MANAGEMENT OF URBAN WATER SUPPLY AND SANITATION - CHALLENGES AND STRATEGIES

S.R. SHUKLA
PHEE, Ministry of Urban Development, New Delhi

Abstract *Due to rapid urbanization and industrialization, urban population of the country is increasing year after year posing a challenge to the planners, engineers and administrators to cope up with the problem of providing the basic amenities. There is an urgent need to initiate action for effective perspective planning for the next 25-30 years keeping in view the targets to be achieved in respect of water supply, sanitation, solid waste management and drainage facilities. To achieve these targets, suitable strategy and policy framework has to be evolved giving due consideration to important aspects such as development of water resources, mobilization of financial resources, adoption of appropriate technology, effective operation and maintenance, water conservation, reuse and recycling of effluents, institutional strengthening, capacity building and private sector participation.*

INTRODUCTION

As per the Constitution of India (Items No. 5&6 of Twelfth Schedule of Article 243 W), water supply and sanitation is a State subject. As such, the State Governments and Urban Local Bodies are primarily responsible for planning, designing, execution, operation and maintenance of water supply and sanitation schemes including billing and collection. The Government of India's role is basically to formulate broad policies and programmes, fixing norms, provide technical assistance, development of human resources and to act as a facilitator in attracting external funding for this vital sector. The demands on the urban water supply and sanitation sector which serves the urban, domestic, commercial and industrial needs are tremendous. To date, the urban water supply and sanitation sector has by and large under-performed against expectations. Quantities of water delivered are inadequate and service is unreliable, requiring consumers to make alternative arrangements which are more costly in terms of time and money, particularly for women and the poor. Due to inadequacy of financial resources, low quality of service has become endemic in most of the cities, resulting in deleterious impacts on consumers, especially the poor. As such the urban water supply and sanitation sector needs urgent attention to meet the ever increasing demands and to ensure that all city dwellers have access to these basic services at reasonable costs.

URBAN SCENARIO

The National Report for Habitat-II has projected the total and urban population of India as indicated in Table 1.

Table 1 Urban population 1951-2021 (in million)

Year	Total Population	Urban Population	% of Urban to Total Population
1951	361	62	17.30
1961	439	79	18.00
1971	548	109	19.90
1981	683	160	23.34
1991	846	218	25.72
2001	1006	307	30.50
2011	1164	426	36.50
2021	1545	618	40.00

Source: India National Report of Second United Nations Conference on Human Settlements - Habitat II.

These projections are based on an analysis of the past demographic and economic trends. However, in a scenario of higher economic growth due to liberalization, the rate of urbanization is bound to be higher. The United Nations has projected that by 2025, more than 50% of the country's population will live in cities and towns.

EMERGING SCENARIO OF SLUM POPULATION

Details of distribution of slum population among different size-categories of the cities/towns are given in Table 2.

Table 2 Size/class-wise identified/estimated slum population in 1991 (population in lakhs)

Size-class category of Cities/Towns	No. of cities/ towns	Total Population	Slum population	Percentage of total population	Percentage of total slum population
> 10 lakh population	23	709.966	188.659	26.6	41.3
5-10 lakh population	31	214.500	42.555	19.8	9.3
3-5 lakh population	39	151.239	28.596	18.9	6.3
1-3 lakh population	207	325.139	54.493	16.8	11.9
Total Class I	300	1400.844	314.303	22.4	68.8
50,000 to 99,999 population	345	236.288	47.151	20.0	10.3
< 50,000 population	3052	520.281	95.232	18.3	20.9
Total	3697	2157.713*	456.686	21.2	100.0

*excluding Jammu and Kashmir

Provisions of services in slum areas is a very complicated and sometimes expensive exercise. Problems of land tenure, institutional/community arrangements, financial credit facilities, technology choice, legislation and resource allocation, compound the problem of improving the peri-urban Water Supply and Sanitation (WSS) services. High population density in these areas increases the risk of communicable diseases especially those which are water or environment related.

HEALTH RISKS

Several diseases like diarrhea, hepatitis (jaundice), ascariasis (roundworm), hookworm infection, trachoma, and dracunculiasis (guinea worm) have been linked to human contact with polluted water. The quantitative measure that integrates premature deaths and temporary disability due to diseases is Disability Adjusted Life Years (DALYs). It is estimated that about 30.5 million DALYs are lost each year due to poor water quality, sanitation and hygiene as illustrated in Table 3.

