ASSESSMENT OF WATER SUPPLY OPTIONS FOR URBAN INDIA

- Large Dams have no Case

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Assessment of Water Supply Options in Urban India: Large Dams have no Case

Abstract

Urban Water Sector is a zone of serious mismanagement. Typically, the large urban areas represent concentrated demands, both due to large populations and large per capita use and waste. Most urban areas have depleted, polluted or destroyed their local sources of water like rivers, lakes and tanks and in many cases even groundwater. The rainfall is generally seen as a bane rather than boon as it brings floods because the drainage systems are seriously ill designed or mismanaged. Lack of provision of adequate minimum water for vast proportions of poorer segments on the one hand and wasteful use without paying even cost prices by more prosperous segments on the other hand is typical picture of most urban areas. Thus having exhausted, mismanaged and polluted the local sources and after continuing to neglect the local water potential, the urban areas increasingly look to existing large dams or new proposals of large dams to satisfy its water demands. Though water supply forms a minor component of the 3303 large dams constructed in India since Independence, in recent years it assumes significance.

In the light of the above, paper argues for various options for augmenting water supply in urban India, in addition to demand management, which the urban policy makers have ignored. It illustrates from the case of Chennai, where efforts are made to augment water supply through rainwater harvesting, groundwater recharge and wastewater recycling. Successful case of rainwater harvesting (in macro and micro scale) in north Chennai, supported with groundwater regulation Act have enabled in overall improvement of water resources in the city and through roof-top rainwater harvesting at household level. It also discusses some of the comprehensive report by development agencies in Delhi to augment water through rainwater harvesting. Though these are novel efforts of the government agencies, what is equally important is innovative measures promoted by private and individuals in cities to augment water supply and in treating wastewater. Though these are piecemeal cases the paper calls for other urban centres to learn from these experiences to augment water supply, through a decentralised approach.

An decentralised approach is called for where powers are devolved to local institutions and where co-ordination among the state, private sector and civil society are ensured for evolving water supply options in urban India. For this, the State should decentralise the water sector to facilitate participation and inter-sectoral co-ordination, develop and operate water supply that is more responsive to the needs of the users and to engender a sense of ownership. Such decentralisation needs to be gradual, as this requires more comparative studies of the conditions under which users are most likely to be organised and take part in participatory management. More importantly, it is important that firm foundations for participatory institutions are built up so that the institutions are sustainable. This calls for the government to provide an enabling environment by shifting away from 'centralised' to decentralised' governance system and creating a debate among users through a framework. Such vertical integration needs to be linked with horizontal integration of institutions for inter-sectoral co-ordination. This calls for institutional reorganisation of the water supply agencies based on priority emerging from the basin level available resources and needs.

Moreover, there is need to look at the local options for water supply augmentation and proper management of available sources. There is also substantial potential for demand side management options. Typical figures of Unaccounted for Water in urban areas exceed 50%. If these options are properly taken into account, there is little justification for large dams as option for urban water supply.

CONTENTS

Abbreviations

BCM: Billion Cubic Metres
BHC: benzene hexachloride
CGWB: Central Groundwater Board
CMDA: Chennai Metro Development Authority
CMWSSB: Chennai Metro Water Supply & Sewage Board
CPCB: Central Pollution Control Board
CSE: Centre for Science and Environment
Cusecs: Cubic feet per second
DDT: Dichloro-Dipphenyl-Trichloroethane
DWSSDU: Delhi Water Supply and Sewage Disposal Unit
Ha: Hectares
HUDCO: Housing and Urban Development Corporation
INTACH: Indian National Trust for Arts and Cultural Heritage
lpcd: Litres per capita per day
kl: Kiloliters
LIC: Life Insurance Corporation
MGD: Million Gallons per Day
MLD: Million Litres per Day
PHED: Public Health Engineering Department
PSI: Peoples Science Institute
PSP: Private Sector Participation
PWD: Public Works Department
RWH: Rain Water Harvesting
RWSS: Rural Water Supply and Sanitation
UfW: Unaccounted for Water
UWS: Urban Water Sector
UWSS: Urban Water Supply and Sanitation

Currency

US$ = Rs. 43.4 (as on Nov. 12, 99)

1. Introduction[1]

> To date, the UWSS (Urban Water Supply and Sanitation) sector has under performed against expectations. Quantities of water delivered are inadequate and service is unreliable, requiring consumers to make alternate arrangements, which are more costly in terms of time and money, particularly for women and the poor. Low quality of service is endemic, resulting in deleterious impacts on consumers, especially poor, as well as on the environment. The UWSS sector needs urgent attention both to meet the new demands and to ensure that all city-dwellers have access to basic services at reasonable costs.
>
> The World Bank, 1998: i.

India's National Water Policy (GOI 1987) gives priority to drinking water among the various uses. Thus, though domestic water supply consumes no more than 5% of total water consumption in the country, the importance of water supply has risen in recent times. This is particularly so in case of urban water sector as demands are concentrated in smaller pockets.

Urban Water Sector (UWS) is a zone of serious mismanagement. Typically, the large urban areas represent concentrated demands, both due to large populations and large per capita use and waste. Most urban areas have depleted, polluted or destroyed their local sources of water like rivers, lakes and tanks and in many cases even groundwater. The rainfall is generally seen as a bane rather than boon as it brings floods because the drainage systems are seriously ill designed or mismanaged. Lack of provision of adequate minimum water for vast proportions of poorer segments on the one hand and wasteful use without paying even cost prices by more prosperous segments on the other hand is typical picture of most urban areas. Thus having exhausted, mismanaged and polluted the local sources and after continuing to neglect the local water potential, the urban areas increasingly look to existing large dams or new proposals of large dams to satisfy its water demands. Though water supply forms a minor component of the 3303 large dams constructed in India since Independence (Central Water Commission, 1996, *Water and related Statistics*, quoted in CSE 1999: 47), in recent years it assumes significance.

A sample of dams, under operation and proposed (Annex. 1) illustrate the dam based water supply to urban centres gaining currency due to lop sided urbanisation and urban water supply policies. In addition efforts are being made to transport water from long distances, such as Telugu-Ganga project to supply water to Chennai City[2]. Rural regions due to less density of scattered settlements depend on the locally available source, largely from ponds and ground aquifers. What is important to note is that large-scale water supply projects (even excluding the social, environmental and economic impacts of the dam), are expensive. The inability of the water supply agencies to recover this cost, mismanagement of water, health hazards in transporting the water

[1] Inputs from V S Sarvanan for this paper are gratefully acknowledged.

[2] The World Bank (1998b: 32) notes that buying water from a nearby groundwater aquifer used by farmers could provide less expensive option for Chennai Water Supply rather than transporting water over long distances from Andhra Pradesh.

and inadequate distribution of water supply and ground water exploitation are some of the general characteristics of Urban Water Supply in India.

In the light of these developments, the paper illustrates the status of water supply and sanitation in urban India, in terms of its coverage, equity and in financial management. It argues that the policy makers, who are still depending on large dams as an option, are yet to explore various options for water supply and management. It identifies, various water supply and demand management options: through rainwater harvesting (large scale and small scale), efficient water treatment methods, and calls for an institutional approach to overcome the urban water crisis.

The following section provides a profile of water supply and sanitation in Indian urban scenario on the institutional front, their financial status and on the overall coverage and access to water supply. The third section examines the increasing demand for water in 2050 AD. In view of increasing demand, the potentials of water supply options are explored for a reliable and protective water supply, from the case of Chennai and Delhi in the fourth section. The section also examines the overall applicability of this measure for the nation, with examples from international experience. The paper also suggests for demand management options. However, to make such options viable in final section, the paper calls for an institutional approach (water supply and demand) to manage urban water supply and sanitation services.

2. Water Supply and Sanitation in Urban India: A Profile

> The Urban Water Supply Sector's problems can be summarised by poor institutional structure, weak organisations and poor governance. Assessment of UWSS in India, however, is made difficult by the very weak information base.
>
> The World Bank, 1998: 4.

Rapid growth of urban population has been the character of Indian urbanisation. The urban population in the country has increased more than 8 times, since the turn of the century, and has more than trebled since Independence (Fig.1). The level of urbanisation that was 11-12% during the first three decades of this century, has been increasing since then. 17.3% of Indian population was living in urban areas in 1951 and that has risen to 25.7% in 1991. The Planning Commission's Technical Group on Urban Perspectives and Policies has projected the urban population at 31% of the total population in 1996-97 and 38% in 2006-07. (GOI, 1999b: 262) The urban population growth rate is significantly higher (3.1%) than the overall population growth rate (2%) and is projected to grow by a factor of three, to some 658 million by the year 2025.

The decadal growth rate in urban population between 1981-91 has decreased to 36.4% compared to 46.1% in 1971-81. The reasons for rapid urban growth rate have been largely attributed to natural increase in urban population, rural-urban migration and reclassification or declassification of urban zone. Of the various reasons ascribed, the natural increase has been dominant since 1961, followed by rural-urban migration and reclassification (Fig.2). The recent fall in rural-urban migration might have been in response to higher income in rural areas, increasing unemployment and deteriorating quality of services in urban areas. Annex 10 gives an idea about institutional set up in urban water sector in India.

2.1 Status of Water Supply and Sanitation

> Usually most national reports describe the total population of a whole town as covered if there is some kind of water supply system functioning the city. Per capita figures of supply are calculated even more simplistically by dividing the total installed capacity by the population. We need to go very far to search for the truth. In Delhi itself the per capita water supply, as officially reported, is about 200 lpcd. This comfortable average, however, doesn't mean much to about 30% of the city's nine million people who have access, if at all, to about 25 litres or less.
>
> The sanitation cover of the urban population in the country is extremely unsatisfactory. Only about 42-43% of the total urban population is reported to have access to basic sanitation. In the low income slum and squatter settlements, the percentage is even less, with only 15% of the households having toilets and another 21% having access to community toilets. What is important to that 61% 0f the poor households use 'open spaces' for personal sanitation. Apart from being a major source of environmental deterioration and high negative externalities, it is the root of many human and social problems.
>
> Some 1993 reports quoted in the World Bank 1998: 5.

The increasing urbanisation demands effective service facilities. The 1991 census data claims that nearly two-thirds of the households in India have access to safe drinking water. The proportion of population with access to safe drinking water is claimed to have increased considerably over the 1981 level by 38 %, as a result of conscious policy efforts to improve the availability of water supply and sanitation. The improvement claimed is much more in rural areas (from about 26 % in 1981 to 55 % in 1991) than in urban areas (from about 75 % in 1981 to 81 % in 1991). However, this increase is not uniform across the states (Table 1).

Table 1
Access to Safe Water Supply in Urban Areas (1991)

Proportion of Urban Households with access to safe water	States
High: More than 85%	Gujarat, Haryana, Maharashtra, Punjab, Rajasthan, West Bengal
Medium: Between 75 and 85%	Karnataka & Madhya Pradesh
Low: Less than 75%	Andhra Pradesh, Bihar, Kerala, Orissa, Tamil Nadu, Uttar Pradesh

Source: NIUA, 1997 cited in TARU, 1999:6.

In terms of per capita availability in class I cities (Table. 2) across these states, water shortage was reported to be more acute in eastern coastal states, while the larger states were fairly able to meet the 125 litres per capita per day (lpcd) requirement.

