 springs in the Danda watershed, most of which either dry up or are drastically reduced during the summer. Additional fresh water supplies come from the Hindolakhal-Hinsarikhal water supply scheme of the UP Jal Nigam. Supplies from the standposts of this scheme, however, have been undependable, both in quantity and quality

Much of the land in the Danda watershed is either under cultivation or used for grazing Agriculture is mainly rainfed, with only 1 33 per cent of the total land area under irrigation agriculture Little forest remains in the watershed. The Chandrabhaga watershed has 11 springs which retain much of the water flow during the summer

Barren rocky land in the Danda village area

Table 3. Fresh water consumption in the micro watershed study areas of Maharashtra

Village	Population	Water Consumption (m^3 per year)			*per capita (m^3 per year)
		Domestic & cattle (m^3)	Irrigation (ground water)	Total (m^3)	
Adgaon	870	13	908	921	1,060
Lohom	1,105	17	799	816	740
Sanaswadi	4,407(1981) 5,000(estimate)	77	2,960 (incl. industry)	3037	606
Jogwada and Sos	1,810	14	3,018	3032	1,675
Overall	8,785	121	7,685	7,806	889

Box 14: Maharashtra villages: despair and helplessness among villagers towards the fresh water situation

- Villagers in Lohom are poverty stricken and while they do not extract excessive quantities of water for agriculture, existing drinking water technologies are inadequate to satisfy drinking water needs in summer, there is little scope for other traditional low-cost methods.
- Sanaswadi has transitioned from agriculture to industry-based dependence, but there is inadequate protection of the water environment, water pollution and rate of extraction are of concern.
- Adgaon drinking water problems will persist as a result of over-extraction for sugarcane in neighbouring villages Regulation and community-based contracts systems may offer some directions.
- Jogwada and Sos have no major drinking water problems, but bringing water closer to the home and ensuring water security are key challenges.

and also provide dependable irrigation supplies in the watershed. Higher areas also have a considerable area under dense mixed oak forest Almost 17 per cent of the land area in this watershed is under irrigated agriculture

The people of the Chandrabhaga watershed have dependable supplies to satisfy domestic fresh water needs. Sources are based on local springs fed by the well forested upper parts of the watershed and are stored and made available through water pipes There are 95 standposts in the area, covering all the villages Spring discharge declines substantially during the summer, but five of the seven villages in the watershed have sufficient supplies all year round. Two villages in the Chandrabhaga watershed face water shortages during the spring and summer months.

People of the Danda watershed do not have adequate local sources during the spring and summer months Local spring supplies dry up by January or February each year. Women then become dependent on a spring located far away, a three and a half hour rough trek. In the Danda area, water scarcity is a root cause of conflict Harijans are not allowed to take water from springs which the upper caste Rajputs use Even in the summer when the *dhara* (small stream) dries up, they are still not allowed to use the *dhara* used by the Rajputs As a result, the Harijans have to walk long distances to fetch water

There is sufficient annual water input available in both watersheds to satisfy basic domestic needs, if adequate conservation and storage measures are taken — the problem is not water scarcity but rather a need for the management of available water resources

On an average, water discharged from the village springs amounts to about 190 lpcd and 117 lpcd from Danda and Chandrabhaga, respectively, which is much more than the desired level of 40 lpcd (Table 4). If stream flows are taken into consideration, then there is much more water than the community needs for its domestic

Table 4. Fresh water availability in Danda and Chandrabhaga, Garhwal Himalayas

Village	Population	Water available (m^3)		Per capita (m^3)		Total water per capita (m^3)
		Spring	Surface	Spring	Surface	
Danda	982	67,400	338,000	68.6	344	413
Chandrabhaga	2,148	92,500	2,422,000	42.8	1,127	1,170

There is more water than the community needs if simple low-cost initiatives are taken

and household needs, as well as for some irrigation. Despite this, the per capita annual availability of fresh water in these two villages — 410m^3 and 1170m^3 respectively — is much less than the national average of 2,200m^3 Input from rainfall at Danda and Chandrabhaga is 2.6 MCM and 3 3 MCM, respectively The spring water output is around 2 5 and 2.8 per cent of the total rain water Per capita annual rain water input into the region is less than 2,000m^3

Jagdeep Rajput

Garhwal: Increasing deforestation compounds water problems

There is, however, an acute water shortage in these villages for domestic purposes. Forest degradation and soil erosion are among the main reasons why this region cannot store water Although there are more than 60 days of rainfall each year, there is no water in the summer months. This results in many hardships, especially for women who have to travel long distances in search of water Irregular water supplies also mean that irrigation is limited (2 ha in Danda and 65 ha in Chandrabhaga villages) If water resources were better managed by taking account of soil conservation and forest regeneration, the present needs of the population could be met without difficulty Short-term actions such as water storage tanks and spring protection to improve the quality of the water can be initiated in order to reduce the burden on women and children

Forest degradation and soil erosion are the main reasons why this region cannot store water

Water quality tests from Garhwal indicated that biological contamination is a concern Samples analysed after the monsoon showed very high coliform levels As was expected from a hilly region, the fluoride content was almost zero, a factor that contributes to dental decay Adding fluoride to food products is a standard practice in many countries, but here, alternate procedures have to be found. Samples from two springs have shown very low pH (4.14 and 3.68) levels, and correspondingly high values of total dissolved salts (TDS). This situation needs to be re-examined before any specific suggestions can be made (Box 15)

Box 15. Garhwal Himalayas: community management, afforestation, and low-cost technologies offer solutions

- The region has sufficient fresh water for drinking and agriculture, but there is need for management.
- Community management of the piped water supply scheme needs to be supported.
- Protecting the forests and springs, and other low-cost technologies should be promoted to reduce the ecological stress on women and promote water security.
- Environmental sanitation for protecting water quality should be a priority.

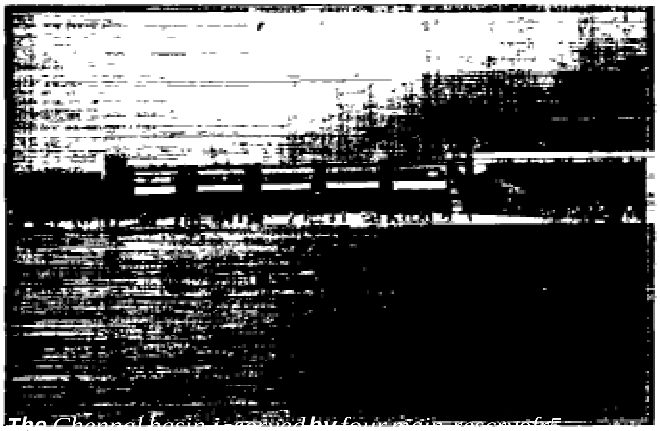
Chennai: Basin management

Chennai receives rain from the south-west and north-east monsoons. The former is usually not sufficient to increase the surface storage; however, it does contribute to improving the ground water table in the crucial period after summer The north-east monsoon manages to fill (in good years) all the surface storage tanks and recharge ground water The basin receives 943mm rainfall each year with 75 per cent dependability The total basin area is 7282 km^2, with 1740 km^2 in Andhra Pradesh and the remainder in Tamil Nadu

Rainfall is Chennai's main source of water Water is trapped in reservoirs and used cautiously so that they are virtually empty before the next annual rainfall What these surface water storage systems are not able to supply is met from ground water resources. The basin has four main reservoirs Of these, Chembarambakkam is used exclusively for agriculture,

Table 5. Chennai: Where does the water go?	
Source	**Amount (MCM)**
Surface water	784.20
Ground water	1,119.39
Run-off to sea	274.00
Unaccounted	4,688.41
Total	**6,866.00**

while part of the water in Poondi is also used for this purpose. Most of the water in Poondi and the entire capacity of Red Hills and Cholavaram are used for providing drinking water for Chennai city The combined total storage capacity of these reservoirs is 272 MCM At 75 per cent dependability (943mm) the total water that the basin receives from rainfall is about 6,866 MCM (i e 7282km^2 x 0.943m) Where this water goes is shown in Table 5.



The Chennai basin is served by four main reservoirs

Only about one-third of the water is accounted for The remaining water is lost through either evapotranspiration or not available because it is widely dispersed. The only other source of water into the basin is the Krishna Water Project[2] which, when fully

Table 6. Chennai Basin: Rainfall and variations in the watertable in 1994		
Month	**Rainfall (mm)**	**Depth (m)**
January	0.70	3.69
February	18.30	4.33
March	0.00	4.70
April	0.55	5.02
May	63.90	5.32
June	54.05	5.30
July	81.00	5.56
August	130.90	5.68
September	47.70	5 62
October	409.85	5.81
November	517.60	3.22
December	234.25	3.15

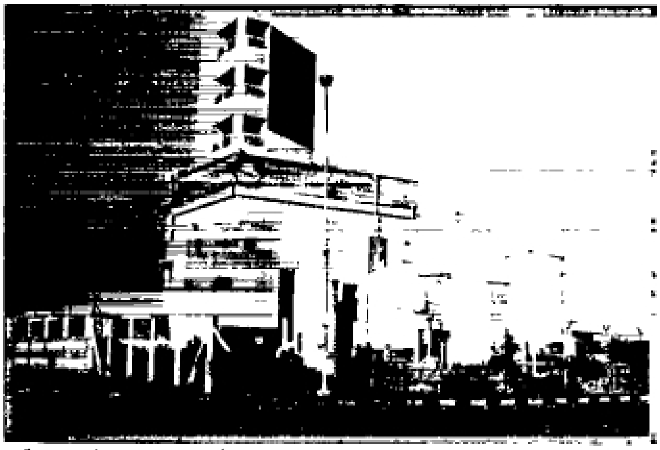
operational, will bring in about 340MCM of water annually. Another 65MCM could be brought in if the abandoned Veeranam pipeline project[3] is taken up The copious rains available between October and December (Table 6) fall in such short, intense spells that storing the water is difficult. The rains also cause a rise in the watertable level.

A household survey was undertaken as part of this study. 10,000 households were interviewed to understand the role of the various water sources in a typical urban household The results are summarized in Table 7, and indicate that demand for water does not undergo any substantial change over the year. It is the seasonal variation in availability that makes water management a difficult exercise for the city. If the population in the urban agglomeration of Chennai was to depend on the MMWSSB it would not have been able to meet its needs.