Table 3 Burden of water related diseases in India, 1990 (in million of DALYs)

Disease	Female	Male	Total
Diarrheal Diseases	14.39	13.64	28.03
Intestinal Helminthes	1.00	1.06	2.06
Trachoma	0.07	0.04	0.11
Hepatitis	0.17	0.14	0.31
Total water-related diseases	15.63	14.88	30.51

Source: World Development Report (World Bank, 1993)

Using the human capital approach, the statistical value of one DALY is equal to the annual average productivity of Indian workers (since one DALY implies one year in which a worker cannot work due to either sickness or premature death). If we take merely the economic value of life year at the average per capita GDP of Rs. 12,000 per person, the annual loss of 30.5 million DALYs is worth 30.5 × 12000 million rupees i.e. Rs. 36,600 crores. Thus the country should be willing to spend that much annually to provide clean drinking water to all. Improvements in water supply and sanitation can substantially reduce the incidence and severity of these diseases, as well as the infant mortality associated with diarrhea.

STATUS OF WATER SUPPLY AND SANITATION

As per the reports from various State Governments and Union Territories, about 90% of urban population was provided with safe drinking water supply facilities and about 49% population with sanitation facilities in urban areas of the country by 31st March, 1997, i.e. by the end of the Eighth Five Year Plan. The status of urban supply sanitation at the end of the Eighth Plan is given in the Table 4.

Table 4 Status of urban water supply and sanitation, as on 31.3.97 (population in million)

Estimated population as of 31.3.97	Population provided* with water supply through				Population provided with sewerage and sanitation facilities			
	HSC^{+}	PSP^{+}	Total	%	Sewer	On-site Sanitation	Total	%
23.93	13.50	8.07	21.57	90.15	6.75	5.05	11.80	49.32

+HSC: House Service Connection; PSP: Public Stand Posts

* Indicates accessibility only. Adequacy and equitable distribution of water is not as per the norms of Government of India.

Sewerage systems exist only in 72 out of 300 Class I cities and where they exist, the coverage is partial. Of the total municipal waste water generated in most cities, less than half is collected and of what is collected, less than half goes through some from of treatment (invariably primary) before final disposal. The high cost of conventional sewerage and treatment places this option out of the reach of most of the cities. Wastewater management is a serious problem in major cities of the country. Table 5 indicates the status of the waste water in 6 mega cities. It is evident, that there is an urgent need to take effective steps for collection, treatment and disposal of wastewater to control environmental pollution and its degradation.

Table 5 Waste water management in the mega cities

S. No.	Name of the city	Waste water Generated (mld)	Waste water Treated (mld)
1.	Mumbai	2400	1800*
2.	Delhi	2160	973
3.	Chennai	276	173
4.	Kolkata	690	690*
5.	Hyderabad	350	115
6.	Bangalore	496	286

*Primary Treatment Only; Source: Information collected from respective urban local bodies.

SOLID WASTE MANAGEMENT

Indian cities and towns are estimated to generate about 80,000 metric tonnes of solid waste every day. About 60% of solid waste is collected and the disposal of the uncollected solid waste fills open space, drains and roads and it is a major cause of insanitary conditions and diseases. It has been reported that Indian cities spend on an average about Rs. 130-260 per tonne on solid waste collection, transportation and disposal. The cost does not include the cost of land used for this purpose.

With huge level of organic content in municipal solid waste, which at times goes up to 30%, it is possible to recover some of the by products like gas, energy and organic manure instead of straight away dumping in landfills. This can be achieved by developing appropriate technologies in the country. If we do so, some of the recurring expenditure on solid waste management can be saved. The scenario of solid waste management in 6 mega cities is as given in Table 6.

Table 6 Solid waste management in the mega cities

S. No.	Name of the city	Solid Waste Generated (mld)	(mt/day) Lifted
1.	Mumbai	5000	4850
2.	Delhi	4600	4140
3.	Chennai	3500	3150
4.	Kolkata	3500	2625
5.	Hyderabad	2800	2100
6.	Bangalore	1800	1260

CHALLENGES AND STRATEGIES

The management of water resources sector at various stages of investigation, planning, implementation, operation and maintenance has to be viewed keeping in view sustainability of various aspects such as adequacy of water resources, appropriate technology, operation and maintenance, finance etc. When sustainability of these aspects is given due importance, it is necessary to consider each aspect meticulously keeping in view the related problems and issues so as to arrive at a more comprehensive and reliable approach for implementation of various water supply and sanitation schemes in urban areas. These aspects are discussed briefly in subsequent paragraphs.