Table. 2
Water Availability in Class I Cities (1988)

Per Capita water availability	States
High: Over 160 lpcd	Maharashtra, Orissa, Uttar Pradesh, Jammu & Kashmir, Delhi, Chandigarh, Pondicherry.
Medium: 120-160 lpcd	Andhra Pradesh, Bihar, Gujarat, West Bengal
Low: Less than 120 lpcd	Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu, Kerala, Madhya Pradesh, Manipur, Tirupura

Source: Compilation from TARU (1999: 7) and MIDS (1995: 7)

In terms of per capita availability across the metros, the availability varies from 75.8 lpcd in Chennai to 307 lpcd in Kanpur. The population coverage is said to be 93 % with a per capita supply of 189.4 lpcd (Table.3). However, this claim seems to be on a higher side**.** Most of these metros have significant slum and peri-urban areas who are not included in the official statistics and many of these areas often lack piped, safe water supply (MIDS, 1995).

Table 3
Status of Public Water Supply in Metropolitan Cities (1988)

Metropolitan city.	Population (in million)	Per capita Water Supply (lpcd)	% Population coverage
Mumbai	10.33	207.8	99
Delhi	7.46	258.	96
Calcutta	4.53	226.7	95

Chennai	3.88	75.8	85
Bangalore	3.82	113.9	100
Hyderabad	2.7	241.6	100
Ahmedabad	2.61	200.1	90
Kanpur	1.77	307.	75
Nagpur	1.54	206.5	75
Pune	1.52	169.8	78
Jaipur	1.35	155.5	80
Lucknow	1.05	262.3	100
Total in Metros	**42.63**	**189.4**	**93**

Source: Central Pollution Control Board (1990) *Status of Water Supply and Waste Water Collection Treatment and Disposal in Class Cities - 1988*, CPCB, New Delhi.

An independent survey (cited in MIDS, 1995) across the major metros (Mumbai, Delhi, Calcutta and Chennai) indicates the coverage being less than 70 lpcd and the water availability ranging from 3 hours per day in Chennai to 10 hours in Calcutta and (Annex 3). In addition, the study throws more light on the inefficiency of water supply and unaccounted water.

An assessment of the water supply status in Class I cities indicate about 37 % of them receive less than 100 lpcd water supply, followed by 31 % between 100-145 lpcd and rest 32 % more than 145 lpcd. The water shortage appears to be more acute in the Class I cities of Haryana, Andhra Pradesh, Rajasthan and Tamil Nadu, where 55.6 to 68.4 % of these cities receive less than 100 lpcd of water. The situation is much more grim in case of the increasing Class II towns (population size ranging between 50 000 to 1 00 000) with 80 % of the towns receiving less than 140 lpcd. A detailed analysis of the state-wise break-up indicates that 21 to 30 % of the Class II towns in the states of Tamil Nadu, Rajasthan and Gujarat receive less than 40 lpcd of water (MIDS, 1995).

The access to sanitation facilities for urban household is claimed to have increased from 58 % in 1981 to 64 % in 1991. In Punjab and West Bengal more than 70 % of the urban households have access to sanitation facilities, in comparison to Andhra Pradesh, Bihar, Orissa and Tamil Nadu where less than 60 % of the households have access to sanitation facilities (TARU, 1999: 7).

Urban centres were set up near the water sources to begin with. Having exhausted, destroyed and polluted the nearby sources and neglected using the potential of local sources, cities are reaching out to far away sources for their water supply needs as can be seen from the Table 4.

Table 4.
Cities Reaching out to New Sources

City	New Source	Distance to New Source (km)
Bangalore	River Cauvery (KR Sagar)	100
Ahmedabad	River Sabarmati (Dharoi)	150
Hyderabad	River Krishna (Nagarjuna Sagar)	160
Delhi	River Bhagirathi (Tehri) Renuka dam (Planning stage)	250 280

	Kishau Dam (Planning Stage)	300
Chennai	River Krishna (Telugu Ganga)	400
Mumbai	Bhatsa Dam	54

Source: IWRS, 1999: 23-24.

The rivers are the lifeline of the many cities and towns along their banks. Almost the entire country is crisscrossed by rivers with total length of some 45,000 kms. The country has 12 major, 46 medium and 55 minor river basins. Half a century ago, most of the rivers in India were biologically in good condition, ambly met the water needs of their basin populations and supported diverse fish and flora species (World Bank 1998: 8). Today, it would be difficult to find a single river in the plains area of the country that would have potable water.

The inadequacy of water supply by urban authorities has led to boom in bottled water across the country in the name of ‘mineral water’. With Rs. 3 billion annual turnover (86 per cent through retail outlets) and with annual growth rate of 40-50%, mineral water is witnessing an unprecedented boom in the country. However, investigations reveal that this is no solution to the problem of drinking water in the country, as there is no worthwhile regulating or monitoring authority on the water quality that is being marketed (Thakkar 1997b). More importantly, only the rich people can afford the more expensive bottled water and this is no solution of drinking water needs of the society.

Nonirrigation related revenue of canals (includes income from selling water to domestic and industrial users, leasing fishing rights, selling timber, and other activities) have shown rising trend. Income from nonirrigation sources tripled between 1976 and 1988, rising from Rs. 30 million to Rs. 99 million. The increase is most pronounced in Maharashtra (nonirrigation income rose 11 times) and Madhya Pradesh (6 times). Together these two states accounted for over 70 % of total nonirrigation income. This reflects the growing demand for irrigation water from other sectors. (World Bank, 1997: 56)

Eighth Plan Achievements: India’s Eighth Five Year Plan (1992-97) spent about Rs. 70 billion on Urban Water Sector, which was 274% higher than the Seventh Plan expenditure in nominal terms. The task set out was to increase the coverage of access to safe drinking water to about 94% of the urban population from 84% at the end of Seventh Plan. The coverage of urban sanitation services was to go up to 69% from 48%. The Ninth Five Year Plan notes most significantly that “the coverage of urban population is unlikely to increase from the level attained in the Seventh Plan”. All the efforts of the Eight Five Year Plan seems to have been absorbed by the population increase (GOI, 1999b: 265).

Ninth Plan Target: India’s Ninth Five year Plan plans to achieve 100% population coverage in Urban area with safe drinking water supply with an investment of about Rs. 207.5 billion (GOI, 1999b: 271). External assistance is supposed to be Rs. 52.5 billion (GOI, 1999b: 275).

⇒ The Ninth Plan Sub-group of the Planning Commission on Environment and Health had concluded that the unsatisfactory progress in supply of safe drinking water and sanitary disposal of solid and liquid waste has contributed to the continued high morbidity from water-borne and vector-borne diseases. The absence of integrated approach with equal emphasis on water supply and liquid waste management schemes has meant provision of water supply without commensurate wastewater management systems, leading to pollution of more water supplies (GOI, 1999b: 269).

⇒ It has long been government policy not to build sewerage systems in towns of less than ten million people. (World Bank 1998: 6)

2.2 Future Water Demand

India's urban population of 217 million in 1991 or 26 % of the total population is projected to increase to 659 million by the year 2015, an addition of 400 million people (Peoples Science Institute (PSI, 1998; GOI, 1999). Several projections have been made to predict future water requirement.

The United Nations' urbanisation projections indicate a slow growth between 1990 and 2000, but a rapid acceleration thereafter. While projections by Technical Group on Population Projections (termed as RGI) indicates a slower pace, due to declining average annual fertility rate in urban areas (Fig.5). If these percentages are converted into actual figures as per the projection of total population in the country (Annex. 4b), the highest projection indicate 72 % increase by 2050 (almost the size of India's total population of today) and the lowest projection indicate 63 % increase for the same year (PSI, 1998). The relative share of Population in different class of cities indicate rapid growth of class I and Class IV-VI cities by 2050 (Table 5).

Table. 5
Urban Population Projection

Urban Areas	Population size	Population in millions							
		2000		2010		2025		2050	
		High	Low	High	Low	High	Low	High	Low
Class I	>100,000	195	189	268	242	378	296	503	380
Class II & III	20,000 –100,000	68	66	94	85	157.5	123	252	189.5
Class IV-VI	<20,000	29	28	40	36	94.5	74	252	189.5
Total		292	283	402	363	630	493	1007	759

Source: PSI, (1998: 7)

The increasing demand for water for these numbers will vary depending on the characteristics of the community, the commercial and industrial activities, and a host of other factors, such as climate, technology, costs, conservation needs, etc. This further complicates in evolving water supply norms for the urban cities. The norms proposed by Zakaria commission, one of the earliest to propose water supply norms for the urban India have been considerably scaled down in recent decades. As per the Indian standard code (IS: 1172: 1983) the per capita water supply norm is at 135 lpcd (Table 6). Based on this standard the high and low water demand by 2050 is expected to be 50 million and 37 million litres per day (mld) of fresh water (Table 7).

Table 6
Break-up of Minimum Domestic Water Supply Standard.

Use/ Activity	Amount (lpcd)	% of Total

Drinking & Cooking	15	10
Bathing, washing of clothes, vessels, floors etc.,	75	55
Flushing Toilets	45	35
Total	135	100

Source: Alacrity (1998:28).

Table 7
Estimated Urban Water Demand

Year	2000		2010		2025		2050	
	High	Low	High	Low	High	Low	High	Low
Water Demand (BCM)	14.38	13.94	19.81	17.9	31	24.3	49.6	37.4

Source: Compiled from PSI (1998).

Of the total 4200 billion cubic metre (BCM)[3] of water received in India, the utilisable potential is about 1122 BCM, of which the present utilisation is only about 1.9 % of the utilisable volume, thus leaving enough potential yet to be tapped. To tap the potential many urban authorities source freshwater from distant locations. This has only proved to be cost-ineffective, environmentally unsustainable and increases conflicts over water across the country. Chennai is dependent on Krishna River water from across neighbouring state of Andhra Pradesh. Mumbai is facing a similar situation. Delhi is looking forward to water supply from storage reservoirs in Himalayas. Since most urban centres depend on river flows, it is only likely to increase potential conflicts, which is already visible between Delhi and Haryana; between Chennai and farmers of Andhra Pradesh; and between Ahmedabad and farmers on the banks of upstream Sabarmati river.

One of the factors that determined the location of urban centres in earlier times was easy access to water sources, through rivers, tanks, lakes and groundwater source. However, in recent decades increasing population, neglect of the existing water harvesting and storage structures, obstructing the water supply channels by people and by urban planners, due to ill planned drainage system, have resulted in encroachment and dysfunctional nature of tanks in the country. Once dependent on tanks and lakes, Bangalore City depends on the Cauvery Water Supply scheme for 83 % of its demand. Making it one of the costliest cities in the subcontinent (CSE, 1997a: 206). Of the 127 tanks in the city, 46 were identified as defunct and still confusion rests over the status of the rest. Once self-sufficient in water (till 1961), the Hyderabad City now faces water deficit (Ibid. 216). To minimise such impacts it is important to augment water supply by harvesting rainwater, conserving the available water and recycling wastewater wherever possible, and by evolving demand management options for efficient utilisation and distribution of water. However, very little attempt is made in these directions and mega supply side solutions in terms of large dams are sought as answer to urban water needs. A list of large dams projected to supply urban water needs is given in Annex 1.

2.3 Financial Trends

The Planning Commission estimated the investment requirement for the water supply and sanitation sector over 1997-2001, to be about Rs. 513 billion. The Rakesh Mohan

[3] 4000 BCM of annual rainfall and 200 BCM of water from outside the country (PSI, 1998:15)

Committee, appointed by the Government of India, estimated the requirement to be Rs. 163 billion over 1996-2006 for water supply and Rs. 691 billion for sanitation (TARU 1999: 26).