Total water consumption per person in the city is about 103 litres per capita per day. Together, metrowater

2 This scheme also known as the Telegu Ganga Project was initiated to bring 340MCM of water to Chennai city from Krishna river in the neighbouring state of Andhra Pradesh. The project involves the digging up of canals and the contraction of reservoirs, channels and pipelines in both Tamil Nadu and Andhra Pradesh Water will be drawn into the Srisailam reservoir in Andhra Pradesh when the river is in flood, and conveyed to the Somasila reservoir located in Pennar river through an open channel. Another reservoir has been constructed in Kandaleru which will be connnected to Somasila by another canal. From Kandaleru a canal runs to the Poondi reservoir on the Tamil Nadu side. The Krishna water will thus be transported some 600km from the source to Chennai city.

3 The project envisages bringing water from the Veeranam lake nearly 150 km away through a pipeline. The cost of the Krishna and Veeranum project is estimated at Rs. 14,000 milion (US$ 400 milion) which will provide water at an estimated delivered cost of Rs 6 10 for 1000 liters (1987 prices excluding investment costs), compared to the existing cost of Rs. 3 50 An alternative suggestion is purchase water from the Arani-Kortelіyar Aquifer near Chennai which has an estimated yield of 400MCM, currently used mainly for paddy cultivation. The cost of the option is estimated at US$20 million, if a system of water rights is allowed (World Bank/GOI, 1997a)



Chennai water works

and ground water account for over 98 per cent of the water used by households. Metrowater provides 45 per cent of the total water consumed, and the balance is from ground water (55 per cent) In the summer months this proportion changes to 39 per cent and 60 per cent, respectively Not only is there a high degree of reliance of households on ground water directly, but metrowater itself obtains 25 per cent of its supply from ground water thorough well fields So the city relies on fulfilling 65-70 per cent of its requirements from ground water, but heavy reliance has, however, not been accompanied by adequate efforts to maintain the resource base (see Box 16)

Over 65% of all water supply in Chennai is from ground water

The household survey along with a survey of 2,500 non-domestic sector units, provided a good estimation of existing water demand. These estimates, projected on the basis of a 25 per cent growth made in the population over the decade, as well as a 25 per cent industrial growth, were based on survey data The annual requirement of water, estimated for an increasing population and for a growing industry over the next 50 years, is shown in Table 8 and compared with other studies The total water demand is 312MCM which is projected to rise to 560MCM by the year 2021. Total water supply from various studies is shown in Table 9 Theoretically, therefore, sufficient water comes into the basin to meet the growing demand

Consumption of water for agriculture in the Chennai basin is presently about 85 per cent and expected to drop to around 60 per cent within the next 50 years. A consequent rise in the domestic sector from 7-22 per cent is expected. For industry, power, and recreational water users, the rise will be from 5 to about 15 per cent In absolute terms there will, therefore, be an increase in demand of about 1,000MCM over the next 50 years

Table 7: Chennai: Water consumption by different sources during summer and winter

Source	Summer (% of total)	Winter (% of total)
Metrowater pipe supply	32 80	40 40
Metrowater supply by tanker lorries	5 70	3.20
Private tanker lorry supply	0 09	0 06
Open wells	26.07	26 40
Borewells	34 09	28.47
Other sources	1 25	0.97
Total	**100**	**100**

Box 16. Environmental impact of ground water extraction for Chennai city

Three well fields in Minjur, Panjetty and Tamaraipakkam which were put into production during the 1969 drought have shown a drop of 8-12 metres. Minjur has a deep cone of depression as a result of water exploitation. Seawater has flowed into this depression as far as 9 km inland, making ground water more saline and non-potable even for domestic use. Similarly, the water table in the southern aquifer which has been used for tanker supply by as many as 100 tankers each carrying 8,000 litres of water and running up to 8 trips a day, dropped 4 5-6 metres between 1983 and 1989, with some areas recording intrusion of sea water. The Buckingham Canal, constructed at sea level for navigation has also shown extensive sea water percolation in the fresh water bearing sediments, with the canal's inclination aiding salt water injection into the ground, which is irreversible.

Table 8. Estimates of total water demand for Chennai 1991-2021 (domestic and non-domestic) made in different studies (MCM)

Agency	1991	1995-96	2001	2011	2021
Murugappa Chettiar Research Centre		312	347	440	560
Chennai Municipal Development Authority	344		438	549	
Madras Municipal Water Supply & Sanitation Board (MWSSB) study	332		418	526	
Ayyadurai S.N (Chennai city) Institute of Water			354	485	565
Studies (for Chennai basin)		315(1994)	536		

Chennai Basin is not lacking in rainfall Given the size of the basin and the annual rainfall, it is seen that the quantity of water theoretically available is more than adequate to meet the needs of the metropolis, and to support agricultural activity within the basin

The concentration of rain in a very short period has made engineers and planners look for easier solutions which have a longer time frame (e g the Krishna Water Project) Tackling the problem with alternate technical approaches which are ecologically and environmentally sustainable means that the net inflow into the basin via rainfall will be more than adequate to meet the needs of the city and agriculture combined

Box 17. Chennai city: sustainable and ecologically sensitive solutions call for an examination of various alternatives

- The pattern of demand and supply for water suggests that current solutions will be inadequate, despite the high financial and environmental costs being incurred.
- The basin receives sufficient rainfall but all that water cannot be stored. However, opportunities exist for improving recharge, storing rainwater, renovating temple tanks, and cleaning waterways. All of these can contribute to improving ground water availability.
- Reducing water loss through the piped water system and metering must complement technological approaches to improving the quantity of water available.
- Awareness and action for water conservation through pricing, regulations, incentives and water recycling should be promoted rather than increasing total water supply for the city.

Table 9. Estimates of total water supply for Chennai (1991-2021) made in different studies (MCM)

Agency	1991	1994	2001	2011	2021
Chennai Municipal Development Authority	158			514	
Central Ground Water Board	169			374	
Ayyadurai S.N. (Chennai city)	127		294	294	498

Chennai: Renovation of temple tanks offer a low cost option for improving water supply

Plans to increase water supply must seriously consider ways, means and opportunities for storing rain water in the most convenient way This is the challenge of solving the fresh water problem of the city (Box 17). Some of the options are renovation of the temple tanks, cleaning of waterways, adoption of low-cost, rain water harvesting and storage system, and water treatment systems for ground water at the domestic level The costs involved would be comparable with alternative short-term practices now underway Such efforts would also force development to look at problems of sewage and waste disposal in a environmentally-friendly way. Pollution levels would have to remain low since they would otherwise render water from the aquifers unsafe for consumption This would have an additional impact in terms of cleaner waterways and, possibly, better health (lower incidence of mosquitoes) due to the removal of stagnant waterbodies.

3.2 Water, Women's Stress And Migration

The effort that women and girls have to make to fetch water for household consumption has been one of the underlying social ills of Indian life Water scarcity has a significant impact on the health of women and girls. Despite the high levels of official coverage, women still carry the burden of bringing water into the home. This burden is compounded by stress as a result of ecological degradation, and migration of men to cities in search of work, partly because of agricultural activities being affected owing to water shortages

Water burden of women and girls in Gurrabbadu: On an average, a woman has to make ten rounds to the borewell to fetch 150 litres of water (for a family of four) This is equivalent to a 5 km walk and takes at least 2 hours, excluding any waiting time at the handpump During the critical period, normally in summer, some people have to obtain water from irrigation wells, often paying a price both in kind and cash There are 15 handpumps in the watershed — 9 public (of which only 5 are working at any given time), and 6 privately owned.

> ***Children, particularly girls, continue to carry by far the greatest burden of fetching water***

Physical monitoring of all the handpumps on 14 August 1995 and 13 January 1996 indicated that the quantity of water drawn is 50,985 litres and 41,940 litres respectively. This works out to 26 and 32 litres per capita Further, monitoring of the handpumps indicated that some of them are overused for more than 15 hours a day when they provide about 20,000 litres In a season, only two or three borewells are effectively supplying more than 80 per cent of the fresh water needs — the remaining are either low yield or under repair

Women and girls are estimated to carry on an average 150 litres of water per day in the summer months Together, an adult woman and a girl in the same family may carry as much as 375 litres of water per day. Women and girls in the same household in the upper income groups in the study area carry as much as 50 per cent more water — around 562 liters per day — because they have more cattle and a larger family size. A 15 litre water container is used to carry water, and at that rate an average female makes 25 rounds per day between the handpump and home. Table 10 indicates the amount of water carried by men, women and children Among children, it is mostly the girls who carry the burden of fetching water

This effort is further compounded by the non-functioning of handpumps and the waiting time at the pumps. Of the total of 9 public handpumps in the study area, not more than 5 were found to be functional at any given point of time, with differing yields across seasons and depending on their proximity to the irrigation borewells. In the crisis months from 1993 to June 1995, it was noted that males carried water from long distances on bicycles. About 11 per cent of the drinking water by the end of the crisis period came from privately owned pumps, half of which were energized It is felt that this trend of energizing the drinking water borewells will steadily increase as public borewells are perceived more as the poor man's alternative.

There is an economic opportunity cost also to women in fetching water from handpumps, in addition to the health cost The handpump technology was introduced when rural wages were significantly lower than at present. Therefore, the time women have to spend at handpumps is now more valuable than before because it is at the cost of other wage earning opportunities In areas where there is greater water use the labour rate is higher because of the greater opportunity for employment. As a result, the cost of

> ***The opportunity cost for women fetching water is Rs. 6 per day. At this rate, water costs Rs. 40 per cu m — far higher than the cost of water provided in cities***

Table 10: Gender-wise pattern of the water burden in the Gurrabbadu watershed								
Category	Population	Per day water withdrawn (litres)			Annual total (litres)	Per capita water withdrawn (litres)		
		Monsoon	Winter	Summer		Monsoon	Winter	Summer
Male adults	428	13,860	5,550	11,580	3,718,800	32	13	27
Female adults	420	15,765	16,365	31,455	7,630,200	38	39	75
Male children	379	8,610	7,275	9,795	3,081,600	23	19	26
Female children	365	15,345	12,165	23,130	6,076,800	42	33	63
Total	1592	53,580	41,355	75,975	20,509,200	34	26	48

women's time lost in fetching water is higher Women spend more than 3 hours to fetch the required minimal 150 litres. Even at the rate of Rs 2 per hour of a woman's work, the opportunity cost of fetching 150 litres of water is Rs 6 per day. At this rate, the cost of water is equivalent to Rs. 40 per cubic metre — ten times higher than water provided inside a house in Delhi

In the Rayalseema study, 25 families out of 60 living in Palakuntla village migrate on a seasonal basis to adjacent districts, usually from January to June, moving to an area where sugarcane is grown under irrigation Per capita earning in one season could be around Rs. 1,000, a considerable amount considering that annual per capita earnings in this region are about Rs. 2,400 People here say· "We are clearly better off now, we are able to eat throughout the year." A second, but less significant form of migration relates to pastoral movements of shepherds to other areas in search of water and fodder.