SUSTAINABILITY OF WATER RESOURCES

Surface water is dominant source of water supply followed by groundwater in Class I and II cities and towns in the country. The contribution of water supply from these sources is given in Table 7.

Table 7 Water supply contribution from different sources

Class of city	Surface water %	Groundwater %	Combined (surface + ground) %	Average per capita supply per day (lpcd)
I	73	23	4	147
II	50	43	7	78

Table 8 summarizes the demand for water in 1990, 2000 and 2025 for various purposes as also the supply from surface and groundwater sources:

Table 8 Water demand for various uses

Purpose	*Demand in the year* (cu.km.)		
	1990	2000	2025
Domestic use	25 (4.5)	33 (4.4)	52 (5.0)
Irrigation	460 (83.3)	630 (84.0)	770 (73.3)
Energy	19 (3.5)	27 (3.6)	71 (6.8)
Industrial use	15 (2.7)	30 (4.0)	120 (11.4)
Others	33 (6.0)	30 (4.0)	37 (3.5)
Total	552 (100.0)	750 (100.0)	1050 (100.0)
Source	*Supply in the year*		
Surface water	362 (65.6)	500 (66.7)	700 (66.7)
Groundwater	190 (34.4)	250 (33.3)	350 (33.3)

Note: Figure in parenthesis are percentages.

Compared to the quantity of utilizable water resources of 1,140 cu.km., the demand in the year 2025 would be of the order of 1,050 cu.km. Therefore, in

absolute terms, there could be no shortage of water in the country. However, there are large variations in rainfall from region to region, season to season and year to year. The spatial and temporal variations in precipitation have led to complex situations such as the distinctly different monsoon and non-monsoon seasons, the high and low rainfall areas and drought-flood-drought syndrome due to numerous factors.

NATIONAL WATER POLICY

The National Water Policy (1987) of the country has accorded top priority to drinking water supply in allocation of water sources for various beneficial uses. In actual practice, the operationalisation of the national water policy is far from satisfactory. It is very necessary to make long term planning of water resources management for a period of 30-40 years ahead keeping in view the supply and demand. The fact that about 65% of the total urban population resides in about 10% of the urban settlements i.e. (Class-I cities) would seem to indicate the seriousness and complexity of the problems involving extraction, conveyance and associated environmental impact. Most of the Indian cities are increasingly forced to depend on distant sources as the nearby sources have either been tied up for the various beneficial uses or exhausted. Table 9 depicts the scenario of the present status of new sources of water supply in few of the metro cities in the country.

Table 9 Distance to new sources of water supply

City	Local Source	New Source	Distance to New Source (Total cost in million)
Bangalore	Exhausted	River Kaveri	100 km 90 km (Rs. 2800)
Ahmedabad	Water level going down by 4-5 meters per year	River Sabarmati	150 km upstream (Rs. 4900)
Hyderabad	Exhausted, polluted	River Godavari Nagarjuna Sagar Reservoir	160 km (Rs. 9170)
Delhi	Yamuna water reduced flow, pollution, depletion of groundwater and contamination	Tehri Dam (River Bhagirathi) Renuka Dam Krishna Dam	250 km Planning stage
Chennai	Local source highly inadequate and overused	River Krishna Water from Andhra Pradesh Telugu Ganga	100 km 400 km
Mumbai	Local source functioning well (mostly lakes)	Bhatsai Dam	60-80 km (Rs. 3956)

LEGISLATIVE FRAME WORK

For effective regulations and control of both surface and ground water extractions, proper Central Legislation is necessary. Many a times, water supply projects are prepared without giving due consideration to the reliability of the sources and adequacy of water available. As a result, the schemes become defunct after some period, due to non-availability of required quantity of water from the selected sources to meet the demand of cities and towns. It is, therefore, reiterated that proper long term planning of water resources management is very essential to take care of ever increasing demand.

The Government of India has formulated a model legislation with a view to control groundwater exploitation for ensuring primacy of water use for drinking purpose. However, only a few State Governments have adopted this legislation. In so far as the legislation for the control of surface water is concerned, the Central Government/State Governments have not yet given serious thought to it.

SETTING UP OF NODAL AGENCIES

Keeping in view the diversified use of water resources for various purposes and also the role of various agencies involved, there is a need to constitute nodal agencies at Central and State levels. The creation of such nodal agencies is all the more necessary when water sources are limited and depreciating day by day and the competing demands have to be given due consideration.