The responsibility for maintaining of capital assets and collecting water charges rests with the local urban bodies, in many cases they are financially weak. The urban local bodies receive revenue from internal and external sources. The former includes the statutory levies such as tax sources (e.g. water tax, drainage tax) and non-tax sources, which are, called as user charges or utility charges (e.g. water charges, drainage charges, meter rent, fines, penalties, etc.). The external sources include grants from the state government and also overseas agencies. The revenue under internal and external sources are classified as current and capital. The current revenue includes water tax, sewerage tax, sewerage and water charges, and grants and subsidies received from the government. The capital revenue consists of work based deposits by consumers, connection charges collected from consumers, loans and capital grants from state/central government.

There has been a significant increase in planned allocation for the overall water supply and sanitation sector in the Five-Year Plans over the years (Fig.3). From a modest plan investment of Rs. 0.49 Billion in the First-Five-Year-Plan (1951-56) the allocation has increased to Rs. 167.1 Billion in the Eighth-Five-Year-Plan (1992-97). As a proportion of the total plan outlay, investment in water supply and sanitation has also risen from 1.5% during the First Plan to nearly 3.8% in the Eighth Plan (see Annex. 2 for details of allocation for rural and urban water supply in various plan periods). The plan proportion for urban water supply have been maintained at about 1.2-1.3%, though the urban population has risen from 62.4 million in 1951 to 217 millions in 1991 and approximately 250 million in 1995-96. The total investment in the Urban Water Supply and Sanitation sector in the proposed Ninth Plan programmes is Rs. 512.84 Billion, with states contributing 56% and the Centre and the Municipalities/ beneficiaries contributing 34 and 10% respectively (NIUA, 1998:107).

In addition, there is external assistance provided by international funding agencies for urban water supply projects. About 53% (USD 1 223 million) of the urban sector assistance (USD 2 300 million) was given to urban water supply and sanitation in 1998 (TARU, 1999:24). The contribution of institutional finance (like, Life Insurance Corporation of India (LIC), Housing and Urban Development Corporation (HUDCO) and others), to invest in the water supply and sanitation sector has been low. These institutions invest in urban infrastructure facilities, such as housing, education, water supply and roads. Many of these institutions have begun to rely on the market-based approach for the service delivery. HUDCO, one of the largest financial institutions for urban sector, has sanctioned about 37 % of their funds for urban water supply sector.

The Working Group on Rural and Urban Water Supply set up in connection with the Ninth Plan has reported substantial slippages on the expenditure side in this sector. At the same time, institutional finance flows have also been low. The working group has recommended full cost recovery of the operation and maintenance expenses and greater role for institutional finance. (Mathur 1998: 100)

Substantial variation can be noted across states in share of water supply, sewerage and sanitation in the total public expenditure. As a proportion, it ranges between 0.35% for Karnataka to as high as 7.02% for chronically water deficit state like Rajasthan. Expenditure growth on this sector has been particularly high in Gujarat (6.75%), Haryana (5.2%), Rajasthan (6.36%), Tamil Nadu(8.35%) and Uttar Pradesh (8.19%). (Mathur 1998: 37-8)

Though the financial assistance for Urban Water Supply and Sanitation has increased over the years, the Urban Institutions have not been able to recover the cost for maintaining these assets. The per capita revenue and expenditure (1993-94) for selected cities indicates most of the cities incurring huge deficits, excepting Visakhapatnam city, which has larger composition of industrial consumers being charged at relatively higher rate (Fig. 4).

The cumulative effect of centralised management and inadequate powers to local institutions has led to serious bottlenecks in the development of urban water supply and sanitation sector.

2.4 Privatisation of Water

The poor performance of water supply agencies has been used for encouragement of Private sector participation in urban water supply. The World Bank claims that the Private sector participation (PSP) can yield improvement in water supply, provide additional management skills and improved management incentives, leaving government agencies on policy decisions (World Bank, 1998:29). In Chennai the operation and maintenance of sewage pumping station have been contracted out. This, it is claimed, has enabled to achieve 45-65 % of cost savings. However, PSP through market-based mechanisms becomes disadvantageous in providing services to the poor and disadvantage sections of society, and in safeguarding the environment. For instance, private water markets exists in one form or the other, they contribute 5 % of the total water supply in Chennai. They supply bulk of untreated water as well as mineral/ purified water in Chennai. The buyers of this water are mostly that of urban middle and upper class and catering less to urban poor class, as they find it too expensive (UNDP-World Bank, 1999). In addition, these private parties extract water from groundwater outside the metro limit. They were not willing to reveal the sources when contacted. In addition, most of the urban services have been monopolised by a large section of urban middle class, who have gained from the New Economic Policy, thereby depriving large sections of rural poor (Chaplin, 1999).

If PSP is to be at all useful in urban water supply sector, then *firstly*, the state will have to create credible regulatory mechanism. Without such credible mechanism to ensure quality, equity and sustainability, PSP will only prove disastrous for the people.

2.5 Water Quality Issues Issue of quality of the urban water supplies if gaining increasing importance as more and more water supply sources get polluted. Industrial pollution, urban pollution, agricultural pollution, seawater intrusion and pollution due to geological sources (Fluoride, Arsenic) are some sources of pollution. Not a single river in plains of area of the country is left with potable drinking water. More and more areas are also experiencing groundwater pollution.

Printing and dyeing units in Pali and Jodhpur in Rajasthan and Jetpur and Rajkot in Gujarat have caused high levels of pollution of the groundwater. Tannery industry in North Arcot district in Tamil Nadu, printing and dyeing units in Panipat and Sonipat in Haryana are other examples of pollution.

Very little attention gets paid to problems related to quality of water supplied in India. Firstly, there is little monitoring of the quality of water supplied. Even in the most high profile and large city like Delhi, the water supply agency does not have instruments to monitor levels of carcinogenic chemicals like pesticides in the water supplied. As a direct result of the concerns related to the quality of water supplied, the bottled water industry is expanding at a very high rate, though there too, there is no monitoring of the quality of water supplied.

3. Water Supply Options: Some Examples

Options for water supply to urban areas could be explored through in-situ water harvesting (at macro and micro scale); repairing, renovating and properly maintaining existing water storage structures; huge scope of demand side management measures including proper pricing, saving from wastage and conservation; and recycling wastewater. Though the approach has been piecemeal in different parts of the country and few states in recent months are formulating acts to augment water through water harvesting. In Delhi and Tamil Nadu, some efforts are already underway to harvest local water sources for the augmenting water supply in the respective cities. Here it would be useful to note that cities like Jaisalmer and Jodhpur, both in water scarce areas, hd for centuried relied on harvested rainwater for its water needs.

Annex 6 gives an account of two rainwater harvesting crusaders from Chennai. Annex 8 gives some details of rainwater harvesting in Hyderabad. Annex 9 gives some examples of international rainwater harvesting efforts.

3.1 Water harvesting potential - the Case of Delhi

Delhi receives about 275 lpcd, which is much higher than most of the Indian Cities, yet the city faces water crisis. The city receives about 4109.57 million litres per day (mld) from different sources (Table 8) against the projected requirement of 4552.8 mld. Thus, there is supposed to ba a deficit of 443.29 mld.

Table 8.
Source of Water for National Capital Territory -Delhi

Source of Water	Amount of Water (MGD)
Yamuna	210
Ganga	100
Bhakra Storage	200
Groundwater (government tube wells)	120
Groundwater (private Tubewells)	274
Total	**904 (4109.57 mld)**

Source: INTACH, 1999.

In addition, there is transit loss of water that is estimated to be about 15 to 18 %. (Last year the ex-Chief Minister of Delhi quoted them as 33 %) (Richard, 1999). In fact, the water actually supplied to the consumer is only 3370 mld.

In terms of access to the quantity of water available, the picture is rosy at macro level indicating per capita supply to be around 320 lpcd, with New Delhi Municipal Corporation areas receiving 388 lpcd, Municipal Corporation of Delhi areas at 206 lpcd and Delhi Cantonment Board areas at 194 lpcd. However, the ground reality has been different, with not only poor localities getting less water but also getting water of poor quality (Refer: Annex 5).

An independent survey (CSE, 1997) revealed that areas like Jorbagh, Chanakyapuri, etc. receives about 300 lpcd, while the slum dwellers who contribute about 40 % of the cities population, receive only 75 lpcd (CSE, 1998). According to Delhi Jal Board (formerly DWSSDU), the consumers in urban zones who are on the planned water supply network consume about 96 % of the water produced, while their rural counterpart consumes 4 %. It is estimated that about 30 % of the slum population have legal access to about 7.5 % of the Delhi's water.

The inadequacy of surface water, both in terms of quality and quantity, has put pressure on ground water resources, which has led to decline in ground water table in the different parts of Delhi. The average decline in groundwater table during the last decade is about 0.4 metre per year. Further, unplanned developments have disturbed the hydrological balance, leading to a decline in productivity of wells, increasing pumping cost, more energy requirement and more seepage loss from canals. Another hurdle in the development of ground water in Delhi is the brackish nature of water.

The inadequacy of water has put pressure on the Delhi Jal Board, the agency responsible for supplying treated water and collection, treatment and disposal of sewage, to find potential source of water from other source. And strangely, the Board has looked to water supply for Delhi from dam projects. As (Table 9) indicates, 3659 mld is proposed be supplied from these dams at a cost of Rs. 24.15 billion (i.e. Rs. 6.6 million per mld). The cost would be ever higher if proper costs of rehabilitation, environmental management and other works are included.

Table 9.
Water Supply Schemes in Delhi

1. Tehri Dam	
Location	: River Bhagirathi, District Tehri, Uttar Pradesh.
Water Allocation for Delhi	: 727 mld (300 cusecs)
Delhi share of Project cost	: Rs. 5 billion.
Status	: Hopefully by 2004
2. Renuka dam	
Location	: River Giri, District Sirmur, Himachal Pradesh.
Water Allocation to Delhi	: 1250 mld (572 cusecs).
Delhi's Allocation	: Rs. 8.05 billion
Status	: Not Commenced.
3. Kishau dam	
Location	: River Tons, Dehradun & Sirmur districts of Uttar Pradesh and Himachal Pradesh.
Water Allocation to Delhi	: 1682 mld (689 Cusecs)
Delhi's Cost of Allocation	: Rs.11.1 billion.
Status	: Project yet to be formulated.

Source: INTACH, 1999.

Delhi's mismanaged water sector has led to inter-state political friction in the past and has the potential for serious conflict with the riparian neighbours. This has also led to alarming dependence on the ground water table. Thus, while the demand has been drastically increasing the supply position is not so elastic. With no foreseeable augmentation on raw water supplies through conventional solutions, there is no option other than demand side management and harnessing water locally to substitute water supply. This means to capture the rainwater where it falls or capture the run-off in your own town and take measures to keep them clean.

The rainwater if harvested from the roof-tops; from local catchments; seasonal floodwaters from local streams; and conserving water through watershed management will increase water availability, reduce the floods in the city, reduce dependence on the external water supply systems and reduce the burden of the water supply agencies to distribute the water. This will also make water everybody's business. Therefore, there is eminent sense – social, ecological, economic, financial and political - in promoting community and household-based water harvesting systems.

3.1.1 Potential of Rainwater Harvesting

"You do not know it yet, how a globule of sap ascends"

- Emerson

To meet the growing water requirement rainwater harvesting could be one of the promising options. A rational calculation on the water harvesting potential indicates that rainwater harvesting will enable full coverage of the population (Thakkar, 1997).