Box 18. Fresh water conflict in Rayalseema

Kuruva Dasarath, a small farmer, dug an 11mm diameter borewell at the edge of his one acre plot. It was a success and he was happy that he could irrigate an acre of paddy, followed by groundnut. Shortly thereafter, his neighbour Kuruva Tirupal, a well-to-do farmer, sunk a 16.5mm diameter borewell fitted with a submersible pump just three metres from Dasarath's borewell, in spite of the latter's request not to drill too close to his well. Immediately, Dasarath's borewell dried up and an acre of paddy was lost as a result.

Dasarath has four brothers who encouraged him to drill another 16.5mm diameter borewell at the same spot. They collectively borrowed the money for the second venture. The drilling process affected Triupal's well so badly that the casing of the borewell fell out and the submersible pump was stuck inside. Immediately, Tirupal accused the brothers of ruining his borewell and took the case to the village elders.

Tirupal has now demanded that he be allowed to share the running borewell along with Dasarath. The Panchayat was unable to resolve the case.

The per capita consumption of water in the Gurrabbadu watershed, including irrigation, varies among social classes If all fresh water use is considered, including irrigation, then per capita consumption is four times higher among the households with over 10 acres of land compared to those owning only 5 acres.

While no differences were noted in terms of access to drinking water by different castes, water conflicts are not uncommon and generally difficult to resolve even at the community level because of the nature of 'water rights' conferred on landowners (Box 18).

The per capita daily human consumption in the Gurrabbadu watershed was 44 litres during summer, 27 litres in winter and 36 litres during the rainy season The proportion of fresh water use by sheep, cattle and humans in the watershed is 11 per cent, 17 per cent and 72 per cent, respectively. There was, however, little difference in the consumption rates of the different communities of Madiga, Boya, Golla, the rich farmers, and the landless — all of whom seem to suffer equally low levels of consumption During the two days of the study in August and January, per capita consumption was noted as 22 litres and 17 litres, respectively, with the latter lower because of the bathing pattern and the migration of sheep and people.

Eco-stress in Danda

In the Garhwal hills, women are engaged in a variety of agricultural activities such as fertilizing the fields, ploughing, sowing, weeding, harvesting and threshing Women typically spend eight hours a day in the fields apart from the time spent in collecting water

In the Danda area, the water authority provides water through a rural water supply scheme Although there are four storage tanks and 15 standposts, the water supply is highly irregular and unpredictable. On an average, the

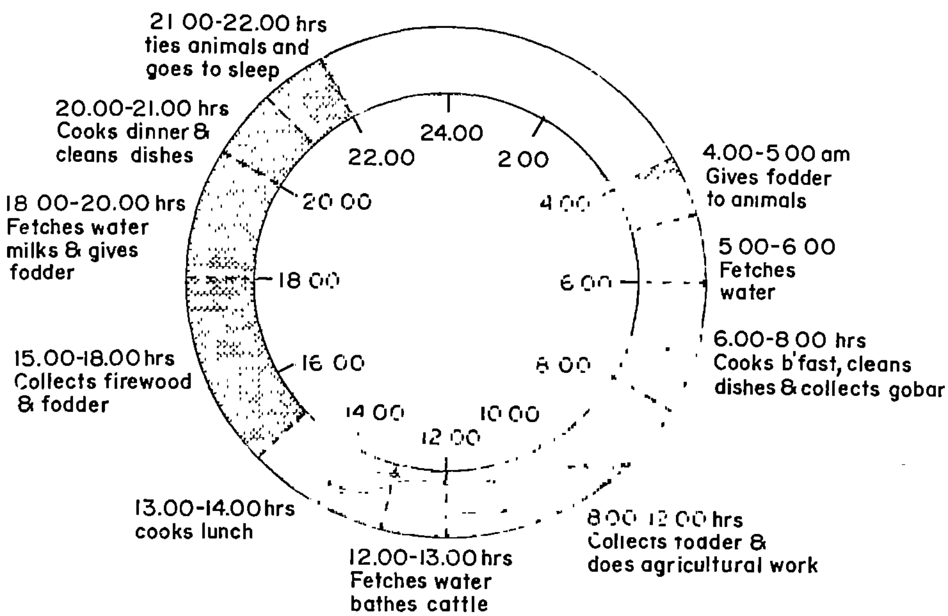
Garhwal: Water stress is a major factor in the hard life of women and children

standposts function for just nine days a year; in May 1996, at the height of summer, they only provided water on one day. As a result, the Danda women are highly dependent on spring water.

Water stress contributes to many hardships for women in this region. Because of the low availability of water, vegetation growth is low, which means that there is less green fodder This in turn lowers the production of both *gobar*(cowdung) and milk. Since *gobar* is used as manure, less quantities produced ultimately result in low agricultural yields. There is, therefore, a vicious circle of water and ecological degradation impacting on the health of women, termed eco-stress (Box 19).

On an average, women spend 1 5, 2, and 3 5 hours collecting water each day in the post-monsoon, winter and summer months, respectively Collection of fodder and fuel is also time and energy demanding It was estimated that women spend 3-4 hours daily collecting fodder, and 5-6 hours collecting fuel at different times of the year. In total, working in the fields, collecting water, fuel and fodder takes from 10-13 5 hours of the women's time each day A typical work schedule of the women in Danda is shown in Figure 2

Figure 2
Woman's Typical Work Schedule
Danda Area - Garhwal Himalayas



Box 19. Saraswati Devi: a story of eco-stress in Danda

Saraswati Devi was born and brought up in Danda. Married at the age of 11, her husband used to earn a living by taking pilgrims in a *dola* (wooden carriage) to Badrinath and Kedarnath. Unfortunately, her husband died soon after their marriage and Saraswati did not marry again but returned to Danda and took responsibility for her two younger brothers. Her brothers have migrated to the cities. She is left with one acre of agricultural land, one cow and Rs. 120 as a widow pension.

Even at the age of 72, Saraswati gets up at 7 o'clock, and after having tea, she feeds the cattle. Then she goes to the spring to collect water, travelling almost 300 metres, waits for a long time for her turn and then carries almost 7 to 8 litres of water back to her house. She makes two *chappatis* for herself and goes to get fodder. She then walks almost 600 metres to reach the field where she spends 3 hours. She comes back and cooks and eats her meal. After a little rest she again walks almost 600 metres and brings 5 - 6 kg of fuel, cooks her evening meal and goes to bed.

Fuel and fodder collection put an additional burden on women in the region

By comparison, women in Chandrabhaga have functioning standposts and good forest cover, which caters to their requirements of fuel and fodder

In the Garhwal area, upper-castes migrate to towns for settlement purposes People of the lower castes remain in the villages Migration in the Chandrabhaga and Danda villages was found to range from 26 to 50 per cent of the total population. Migration entails a high cost to the community, particularly to women. Differences prevail between the two villages in this study area In Danda, which suffers greater water scarcity than Chandrabhaga, of the total population of 983,148 people are seasonal migrants, while 289 are permanent migrants In other words, almost 50 per cent of the population migrates to outside towns. In the case of Chandrabhaga, around 26 per cent (342 people of a population of 1,320) migrates to other areas Male migration, particularly seasonal, is higher than female migration. A comparison of the two areas showed that migration is higher in the village with greater water scarcity, although they are both in the same eco-region. Male migration has a significant impact on women who are left behind not only to fetch water from far distances in mountainous areas, but also to ensure that there is adequate food, fodder and fuel for the family

> ***The 'water poor' are more likely to migrate to cities***

3.3 Environment And Eco-System Sustainability

Protecting the environment and enhancing water resources in Rayalseema

In the 1900s the forested areas of Rayalseema supported a wide range of wildlife, including elephants, but the area is now devoid of major vegetation, remaining ground cover being mainly scrub. Much of the forest was cut for timber: by the mid-1960s, cartloads of timber were being transported to neighbouring towns to meet growing demands. Local farmers participating in the present study noted that deforestation was associated with two major changes in livelihood pattern and resource use:

- the replacement of cattle by sheep, as a result of which more grazing land was needed;
- a change in cropping patterns from equal areas under *korra* (foxtail millet), sorghum, *ragi* (finger millet) and horsegram, to groundnut (about half of the sown area) and castor instead of pulses (Groundnut depends heavily on ground water for irrigation. In the 1980s, the rapid increase in the price of groundnut — Rs 40 in 1974-1975 to Rs. 300 in 1990, and currently Rs.600 for a 40kg bag — encouraged many farmers to increase the

A water storage structure in Danda area

area of cultivated land)

Since the 1980s, several initiatives have been taken by the government and NGOs to improve the local water situation The Prime Minister's Office has put together a package of programmes to combat and arrest desertification in the region. NGOs are working with the government in the implementation of watershed programmes. These efforts have led to a wider acceptance of the need to increase ground water recharge, development of water harvesting structures, and watershed management institutions with people's participation

> ***The problem is not lack of water but the 'right' kind of water resource management***

How much water for an eco-region?

A central question is how much water is enough for an eco-region or urban situation? Each of the case studies illustrates that there is sufficient water that comes into the study areas at various times during the year, but because of competing uses and limited storage possibilities (on the surface or ground), water scarcity (quantity and quality) is affected at periods during the year. The problem is not lack of water but inadequate water resource management and the perverse market signals and incentive mechanisms that are provided to farmers and communities. The impact is on the environment and ecosystem since the more water that is supplied without environmental protection results in more water downstream which is unfit for the ecosystem as well as human use

The Chennai situation not only shows that it is possible to address, or at the very least, consider alternate approaches to the water scarcity problem, but also from an environmental perspective consider the implications of not adopting ecologically sustainable patterns of water utilization (See Box 20)

3.4 Water Quality And Pollution

Significant problems pertaining to high levels of fluoride have been noted in some of the study areas (Gujarat and Rayalseema). Other quality related issues included biological contamination (Garhwal) In Pathoda, while fluoride levels were well within the required limits, the water was found to contain more dissolved solids, particularly chlorides and calcium carbonate High concentrations of chlorides and sodium were found in irrigation borewells In addition, water drawn from greater depths contained higher total dissolved salts and the overall quality was low In such situations, it is necessary to identify wells with good water quality and protect them for drinking water purposes Pollution from the encroachment of industry into agricultural areas (Sanaswadi) is another issue to be addressed by policies and programmes.

3.5 Traditional And Low-Cost Options

Despite the many differing challenges, the case studies have highlighted many opportunities to initiate measures to increase water availability, as well as maintenance and rehabilitation of the local ecology. Traditional water harvesting techniques offer some of the most practical opportunities, but in practice they also pose some problems In the past 40 years, many such systems have fallen into disrepair, and their services may no longer be able to meet current demands And because they are often not close to the home they may not be used But they can be important for recharging the ground water and as storage in critical periods.

