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Does Mumbai Have Enough Water?

By *Dhaval D Desai*
Research Fellow ORF Mumbai

Reviewed by Dr. M. A. Chitale

[ABOUT THE AUTHORS]

DHAVAL D DESAI
Research Fellow,
ORF Mumbai

Dhaval D. Desai started his career in Mumbai as a journalist, spending 13 years with both print and electronic media. He worked with *The Daily* and *The Indian Express* before switching over to television news, working in senior editorial positions in Zee News and Sahara Samay. He quit active journalism in 2006 as the Chief of Bureau of Sahara Samay Mumbai. He later did a two-year stint with Hanmer & Partners, a public relations consultancy, where he was part of a World Bank consortium handling communications for a consultant appointed by the Municipal Corporation of Greater Mumbai to study and recommend ways to improve the city's water distribution. At Observer Research Foundation Mumbai, he works as Research Fellow and Programme Coordinator, and is involved with outreach and media relations.

VARSHA RAJ
Research Fellow,
ORF Mumbai

Varsha Raj studied B.A. Economics (Honours) at The University of Manchester (U.K.) and recently completed her M.Sc. in Development Studies at the London School of Economics and Political Science. Her Master's thesis was on the domestic developmental impacts of Sovereign Wealth Funds with a focus on Botswana's Pula Fund. She previously worked as Communications and Public Relations Officer for the German Swiss International School in Hong Kong and has also undertaken research in the area of Global Political Economy for an international think-tank based in Norway. Her research interests include Development Finance, Trade, Economic Development Policy, International Organisations and Globalisation.

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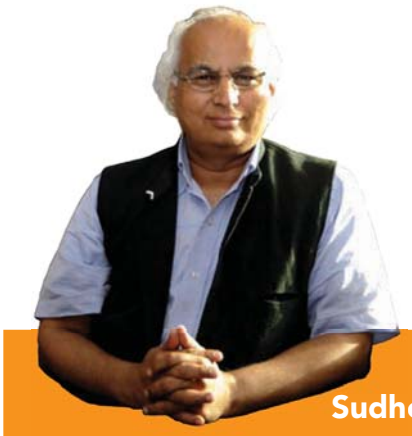

Sudheendra Kulkarni
Chairman
ORF Mumbai

The failure of the monsoon in 2009, which had followed erratic rainfall of the previous year, had created a major water supply problem in Mumbai, a city that in the past has enjoyed a high reputation for sound water management and good municipal governance. The Municipal Corporation of Greater Mumbai (MCGM), still widely known as BMC (Bombay Municipal Corporation), was forced to announce across-the-board water cuts. To tide over the situation, which could have snowballed into a catastrophe, the BMC and the state government were also forced into taking some hasty decisions aimed at source augmentation. However, the water crisis exposed a deeper systemic malaise, which needs to be cured.

As Mumbai's unplanned growth continues, the city is witnessing growing inequity in water distribution, with the poor ending up getting less and less water, for which they often have to pay more than the rich.

This report, although focusing on Mumbai, tries to assess the problems of water supply in the larger context of urban India. As in most other city municipal corporations across India, much of the BMC's focus continues to be on demand-driven measures, focusing largely on source augmentation. However, paying less attention to preventing water loss and water theft is not sustainable. There is no mission-mode approach to adopting global best practices in water saving and water recycling by all categories of users. Key departmental weaknesses that have led to gross mismanagement of this vital resource continue to be ignored by the BMC.

The report concludes that the problem will not be solved unless the BMC integrates its much-needed demand-driven measures with serious and urgent steps for equitable supply management. It emphasises the need for cooperative participation by all the stakeholders — including political parties and their elected representatives, whose myopic populism frequently undermines the Corporation's plans. With the help of case studies, the report also offers a set of potential recommendations, which, if implemented, can help India's commercial capital manage this limited and critical resource in a sustainable way. We believe that many of these recommendations, in the areas of leak detection and prevention to reduce water loss, waste water treatment and recycling, and mass public education campaigns to spread awareness of the traditional and modern water conservation methods etc. are salient in the broader context of urban India.

[THE CONTEXT]

With increasing urbanisation taking place across the country, Indian cities of all sizes are grappling with challenges of balanced and sustainable growth. The desire to promote inclusive, productive, efficient and manageable development is not easy to reconcile with the realities of resource scarcity made worse by vested interests. Within this context, provision of clean and safe drinking water to India's burgeoning urban population — in the face of limited water resources and environmental degradation — is an area that needs sincere and systematic attention.

According to the 2001 census, the number of households with access to safe drinking water in India's urban areas increased by 6.3 percent between 1981 and 1991. However, the number of households using taps as the principal source of water declined from 72 percent in 1988 to 70 percent in 1998; indicating growing dependence on the already over-burdened source of groundwater. This trend is expected to continue when the provisional data of the 2011 census is finalised.

Comparison of the data released by the National Sample Survey Organisation (NSSO) for the periods 2002-03 and 2008-09, too, shows an increasing dependence on groundwater. While the NSSO data for 2002-03 showed 51 percent of India's rural population dependent on hand-pumps and tube-wells as their sole sources of water, the 2008-09 data (released in November 2010), showed an increased dependence on these groundwater sources to 55 percent of total rural households.

Water problems have been exacerbated due to inadequate attention paid to water legislation, regulation, management, conservation, efficiency in use, recycling and infrastructure. As a result, many areas across India face a recurring drought-like situation.