Recently, Indian National Trust for Arts and Cultural Heritage (INTACH) was commissioned to revive the Yamuna channel and promote rooftop water harvesting, through their water augmentation plan. According to the report by INTACH, water harvesting and recycling within Delhi is expected to yield 675 MLD and 2205 MLD respectively, which is more than meeting the projected demand-supply gap within five years at affordable costs. From a scientific study, INTACH proposes to augment about 980 billion litres of water per year mainly through water harvesting (Table 10).

Table 10.
Volume of Water Harvested and Recharge Potential (in million litres per year)

Water Harvesting	Volume of Water Harvested	Estimated annual Recharge
Drainage Channels	107770	29670
Quarry reservoirs	8870	-
Historical Water Bodies	350	-
Lakes and depressions	39590	7000
Checkdams	183	-
Village Ponds	7659	4510
Floodplain reservoirs	11140	30400
Rooftop harvesting	1890	-
Ecoparks recycling	803000	-
Grand Total	**980452**	**71580**

Source: INTACH. 1999.

The comprehensive assessment of the plan promises water harvesting as potential option to be considered.

In addition, the CGWB plans to extract and replenish the ground water to augment the city's water supply. This is expected to be done from the flood plains of the Yamuna in five zones of the National Capital Territory of Delhi during the lean April- May- June period. Central Ground Water Authority (CGWA) considers it feasible to de-water and refill the unconfined aquifer group underlying the Yamuna flood plains during the pre-monsoon and monsoon period respectively in view of favourable hydro-geological set-up and available surplus Yamuna flood flows. The Authority estimates that on an average de-watering of 4 metre thickness in 97 Sq. Km. flood plain area would yield 78000 million litres of ground water (CGWB, 1996: 41). It is expected that the scheme would supply Delhi with an additional 900 MLD of water and that the first phase of the plan will cost Rs. 250 million at 1996 prices. The plan has been given to Delhi Jal Board, Government of Delhi for implementation about a year ago. "After considering various options the Jal Board found this to be the only option for meeting water demand." Says S.P. Singh of the CGWB.[4]

The importance of rainwater harvesting has also been realised by President of India, K.R.Narayanan, when he evinced interest to meet President Estate's water requirement through rainwater harvesting. Under his initiation, Centre for Science and Environment (CSE) has set up a team of experts to prepare water-harvesting plans. The plan is expected to be implemented in two phases and is expected to meet most of the estates' water needs, improve ground water quality (where traces of fluoride have been found) and finally reduce Rs. 5 million water bill to New Delhi Municipal Corporation (Saravanan, et.al, 1999).

3.2 Pioneering Efforts for Water Supply Options – Case of Chennai

Chennai has the lowest per capita water availability out of all the metros in the country (Table 3). In the absence of perennial rivers, the Metro Water had to exploit ground aquifer to complement water from reservoirs. However in recent years, the Chennai Metropolitan Water Supply and Sewerage Board (hereafter referred to as Metro Water), the agency responsible for water supply and sewerage systems in Chennai, is shifting its strategy from extraction-based to conservation-based water supply.

The metro faced problem of ground water depletion and seawater intrusion into the aquifers in the last three decades. In 1987, Chennai Metro evolved strategies to overcome this crisis through water harvesting at macro and micro level. At macro level, check dams were constructed along the river basins and floodwaters were injected into ground aquifer though injection wells.

Minjur area, north Chennai, was well known for the availability of ground water aquifer in mid 1960's (CMWSSB, 1998). As per the Study by UNDP the aquifer was expected to yield 125 MLD in 1969 and about 55 MLD in 1989. However, Metro Water could never reach the estimated yield. The extraction only gave way to intrusion of saline water from a mere 3 km inland in 1963 to 9 Km in 1987. To overcome this, Metro Water evolved strategies to harvest rainwater on a large scale through check dams along the Araniyar-Korataliyar basin. These check dams have shown significant results in improving the water table in various observation wells set-up by the Metro Water (Fig. 6) (Nair, 1998).

[4] Personal Communication from S. P. Singh CGWB, New Delhi on 22 June 1999.

To further reduce the sea water intrusion caused by over-extraction of ground water, pollution from industries and existence of salt-pans, along the Minjur region of the north Chennai, large scale recharging wells were constructed between the coast and Minjur. Floodwater was injected in these wells as a recharge to create a barrier to the salt-water intrusion. These measures have shown significant results in the decrease of Electrical Conductivity values, one of the measure to assess the saline content in the water, from as high as 65 000 in 1992 to 46 750 micro MHOS/cm in 1998 in Thiruvellavoyal observation well (CMWSSB, 1998:45).

Learning from the experience in Minjur area of north Chennai, the Metro Water realised the importance of saving the coastal aquifers and other ground water potential zones in and around the city. The Board introduced an Act to regulate and control extraction, use or transportation of ground water, called "The Chennai Metropolitan Area Ground Water (Regulation) Act 27, 1987." The Act envisages registration of existing wells, regulations for sinking new wells, issuing licenses to extract water for non-domestic use and issue of licenses for transportation through goods vehicle. The Act covers the city and the adjoining 243 villages. The Act has been able to control the private water market, to regulate water extraction and improve the ground water levels (refer. Fig. 7) in the southern aquifers, in particular, and Chennai city in general (CMWSSB, 1998). Though there has been significant reduction of private water suppliers using tanks, in recent years it has been noticed that water is being supplied in a more sophisticated manner, through water cans in the name of mineral water. Where does this water come from is still to be answered. These cans are so popular, that households and commercial companies buy them every day in 10-15 litre sizes.

To complement these macro strategies, particularly after the 1993 drought in Chennai, Metro Water has taken initiatives to harvest rainwater at micro level. In 1994 Metro Water along with Chennai Metropolitan Development Authority (CMDA) have made it compulsory (however, it was implemented in 1997), that rain water harvesting structures form a part of building plans of houses with more than 2 floors submitted for approval. Both the agencies ensure that these structures are completed before the water supply and sewerage connections are provided to the buildings.

Though in the initial stage there was lukewarm response from the builders, campaign through media and insistence by Metro Water evinced responses from the construction industry. Official statistics reveal an increasing number of planning proposals with rainwater harvesting structures. Since 1997, about 500 buildings had rainwater-harvesting structures[5] in Chennai.

3.2.1 Private Effort of Builders

Water harvesting is not a new technology. Though such practices are prevalent to overcome the vagaries and inadequacy in water supply, in recent years in Chennai there has been a systematic effort to harvest the rainwater and methods to treat and reuse them.

[5] Personal Commu nication from Mr. Annamalai, Junior Engineer, CMWSSB, Chennai on May 5, 1999.

1. Rooftop harvesting methods, recharge ground water and to store it in underground tanks.
2. Recycling wastewater. Alacrity Foundation in their project in Valasaravakkam has been recycling the kitchen wastewater by diverting it into a treatment bed. The water collected in the treatment bed (where plants are grown) is allowed to percolate to recharge ground aquifers.

3.2.2 Impact of these methods:

Though comprehensive evaluation of their approach is underway, based on field visit one could identify some of the improvements.

1. Improvement in water level in the ground aquifer. Rise in groundwater table in Mr. K. R. Gopinaths' residence in Anna Nagar from 28 feet to 2 feet in water column even during peak summer.
2. Improvement in water quality and quantity in the residence of Ramani and in most projects of Alacrity Foundation.
3. Reduces the flooding in the low-lying regions.

Though these are efforts by Corporate Builders in the city, few residents have also taken systematic ways to harness water in their houses. The effort of Mr. R. Ramani resident at Korattur region in Chennai is worth noting (Annex 7). In 1994, he constructed water-harvesting structures. Now this has enabled him for a secure access to water supply over the years and also improve the water quality in the aquifer (Table. 11). In addition, peoples movement is emerging in the city to harvest the precious water, through rehabilitating tanks and other existing storage structures and influencing the government to change their programme to implement them (Annex 7). Many industrial estates are also taking efforts to harvest water in their complex.

Table. 11
Water harvesting - Improvement in Water Quality
(Ramani's Residence)

Sl. No.	Parameters	Desirable Limit	Permissible Limit	Quality on May 12, 1994*	Quality on April 9, 1999**
1	Turbidity (NTU)	5	10	5	2
2.	Total Solids (at 105 C)	500	2000	3325	1335
3	pH	6.5-8.5	No relaxation	7	7.1
4	Chlorides	250	1000	989	580
5	Total Hardness	300	600	900	540
6	Iron	0.3	1.0	Nil	Trace

*Test results from S&S Industries and Enterprises, Chennai.
** Test Results from Chennai Metro Water Supply and Sewage Board (CMWSSB), Chennai.

Evolving methods at the 'need of the hour' and spreading awareness over these issues through booklets and pamphlets are some of the measures that make the efforts by corporate builders successful. More effective are the accountability practices by these private agencies to their client. Alacrity Foundation, one of the leading corporate builders in South India, provides a detailed report on the water quality for their clients and various water harvesting and treatment methods that they have carried out to overcome them. In addition, these builders provide their own staff for future maintenance of these systems. These private agencies have carried out water harvesting in more than 500 buildings in the past few years.

3.3 Groundwater Recharging in Rajkot

In arid Saurashtra region of Gujarat, the water situation is made difficult by destruction of forests, local water systems, by over use of groundwater and consequent salinity ingress along the long coast line. In this region, a people's movement to recharging existing wells by diverting local streams to the wells via a filtration pit has lead to remarkable change in water availability situation. Over 300,000 of the total 700,000 wells have already been recharged. Hundreds of local tanks have been renovated or dug up. In the urban areas, the movement has lead to groundwater recharging through hand pump tubewell. IN Rajkot city alone, in 1995, more than 4 000 hand pumps were recharged by this method. A roof or terrace water is diverted into a small tank from which it is allowed to flow in the casing pipe of hand pump. (Parthsarthi, et al, 1997: 54-56)

3.4 Restoring the Existing Water Harvesting Structures

In recent years the importance of lakes and ponds have gained importance in urban centres. Hyderabad once had about 532 lakes, tanks and *kuntas* around the city (Vyas, 1998). The undulating rocky terrain of Telangana region has made it easy to collect rainwater through these storage structures. These tanks which played an important role in recharging groundwater and supplying water for the urban people are being destroyed systematically due to rapid urbanisation encroaching the storage structures and channels, and polluting the water. A group of people, comprising of scientists, local people and fishing community have come together under the Save the Lakes of Hyderabad campaign to protect the lakes in the city. Taking Saroornagar Lake (the biggest fresh Water Lake in the eastern part of the city) as a pilot project, the group aims to raise awareness on the importance of protecting and conserving these ecosystems. Saroornagar Lake is important tank system in the city, as it acts as shock absorber by containing the sudden gush of flooding rainwater during heavy rains and provides a major source of livelihood for the fisherman community. The group has been able to mobilise support from the government officials. The Chief Minister of Andhra Pradesh has initiated steps to protect and conserve 12 lakes in the city and has also promoted measures for rainwater harvesting to augment water supply in the city. He is expected to constitute a Lake Protection and Information Cell to protect, conserve and develop lakes around the city.

Similar efforts are underway to save lakes and tanks from being encroached and from becoming dysfunctional in different urban centres. In Chennai Rotary Club (a voluntary association) has taken efforts to revive the temple tanks in the city. While in Bangalore, the city with 127 tanks, 83 % of the water comes from Cauvery Water Supply Scheme. The City spends Rs. 40 million every month on electricity charges to supply this water (CSE, 1997a: 206). A project for Rs.5 million has been launched by Karnataka Forest Department to create awareness and protect tanks through committees. However, due to absurd planning the project is expected to run into rough weather (Ibid. 207).