These nodal agencies should draw a holistic urban water supply management action plan keeping in view the availability of resources and its uses for different purpose by the various user groups. This action plan should have a time frame of not less than 50 years for long term and 20-25 years for medium term planning. It should be mandatory on the part of the users to strictly adhere to the action plan.

SUSTAINABILITY OF FINANCES

Investment made so far

The National Water Supply and Sanitation Programme was included in the First Five Year Plan (1951-56) with an outlay of Rs.49 crores (1.46% of total public sector outlay). The programme gained recognition over the successive Five Year Plans due to which the outlay for this vital sector progressively increased to Rs.1030.68 crores (2.10%) in the Fifth Five Year Plan and Rs.16,711.03 crores (3.85%) in the Eighth Five Year Plan.

A total investment of around Rs.13,640.00 crores made over the successive Five Year Plans up to Eighth Plan has resulted in significant achievements in urban water supply and sanitation sector. It is very encouraging to know that the allocation for urban water supply and sanitation sector is Rs.14200 crores (4.46%) during the Ninth Five Year Plan (1997-2002). Though about 90% of the urban population has

been provided with safe drinking water facilities, the access to safe drinking water supply in most of the cities and towns is still inadequate, particularly in slums inhabited by poor sections of the society. In so far as the sanitation is concerned, around 50% of the population living in urban areas has been covered with sanitation facilities.

Future Requirements of the Sector up to 2021

It has been estimated that by year 2021, the urban population of the country will be about 550 million. For achieving 100 % coverage in urban water supply, sewerage, low cost sanitation, solid waste management and drainage facilities by the year 2021 and taking into account the coverage of urban population with these facilities upto 31st March, 1997, 324 million population need new services and 115 million population need augmentation facilities in respect of urban water supply. Similarly, 417 million population need new services and 24 million population need augmentation facilities in respect of sewerage, sewage treatment and low cost sanitation. In so far as solid waste management and drainage facilities are concerned, 390 million population needs new facilities and 160 million population needs augmentation facilities in solid waste management and 470 million population requires new facilities and 67 million population need augmentation of drainage facilities.

The requirements of funds has been assessed for all the aforesaid sub-sectors for 100% coverage by 2021 at 1997 price level and the details of which are given in Table 10.

Table 10 Requirement of funds up to 2021

Sector	Population to be provided with		Funds Required (Rs. in millions)
	New facilities (million)	Augmentation facilities (million)	
1. Water Supply	324	115	6,41,250
2. Sewerage, Sewage treatment and low cost sanitation	417	24	7,29,700
3. Solid waste management	390	160	1,29,500
4. Drainage	470	67	2,28,600
Total			17,29,050

Financial Implications and Resources Mobilization

There are no two opinions that these basic amenities should be provided to all the citizens at any cost keeping in view the alarming increase in the incidence of water borne diseases in the urban areas of the country. As such, the high order of

investment for this sector is considered essential and inescapable. However, keeping in view the resources constraint and competing demands of other sectors, it may not be possible for the Central and State Governments to provide the requisite funds for the sector through budgetary support alone. As such, there is a need for other sources of additional funding for this sector.

Given the experience of VIII Plan as well as the policy trends in the country, the net resources likely to be available in the Central and State Plans for investment in the coming years may be of the order of Rs. 527,500 million. In addition, on the basis of available information and previous trend, it would be possible to mobilize additional resources amounting to Rs. 269,642 million from LIC, HUDCO, World Bank, OECF and other international and bilateral agencies. Thus, there exists a resource gap of Rs. 931,908 million. It is, therefore, necessary that efforts should be made to utilize the existing resources more efficiently and at the same time concerted efforts should be made to tap additional resources from:

(a) The normal budgetary allocation to the extent possible;
(b) Tariff reforms to make the schemes self-sustainable;
(c) External funding from World Bank, ADB, OECF and other bilateral agencies;
(d) Private sector investments.

Externally Aided Projects

Under Urban Water Supply and Sanitation Sector, 14 projects have so far been implemented with World Bank assistance at a cost of Rs. 4013 crores. Currently 5 projects are in different stages of implementation in four States with external assistance from World Bank and OECF at an estimated cost of Rs. 5406 crores as indicated in Table 11. Another 11 projects at an estimated cost of Rs. 10282 crores are under consideration of Department of Economic Affairs, Ministry of Finance, Government of India for possible assistance from different external agencies. The State Government would need to provide adequate counter-part funds in their State Plans during the Ninth Five Year Plan so as to complete the projects in time and to take up new projects likely to be approved.