Ground water can be recharged through the adoption of simple low-cost techniques (Rayalseema). Existing traditional water harvesting structures also provide opportunities for recharging the ground water (Narsipur and Chennai). But such recharge alone is not capable of meeting the trends of increasing ground water withdrawals, and

> ***Traditional water harvesting techniques offer some of the most practical opportunities but have limitations***

Box 20. Can Chennai offer insights for other urban situations?

The approach in Chennai is to explore various alternatives to increase the amount of water available on a per capita basis. Consider the following:

- More than 42 million people live in 12 major cities of India [Mumbai (Bombay)], Delhi, Calcutta, Chennai [Madras], Hyderabad, Ahmedabad, Bangalore, Kanpur, Lucknow, Nagpur, Pune and Jaipur). Together they are provided more than 8 billion litres a day or 189 lpcd on an average.
- Chennai is presently consuming 100 lpcd. Although it experiences water scarcity at certain times, this amount of water is adequate in other periods. If this amount of water is available and utilized judiciously there should not be any significant impact on health and hygiene. If this norm is available in the urban areas, then the currently available 8 billion litres should be sufficient for 2.5 times more people than are currently living in these cities.
- Delhi's 1848 Mld at 100 lpcd would be enough for 12 million people (4 million more than the current population) Similarly, Jaipur city is consuming 155 lpcd and Kanpur is at the top with 307 lpcd — comparable to many cities in developed countries.

Some insights based on the Chennai case study with implications for other areas are

- sufficient water is currently coming into the urban areas but it is not necessarily reaching the people due to water losses, and some people consume a lot while others have to do with the minimum;
- there is a lack of water conservation measures, partly because of an absence of water pricing and full cost-recovery and lack of awareness;

Regular maintenance of handpumps is vital

- prevention of water pollution is not high on the list of results to be achieved;
- water recycling is not widely advocated and practised;
- freshwater conservation and environmental protection are not factored into the strategies; instead the response is to bring more water from afar.

Unless actions are taken on the above, adequate water supply for cities cannot be ensured with ecosystem sustainability.

ground water legislation and regulation implemented with the communities will be needed for controlled use of ground water and environmental protection Afforestation provides good opportunities for storing water above the surface and underground (Rayalseema and Garhwal). In Garhwal, there is a possibility of improving the water storage system to increase per capita availability at a relatively low cost through the protection of springs, prevention of faecal pollution and afforestation

Jagdeep Rajput

To meet the growing demand for water in Chennai by the year 2020, expensive technological solutions are being considered, but they still do not guarantee adequate water supply for the city. Almost four times the projected demand for Chennai and six times more than the expected capacity of the Krishna diversion project could be met through improvements in the surface canals, recharge of the ground water through temple tanks and existing borewells, de-sedimenting the rivers and deepening them suitably, and preventing run-off to the sea.

Traditional water harvesting techniques and recharge options also face limitations arising from the topography, hydro-geology and available land With a high percentage of village land under cultivation, the scope for traditional or low-cost solutions is limited in cases such as Lohom where 84 per cent of the area is taken up by agriculture and grazing, and the remaining topography is not suitable for

> ***There is not enough land, or the topography does not permit traditional low-cost solutions in some cases***

Reuse of traditional water storage systems could ensure ground water recharge

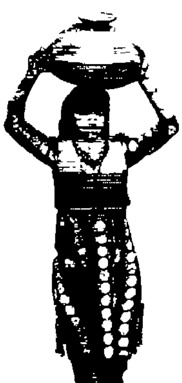
water storage techniques or recharge systems In Sanaswadi, agriculture and industry also occupy 84 per cent of the land area, and given the topography, bunds are not suitable though the area is prone to flooding in the monsoon season Similarly, traditional low-cost options are limited in the case of Adgaon and even Narsipur. It must also be questioned whether additional storage facilities and recharge alone can be solutions, because in the absence of arresting the demands for other competing uses, this may simply result in, for instance, increased cash cropping. More water may simply mean more cash cropping, not necessarily household water security

Further work is needed on how community-based initiatives should be designed

The challenge, therefore, is not only to explore traditional low-cost options, but to determine with the community what is an ecologically sustainable level of ground water extraction in a given local situation, and work with the people to design and implement regulations to conform to these standards

3.6 Public-Private Conflicts And Partnerships

Under the existing system of 'water rights' in India, it is difficult to give primacy to and fulfill the basic right to drinking water Difficulties arise because of conflicts which develop between public and private interests. An aquifer which is shared by many households and villages is seen as a common resource pool for the benefit of everyone, although if the rate of extraction is greater than the rate of recharge, one consumer can dramatically reduce the availability of water reaching others further downstream. Pollution of ground water from non-point sources, such as agricultural fertilizers and pesticides and from industrial and municipal effluents, represents another dimension of the public and private conflicts over fresh water.



Ensuring the fundamental right to water is difficult to achieve under existing legislation and implementation approaches

Some regions which do not as yet have a drinking water problem can nevertheless impact on others because of their location (Kubda) In other cases, the production of certain crops such as sugarcane impact on the water availability for adjoining villages (Adgaon) In such instances, community-based actions alone will not be sufficient, and legislative and regulatory measures with economic incentives and controls will be needed to ensure adequate water for drinking purposes But equally, legislation and regulations alone are not the answer

There is an increasing need for partnerships within and between communities and between communities and the government in order to ensure a 'fair' and equitable sharing of water resources among its competing uses and protection of the environment Building such partnerships requires a close understanding of the social dynamics in the communities. Encouragingly, some local initiatives and partnerships exist for sharing water resources for irrigation (Pathoda), for drinking water supply (Narsipur); and for arresting the decline of the forests (Rayalseema)

More work is needed in the area of public-private partnerships in order to learn from experiences and to promote sustainable community-based approaches for managing fresh water resources This should include, *inter alia,* the possibility of supporting contracts between Gram Panchayats for determining the quantity of water to be extracted for various purposes, and actions to manage fresh water resources in rural areas, as well as improved cost recovery in urban water supply based on the criteria of adequate quantity, quality and reliability of water supply services within alternate financing mechanisms such as credit (Nigam 1996) In the absence of implementable legislation, community-based approaches need to be explored which create awareness and devolve authority and responsibility at that level.

3.7 Equity

Equity in the access and use of fresh water resources has a number of important dimensions. competing uses between agriculture, industry and household demand, which gives rise to the concept of 'fair sharing', economic relationships across different income groups, as in the case of rich and poor farmers, and social conditions across different castes or groups

Ground water is a common pool resource but with undefined and unconfined common pool aquifers. It is the primary and preferred source for irrigation because of its proximity to the crops, and provides a more efficient system for irrigation, but it also requires less capital investment by the government, and lower seepage and evaporation.

Under the current system of 'water rights' for ground water it is difficult to ensure that equity considerations will prevail in access to water for irrigation, industry and human consumption, and by income groups and the landless. Our analysis suggests that it is not possible to determine what constitutes a 'fair share' for domestic, industry and agriculture purposes without at the same time making value judgments and designing effective legislation and government interventions to enforce the equity concept. Market based allocation mechanisms already exist (see Box 21). But if decisions are left to the market, without adequate regulatory safeguards, then agriculture and industry will not only take the lion's share of the resource base, but also threaten the 2 per cent requirement for drinking water

'Fair share' for different uses can be ensured by designing effective regulatory measures and by government intervention

Collective action at the community level (user based allocation system), such as for drinking water supply in Narsipur with the village constructing common systems, along with the practice of water vending for agriculture (market based allocation system), offer alternatives, but in themselves do not guarantee protection of drinking water If water for domestic purposes and ecosystem sustainability can be protected, then the market allocation system may efficiently allocate water resources within and between agriculture and industry, having ensured primacy for drinking water

Social equity in terms of access to water supply by different socio-economic and caste groups and its implications for fresh water management was not addressed specifically in the studies. This will be an important consideration in community and government based initiatives for watershed management Some insights are provided by the studies, but this is an area where further work will be needed, particularly in pursuing community and user-based allocation systems.

A combination of the public, private and market based allocation systems exist at the micro-level in India, but community based management, and involving the communities in the design of legislation and regulations implemented with their involvement, are necessary to ensure primacy for *the availability of adequate quantities of water for drinking and household purposes at an affordable cost in the right place at the right time for basic needs with ecosystem sustainability.*

3.8 Legislation

The government is acting on the legislative front with the proposed Model Bill on ground water Two deficiencies have been identified in this bill (World Bank/GOI 1997b). By taking a highly technical approach and by not involving communities in the management of the resource, it fails to address a key problem· how will regulations be enforced given the large number of privately owned wells, and the lack of political will to enforce them? In addition, the proposed bill also focuses mainly on extraction of water resources and not on waterlogging, water quality, water pollution, allocation, and environmental considerations. The present analysis suggests that the bill also fails to tackle the broader issues of management of fresh water resources, such as recharge and regeneration, controlling the types of crops grown in water scarce regions, and environmental degradation

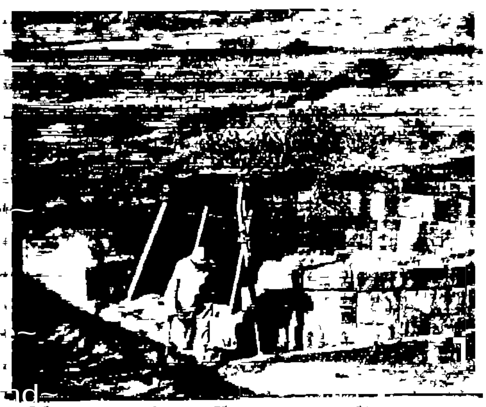
Box 21. Market based approaches to water-allocation in Gujarat

Tubewell co-operatives

In Gujarat, the GWRDC owns 2,728 irrigation tubewells of which 248 are managed by farmer co-operatives Each co-operative deposit security pays advance electricity charges, and pays a token Rs 11 per annum to GWRDC. In return, co-operatives provide water to all farmers falling within the reach of the well, as identified by GWRDC. They are not entitled to alter tubewell installations. However, problems exist relating to the principles and legal framework that governs co-operatives. Co-operative law requires that each member has one vote regardless of investment and stake. As a result, the co-operatives suffer from capital shortages and depend on a 'trustworthy' leader. Tubewell co-operatives seldom get registered without external initiatives and large subsidies. They often tend to disintegrate in the face of competition from private sellers.