3.5 Mismanagement in Shillong Following characteristics of water supply situation in a relatively smaller town in a high rainfall area in North East Indian state of Meghalaya shows the potential benefits of better management.

⇒ Physical water losses exceed 50%.

⇒ The existing water supply rate varies between Rs. 1.1 and 1.5 per kl (kiloliter) of water. The basic cost of supply of supply is Rs. 4.3 per kl. If UfW is included, than the basic cost of supply comes to 8.6 per kl. Thus, price of water is much lower than the cost of water supplied.

⇒ Most households in the city have to resort to purchasing water at between Rs. 7 and Rs. 12 per litre 16 litre tin during the lean season. This adds up to between Rs. 437 and Rs. 750 per kl. This shows that the households, mainly the poorer people, are willing to pay higher amounts when necessary.

⇒ Even during the lean season, significant spring and sub-surface flows in key drains and rivers can be observed.

⇒ There is strong focus on supply side enhancements. A concerted effort on demand side management is yet to be taken up.

⇒ No treatment or recylce of wastewater is practised. This leads to severe stream and drain pollution and public health risks. The untreated sewage enters Barapani reservoir.

⇒ Shillong should look into the possibilities of local drainage zone and local decentralised treatment so that the polluted lengths of drains can be minimised and treated water can be discharged into natural drains

⇒ Having mismanaged the local water system and neglected the local rainfall use, the government is now constructing a 50 m high dam across the river Umiew to supply water to Shillong. Another dam on Umkhen river has been identified for future (TARU, 1999).

3.6 Wastewater: Bane or Boon? There are many examples that show that urban wastewater, in stead of being a bane, can become a boon, some of which are described below.

Centre for Environmental Education 29.4.91, Newstime 28.7.91 Dr. Ranbir Chhabra, soil chemist at the Karnal-based Central Soil Salinity Research Institute, has come up with a cheap and profitable way of treating sewage by growing trees on it. Dr Chhabra has successfully grown Eucalyptus, poplar and subabul. "More than 80% of of all fresh vegetables in the country are grown on sewage water" says Dr Chhabra. However, since vegetables are potential accumulators of harmful elements such as cadmium, lead and nickel, only non-edible crops such as trees should be grown on raw sewage. Chhabra's efforts have been hailed by Ganga Action Plan and the National mission on wastelands development (Thakkar 1997).

Times of India 29.8.92 A scheme has been developed for treatment of domestic sewage after 15 years of intensive research by Shivasadan co-operative society. The scheme envisages treatment of 6 mld of the nearly 50 mld of water collected from the city of Sangli. The actual purification will be done with the help of water hyacinth, which has scavenging potential at stabilisation ponds admeasuring four hectares. Water thus treated will be utilised for agricultural purposes or drained into the Krishna river. The estimated capital expenditure on the Shivsadan waste water treatment scheme will be Rs 48 lakhs and maintenance cost Rs 9.63 lakhs per annum. About 30 tonnes of water hyacinth biomass could be harvested from four hectares daily, yielding nearly 6 tonnes of rich organic manure which will, in turn, enrich the civic coffers by Rs 9.31 lakhs annually.

While the capital investment on a conventional advanced water treatment system operated mechanically will be Rs 15 lakhs per mld, Shivsadan's scheme will cut it down to Rs 8 lakhs. Power consumption will be reduced to one tenth. The entire wastewater of the city can be treated in this way.

Hindu 23.10.92 A simple and cheap bio-cleaning system to treat waste water has been demonstrated at the Environmental Education Centre of the Anglade Institute of Natural History, Shembaganur near Kodaikanal in Tamil Nadu. A pilot project with funding from GTZ, the German development agency has been put up by Palani Hills Conservation Council. Root Zone Cleaning System technology, as it is known, uses certain aquatic plants to clean and purify the waste water with minimum operating costs. Such systems have been successful in various parts of Europe, on the plains as well as in mountain regions.

In the Shembaganur pilot plant, about 6 kl of waste water from the capus where about 60 people live are treated each day, and crystal clear water flows out of the 90 metre treatment tank.

Coimbtore example: Hindu 5.3.96 The Coimbtore Municipal Corporation has set up two sewage farms at Ukkadam (114 acres) and Vellalur (700 acres) to use the sewage water of Coimbtore. Here lagoons have been set up and plantation done from the water passed through oxidation ponds. These two farms have established beyond doubt that sewage water has beneficial use and if streamlined, it can be used to extend the green cover and augment the income of the civic bodies.

The Chennai wastewater example is illustrated in Annexure 11.

4. Demand Management Options

Conservation, which is less expensive and more environmentally sound than new investment, would minimise the future capital requirements. Water conservation can be achieved through more effective maintenance mechanisms, which can help to overcome the problems of pilferage and leaks. Demand management can be achieved through water recycling, through financial incentives and technological interventions.

4.1 Recycling Industrial and Commercial Waste Water

Recycling of water in industrial and commercial sector can in effect mean higher availability of water for consumption of households. The recycled water can be used for low quality uses, such as toilet purpose, gardening and for washing floors. In 1992, Madras Refinery Limited (MRL) and Madras Fertiliser Limited (MFL) has invested Rs. 270 million and Rs.320 million to set up tertiary water treatment plants to treat sewage water. The treatment plant uses reverse osmosis technology to treat the wastewater. Few cities are also considering setting up large scale recycling of wastewater (Thakkar, 1997:21). The Government should introduce incentives in terms of tax rebates and tax incentives to enhance water recycling, supported by adequate legislative measures. Though state pollution control board is expected to monitor and regulate recycling and treatment by commercial establishments (including industries) very often due to political nexus between officials and industrialist treatment and recycling is neglected.

4.2. Treatment of Sewage Water[6]

Recycling of wastewater through treatment could also yield major results quickly and economically. About 12,500 MLD sewage water is produced in India from the organised sector of 212 class-I cities with Delhi accounting for the highest volume at 350 MLD (IWRS, 1999: 25; Thakkar, 1997:16). The survey revealed that only 5 metros have proper wastewater collection system, collecting 1493 MLD. Of the 142 Class I cities surveyed, the mode of disposal in 42 cities was on agricultural land, 44 cities into rivers either directly or through drains, 32 cities both on agricultural land and into rivers and 24 cities discharging into other systems like lakes, ponds or sea. In 166 Class II towns, mode of disposal in case of 66 towns is on agricultural land, 42 towns into rivers directly or through drains, 12 towns both on agricultural land and into rivers and 46 towns into lakes, ponds and sea. The insufficient wastewater treatment facility available with the metros is evident from the Table 12. By not collecting and treating the wastewater generated in the cities, we are not only wasting opportunity to make some reuse of the wastewater, we are also polluting more of the remaining freshwater supplies both of surface water and groundwater kind.

Table 12
Wastewater Collection in Metros

City	Wastewater generated (MLD)	Wastewater Treated (MLD)
Mumbai	2228	12

[6] Also see section 3.6

Delhi	1634	1271
Chennai	276	173
Calcutta	1384	690
Hyderabad	350	115
Bangalore	375	286

Source: IWRS, 1999: 26.

Treatment of wastewater should be given priority by increasing the capacity of the existing treatment plants and to find out innovative options and cost-effective measures for wastewater treatment.

Calcutta Metropolitan Water and Sanitation Authority has developed a system of sewage disposal that is among the most efficient and ecologically benign in existence (People and Planet, cited in Thakkar, 1997). The well-known project that has been the guiding spirit for the city is the Bandipur project. The project consists of five ponds over an area of 11.48 Ha through which the effluent is passed. These effluents are treated through cultivation of fisheries and farmers use the water from the final tank to cultivate paddy crop. The project required an initial expenditure of Rs 0.2 million per million litres to be treated compared to Rs. 2.5 million by way of conventional one.

Measures have also emerged in other parts of the country to treat sewage water through water hyacinth (as in Sangli district of Maharashtra). The treatment promises to yield 30 tonnes of hyacinth biomass and 6 tonnes of rich organic manure from 4 Ha of treatment facilities.

Pani Morcha, an NGO in Delhi, has proposed to treat sewage water being pumped into the river Yamuna and use them to recharge the groundwater. In addition, this is to provide a minimum flow of water to the river (Richard, 1999). The plan emerges from the Co-operative fishery project in Calcutta and in Mirzapur in Bangladesh as well as oxidation project in Sangli district. The plan of Pani Morcha is to treat the water in a cost-effective manner “unlike the power and capital intensive Ganga Action Plan” says Commander Sureshwar Sinha of Pani Morcha. They plan to treat the water through duckweed and through cultivation of fisheries to clean up the toxic water. The plan envisages, in short-term, to treat about 70 cusecs of water in west Delhi from Nangloi Plant and in the long term to harvest flood water to revive the dead streams. INTACH proposes to convert the existing sewage treatment plants into ecoparks. It is estimated that such recycling can augment about 804 million cubic metre of water at a cost of Rs. 2.2 million per million cubic metres.

4.3 Water Pricing

Water charges for urban and industrial water are either subsidised or set to recover costs. A World Bank study highlights that the water sector alone contributed a loss of US $ 18 billion (of which $13 billion due to under-pricing and $5 billion due to illegal connections) in developing countries (ORG, 1996). Pricing a public commodity like water is expected to reduce the wastage of water and resource depletion, achieve equity and enable to generate revenue for the government. The agencies in India supply water as part of its programme on a welfare basis and water to industries as part of the industrial development efforts. Though metering of water supply has become common in many of the urban cities, metres very often do not work, or get tampered. In reality volumetric pricing of water has remained on paper (Maria, 1997:57). Households who do not have metres or receive water from standpipes pay a fixed amount. What makes water pricing ineffective is that the system does not contain any incentive for efficient allocation of water. The government prices the water to recover cost rather seeking promoting water use efficiency. It is important to estimate the full cost of the water – in terms of opportunity cost and environmental externalities and estimate the value of water that reflects the societal, poverty alleviation and food security objectives (Rogers, Bhatia & Annette, 1998).

4.4 Leak Detection, Preventive Maintenance and General Mismanagement

The World Bank (1998: 5) estimates that water losses in systems can range from 25% to over 50%. Administration losses are also likely to be high. International experience shows that administrative losses can be two to three times the physical losses. Thus there is huge potential for saving these losses. UWSS services in India deliver an average of less than 50-60 % of their capacity to end-users, compared to with the best practice delivery rates of around 80-85% in other countries. Poor and in some cases non-existent management leads to waste and inefficiency, with the resultant large claim on resources that could be re-deployed for service improvements. Overstaffing is endemic, the ratio of staff per 1 000 service connections, an accepted measure of efficiency in water utilities, ranges from 40 to 60 staff per 1 000 connections in India. The regional average is around 10 staff per 1 000 connections; international best practice is around 2-3 staff per 1 000 connections (World Bank, 1998: 12).

Other pilot studies have shown that the water losses in the water distribution system alone to be above 20% of the total flow, with maximum leakage in the house service connections. Another 10-15% losses occur at the source, in transmission mains, treatment plants and service reservoirs. A systematic approach towards waste prevention and leakage control should form part of the O & M to save considerable quantity of water, and to increase the revenue at the same time. There is also huge scope for conservation at household level and through proper metering of the water supply (IWRS, 1999: 24-5).

In India there is very little money available for actual repair and maintenance of existing systems. About 30-40% of the total annual O & M costs goes towards staff costs, 35-45% of the cost is incurred on power charges and only the balance is available for actual repairs and maintenance (IWRS, 1999: 25).