Cost Recovery

While some of the larger municipalities are financially viable and are able to service their debts, most local authorities and utility boards are in financial disarray. The main problem is the lack of incentives for cost reflective, rational tariffs and efficiency improvements in operations and new investments. The importance of user charges in UWSS is crucial.

Cost recovery in the water and sewerage sector has not received much emphasis in most Indian cities. As a result hardly any rigorous analysis of financial viability in the sector exists. For example, a recent survey reported by MoUD suggests that out of 17 local bodies, 7 were able to meet their operation and maintenance costs whereas only 2 covered also their debt servicing costs.

The main argument for the low sector tariffs has been the inability of the poor to pay. Very little hard evidence exists for Indian cities, however, as to what the poor really spend on obtaining these services. Often, large proportions of the poor do receive the minimal shared services free or at very low prices. While there are not many such rigorous studies available for Indian cities, there is considerable anecdotal evidence from many cities which indicates that the poor often pay high prices to purchase water from illegal suppliers in slum settlements or from other private suppliers, especially through water tankers. In order to make water supply systems self-sustainable, the possibility of suitable tax or tariff structure should be worked out and levied on the beneficiaries for providing sewerage, sanitation, drainage and solid waste management facilities.

Table 11 Ongoing externally aided urban water supply and sanitation projects (Rs. million)

S. No.	Water Supply & Sanitation Schemes	Cost (Rs.)	Year of Approval	External Assistance (Rs. million)	Agency
1	II Chennai WS Project (New Veeranam)	5468.00	1997 (Revised)	3460.00	World Bank
2	Mumbai Sewage Disposal Project	11312.00	1995	7680.00	World Bank
3	Functional Improvements to Chennai water Supply & Sanitation Systems	5986.00	1995	4890.0	OECF, Japan
4	Bangalore Water Supply & Sewerage Project	13420.00	1996	7960.00	OECF, Japan
5	Kerala Water Supply Project	17874.00	1997	3360.00	OECF, Japan

Private Sector Participation

Privatisation of urban water supply and sanitation is a long felt need of the country to make the sector efficient, effective, reliable and self-sustainable. If the system is in the hands of private agencies, it is possible to maintain financial discipline, curb wasteful consumption and ensure a net return on investment for future development. A privatised water authority would be able to prepare a well structured and well defined operating policy to mobilize funds from open market for installation, O&M, upgradation and rehabilitation of the system in a more efficient and systematic manner. In India, a beginning has to be made in this regard in so far as water supply sector is concerned.

Salient features of a few urban water supply and sanitation projects which are under active consideration of private sector participation are listed in Table 12.

Table 12 Salient features of Private Sector Participation (PSP) Projects - Urban Water Supply and Sanitation (UWSS) in India

City	Services	Management option	Capital finance arranged by	Time (years)	Project cost (Rs.in crores)
Chennai	O&M WS&S (pumping stations, tube wells & treatment)	Service contracts	Public agency	1-5	NA
Ahmedabad	Augmentaton of WS&S	Private project consultant	Public agency	NA	490
Tiruppur	Bulk WS and new sewerage	Joint sector company/BOT	Joint sector company/BOT	30	900
Pune	Augmentation of WS&S	Fixed price and time construction contract, management contract for O&M of new facilities collection	Public agency	5 for O&M	715
Bangalore	Bulk WS	BOT	Private agency	25-30	800
Alandur	(a) Sewage collection & (b) Treatment plant	(a)Construction contract and (b)BOT	(a) Public agency (b) Private agency	(a)NA (b)15-20	(a) 40 (b) 8
Four Karnataka Towns	WS&S O&M, bill collection and augmentation	Concession	Private agency	25-30	Not known

There are some inherent problems due to which privatisation could not be introduced in the existing water supply systems. For instance, most urban local bodies and water supply departments which are responsible at the local level for the operation and maintenance of such systems are unable to recover event the O&M cost from the beneficiaries. By and large, tariff rates being charged from the consumers are very low and there is a general reluctance for enhancing the same. Under the circumstances, without full cost recovery privatisation cannot be a successful proposition. It is felt that it would be easier and convenient to introduce privatisation in new areas where the private companies will have a free hand to take up the task of planning, design execution operation and maintenance, billing and collection including tapping of raw water from the selected source either on Built, Operate and Own (BOO) or Buiit, Operate, Own and Transfer (BOOT) basis.