Tubewell companies

have been created in response to the high cost of extracting water from great depths, particularly in Mehsana district where fossil water is being extracted from depths of 200-400 metres. A tubewell costing Rs 1 million is beyond the capacity of an individual, particularly because of the high risk factor of not striking high yielding aquifers. Tubewell companies of 5-150 farmers have been formed to share the high capital costs, risks and rewards of deep ground water extraction. Members divide water shares, profits and maintenance costs in the same proportion as their shares to the initial equity contributions. Those companies which have come up through grassroots action perform very well without the need for external support. However, the system does not guarantee protection for drinking water and the ecology



Old community well at Sanaswadi village

Sharing of risks

has evolved in the water markets. In Banaskantha district, Gujarat, high risk *jeera* cultivation has given rise to risk-sharing arrangements *Jeera* crops fetch high prices in a good season, which occurs once in three years. The risk involved in its cultivation, however, is very high and farmers stand to lose Rs. 3,000-4,000 per acre, in addition to fertilizer and labour costs. As a result, farmers do not buy water at a flat rate for *jeera* irrigation. Instead, water transactions are related to share-cropping Tubewell owners claim one-third of the crop in return for irrigation supplies, but do not incur any other costs. The farmer is, therefore, able to diversify his risks for a lower reward.

The key elements that should be included in ground water legislation as suggested by the studies are.

- Identification of areas at the micro level where control and/or regulation of the extraction of ground water is deemed necessary on the basis of standards and other underlying reasons;
- Control of water extraction with community involvement,
- Requirements for compulsory recharge and regeneration,
- Prohibiting the production of certain crops in areas deemed necessary;
- Measures to prevent waterlogging and pollution;
- Implementing legislation and regulations through community awareness, involvement and management

Further, the micro level studies also suggest that broad classifications of notified areas for controls/regulations, even at the Taluka level, may penalize villages which, with resource management, may have the potential for sustainable rates of utilization of water. Local-level analysis should be conducted to understand the dynamics of the water situation before water scarce regions are identified for controls and/or regulations

Controlling extraction in identified areas through legislation and regulation in spite of the difficulty in implementation in the Indian context should not be the only response. Awareness must be created in communities of the fresh water situation, and they should be empowered with authority and responsibilities to enforce regulations and agreements themselves

Many of the features of the present proposals were present in the national water policy, including primacy for drinking water, but have not been implementable Additional actions indicated above but designed, developed and implemented by the communities will be necessary in order to address the wider challenges of water resource management, including that of earning a livelihood from agriculture in water scarce regions.

Chapter 4

WHERE DO WE GO FROM HERE?

These case studies are an initial multi-disciplinary approach to understand the dynamics of the 'water environment' at the smallest level of habitation — households and communities Through a comparative assessment, they highlight what can be done at different levels of action — local, state, national and international — and what needs to be done jointly in order to address the problem This chapter synthesizes the observations and insights and provides policy and programme implications

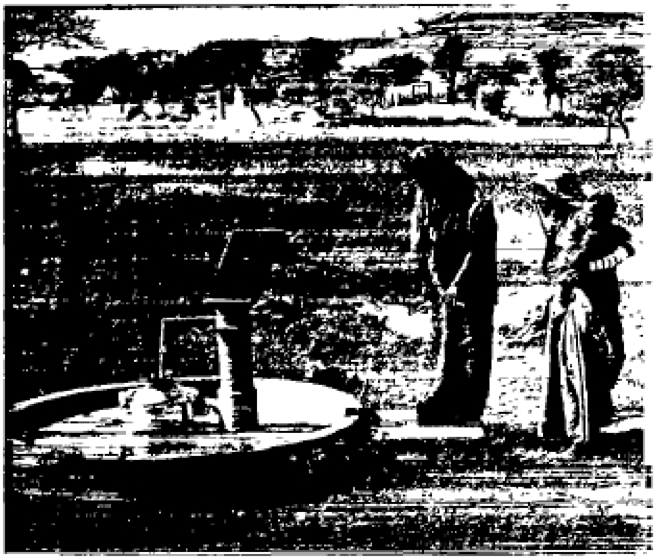
4.1 SYNTHESIS OF OBSERVATIONS AND INSIGHTS

It is theoretically possible to meet a significant increase in demand if water can be transported from far away either through inter-basin transfers, piped system, tanker or bottled water for drinking The technological constraints are essentially related to affordability and ecological sustainability[4] But the government does not have the resources, and many of the poor cannot afford to engage in expensive technological solutions which may, in any event, not be appropriate and environmentally sustainable Similarly, suggestions have been made to curtail individual rights over ground water through Constitutional reform, whereby individuals do not have the right to any water from underground aquifers without the permission of the community (see Box 3) There is much to be said in favour of such approaches. But policies and programmes must focus not only on what is technologically and legislatively possible in theory, but what is feasible in practice in both the short and long run in the context of India, because 70 per cent of India's rural population lives in poverty and the problems are immediate

The studies have provided observations at the micro level on the fresh water situation. supply, demand and use over time, the linkages with the environment, indications of how the present water scarcity situation was reached, and what are the constraints and possibilities for managing fresh water resources. The insights and recommendations in each case study area and the limitations point to a set of policy and programmatic actions Box 22 summarizes some of the insights that have been provided by these studies

The case studies have explored several dimensions of the emerging fresh water crisis and its implications in the short and long run The 'water wars' referred to in global discussions are not yet prevalent between countries, but 'water conflicts' already exist in communities between neighbours, villages and states Many of the 'water poor' and landless are helpless to resolve such conflicts, and even at the community level there are limitations on what can be done. In designing policy and programme options several factors need to be considered, some of which may be contrary to what is generally accepted

First, domestic water use at the village level and in some of the urban areas is not excessive in relation to the needs of people Rural communities also need water for agricultural production Both water security and food security are important.



Second, cultivated land (not irrigated) is extremely low ranging from 0.01 to 0.55 hectares in all the study villages (Table 11). This is low by most standards and there is, therefore, limited possibility of reducing this further in terms of ensuring food security and social stability Density of population is also high, for example, in the Garhwal area

4 *For example, it is estimated that changing from a rather simple handpump scheme or a mini/small piped water supply scheme at the village level to a more complex technology alternative will result in a 1000 or 1500 per cent increase in both the capital investment and recurring costs with serious implications for its technological and institutional sustainability (World Bank/ GOI 1997b)*

Box 22. Summary of insights on the fresh water situation from local-level studies

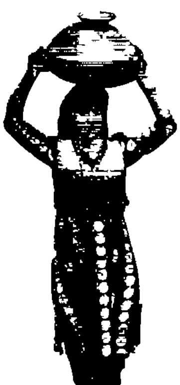
- India is and will continue to be, in the foreseeable future, heavily dependent on ground water. This high level of dependence on ground water in all the study areas has not been accompanied by social, economic, technological and community-based actions to ensure the sustainability of this critical resource base.
- The stated government national water policy which gives primacy to drinking water has not been met because of the system of water rights and excessive extraction of water for irrigation. It is difficult to implement such a policy through legislation alone.
- With the high levels of extraction of ground water for irrigation, the percentage of water utilized for household purposes has declined to as low at 1.5 -2 per cent of total water extracted annually from the ground in some regions, even in semi-arid areas. But even this amount of water for domestic purposes is under pressure.
- Sustainable levels of water use must be defined against standards for areas under water stress. Legislation and regulations to enforce these levels should be implemented with the involvement of communities at the local level, such as the Panchyat Raj institutions. In certain areas, decisions may have to be taken on restricting the amount of water extracted, the depth of the borewells for irrigation, the planting of certain water intensive crops, and prohibiting construction of irrigation wells within certain distances of the drinking water well.
- In some regions, affordable traditional water harvesting systems with environmental protection measures can ensure a balance between water availability and demand in its conjunctive uses.
- Meeting the drinking and household water needs often continues to be at high cost to the health and time of women and girls. This is compounded by stress as a result of ecological degradation.
- In drought-prone regions, such as Rayalseema, if the environment and the fresh water resource base are properly managed, there can not only be sufficient water for household purposes throughout the year, but also for increased food production.

Women meeting the household water needs from a village pond

- The Chennai basin receives enough rainfall to meet the present and anticipated future needs. A primary challenge is to develop water harvesting, storage and recharge systems that can take advantage of the natural and environmentally sustainable approaches.
- In some eco-regions, water quality fluctuates significantly between wells in the same village. Monitoring of water quality, identification of wells which are safe for drinking water and protecting them will require on-going government and community awareness and actions.

compared to the plains

Third, in some of the villages there is limited land available for initiating water conservation and low-cost technological options such as rain water harvesting. Cultivable waste which is often looked at to provide land for new water harvesting structures such as percolation tanks is extremely limited. At the same time, it is difficult to propose any measures to reduce cultivable or irrigation land. Although water is a priority, community-based options must take account of land scarcity along with water scarcity.



Fourth, the encroachment of industry into agricultural areas brings with it not only urbanization but also water pollution. The water problems of urban areas are being transported to agricultural areas — now these villages experience competition for domestic water supply not only from agriculture but also industry. Industrial pollution brings with it added problems without adequate regulatory safeguards.

Fifth, while a number of eminent earlier studies have recommended the removal of subsidies for electricity and multi-part pricing as one mechanism for controlling ground water extraction, in practice this carries with it significant equity implications for the small farmer, apart from the difficulties of enforcement and substitution for other forms of energy.

Sixth, water markets already exist in some of the study villages, although in some cases people have preferred to enter into a partnership for sharing water resources during different periods of the year. However, this has not prevented extraction of water for cash cropping in water scarce regions. Regeneration of ground water resources, therefore, calls for some form of official or self-regulation by the community. The latter may be more practical in the Indian setting.