5. Measures for Evolving Diverse Water Supply Options

Though availability of water is limited, we are yet to utilise the full potential of existing infrastructure and local water harvesting systems. Policy makers propose large dams as the only option for augmenting water supply, which is cost ineffective and leading to various environmental and social problems, and is unsustainable. Through adequate devolution of power and peoples participation diverse local water supply options can be explored. Such an approach requires households to be involved in evolving options, distribution and protection of water. It means empowerment of our urban (as well as rural) communities to manage their own affairs with the state playing a critical supportive role. It also means re-establishing the relationship between the people, the environment and the government. Such an institutional approach requires understanding the role of community, environment and the governance system in solving the resource crisis.

5.1 Awareness on Innovative Measures

Adequate awareness building measures are necessary to facilitate innovative measures of water supply options. Successful cases of awareness building are notable like Exonora International in many of the south Indian cities, Bombay First in Bombay, Civic Affairs Centre at Bangalore and others. It is important that the government, along with these civic societies carry out series of campaigns to promote the importance of diverse water supply and recycling options through diverse technologies. For instance, in Chennai CMWSSB, Raj Paris Civil constructions Alacrity Foundation and Rotary Foundation, and individuals like Dr. Sekar Raghavan have made a modest beginning in this regard in terms of water harvesting options. They are bringing out brochures, handouts and conducting meetings to spread awareness to their clients and to the public on water management. They have evolved diverse technologies for water harvesting, as well.

Water harvesting locally can utilise the already paved ground and rooftops in urban region. This can reduce the cost of water harvesting. In new buildings such pavements are included in the building plans for parking and for other uses. This can reduce the cost of water harvesting. The cost of the local rainwater harvesting for water supply though varies according to need and geological factors, but they are certainly not more than the costs involved in large dam based systems. The Central Ground Water Board estimates the cost of incorporation of water harvesting measures to range from Rs. 5,000 in individual houses to about Rs. 20,000 on complex. In housing societies, lesser will be the cost of rainwater harvesting per home, the larger the number of houses. Private builders, who have been carrying out similar structures for industrial complexes and campuses, estimate about Rs. 1 00 000 for rainwater harvesting per establishments (KRG Rainwater Harvesting Company estimates for RWH in commercial and industrial complexes). Further, it is a misconception to assume that there are only '*the*' techniques to harvest water. Technologies of water harvesting are diverse and should be designed as per local conditions. Alacrity Foundation, one of the pioneers in water harvesting for their clients, from their experience in different parts of the Chennai Metro have evolved various technologies of water harvesting that suits the local conditions.

Further, it cannot be assumed that once the structures are built, water availability will be assured. This is because of the diverse topography and uncertain rainfall pattern. For instance, in one of the projects in Shashtri Nagar by Alacrity Foundation, the water level in well was at 23 feet depth. Even with rainwater harvesting the water level did not improve. Then the Foundation injected a borewell to a depth of 43 feet on the assumption to increase water availability, but this only increased the iron content in the water. Rainwater harvesting did not prove beneficial, and the foundation had to restrict the water level to a depth of 33 - 40 feet to reduce the iron content. To benefit from water harvesting efforts, a collective effort is required where water is harvested everywhere and everyone benefits.

5.2. Decentralised Approach

As the availability of rainwater and demand for water are decentralised and dispersed, a centralised control and management is incompatible. As Manu Bhatanagar of INTACH points out such a measure requires a localised approach of water harvesting and management. In fact, such measures calls to implement and strengthen the concept of the Indian Constitutional 73rd and 74th Amendment, which have proposed to delegate powers to local bodies to manage and distribute water in their jurisdiction. The water supply agencies should delegate powers to the local municipal bodies to harvest, manage and distribute water in their jurisdiction. These local bodies in co-ordination with the civil society can play an important role in implementing the rainwater harvesting within a region. The decentralised governance system can not only take efficient implementation of rainwater harvesting in the region, but can also identify the water scarce pockets, the disadvantageous groups and to carry out regular monitoring of quality of the harvested and retrieved water and to make efforts to treat the water where necessary. Decentralisation can also ensure the sustainability of the programme.

5.3. Institutional measures

Rainwater harvesting needs to be supported through policy and fiscal incentives and dis-incentives. It is important to take lessons from the experience of other states and countries involved in promoting water harvesting in their region. The Government of Mizoram, for instance, has been promoting rainwater harvesting by giving grants for the structures, with people maintaining them at their own expenses. In the beginning of this year, the Himachal Pradesh government has made rainwater harvesting a mandatory for all buildings in the state capital Shimla. Many countries are providing incentives to promote water harvesting. Germany for instance, has devised a taxation system, where residents are taxed on the basis of paved and sealed areas in their houses, such as backyards and drive-ins. A tax-inspector measures the paved area and calculates the average run-off it will generate. The tax amount is increased with the increase in paved area. Lowering the water bills to carryout rainwater harvesting compensates resident's efforts (CSE, 1998a). Such incentives will reduce the cost burden and will also solve part of their water problem. It is important to bring out legislative measures to support water harvesting and provide various incentives and disincentives.

The acceptance of rainwater harvesting also requires co-operation among the residents. Mr. K. R. Gopinath, who has been involved in rainwater harvesting in housing and commercial complexes says, "in a group housing complex differences among the society members mainly hinders in promotion of rainwater harvesting." Where the households have been co-operative like in Madeline Court in Arumbakkam, the households have contributed Rs. 1000 per household to divert the roof water to various bore-pits in the complex and recharge the ground water. The willingness has paid them five years after the construction of the rainwater harvesting structure. Ms. Sheela, the society's Secretary is proud to inform that the quality of well water is better compared to its saline nature five years back.

Rainwater harvesting though may be able to increase the quantity of water, with industrialisation caution is required on the quality of water. Large-scale industrial growth and burning of fossil fuels is mainly responsible for creation of sulphur dioxide (SO2) and oxides of nitrogen (NOX), which lead to the formation of acid rain. Already acidic content in the rainwater of Delhi is on increase. Analysis of Background Air pollution Monitoring Stations information has confirmed that the pH levels decreased from 7.0 in 1965 to 6.1 in 1984 (Anon, 1999:28-9).

5.4. Rights over harvested water

Further, local water harvesting measures requires a collective effort. Earlier it was access to water in the surface and ground aquifers that played an important role, now is the turn of water that is present above the surface (in rooftops) that might add a new dimension to water rights issue. Most of the people in urban area have common roofs, especially in multi-storied buildings. In addition, it is also likely to create right over harvested water.

In Chennai water harvesting done in the residence of Prof. Swaminathan, noted agricultural scientist, is exploited by a well-known hospital located in the neighbourhood, who has dug a deep bore well. In these circumstances it is difficult to assure rainwater harvesting in a complex. "This is one of the hindering factor in promising water from water harvesting structures to our clients" says Mr. Indukanth Ragade of Alacrity Foundation in Chennai. In fact 'others' may reap the results of the efforts made by the water harvesters.

6. Decentralised Framework of Water Supply and Management Options

The urban water supply agencies need to decentralise planning, regulation and monitoring functions for evolving efficient water supply options. This will enable to facilitate participation and help inter-sectoral co-ordination, develop and operate water supply that is more responsive to the needs of the users and to engender a sense of ownership.

Participation by water users will ensure that design choices and management practices of diverse water supply options are consistent with the local requirements and, valued and maintained by the local population. Though the Indian Constitutional 74th Amendment vests powers with the urban Local bodies for the provision of infrastructure services, it is yet to be devolved. To devolve powers to community, urban managers need to understand the diverse existence of the community institutions and their linkages with resources. It is important to understand how the water is used; allocated between users; what are the various claim-making strategies; the rules governing the use and access; and motives behind the community in evolving institution.

1. Devolving powers to the community needs to be gradual as this requires more comparative studies of the conditions under which users are most likely to be organised and take part in participatory management (Gulati, et.al, 1999). More importantly, it is important that firm foundations for participatory institutions are built up so that the institutions are sustainable.
2. The key need of the hour is to develop a new ‘enabling environment’ from the government, as it is the primary decision maker in the sector at present.
2.1 Such ‘enabling environment’ of government requires moving away from ‘centralised’ to ‘decentralised’ means of governance. In other words, moving away from large dams and sources of water to that harvesting water locally.
2.2 Create debate, dialogue and networking among various inter-sectoral interests groups on the importance of locally available urban water supply options, through a framework.
2.3 Facilitate, the community institutions, wherever they exist. In regions where such institutions are dysfunctional or do not exist, community institutions for harvesting local water supply options, to monitor the water quality and quantity, and regulate their maintenance needs to be encouraged.

The state should strengthen and regulate these actors. Zonal (local institutions) groups should be empowered to regulate private agencies for water supply and promote incentives to build rainwater-harvesting facilities. This will reduce the burden on Metro water suppliers to find expensive options for water supply and sewerage discharge. In addition, this can reduce flooding in urban areas. The State should also strengthen them by devolving financial autonomy to generate revenue and to evolve innovative measures for water supply and management options. Such vertical integration of institutions should be adequately supported with co-ordination with various sectors (Appasamy, 1997). The Water supply agency needs to be provided with planning powers in co-ordination with basin level institutions. This calls for institutional reorganisation of the water supply agencies based on priorities emerging from the basin level available resources and needs.

The national level agency (the Ministry of Urban Affairs and Employment) as an apex body should:

1. Formulate broad policy framework on the water supply and sanitation programme in the country.
2. Create awareness over the importance of water conservation, local water systems, through dissemination of various measures, that are local based, to augment water supply in different parts of the country.
3. Undertake technical and financial audit of the state level agencies (NIUA, 1998).
4. Evolve a systematic mechanism to pool data (hydrology, water quantity and quality, coverage and access to population) at national level.
5. Carry out research for an effective on water supply and management options.
6. Evolve legislative measures to provide incentives and disincentives to encourage water conservation and local water harvesting in domestic and industrial urban areas.

State Level Agencies could:

1. Collect information on the hydrology of the rivers, potential sources of water harvesting options, water supply coverage and access in urban and rural regions. For instance, INTACH, a Delhi based NGO has carried out extensive study on the basin hydrogeology in National Capital region in identifying the potential areas of water harvesting. With this study INTACH is preparing feasibility option for Delhi residents.
2. Evolve water quality monitoring standards. These can be monitored locally by the state in co-ordination with community institutions and research centres.
3. Promote inter-sectoral co-ordination for institutions at basin level.
4. Prepare broad framework for planning and management of water resource in a basin taking inputs from local institutions (municipal bodies and *Panchayat* institutions).
5. Devolve powers to local urban institutions to plan, mobilise funds and implement for water supply in urban regions.
6. Evolve adequate regulatory mechanism for operation and maintenance of water supply and sanitation.
7. Carry out research on technical and institutional dimension for water management.

Local Level Institutions can do the following.

1. Promote and interact with user groups in the conservation and management of water, by adopting diverse water supply options.
2. Facilitate local solutions to the water problems rather than investing on large dams options that are cost-ineffective, difficult to monitor and unsustainable.
3. Evolve mechanisms to monitor and regulate water use, through leak detection, water conservation, rationing and restricted water use through community institutions.
4. Evolve a forum to create awareness on the water conservation and management and monitoring water quality.
5. Mobilise funds for the operation and monitoring of the water supply.
6. Provide tax incentives and rebates for people, who promote water conservation and management.
7. Appraise the state level institutions on the water supply quantity and its quality, potential sources of water supply options and potential demands in future.