SUSTAINABILITY OF TECHNOLOGY

Appropriate Technology

A technology in the long term will be sustainable only if capability of production of that system is built up indigenously. Very often, we come across systems where technologies have been imported and commissioned without paying attention to building up self reliance. Water supply systems fail and lie in disuse for extended purpose waiting for spare parts and help from outside. Building up self reliance in production of such system should be an important component in our management system. One of the problems faced by institutions engaged in providing water supply and sanitation facilities to the urban population in the country is the need to develop expertise in handling a wide range of technology. Most training programmes do not expose them to the whole range of technology options. Technical personnel in these institutions, not being geared to handle community-based system tend to leave this out while considering options.

Normally "low cost" technologies are invariably associated with low income groups. The argument is that since the poor cannot afford to pay, let us give them "low cost". Most of the so called "low cost" systems are no doubt low in capital cost but require high skill in maintenance. When we talk about "appropriate technology", it should apply equally to rich and the poor. We must optimise the total costs and not merely the capital cost of the system provided. The appropriateness of the technology will be dictated by the need of the end user on specific local conditions and not necessarily by income group. Ease of maintenance using local skill should be an important deciding factor in the choice of technology. It must also be added that there is need to do considerable research in order to make the so called "low cost" technologies easy to set up and maintained.

There is another consequence of association of "low cost" to low income. These technologies are considered to be of inferior grade and not favoured by engineers generally. There is a need for creating awareness among them for not to shy away from adopting such technologies. Concerned agencies should give a special thrust to the promotion of such indigenous appropriate technology. This would endow the technologies and the programme a certain status.

Water Conservation

There are various options available to conserve water. In view of increase in demand of water supply and diminishing water resources, sincere efforts are required to be made to conserve precious water. This objective can be achieved mainly by (1) Leak Detection and Preventive Maintenance and (2) Metering of Water Supply Systems. These are briefly described below.

Leak Detection and Preventive Maintenance

Several pilot studies conducted in the country in the last decade have shown the water losses in the water distribution system alone to be of the order of 20% to

40% of the total flow in the system. From the past experience it has been observed that maximum leakage occurs in the house service connections. In additions, losses also occur at the source, in transmission mains, treatment plants and service reservoirs which may be added to another 10-15% of the total output. At a conservative estimate, it has been assessed that precious water worth Rs.300 crores per year is wasted through leakages.

In India, water supply by and large is intermittent (supply duration ranging from 2-8 hours) and therefore during non-supply hours when the system is not under pressure, external pollution may get into the system through points of leak posing health hazards. Therefore, a systematic approach towards waste prevention and leakage control should form an integral part of the Operation and Maintenance (O&M) on a regular basis to save considerable quantity of water, to prevent possible contamination, to improve pressures in the distribution system and to increase revenue to some extent.

All the mega cities namely, Delhi, Kolkata, Mumbai, Chennai carry out leak detection exercise in a systematic manner, to identify the underground leakages, and to carry out repairs of distribution system to save precious water, however, such an exercise is not being carried out by other metropolitan cities. As such to begin with, it is necessary to spread this kind of activity to all the twenty-three metropolitan cities at the earliest. Since leak detection equipment of desired quality and precisions is not at present manufactured within the country, the same will have to be imported. In order to encourage the water supply authorities and municipal corporations in this endeavour, it is suggested that leak detection and preventive maintenance programme as a Joint Venture of both Central and State Government/Local Bodies be taken up.

Metering of Water Supply Systems

There are no two opinions that metering of water supply is desirable to minimize wastage and to maintain economic pricing of water. In this country, though most of the important towns have been provided with domestic and bulk water meters, over the years it has been observed that 20 to 50 % of the installed meters remain defunct due to their poor quality. Sometimes tampering of the meters by the owners has also been noticed. Moreover, the infrastructure and repair facilities for water meters are not adequate in most of the Urban Local Bodies and Water Supply Boards which delay their repairs and early reinstallation. In the absence of working meters, billing for water consumed is often estimated either on average basis or on flat rate, as the case may be.

Though a couple of Indian Companies are, of late, manufacturing water meters for domestic use, it is necessary to get domestic and bulk water meters of the desired quality and precision manufactured within the country in collaboration with some reputed foreign companies as a joint-venture for Indian market. As per the prevailing practice, the domestic meters are owned by the consumers. As such, they have direct access to the meters. However, it is perhaps worthwhile to explore the possibility of owning such meters by the respective water supply agencies and local

bodies themselves to ensure that the consumers do not have direct access to the meters so as to avoid tampering of the meters.