Table 11. Utilization of land in the case study villages for agriculture and other purposes

Name of the village/watershed	Total area (hectares)[1]	Population (pop. density per sq km)	Area under cultivation (irrigated) (hectares)[2]	Per capita cultivable area, (hectares)	Uncultivable (waste) area* (hectares)	Forest Area (including degraded), (hectares)	Remarks
Gurrabbadu	1831	1603 (88)	881 (33)	0.55	396	587	*includes barren rock (19), fallows(18), tanks (50), village settlements (13)
Narsipur	487	2457 (505)	400	0.16	87	---	includes pond (4 6), village (7 7), village boundaries (11 3)
Pathoda	483	394 (193)	375	0.4	108	---	
Kubda	452	510 (113)	123	0.24	329[3]		includes 250 ha of non-cultivable area
Danda area (5 villages)	248	982 (396)	139 (20)	0.14	101	8	forest area is actually plantation
Chandrabhaga area	388	2148 (554)	190(66)	0.01	188	10	village forest
Adgaon	418	870 (208)	381	0 43	37	---	
Sos-Jogwada	1004	1810 (180)	949	0.52	55	---	
Sansawadi	1707	4407 (258)	585	0.13	166	153	803 ha have been taken over by industry
Lohom	399	991 (248)	298	0.3	89	12	

Notes.
1. Figures are rounded so the totals may slightly vary
2. Area under cultivation includes area under irrigation which has not been mentioned in every case
3. Population density, number of persons per sq km is on total geographic area

The observations synthesized above suggest that the policy and programme options must take account of the following realities:

- Water conflicts already exist at the micro level which cannot be resolved by traditional approaches.
- Community based management and traditional water harvesting approaches have potential for domestic water supply and sustainable water resource management, but there are also serious limitations because of the constraints imposed by the physical environment, pressure on land for ensuring food security for the villages, the nature of 'water rights', the degree of control by the community of its 'water environment', and difficulties in enforcing legislation and regulations.
- Existing policies and recommendations such as electricity pricing, water markets, creating legal frameworks, and re-orienting government organizations (World Bank/ GOI 1997a) should also take account of the local/micro-level realities in developing options
- Under the current system of 'water rights' it is difficult to implement the stated aim of the government's national water policy that drinking water needs of humans and animals should have priority on the available resources. In the Indian context, a dramatic change is needed to effectively implement this policy and ground water legislation and regulations But these can only be complementary to community actions to ensure adequate quantities of water supply for domestic use and ecosystem sustainability. In the absence of such a comprehensive approach, it is difficult to determine a 'fair share' in the allocation of the country's freshwater resources among its conjunctive uses.

The micro-level studies suggest that broad macro-solutions to local situations have considerable limitations.

A composite set of actions is necessary in response to specific micro-level analysis.

4.2 Policy And Programme Implications

Our analysis suggests that alternate water allocation mechanisms will be complex in the context of what can be implemented in India, given the political will and the nature of water rights that have already been conferred to landowners A set of policies and actions are needed at each level as conceptualized in Figure 1

The issues and levels at which actions need to be implemented can be related to the conceptual framework in Figure 1 In each case, the issue of 'water rights' conferred on individuals and households impacts on the community level which can only be addressed at the national level (O 1) if community-based approaches are unable to resolve public/private conflicts, The figure (O2) represents the water situation in Narsipur, Pathoda, Lohom, Danda, Chandrabhaga and Gurrabbadu — villages where significant actions can be undertaken at the community level; O3 represents the situation in Sanaswadi, Adgaon and Kubda where action needs to be taken both at the community and the district levels with industry in the case of Sanaswadi, adjoining villages in the case of Adgaon, and Mehsana district in the case of Kubda where water use affects those depending on the same aquifer further down, O4 and O5 represents the situation in Chennai where water is being transported within and across state boundaries although there are clearly a number of actions that it can take within its own basin; O6 covers situations such as the sharing of the Ganges water with Bangladesh (riparian rights) which is not covered in this study

Macro-level analyses and recommendations can often miss the options that are available at the local level. Equally, however, for some water scarce regions, legislative changes and regulations will be needed Each of the case studies provide specific actions that need to be taken in their respective ecological regions (Annexure 1). Based on the studies, this section provides policy and programme recommendations at various levels of action.

The underlying strategy in the proposed recommendations is to decentralize the management and regulation of water resources to the communities through institutions such as the Panchayat Raj, but to also provide them with the authority, responsibility and financial support to manage the water environment and implement legislation for the protection of ground water resources to ensure primacy for domestic water supply

In the following recommendations, synthesized from the case studies and pitched primarily at the state and national levels, the villages or eco-regions from whose experiences they are derived are indicated in each case

Community awareness and management of fresh water resources

The awareness of communities of their fresh water situation should be enhanced through a more scientific approach to provide them the proper and required information which will add to their practical understanding of the problems and possible responses (all study areas)

Communities should be vested with the authority, responsibility and accountability to be the caretakers and managers of their fresh water environment and empowered to take action. Domestic water supply in rural areas should be owned and managed by the communities (Narsipur, Gurrabbadu, Jogwada-Sos)

It should not be assumed that homogeneous communities exist and that they are the only custodians of their immediate environment Different interest groups and conflicting property interests suggest that in practice defining what constitutes a community is complex (Adgaon, Sanswadi, Gurrabbadu, Danda, Kubda). Moreover, environmental degradation is often the result of the 'tragedy of the common property resources'. Any improvement to the ecosystem which in turn provides fresh water is not generally viewed by the community as a priority While it may seem that communities living around a water source often control the water resources, this may also be a misleading perception. The following actions are recommended for community management of the water environment in the Indian context.

- identify groups/communities and bring people together for management: their water environment such as through the Panchayat Raj institutions — Gram Panchayat, Pani Panchayat or a municipal committee (Narsipur, Kheda, Pathoda, Gurrabbadu, Adgaon);
- give these groups/communities the responsibility, authority and accountability to manage their immediate water environment (Danda, Chandrabhaga, Narsipur, Pathoda, Gurrabbadu, Adgaon, Sanaswadi);
- support communities to enter into contracts with each other and develop public-private partnerships to share

ground water resources with primacy to drinking water but within defined legal bounds and ecological and environmental standards (Gurrabbadu, Narsipur, Pathoda, Adgaon, Sanaswadi),

- build and support the capacity of communities to develop, design and implement alternative traditional water harvesting systems for domestic water supply (Gurrabbadu, Narsipur, Pathoda, Danda),
- promote ongoing monitoring, assessment and analysis of the fresh water situation, including water quality, with community participation (Pathoda, Dānda, Chandrabhaga, Gurrabbadu)

Only if communities are aware and participate in managing their water environment will they be able to protect it

Financial and capacity building support should be provided to communities to help them assess their fresh water situation, adopt alternate technologies, develop public-private partnerships, and enter into contractual arrangements among themselves within defined legal bounds and ecological and environmental standards They should be empowered to enter into agreements with each other, backed by legislation, for ensuring that domestic water supply is protected This includes the collection and management of any revenues raised at the local level (Narsipur, Pathoda, Kubda, Gurrabbadu, Danda, Chandrabhaga, Adgaon, Sanaswadi)

Technological re-orientation of water supply programmes and defining basic levels of services

For eco-specific regions, affordable technological options such as recharging aquifers through tanks, rainwater harvesting, rehabilitation of traditional sources of water supply such as *kuntas* and bunds, check dams, afforestation and the building of water storage facilities where affordable, technically feasible and sustainable by the communities should be more actively supported by the government and external support agencies (Narsipur, Pathoda, Danda, Chandrabhaga, Gurrabbadu, Chennai)

In the absence of effective legislative protection for ground water for domestic purposes, in some water stressed eco-regions construction of mini-piped water schemes with storage facilities or larger storage reservoirs will be needed, but with community level management and cost-recovery. This approach is needed to protect domestic water supply from competition from agriculture and industry and ensure that adequate quality water is available throughout the year

(Gurrabbadu, Pathoda, Adgaon, Lohom, Sanaswadi)

Basic levels of domestic water supply services in rural areas should be defined in relation to adequate quantities of quality water that should be available for domestic purposes to households *throughout the year* at a reasonable distance, rather than by the low-cost technology of a handpump This criterion should be used to define household water security.

Alternative affordable financing mechanisms, including credit, will need to be examined in further studies and analyses to meet this basic level of service criterion (all study villages and Chennai).

Water quality should be a central consideration when designing and implementing programmes

Ensuring adequate quality water for basic needs and ecosystem sustainability should be central to strategies for fresh water management. In designing strategies and implementing programmes a long-term view should be taken on the implications for water quality. Urgent measures are needed to address water pollution and environmental sanitation in both rural and urban areas (Pathoda, Sanaswadi, Danda, Chandrabhaga, Gurrabbadu, Chennai).

The government should implement effective ground water legislation and regulations through, inter-alia,

self-regulation by communities and local-level institutions.

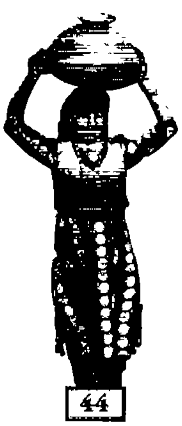
Ground water legislation and regulations should have the following components:

- control and/or regulation of water extraction in identified areas based on micro -level analysis of underlying reasons for water scarcity and *defined standards* (Narsipur, Pathoda, Kubda, Adgaon, Sanaswadi),
- control of types of crops grown in identified areas and economic incentives for dry-land cropping (Narsipur, Pathoda, Kubda, Gurrabbadu);
- mandatory construction of recharge structures in identified areas (Narsipur, Pathoda, Kubda, Gurrabbadu, Danda, Chennai);
- prohibition of withdrawal of water below certain depths for irrigation and industry (Narsipur, Pathoda, Gurrabbadu);
- provision for prevention of waterlogging and pollution (Adgaon, Lohom),
- devolving authority and responsibility to communities for management of water in its conjunctive uses and involving them in the implementation of legislation and regulations (all study villages).

Central to the success of legislation and regulations is the involvement of communities through local institutions in their design, and implementation. Self-regulation by communities/local institutions such as Panchayats within defined legal bounds is likely to achieve greater success Previous efforts have failed because they have been top-down.

Water should be treated as an economic resource

Treating water as an economic resource has two implications ensuring equity, and protection and conservation of fresh water ecosystems. As a scarce economic good, water has economic value and should carry a price as it already does in some instances (Narsipur, Pathoda, Kubda, Sanaswadi, Danda, Chandrabhaga, Gurrabbadu, Chennai).



But as an economic resource water also implies the need for national protection and equity in its allocation. While market forces may allocate water for agriculture and industry, the government has a role in ensuring equity and protection of water for domestic purposes and ecosystem sustainability Measures for water conservation, water reuse, and greater efficiency in water use in irrigation and in urban areas should also be promoted (all study villages and Chennai). Two specific actions are:

- *Water pricing and cost-recovery.* The cost of provision of water for its conjunctive uses, in particular for urban water supply and industry, should be recovered. Improving the efficiency of urban water supply through such measures as prevention of water losses, re-cycling and full cost-recovery should be implemented prior to alternative high-cost options for meeting urban demands. For urban water supply, alternate environmentally sustainable approaches for meeting water demands should be examined before water is transferred from far distances (Chennai) Pricing of water or, more appropriately in the context of 'water rights' in India, water taxation in agricultural use with revenue retention at the local level, should also be examined with the objective of protecting the resource base and the equitable distribution of both surface and ground water
- *Water markets should be regulated.* Water markets have been suggested as one mechanism for water resource management in India. Where such markets are promoted by the government for urban water supply (Chennai), and where they emerge in rural areas (Narsipur, Pathoda), they should be encouraged through community based actions (self-regulation) and government regulations where necessary and feasible, to ensure·
  - primacy for domestic water supply,
  - extraction rates which are commensurate with the rate of recharge either through natural means or technological; and
  - protection of the environment.