These are general frameworks of a three-tier institutional system. Such an institutional set up needs to be 'learning organisation' that is best able to adapt to the requirements for implementing and sustaining urban management institutions. Such institutions will involve a rational and informed decision-making process, channels for effective popular participation and financial process, and will be able to respond to the dynamic environmental changes though diverse local water supply options.

Conclusion All available evidence point towards serious mismanagement in UWS. There are many options available before there is question of exploring large dams based solutions for urban water demands. Renovation, repair and proper maintenance of existing systems, local water harvesting, groundwater recharge, wastewater recycle, proper pricing, reducing losses are some of the options that have been least tried in Indian urban areas. Few places where some of these have been tried show that there is substantial potential in these options. There is urgent need to prepare a bank of least cost options for meeting the present and future urban water needs. The need is to do this exercise in a transparent and participatory manner. If this is done, all indications suggest that there is no case for large dams as an option for UWS.

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Annexes

Annex 1.
Dam-Based Water Supply Schemes

S.No.	Schemes	Area of Water Supply.
1.	Bisalpur dam	Jaipur, Ajmer, Kishangarha, Beawar, Nasirbad, Kekri and Sarwar
2.	Jawai dam	Jodhpur city
3.	Bhakra Storage	Delhi
4.	Tehri Dam	Delhi
5.	Renuka Dam	Delhi
6.	Kishau Dam	Delhi.
7.	Kanke Dam	Ranchi
8.	Bhadar dam	Rajkot
9.	Aji-I	Rajkot
10.	Nyari-I	Rajkot
11.	Und dam	Jamnagar
12.	Aji-3	Jamnagar
13.	Viatarna Scheme	Mumbai
14.	Bhatsai Project	Mumbai
15.	Usgaon Dam	Vasai-Virar (Mumbai)
16.	Nagarjunasagar	Hyderabad
17.	Osmanasagar	Hyderabad
18.	Himayatsagar	Hyderabad
19.	River Krishna	Hyderabad
20.	Vaigai dam	Madurai
21	Pilloor dam	Coimbatore
22.	Sardar Sarovar	Ahmedabad, Baroda and all towns of Kutch and Saurashtra
23.	Dharoi Dam	Ahmedabad
24.	K.R.Sagar	Bangaleore
25.	Telugu Ganga	Chennai
26.	Umiew	Shillong
27.	Umkhen	Shillong

Source: Compiled from Thakkar (1997), Indian Water Resources Society (1999), TARU (1999: 65-68) & INTACH (1999).

Note: The dams include those already completed, those under construction and those planned for future use.

Annex 2
Plan Outlays on Water Supply and Sanitation in India (current prices)

Plan Period	Plan Outlays (Rs in millions)			
	RWSS	UWSS	Total	% of Total Plan Allocation
1951-56 (Ist Plan)	60	430	490	1.46
1956-61 (Iind Plan)	280	440	720	1.07
1961-66 (IIIrd Plan)	163.3	893.7	1057	1.23
Annual	NA	NA	1064.2	1.80
1969-74 (IVth Plan)	1550	2820	4370	2.75
1974-79 (Vth Plan)	4812.4	5494.4	10306.8	2.62
Annual	2322.9	1979.3	4302.2	3.43
1980-85 (VIth Plan)	22803.2	17666.8	40470	4.15
1985-90 (VIIth Plan)	35556.7	29657.5	65224.7	3.62
Annual	27059.2	17213.7	44272.9	3.23
1992-97 (VIIIth Plan)	107287.9	59822.8	167110.3	3.85

Source: Mathur, 1998: 34.

Annex 3
Service and Efficiency Indicators for the Major Metropolitan Cities

	Mumbai (1991)	Calcutta (1992)	Delhi (1992)	Chennai (1991)
Service Indicators				
Service Coverage (in %)	N.A.	64	69	48
Water Availability (in hours per day)	5	10	7	3
Avergae Tariff (Rs. Per cubic metre)	2.1	1.5	1.4	-
Efficiency Indicators				
Unaccounted Water (%)	24	36	30	-
Unit Production Cost (Rs./ Cubic metre)	1.1	1	0.6	2.9
Operating Ratio	0.6	1.11	0.81	1.57
Accounts Receivable (months)	2.5	2	NA	9.5
Staff per 1000 Connection	61	16.2	8.9	38.7
Average O&M cost per person (in Rs.)	90.25	84.30	98.80	85.9

Source: MIDS, 1995: 4.

Annex 4a
Population Projections for India

Estimation	All India Projection			
	2000	**2010**	**2025**	**2050**
V & V	995	1146	1333	1581
WPP	1022	1189	1392	1640

V & V: Visaria & Visaria.
WPP: World Population Projection
Source: PSI (1998: 2)

Annex 4b
Urban Population Projections

Total Population Reference	Projection Basis	Projected Population Projections			
		2000	**2010**	**2025**	**2050**
V & V	UN	285	387	603	971
	RGI*	283	363	493	759
WPP	UN**	292	402	630	1007
	RGI	291	376	515	787

* Low Population Projection.
** High Population Projection.
Source: PSI (1998: 4)

Annex 5
Quality of Drinking Water in Delhi

The water supplied in Delhi is many a times not safe due to the presence of pesticides, heavy metals and certain carcinogenic chemicals. The Central Pollution Control Board (CPCB) reveals the presence of alarmingly high levels of pesticides, heavy metals and definite accumulations of carcinogenic chemicals like benzene hexachloride or BHC, DDT, aldrin, dieldrin, heptachlor and endosulphan in the river Yamuna (CSE, 1997). World Bank study indicates that these polluted waters lead to trachoma, diarrhoea, liver infections, intestinal worms and hepatitis, and this does not include the types of cancer that dissolved pesticides can produce (Ibid. 55). What is alarming is the assumption that the water treatment plants can remove all these pollutants. In fact, many of the plants are not even capable of identifying them. The river Yamuna, the major source of fresh water to Delhi contains significant levels of pesticides such as DDT, aldrin, dieldrin, heptochlor, BHC and endosulphan. Some of these are persistent organochlorines known to cause serious maladies including cancer, present at levels that far exceed limits considered fit for human consumption (Table A5-1). The Indo-Dutch study points out that the concentration of pesticides are not detected by the present monitoring systems and thus form a serious threat to the drinking water quality. This is increased with the growth of industrial activity and due to drive for greater agricultural productivity using heavy doses of fertilisers and pesticides.

Table A5-1.
Pesticides Concentration in Yamuna Water Supplies to Delhi
(in nanograms per litre)

Pesticide	Desirable limits for Drinking water.	Range of Concentrations.
T-DDT	Pesticides to be absent	3 - 304 - 1,064
Aldrin/Dieldrin	Pesticides to be absent	1 - 23 - 55
Heptachlor. Heptachlor epoxide	Pesticides to be absent	97
BHC	Pesticides to be absent	1 - 25 - 115

T-DDT: all isomers of dichloro-dipphenyl-trichloroethane.
BHC: benzene hexachloride.
Source: CSE, 1997: 54.

In addition, Delhi's drinking water is contaminated with hordes of microorganisms. All India Institute of Medical Science finds an alarming prevalence of various disease-causing bacteria, amoebae, parasites and larvae of insects in the drinking water. Use of which will lead to several life threatening diseases. The amoeba has been present in over 90 % of examined cases. They not only cause various eye and brain diseases but also harbour other pathogenic bacteria and parasites within them. Delhi is endemic to fluorosis as well, where the people drink water that is naturally contaminated with fluoride up to 32.46 PPM. Investigation of 36 out-patients at All India Institute of Medical Sciences reveal that drinking fluoride contaminated water is a later event, as is evident from the age of the afflicted people (Susheela,et.al. 1996: 356). The disease onset is relatively on older age group, compared to peripheral part where even children of 4-6 years are victims of Flourisis (Table A5-2).

Table A5-2
The Prevalence of Flourishes in Delhi

Location	No. of	Age	No. of	No. of	Drinking	Range of Fluoride (in ppm)

	Patients investigated	range	Female patients	Male patients	Water	Urine	Serum
Palam Village	09	4 -50	03	06	1.2 - 32.5	2.00 - 8.5	0.05 - 0.33
Sagarpur	06	6 - 48	02	04	3.4 - 24.6	0.30 - 24.1	0.10 - 0.63
Nangloi	06	18 - 40	03	03	1.7 - 13.6	0.39 - 10.5	0.16 - 0.27
Peripheral areas	10	6 -50	04	06	1.3 - 19.3	0.66 - 7.5	0.06 - 0.60
Central Delhi	05	28 - 65	02	03	1.5 - 19.3	1.25 - 5.2	0.06 - 0.60

Source: Susheela, et.al, (1996: 356).

On the other hand, Delhi is witnessing increased contamination of nitrate due to increased application of fertilisers in Delhi and in the upstream areas. Regular application of nitrogen fertilizers in the irrigated-cropped land is likely to create blanket (non-point) sources of nitrate. Flood irrigation leading to nitrate contamination of groundwater may facilitate downward migration of this. Nitrate contamination may also be associated with point sources such as domestic sewage, industrial waste, and livestock feeding operations and septic tanks. Studies carried out on the nitrate content in the groundwater samples in the city in 1990 ranged from 0.04 ppm in Bakoli to 98.34 PPM on the IARI farms. About 50 % of the samples showed contamination of more than 10 PPM in all the years, while 33 % of the sample indicated above the permissible limit of 20 PPM and 10 % showed more than maximum permissible limit of 45 PPM. Most of this is located in Nangloi block in the western part of Delhi.

Annex 6
Abstract of Self Reliance on Water

Scarcity of water in Chennai has been a vital factor for Alacrity housing Limited to tap and recycle rainwater to meet the demands of their clients. The impact is documented in the second edition of their booklet 'Self Reliance in Water – Alacrity Experience.' Their experience in about 200 housing complexes (currently the number is about 500) in the metro reveals that about 73 to 79 % of annual per capita water need (at the rate of 135 lpcd) can be met by tapping and recycling rainwater. This reduces their dependence on Chennai Metro Water Supply and Sewage Board (CMWSSB), recharges the groundwater aquifers, and reduces the adverse effects of the seawater intrusion. In due course, the effort promises 100 % self-reliance in water.

The booklet is a simple research piece that assures sustained supply of potable water to prospective buyers of flats. The booklet begins with a background of the perilous future of potable water scenario in Chennai. Alacrity has channelled rainwater to shallow dug wells and shallow pits, and revived old dug wells, which is expected to contribute 36 % of the annual per capita need. In addition, recycling grey water meets another 36 to 43 %. On the whole, they assure about 73 to 79 % of the annual per capita water needs can be met. Such novel efforts can be replicated in places like Hyderabad, Delhi, Coimbatore and Bangalore, which have reasonable rainfall, flat terrain and favourable sub-surface soil.

Annex 7
Water Harvesting Crusaders

Ramani and his *Akash Ganga*

Mr. Ramani is an ordinary person residing in Korattur township of Chennai. Depletion in groundwater and contamination of industrial pollutants in his residential area and location of his house in the tail-end of the water distributary system has made him to evolve a systematic means to harvest rainwater for his domestic needs.

"When I started constructing, people thought I was mad trying to collect rainwater, but I know it works", says R. Ramani (Ghosh, 1999). "Now I use the rainwater almost for the whole year and even during the drought period, when my neighbours are on lookout for water tankers."[7] Being proud of tapping most of the rainwater in his residential area, he has named his efforts as 'Akash Ganga' (literally meaning Ganges from the skies). In his simple technique, he collects rooftop water for drinking and household use and utilises the rest for ground water recharge.