Water Conservation at the Household Level

In so far as wastage of water in residences is concerned, it may be mentioned that in towns and cities where there is intermittent water supply, the house taps are kept open with empty containers under them. When supply is on, the containers fill up and then overflow. This is true especially during early hours of the day and also when inmates go out for a long time. This kind of wastage can be minimized by metering the supply. Moreover, about 10 litres of water is normally used for flushing toilets after every use which is not really required. As such, there is a need to adopt low volume cisterns of capacity of 3-4 litres for flushing urinals and toilets in residences as well as public buildings/places. Such pneumatic low volume flushing systems are not available in India for adoption. It is also a known fact that the practice of taking shower bath consumes lot of water.

Reuse and Recycling of Effluents

In India, importance of reuse and recycling of treated sewage and industrial effluents had been realized on account of two distinct advantages –(1) reduction of pollution in the receiving water bodies; and (2) reduction in the requirement of fresh water for various beneficial uses. Reuse of municipal wastewater after necessary treatment to meet industrial water requirements has been in practice for quite some time in India. The sizes of installations vary from 120 cubic metres per day to as much as 23000 cubic metres per day. In some cases of tall buildings, sewerage is treated in the basement itself and reused as make up water in the building's air-conditioning system. A couple of major industries around Chennai and Mumbai have been using treated sewage for various non-potable purposes and several other industries are being persuaded to reuse and recycle the treated sewage to the extent possible. Thus, there is good potential to reuse/recycle large quantities of sewage at present. In the city of Chandigarh about 45 mld of sewage is given tertiary treatment and then used for horticulture, watering of lawns, etc., thereby saving fresh water to that extent for domestic use. In Chennai, it is contemplated to treat 100 mld of sewage up to tertiary level and use the same in major industries. The scheme is in progress with OECF (Japan) assistance.

SUSTAINABILITY OF OPERATION AND MAINTENANCE

Adequate Revenue Generation for Operation snd Maintenance

Urban Local Bodies in general suffer from inadequate finances and more particularly from lack of qualified technical personnel. Therefore, in spite of the technical guidance provided by the specialized departments like Public Health Engineering Departments, and Water Supply and Sewerage Boards, the Urban

Local Bodies, especially the smaller ones, have not been able to operate and maintain the systems with the desired efficiency. It has been observed that the important aspect of Operation & Maintenance has often been neglected and given low priority in several States. Inattention to this critical aspect often leads to the deterioration of the useful life of the systems by 50% to 65%, necessitating premature replacement of many system components. As such, even after creating such assets by investing millions of rupees, the same are unable to provide the services for which they have been constructed as they remain defunct most of the time.

Some of the key issues contributing to the poor Operation & Maintenance have been identified as lack of finances, inadequate data on Operation & Maintenance; inappropriate system designs; multiplicity of agencies and overlapping responsibilities; inadequate training of personnel and lesser attraction of maintenance jobs in career planning; lack of performance evaluation and regular monitoring; inadequate emphasis on preventive maintenance and lack of operation manuals; and finally the lack of appreciation of the importance of facilities by the community etc.

From the Indian experience, it has been observed that by and large 30% to 50% of the total annual Operation and Maintenance cost goes towards the personnel (Operation and Maintenance Staff), 30% to 40% of the cost is incurred on energy charges and the balance is utilized for consumables, repairs and replacement of parts and machinery and miscellaneous charges. In most of the cities in India, the tariff are so low that they do not even cover the operation and maintenance cost. Few of the efficiency parameters relating to operation and maintenance of water supply systems in mega cities have been indicated in Table13 below:

Table 13 Efficiency indicators

City	Parameters			
	Unaccounted for water	Unit production cost per cubic mtr. (Rs.)	Operating ration (REV/O&M)	Staff per 1000 connections
Mumbai	30	2.75	1.40	61
Kolkata	36	2.15	0.07	16
Delhi	30	2.73	0.35	9
Chennai	35	12.10	3.50	39
Hyderabad	25	6.65	2.30	26
Bangalore	30	8.50	0.61	18

Premature rehabilitation of water supply scheme is the result of poor and ineffective Operation & Maintenance of the system components. In the core areas of many cities water supply mains, laid about 50 years back, are in very bad conditions and as such need rehabilitation/renovation at the earliest by providing suitable lining so that their useful life could be further increased and total replacement postponed by some more years.