External support agencies should support fresh water resource management.

Donor and multilateral agency support for rural and urban water supply should be placed within the wider context of water resource management and protection of the environment. Specific support, including pilot projects, should be provided by donors and multilateral agencies for local-level analysis, assessment and implementation of sustainable actions. The case study approach adopted in these studies may be useful for other eco-regions and countries and may be supported by donors and multilateral agencies as a catalyst to national efforts.

Environmental restoration should be promoted along with household water security

The process for achieving both conservation and development should be pursued through a combination of approaches, including reviving traditional techniques, but most importantly, supporting communities in this challenge. Many of the recommendations above have a direct impact on environmental restoration The case studies have shown that the 'right to water' for humans, and reduction of the work load of women and girls in procuring food, fodder and firewood for the household can be met while at the same time preventing environmental degradation (Danda, Chandrabhaga, Gurrabbadu).

The emerging fresh water crisis should be addressed by re-designing conservation projects, watershed management and wetlands preservation. Similarly, traditional water supply programmes should work for the regeneration of fresh water sources for their own longevity, which will at the same time preserve bio-diversity The case studies suggest how organic links between nature and human needs can be integrated not at the conceptual, but at the operational and programmatic levels

Policy and programmatic implications cannot be developed without addressing ecosystem diversity and local issues. The key conclusion from these case studies is that specific strategies and approaches need to be adopted depending upon the local-level situation The integration of the issues of fresh water balance (water availability and demand), technology, institutions, legal, and socio-economic aspects at the local level have to be reflected in the policies and programmes for water resource management

This report has concentrated on ground water since most of the study villages are almost exclusively dependent on it for household and irrigation needs, but it is recognized that issues related to surface water, in particular equity, in any response mechanism dealing with ground water problems cannot be ignored Conflicts over fresh water already exist at the local and regional levels, but their resolution requires action at all levels, including legislation and institutional support. *No single action, whether community based, legislation, techno-fix, including traditional water harvesting systems, or reliance on market forces will in themselves alleviate the crisis in India.* A holistic approach and composite set of actions are needed.

Programmatically, for the two agencies these recommendations suggest:

- Technical, financial and capacity building support to communities to manage their water environment, creating community awareness of the fresh water situation and measures to protect their environment including those in the eco-regions covered in the present studies. Piloting projects of public-private partnerships and contractual arrangements between communities to prioritize and share fresh water resources for domestic water supply and ecosystem needs.
- Promotion of traditional water harvesting systems, afforestation in the catchment areas, regeneration of the resource base and changes in agricultural practices in areas where they are appropriate and feasible.

A degraded watershed in the Danda area

- In regions with water stress and where the handpump technology is not able to ensure adequate quality domestic water throughout the year, advocacy and support for the construction of mini piped water supply schemes with community management. Various alternatives will need to be explored to finance such schemes but on the principle of cost-recovery
- Advocacy with the government at the national level for design and implementation of ground water legislation and regulations with the participation of local-level institutions.

- Analysis and advocacy on water as an economic resource.
- Continued assessment and analysis of the local-level fresh water situation, including water quality, and working with the communities and government to address issues of ecological sustainability. Undertaking further local-level studies to better understand the situation and address issues of cost and financing of alternative, institutional reforms, social equity and learning, and building upon lessons learned.
- Through analysis, actions, assessment, dialogue and communications, mobilize political will for policy changes in favour of integrated water management and environmental protection

The effective answer to the global fresh water crisis is to integrate conservation and development activities at the local level. Making communities aware and involving them fully is critical for success

The case studies strengthen the dictum that what is good for nature is good for people The programmatic suggestions above provide scope for combining conservation of the environment with meeting the basic needs of people Improving bio-diversity can be achieved by meeting the basic needs of people and viceversa The process for achieving both conservation and development calls for a combination of approaches including reviving traditional techniques, but most importantly, supporting communities in this challenge Historically, people in India have had the knowledge of managing their natural resources.

Children and nature go hand in hand. Their futures cannot be separated, neither in the fresh water arena, nor for that matter in other areas of the environment The plea for action must be taken up by the present generation of children and the national and international community at large.

Annexure 1: Recommendations for each of the study areas

Arid and Semi-arid regions: Gujarat	Drought-prone regions: Andhra Pradesh	Plateau and rain-shadow of the Western Ghats: Maharashtra	Mountain and Highlands: Garhwal, Uttar Pradesh	Urban Areas: Chennai city
Community based actions: • *Creating community awareness of the village's potential for ground water and limits of this resource* detailed hydro-geological assessment of the fresh water situation, with community participation • *Alternate low-cost technological solutions:* Check dams, percolation ponds, water harvesting and revitalizing village ponds to enable increased ground water recharge and water storage facilities • *Local-level management and regulation of water supply and use·* Strengthening the role of panchayats in dealing with water issues **Institutional/ government actions** • Various NGOs are already active in Gujarat • Uttan constructed a 100km pipeline but those at the head of the system were better off and powerful and broke the pipes to obtain more water • Mahiti, an NGO, looked for community based solutions solar distillation, reverse osmosis, roof water collection, harvesting rain water in LDPE lined ponds The latter two were widely accepted by people but 14 tanks built without LDPE lining with World Bank support are not suitable	**Community based actions:** • *Improving ground water recharge.* Catchment has 54% area covered with weathered pediplain Simple technologies such as check dams, and desilting of existing tanks can help improve water retention External financial resources will be needed. • *Land centred development.* Management of fresh water at the local level is needed Community actions such as regulation of water use through village level agreements • *Improving the green cover* Opportunities exist to improve the green cover More than 46 per cent of the area or 850 hectares are available for some sort of improvement through afforestation. Action has to recognize local needs — access fodder, firewood, fibre, etc. **Institutional/ government actions** • *Meeting basic human needs:* Improving ground water recharge, promoting appropriate crops and improving green cover will not necessarily guarantee adequate quantities for humans and animals, particularly in critical seasons. Other options need to be pursued through institutions. improving water retention capacity in tanks and mini-piped water systems. • *Constructing an irrigation canal* There are possibilities for an irrigation canal near the village to bring water.	**Community based actions:** • *Creating community awareness* of the unsustainable patterns of fresh water management in their surrounding areas. • *Regular monitoring, analysis and assessment of the ground water situation* is needed with the enforcement of preventive measure such as control of crops to be grown, pollution control, and monitoring of water quality. **Institutional/ government actions** • *Industrial pollution* Actions needed through government and other institutions to control water pollution • *Primacy for domestic water* needs to be promoted through legislation and regulations	**Community based actions:** • *Local level management* Operational responsibilities for maintaining the distribution pipelines for water supply schemes need to be given to the panchayat-level committees • *Spring protection* can provide relatively low-cost improvement to the quantity and quality of water available in the watershed. • *Improved conservation and storage measures* are required which will contribute to enhanced tree cover and agricultural productivity	**Community based actions:** • *Creating community awareness:* Given the extremely low level of public awareness of the main causes of water shortages, a campaign on water conservation, water recharge, water recycling and water harvesting options should be initiated **Institutional/ government actions** • *Recharging the basin and improving water storage facilities.* Aquifers must be viewed as storage systems and all initiatives to augment ground water availability should be encouraged • **Renovation of temple tanks** Rotary Club is already renovating 36 tanks The remaining 34 can be renovated at a cost of Rs 20 million (US$0.6 million) Though storage in these tanks is less than 1MCM, each can recharge ground water in a 1km radius, and improvements in water quantity and quality have already been noted • **Cleaning of waterways** Initiatives are being taken by the state The future of Buckingham Canal should also be reviewed. Given that rivers and canals are used as sewer outlets, alternatives will have to be developed to adequately dispose of waste water of the city • **Adoption of low-cost rain water harvesting/storage systems and water treatment systems for ground water at the domestic level** Low-cost domestic waste water treatment

Arid and Semi-arid regions: Gujarat	Drought-prone regions: Andhra Pradesh	Plateau and rain-shadow of the Western Ghats: Maharashtra	Mountain and Highlands: Garhwal, Uttar Pradesh	Urban Areas: Chennai city
because of the salinity in the area • VRTI in 1987 started construction of check dams behind many of which gravity flow recharge wells were also constructed. Villagers contributed 20% of wages. VRTI has also raised awareness of the type of cropping patterns that farmers should adopt given the agro-climatic condition. • AKRSP is constructing a number of check dams to store rainwater and recharge several wells Costs are borne by the government (70%), AKRSP(20%) and beneficiaries (10%). Construction and maintenance is carried out by the communities. Also raising awareness of farmers for water conservation by initiating dialogue and offering assistance for experimentation of alternate technologies such as sprinklers and drip irrigation • VIKSAT is working in Mehsana to create village institutions for water management and to help communities obtain access to concerned government agencies for technical , financial and legal support It has helped construct recharge tubewells, check dams and percolation tanks				systems exist which can be cost-effective Low-cost techniques for harvesting rain water and for ground water recharge exist and can be promoted. • **Water pricing (metering)** At present Metrowater has no estimate of how much water is actually delivered to the domestic sector, hence it is unable to charge even nominally improved error-free metres in intermittent supply lines is considered as a first step to cost-recovery Initial steps would also include a Awillingness to pay" analysis • **Diverting water from agriculture to industry** Agricultural demand in Chennai basin will decline due to migration and expansion of the city Efforts exist to set up water markets but any large-scale transfer from aquifers should not obviate the need to ensure that extraction is less than recharge, and that ecological and environmental considerations are not compromised

References

Agarwal, A J , Kimondo, G Moreso and J Tinker (1981), '*Water, Sanitation and Health - for All?*' Earthscan Paperbacks (London)

Agarwal, A. and Narain, Sunita S (1997), *'Dying Wisdom - Rise, Fall and Potential of India's Traditional Water Harvesting Systems'* State of India's Environment - A Citizen's Report Centre for Science and Environment (New Delhi).

Action for Agricultural Renewal in Maharashtra (AFARM) (1997), *Fresh Water Case Studies (1995-96) for Maharashtra Plateau Region,* by), (Pune) - UNICEF-WWF Fresh Water Case Study.

Bandyopadhyay, J (1989), '*Riskful Confusion of Drought and Man Induced Water Scarcity'.* AMBIO 18 (5): 284-92.

Bandyopadhyay, J , Rodda, J.C. Rodda, Kundzewicz, Z and Kraemer, D. (1997), *Mountain Waters: A Resource of Global Significance in World's Mountains: A Global Priority.* Parthenon (London), forthcoming.

Bandyopadhyay, J. and Gyawali, D. (1994), '*Himalayan Water Resources: Ecological and Political Aspects of Management'* Mountain Research and Development, 14(1): 1-24.