His rooftop water is collected from a total terraced area of 1100 square feet. In which, water falling in 600 square feet area is used for domestic purpose, while water from the rest of the area is used for gardening and to recharge groundwater (Ramani, 1999:14). To enable the waterflow he has resurfaced his roof with Mangalore terrace tiles to generate a mild slope to direct rainwater to the lentil level storage tank that has the capacity of about 2950 litres, with technical guidance from Mr. R. Jeyakumar, a builder. To keep his rooftop water collection free from fungal formation, with consultation with technical expertise, he mixed the waterproof powder with the cement slurry and acrylic-poly-sulphate cement slurry coating. The first rainwater is utilised to wash the entire terrace area and drain them out to the backyard garden. The subsequent water is collected in the lentil level storage tank. The excess water from this tank is collected in synthetic tanks in the first floor for low quality uses with in the house and still excess is diverted to recharge his well.

The volume of the tank has been recently increased to 3300 litres. He is fortunate to be in a city where rainfall occurs almost round the year. During the dry period, tank gets filled up once in three months, while during the rainy period almost every month the tank gets filled. For instance, the tank got filled up twice in just a week's time in July 1999, once on 1st July and then on 7th July. [8] In fact, there is excess water that he diverts to his recharge pit and sometimes directly to well. A full tank will serve domestic water need of his four-member family for 33 days. Almost for the whole year he does not depend on government supplied water.

The well water being brackish in nature and having high iron content is only used during the rainy months, when water quality is better. During the summer months or dry months, the excess rooftop water collected is used in a succinct means. The rooftop water collected from the rest 500 square feet roof area is used for recharging the well through recharge pit and for watering the garden.

One might wonder what the cost of his system would be? "As per the 1994 costs, the price is about Rs. 8 000", says R.Ramani. However, if one plans properly it will cost only Rs. 6 000. He is likely to get more benefits by utilising rainwater for recharging ground aquifer. What is striking in his approach is he has just not been collecting these rainwater, but has been constantly

[7] Personal Communication from Ramani. May 10.
[8] Ibid.

monitoring the quality in the well and of the water used for domestic purpose. The quality of water has shown a dramatic improvement since 1994.

This is an isolated case where a family, which is facing water crisis has evolved their own arrangement to meet the water needs. Recently, after reading his work in a leading newspaper, a resident in his colony has visited him after finding his address from the newspaper.[9] In addition, people living in Kathivakkam and Ambattur area of the city have evinced interest in his work.

Movement for Harvesting Storm Water

The groundwater is available in sufficient quantities in the suburbs of South Chennai (Besant nagar, Valmiki nagar, Kottivakkam, and Palavakkam). Movement led by Dr. Sekar Raghavan has been promoting awareness to protect these aquifers and also reduce extraction from this precious aquifer.

In 1997, in the name of flood management of these regions, Chennai Municipal Corporation started constructing storm water drainage. However, the movement led by Dr. Sekar Raghavan pleaded to the then commissioner to use these waters to recharge the ground aquifers. Failing to get any positive response, the residents took the matter to the Chennai High Court in the form of public interest litigation. However, due to politicians' influence that storm water drainage was given a go ahead by the court, as it gives them opportunity for 'rent seeking.' Later with the support of a senior government official, the corporation was willing to consider constructing soak pits at 2 metre interval along the drain for rainwater to percolate to the aquifer.

[9] Personal Communication from Ramani on July 10, 1999.

Annex 8
Evaluation of Rainwater harvesting in Hyderabad

Hyderabad is the fifth largest city in India with a population of about 42 lakhs. The city currently faces a deficit of 418.5 million litres (to be converted into to million litres). Approximately 45 % of the city's population do not have access to potable water. To meet the growing demand the Hyderabad Metro Water Supply and Sewage Board launched an ambitious programme of rain water harvesting in the twin cities, to replenish the fast depleting groundwater resources and facilitating its movement into the groundwater.

Hyderabad, that enjoys a tropical climate, receives an annual average rainfall of 780 mm, and due to lack of any perennial rivers adjoining the city, the residents had to depend on the four major reservoirs, Himayatsagar, Osmansagar, Mir Alam Tank and Hussain Sagar, in the city. To combat water shortage rainwater harvesting was carried out through roof-tops and through surface systems in public places, such as roads, pavements, parks and other open spaces, in individual houses, and in Osmania Hospital. The harvesting structures have a capacity to harvest 16.93 million litres of water (7.23 million litres from roof-tops and 9.69 million litres from surface water structures) at the cost of Rs. 7 848 072. The cost per litre works out to be Rs. 0.42 per litre. However, there are wide variations in the cost of water harvested from roof-tops and surface structure. The cost of rooftop water works out to be Rs. 0.05 per litres, while that of water from surface structures comes to about Rs. 0.46 per litre.

Source: Subba Rao, B.V. 1999. Rainwater Harvesting - Evaluation report - 1999. Submitted to Dr. Prasad's Environmental Services Private limited Hyderabad.

Annex 9
Water Harvesting – An International Experience

It is not just Indian cities that are trying to cope up with the grim water scenario. Many countries have taken a lead in this direction, not only through experimentation, but also through legislative steps (CSE, 1998a). There is a lot to learn from them. The Chinese experiment cum demonstration programme in its northwest province since 1988 has met with success. About 1 million people have bid farewell to shortage of drinking water after centuries of difficulties.

After battling both water scarcity and floods, Sumida City in Tokyo has become a trailblazer in catching and using rainwater. Rainwater utilisation policies have been promoted with three basic aims: developing water resources by community efforts, restoring the regional natural water cycle, and ensuring water supply for emergencies. The ward office boasts of a rainwater utilisation system that covers half of the water needs and saves 1.8 million-Yen for the government. One of the major achievement has been the installation of rainwater harvesting facility at Ryogoku Kokugikan, a well-known Sumo wrestling arena in Tokyo, where 70 % of the facilities use only rainwater. In August 1998 six ministries in the Japanese government announced to jointly draw out water conservation policies.

The German Municipalities have devised a taxation system that encourages rainwater harvesting. Residents are charged separately on the basis of paved and sealed areas in their houses, such as backyards and drive-in. A tax inspector measures the paved area and calculates the average run-off it will generate. Accordingly, tax is levied. Residents are compensated for carrying out rainwater harvesting structures by lowering the water bills to recover the cost of harvesting.

Annex 10
Institutional Responsibilities of Water Supply and Sanitation

Institutional responsibilities for water supply and sanitation differ across the states for urban water supply and sanitation. The Seventh Schedule of the Constitution of India has divided the responsibility for water between the state and the Central. The Centre is equipped with River basin Act 1956 and Inter-state Water Dispute Act -1956. With the exception of these, all matters relating to water supplies, sanitation, irrigation, canal drainage, storage and power (subject to Article 56 of the constitutions) rests with the State. However, the Centre, due to its financial and policy-making role, has substantial influence on how urban water supply issues are handled.

The responsibilities for providing basic services rest with the state, which they fulfill through (i) their own departments, (ii) state level boards and corporations, (iii) Statutory and non-statutory bodies at the city level and (iv) urban local bodies. In most states, the concerned state government departments, such as Public Health Engineering Department (PHED), the Public Works Department (PWD), the Urban Development Department and the Department of Local Self-government, through their divisional and district offices carryout the capital works. In a few states, like Tamil Nadu and Karnataka, the responsibilities are vested with the respective Water Supply and Sewerage Boards (Mathur, 1998). The distribution of water, maintenance of the capital assets and collection of water charges and taxes lies with the respective local self-government. The major metros (Delhi, Mumbai, Chennai and Calcutta) have separate boards to handle augmentation of water supply, their operation and maintenance.

The responsibility for maintaining the capital assets, and collecting water taxes and charges lies with the urban local bodies, who are expected to implement the decisions taken at the state or the central level. In addition, they have to depend or get approval from the state government to generate revenue. This has an adverse effect on the municipal services, as they do not have adequate funds to mobilise revenue and have to depend extensively on the state.

Annexure 11
THE MADRAS EXAMPLE

Hindu 26.8.88 Metrowater has just commissioned the first of its two sewage treatment plants at Kodungaiyur. The second plant is expected to become functional before the end of the year and thus Metrowater is hoping to throw out something like 20 MGD of secondary treated water by June 89. Tamil Nadu Government has asked major industries in Manali including Madras Fertilizers (5 MGD), Madras refineries (10 MGD) and SPIC group of industries (5 MGD) to recycle the secondary treated water from Kodungaiyur for their industrial uses. This would mean saving of nearly 10 MGD of drinking water, which is now being supplied to these industries. A tertialry treatment plant will be set up to bring the secondary treated water to the prescribed specifications. Metrowater would offer land on lease for the setting up of tertiary treatment plant and supply secondary treated water, with a BOD level of 50 ppm at nominal cost of 10 paise per 1000 litres.

Business Standard 9.10.91 So far, Madras Refineries Limited met its water requirements with the deep bore wells of Metrowater. The total water requirements for the present and future projects is totally 10 MGD. At this stage it was decided to go in for treatment of city sewage water and use it for the plant's requirements. The option of desalination of sea water had to be rejected on cost considerations. The cost of desalinated water was around Rs 50 per cu. m. compared with Rs 18 cu.m. for treated sewage water.

The tertiary water treatment plant at MRL uses the reverse osmosis (RO) technology and is the first of its kind in India, and only the second of its kind in the world with respect to its application and magnitude. The other similar plant is at Petromin Refinery in Riyadh, Saudi Arabia.

Madras City's sewage water is collected in three different locations- Kodungaiyur, Nesapakkam and Koyambedu. The Kodungaiyur plant, situated about 3 kms from MRL's Manali factory, has about 35 MGD of secondarily treated sewage, of which MRL is collecting about 10 MGD-its estimated water requirements. After recovering the usable water from the secondary stage, the remaining concentrate residue, called rejects, are offloaded into the sea as per pollutions norms. To facilitate this, a discharge piping of about 9.2 kms including about 1.2 kms submerged in the sea has been laid as per the norms laid down by National Institute of Oceanography.

The RO unit has three stages and the brine (rejects) of the final stage is rejected. The overall recovery of the RO unit is 85%. The total cost of the tertiary treatment plant and the RO unit was approximately Rs 186.4 million.

Busness India 27.9.93 The acute water crisis in Madras has hit local industry severely. Of the 55 MGD that the city consumes, industry accounts for about 20 MGD. Shortages have repeatedly forced industries to shut down. For instance, Madras Fertilizers Ltd had to close for 80 days in 1985 and for 93 days in 1987.

In 1992, MRL invested about Rs. 270 million to set up a treatment plant to get 2.5 MGD of water. A similar plant has been set up by MFL in 1993 at a cost of Rs 320 million. This unit also sources sewage from the Kodungaiyur plant. While MRL's RO plant was installed by Hindustan Dorr Olier Ltd, MFL's plant is executed by Nuchem Weir. MRL and MFL buy secondary treated sewage water from Metrowater at a cost of 90 paise per 1000 litres.

Hindu 22.3.94 A Rs 2900 million Japanese assisted tertiary sewage treatment plant will be set up in North Madras to supply treated effluents for industrial use. About 25 MGD of treated water sould be available for industries when the plant is set up. The project, which also includes a reverse osmosis plant, would be set up in about three years at Kodungaiyur. Secondary treated sewage from the sewage treatment plants in the city, situated at Koyambedu, Nesapakkam and Perungudi, would be conveyed to this plant. Metrowater plans to give treated water for parks and gardens so that they reduce consumption of fresh water.