Institutional Strengthening and Human Resources Development

Lack of finance is not only the cause of assets deterioration. There are instances where it has been observed that there is no clear cut demarcation of responsibilities for the O&M functions. The organizations executing the projects often do not consult with urban local body or other institutions which would ultimately be responsible for its operation and maintenance. The involvement of local bodies right from the planning stage would resolve many difficulties faced at present. Local bodies have to be assigned their legitimate responsibility for providing and maintaining these basic services. There is however a growing realization at the government level as well as by the local bodies to improve the efficiency of operation and maintenance and to strengthen the institutions by inducing competent and trained personnel.

In most of the local bodies, leak detection and preventive maintenance gets the backseat whereas it has been observed that higher than the expected percentage of water remains unaccounted for, resulting in direct loss of revenue. It also encourages institutions to take up augmentation schemes after incurring huge investments before they actually become mature for such implementation. It clearly indicates that a huge amount of precious water is wasted resulting into the water scarcity requiring a need for augmentation of the water supply system. If leakages are controlled by creating suitable infrastructure facilities for the purpose, the investment on the augmentation of the system could be delayed for quite sometime.

There is also a need for upgrading skills, particularly of the lower level of technical staff, in the areas of operation and preventive maintenance. The concerned agencies will have to draw up a systematic plan for leak detection and preventive maintenance of the old system. Adequate budgetary allocation to support this should be made and performance of the agencies watched closely in this regard.

Community Involvement and People's Participation

Community involvement and participation in water supply, sanitation and solid waste management systems is of vital importance. Where the community has been fully involved and have a sense of "ownership", ultimately help is often forthcoming to operate and maintain the system. It is also advisable that community should also be involved from the planning stage so as to create the awareness among the beneficiaries that system belongs to them and it is for the community to operate and maintain the system to the best of their efforts for fulfilling the minimum basic needs.

Apart from providing minimum required quantity of drinking water to the people, the water supply authorities should always bear in mind that its quality is maintained at all times to safeguard the health of the community. City level consumer forums may be set-up to keep a vigil on the water sources to prevent possible contamination and make periodical reporting to the supply agencies for appropriate action well in advance. At the same time, awareness programmes on water conservation, wastage prevention, water quality, personal hygiene etc. may

have to be designed and implemented with the help of NGOs and neighbourhood committees.

Consumer satisfaction should be the top-most priority of the water supply agencies and as such complaint/suggestion cells may be set-up in the water supply agencies to enable the consumers to lodge complaints on aspects such as leakage and wastage of water, supply at low pressure at the consumer's end, contamination/poor quality of water, pilferage of system components, malfunctioning of water meters, problems related to meter reading, payment of bills etc. and suggestions, if any, for better performance of the system. At the same time, all such complaints received by the water supply agencies should be attended to within a reasonable time-frame so as to win the confidence of the consumers.

CONCLUSIONS

While the pace of urbanization in terms of sheer numbers has it own pressure on the infrastructural services, the growth of large cities bring in its wake a different set of problems. These cities have grown more often than not, without due regard to the availability of water. Though the availability and know-how of technology is not a limiting factor, the huge cost of tapping distant water sources for these cities is sure to bring problems like increased costs, inter-basin/inter-state transfer questions, reliability of source etc. Moreover, the increasing industrialization, use of insecticides, pesticides and fertilizers in the agriculture sector and the inability of the establishments to effectively deal with wastewater have led to increasing pollution of water sources. This also has contributed to pushing up the costs.

Water is not an unlimited source, more so, with greater pollution of the rivers which had earlier been the source for development of civilizations along the banks. One of the greatest polluters of water sources has been urban settlements which have been dumping untreated wastes into our dwindling water sources. There is, therefore, an imperative need for protection of our water sources through improved sanitation.

Any improvement in the Water Supply and Sanitation Sector will be possible only if we improve the incentive environment for those who are responsible for execution as well as operation and maintenance. We can achieve greater efficiency, if we reduce over-heads in execution and adopt proper design criteria. Operation and maintenance unfortunately, does not get the primacy it deserves. There should be proper training for improving the management capabilities for those at the decision making levels and upgradation of skills for those in-charge of operation and maintenance. Even the smallest steps in this direction would pay great dividends in reducing the costs and thereby reduction on the burden which we propose to put on consumers. If the sector becomes self-sustaining, it will also be less of a drain on the State resources, which are in any case extremely limited and also make it more conducive to induction of institutional finance.

The changes in this sector cannot be brought about overnight but if we recognize that certain basic and fundamental changes are needed to cope with the demands which are imperative for a healthy community, we would at least be

moving in the right direction. The recognition of water supply, sewerage, low cost sanitation and solid waste management services and utilities as well as the sustainability of these basic services should be the guiding principles towards future development in this vital sector.

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