Barot, N (1993) 'Alternative Sources of Drinking Water· The Mahiti Experience'. In Moench, M. and M. Dinesh Kumar (eds.), *Local Water Management Initiatives: NGO Activities in Gujarat Viksat (Ahmedabad).* Pacific Institute, (San Francisco)

Biswas, Asit K. (1976), *Systems Approach to Water Management.* McGraw-Hill, (London).

Biswas, A K. (1992), '*Water for Third World Development'.* Water Resource Dev. 8(1): 3-9.

Brandon, C. and Homman, K (1995), *The Cost of Inaction: Valuing the Economy-wide Cost of Environmental Degradation in India.* Asia Environment Division, World Bank.

Carman And Rangeley R (1994)

Carr-Harris, J., Chawla, A S., Mohanty, R., Singh, A , Mani, S. and Mammen, S.T (1997), '*Fresh Water Case Study in Garhwal Himalayas: Comparison and Analysis of Water and Women's Stress in Two Micro Areas'* by South-South Solidarity, (New Delhi) UNICEF-WWF Fresh Water Case Study

Chand, R. (1994), *'Role of Water Rights in Farmer-Managed Hill Irrigation Systems'.* Economic and Political Weekly, March, 1994

Chitale, M.A. (1992) 'Water Resource Management in India Achievements and Perspectives ' In Guy Le Moigne et al (eds.) *Country Experiences with Water Resource Management: Economic, Institutional, Technological and Environmental Issues.* The World Bank (Washington DC).

Czech, C. (1994), *Socio-economic Aspects of Ground Water Exploitation in Gujarat, India, with Particular Reference to the Economics of Supply-augmentation Structures.* Natural Resources Institute, Overseas Development Administration (London).

Dhillon, P.S. (1987), *Water Resource Development and Management in North-West India: Some Issues.* Centre for Research in Rural and Industrial Development (Chandigarh).

Falkenmark, M. (1984), '*New Ecological Approach to the Water Cycle: Ticket to the Future'. AMBIO,* 13· 152.

Falkenmark, M. and Lindh, G. (1993), 'Water and Economic Development'. In Gleick, P.H *Water in Crisis - A Guide to the World's Fresh Water Resources.* Oxford University Press, (Oxford).

Falkenmark, M., G. Lindh, L. de Mare and C Widstrand (1980), *Water and Society: Conflicts in Development - Part 2* Pergamon Press, (Oxford)

Ghosh, G (1996), Keynote address, *Proceedings of the* 22nd *WEDC Conference, Reaching the Unreached. Challenges for the 21st Century. 9-13 September, New Delhi, Edited by John Pickford and others* Loughborough University, (Leicestershire, U.K)

Gleick, P.H. 'An Introduction to Global Fresh Water Issues'. In Gleick, P.H. (1993) *Water in Crisis - A Guide to the World's Fresh Water Resources* Oxford University Press, (Oxford).

Gleick, P.H. (1993), *Water in Crisis* Oxford University Press, (New York).

Glennie, C. (1983), *Village Water Supply in the Decade* John Wiley, (New York).

Government of India (1986), *Technology Mission on Drinking Water in Villages and Related Water Management,* Department of Rural Development, Ministry of Agriculture.

——— (1987), *National Water Policy.* Ministry of Water Resources, (New Delhi).

——— (1987a), *Technology Mission on Drinking Water and Related Water Management - Submission on Conservation of Water and Recharging of Ground Water Aquifers,* Department of Rural Development,

Ministry of Agriculture
——— (1989), *Rainwater Harvesting.* Department of Rural Development (New Delhi)
——— (1995), *Ground Water Resources of India.* Central Ground Water Board, Ministry of Water Resources (Faridabad).
——— (1995), *Annual Report 1994-95.* Ministry of Water Resources (New Delhi)
——— (1996), *Model Bill to Regulate and Control the Development of Ground water.* Ministry of Water Resources (New Delhi)
——— (undated), *Various measures required in ground water management for its sustainable development including power subsidies and regulatory options* Central Ground Water Board, Ministry of Water Resources, (Faridabad).
International Food Policy Research Institute (IFPRI) (1994), '*Water Resource Allocation: Agricultural Productivity and Environmental Impacts*' (mimeo).
Khosla, A.N (1949), *The Water Wealth of India* ...
Matzger, H and Moench, M (1994) 'Ground Water Availability for Drinking in Gujarat · *Quantity, Quality and Health Dimensions'. Economic and Political Weekly,* March 26, 1996, (New Delhi).
Meenakshisundram (1995), ...
Mehta, L (1997), *Water, Difference and Power: Kutch and the Sardar Sarovar (Narmada) Project.* Institute of Development Studies Working Paper 54, (Brighton, U K)
Meinzen-Dick, R. and Mendoza, M , '*Alternative Water Allocation Mechanisms: Indian and International Experiences*' Economic and Political Weekly, March 30, 1996 (pp A25-A30)
Mishra, A (1993), *'Aaj Bhi Khare Hain Talab (in Hindi)'.* Gandhi Shanti Pratisthan, (New Delhi).
Mitra, A K *Irrigation Sector Reforms: Issues and Approaches* in Economic and Political Weekly, March, 1996.
Montreal International Forum (1990), *Montreal Charter* (Montreal) June.
Narayan, D (1995), '*The Contribution of People's Perspective: Evidence from 121 Rural Water Supply Projects*' in Environmentally Sustainable Development Occasional Paper Series No 1, The World Bank, (Washington DC)
Nigam, A. (1996), 'Sustainable Financing of Water and Sanitation' *Proceedings of the* 22nd *WEDC Conference, Reaching the Unreached: Challenges for the 21st Century: 9-13 September, New Delhi, Edited by John Pickford and others* Loughborough University, (Leicestershire, U.K.).
Paul, A.B. (1989), 'Rain and Dew as Source of Water Supply in Assam· Some Aspects'. Journal of Indian Water Works Association, January-March.
Postel, S (1996), '*Dividing the Waters· Food Security, Ecosystems Health and the New Politics of Scarcity'.* Worldwatch Paper 132, Worldwatch Institute (Washington DC).
Postel, S. (1985), '*Conserving Water: The Untapped Alternative*', Worldwatch Paper 67, The Worldwatch Institute, (Washington DC)
Prabhakar, R , Vani, V , Tatu, K and Patel, S , Institute for Rural Management, Anand (IRMA) (1997), *'Fresh Water Management in the Arid Region (Gujarat)'.* Anand, Gujarat - UNICEF-WWF Fresh Water Case Study
Rathore, M S. (1991-92), *Traditional Drinking Water System in Rajasthan: A Study of Ground water Tanks,* Vikalpa No. 2-3.
Rehoej, V., Glennie, E., Abeyratne, S and Sjorslev, J *Rural Water Supply and Sanitation* on Indian Water Resources Management Sector Work Draft Report prepared for World Bank/Government of India
Sangvi, S. (1994), Peoples Initiatives in Solving Water Crisis in Saurashtra *Economic and Political* Weekly 29(34)
Sengupta, N (1993), *User Friendly Irrigation Designs.* Sage Publications (New Delhi)
Serageldin, I. (1995), *Water Supply Sanitation and Environmental Sustainability. The Financing Challenge,* World Bank.
Shah, T (1992), *Sustainable Development of Ground Water Resources.* Economic and Political Weekly 27 (10-11)
Shar, T. (1989) *Efficiency and Equity Impacts of Ground Water Markets: A Review of Issues, Evidence and Policies.* IRMA Research Paper.
Shiklomanov, I A (1993), World Fresh water Resources In Gleick, P.H. (Ed), *Water in Crisis.*Oxford University, (Oxford), p 13.
Shri AMM Murugappa Chettiar Research Centre (1997), *Sustainable Fresh Water Supply for Madras City,* India - UNICEF-WWF Fresh Water Case Study
Tata Energy Research Institute (1997), *Looking Back to Think Ahead, Green India 2047 - Growth with Resource Enhancement of Environment and Nature,* New Delhi
THINKSOFT (1997), *Case Study of Gurrabbadu Watershed*

on the Management of Fresh Water , (Hyderabad) - UNICEF-WWF Fresh Water Case Study.

UNDP (1990) *Global Consultation on Safe Water and Sanitation for the 1990s - Safe Water 2000 - AThe New Delhi Statement"*, 10-14 September 1990, New Delhi.

UNICEF (1979), *People, Water and Sanitation Assignment Children* 45/46, UNICEF (Geneva)

——— (1995) *UNICEF Strategies in Water and Environmental Sanitation*, New York.

United Nations (1980), *International Drinking Water and Sanitation Decade* Report of the Secretary General (A/35/367).

——— (1992), *Earth Summit, Agenda 21, The United Nations Programme of Action from Rio.*

——— (1997), *Comprehensive Assessment of the Fresh Water Resources of the World -Report of the Secretary-General.* Commission on Sustainable Development, Fifth Session, 7-25 April 1997, (New York).

UNCTAD (1988) *Our Common Future: Recommendations Relevant to Water Resources Development Strategies for the 1990s*, Document ACC/ISGW/1988/5, United Nations, Geneva, Switzerland

Vaidyanathan, A (1996), *Agricultural Development: Imperatives of Institutional Reform* in Eonomic and Political Weekly, Special Number, September, 1996

Winpenny, J T. (1997a), *Managing Water Scarcity for Water Security: A Review and Assessment.* A discussion paper for the FAO E-mail conference on River Basin Management, March-April 1997.

Winpenny, J.T. (1997b), *River Basin Management. A Review and Assessment.* A discussion aper for FAO E-mail conference on River Basin Management, March-April 1997.

Wittfogel, K.A (1957), *Oriental Despotism: A Comparative Study of Total Power.* Yale University Press, (New Haven).

World Bank (1995), *The Cost of Inaction: Valuing the Economy-wide Cost of Environmental Degradation in India* by Brandon, C. and Hommann, K Asia Environment Division, World Bank

World Bank/Government of India (1997a), Ground Water Regulation and Management, Draft Report by Gun, J.V.D , Palanisami, K., Moench, M. and Shah, T. (Based on Background Report prepared by Sub-Group on Ground Water). India - Water Resources Management Sector Work.

——— (1997b), Rural Water Supply and Sanitation, Draft Report by Rehoej, V., Glennie, E , Abeyratne, S and Sjorslev, J. India - Water Resources Management Sector Work.

World Health Organisation (1986), *The International Drinking Water Supply and Sanitation Decade: Review of Regional and Global Data,* WHO (Geneva)

Young, G.J., J.C. Dooge and J.C. Rodda (1994), *Global Water Resource Issues CambridgeUniversity Press (Cambridge), p 10-12.*