The impending crisis was suitably surmised by **Prime Minister Dr. Manmohan Singh**, at a day-long conference of Environment Ministers from all States in August 2009: ***"Climate change is threatening our ecosystems; water scarcity is becoming a way of life and pollution is a growing threat to our health and habitat."***

With the failure of the monsoon in 2009, a water crisis had gripped India's commercial capital after nearly two decades of plenty. Against this backdrop, ORF Mumbai commenced its study of the water crisis in Mumbai and the larger issue of water management in the city, in a phased manner. In the first stage of this initiative, ORF organised a roundtable in January 2010 — during the thick of the crisis — which was attended by key stakeholders and international experts. Subsequently, ORF organised smaller focused meetings to further discuss the practicality of some of the key potential recommendations that were distilled from the roundtable.

Through initial research and a series of discussions with various stakeholder groups, ORF has identified some potential measures that must be taken to provide adequate clean drinking water to all citizens, efficiently, equitably, and at an affordable price. At the same time, ORF has also raised pertinent questions about the practicality of some of the decisions that have been taken or are being considered, involving massive expenditure of public funds, in the name of source augmentation and sustainability.

While acknowledging the fact that Mumbai is one of the country's most well-endowed cities in terms of water availability (with large water resources around it), we believe that a few of these potential measures aimed at effective municipal water management, especially in terms of leak detection and control, and public awareness and involvement, are relevant and applicable in the broader context of urban India.

[EXECUTIVE SUMMARY]

After grappling with water scarcity for well over a year, bountiful monsoon of 2010 brought the much-needed relief to the people of Mumbai. Just one year later, with the delayed onset of monsoon, Mumbai was once again staring at what could have been an even bigger a water crisis than it faced in 2009-10. Thankfully, with precipitation picking up by a good measure in July, the crisis was nipped in the bud. Mumbai's citizens are assured of enjoying unrestrained municipal water supply in 2011 - 12. The anger and unrest manifest in Mumbaikars through 2009 has, in just two years, given way to the usual, general sense of satisfaction. Municipal authorities are relieved that the worst is over, at least for now. Just like all other crises, Mumbai has put this one behind it and doggedly moved on.

Unfortunately, as the city quickly lapsed to 'Business as Usual', the precious lessons learnt from the water crisis of 2009 have once again gone waste — just like the millions of litres of water, that are lost daily from the distribution network of the city without a trace.

Mumbai has the potential to become one of the world's ideal cities in terms of sustainable water management. With abundant natural and perennial water sources around it, the megacity is currently one of the most secure metropolises in the country in terms of water availability. However, a very critical issue in satisfying the ever increasing demands of its teeming millions and overcoming the consequent complex challenges is of sustainable water management.

Water supply in Mumbai is largely impacted by three distinct, yet closely interlinked, factors. Each of these factors individually and collectively affects water service delivery:

1) Technical factors
2) Financial factors
3) Societal factors

Technical factors: Includes source management, treatment, leaks, contamination, metering, pressure, recycling, pipeline network mapping, consumption mapping etc. are just a few examples of the technical factors that impact water supply. Others like departmental autonomy, separate official cadre of water department engineers, departmental empowerment and accountability etc. can also be termed as technical challenges, albeit exclusively in the realm of policy reforms that require a long-term pragmatic vision coupled with strong political and governmental backing.

Financial factors: Source augmentation using multiple methods of water production, expenditure, pricing, revenue, budgeting, prioritising urgent works, provisioning for handling of contingencies, removal of backlog, future planning etc. constitute some of the key financial factors that govern municipal water supply.

Social factors: A large slum population, unplanned development, never-ending and rising influx of people into Mumbai (not just permanent settlers but daily floating population that visits Mumbai only during daytime), illegal connections, water theft, wasteful habits, increasing water supply by private tankers at a much higher price etc. are some of the factors that constitute the social factors. Given the lack of integrated planning for Mumbai in terms of public infrastructure, these issues are the most difficult to solve. Besides administrative efficiency and strength, these require strong political will to bring about a transformation, including the political and governmental ability to take bold and tough decisions. These also require sincere involvement of the people, who need to understand the growing threat to the world's natural resources as a direct result of Climate Change, among which, the dangerously depleting freshwater level that is particularly posing a perceptible threat to our collective survival globally.

A very complex mix of these three critical factors, without any serious attempt at finding long-term and sustainable solutions, has put unmanageable pressure on Mumbai's water management.

Water service delivery has already suffered greatly because of the failure of the municipal corporation to implement in a timely manner, the various important recommendations made by the Expert Committee (Water Planning) – popularly referred to as the Chitale Committee – which was appointed by the State Government under the Chairmanship of internationally reputed water expert Dr. Madhavrao A. Chitale. This committee, appointed following a grave water crisis in the city in 1992, had made numerous recommendations to ensure sustainable water supply for Mumbai. According to informed estimates, in the context of overall public infrastructure development too, the various local and state government agencies have accumulated a massive backlog of works that should have been executed and made operational as many as 15 to 20 years ago.

There is a dearth of availability of water related BMC data in the public domain. Critical information about the massive backlog of ongoing and planned works, information related to their financial and contractual details etc. are not available publicly. City activists have to file RTI applications for even the most basic consumer-related data that should ideally have been provided openly to the citizens in forms of periodic newsletters, information booklets and on the BMC's website.

This report has used a combination of official primary data gathered through consultations and interviews, and relied on authentic secondary inputs to understand the current complexities and future challenges. It analyses the supply and demand aspects, focuses on the critical technical, financial and societal challenges, and uses a number of local, Indian and international case studies and recommends a series of short-, medium- and long-term measures to make Mumbai a water sustainable city. An understanding of reality should catalyse long standing changes that will help the city achieve this difficult, but inevitable goal.

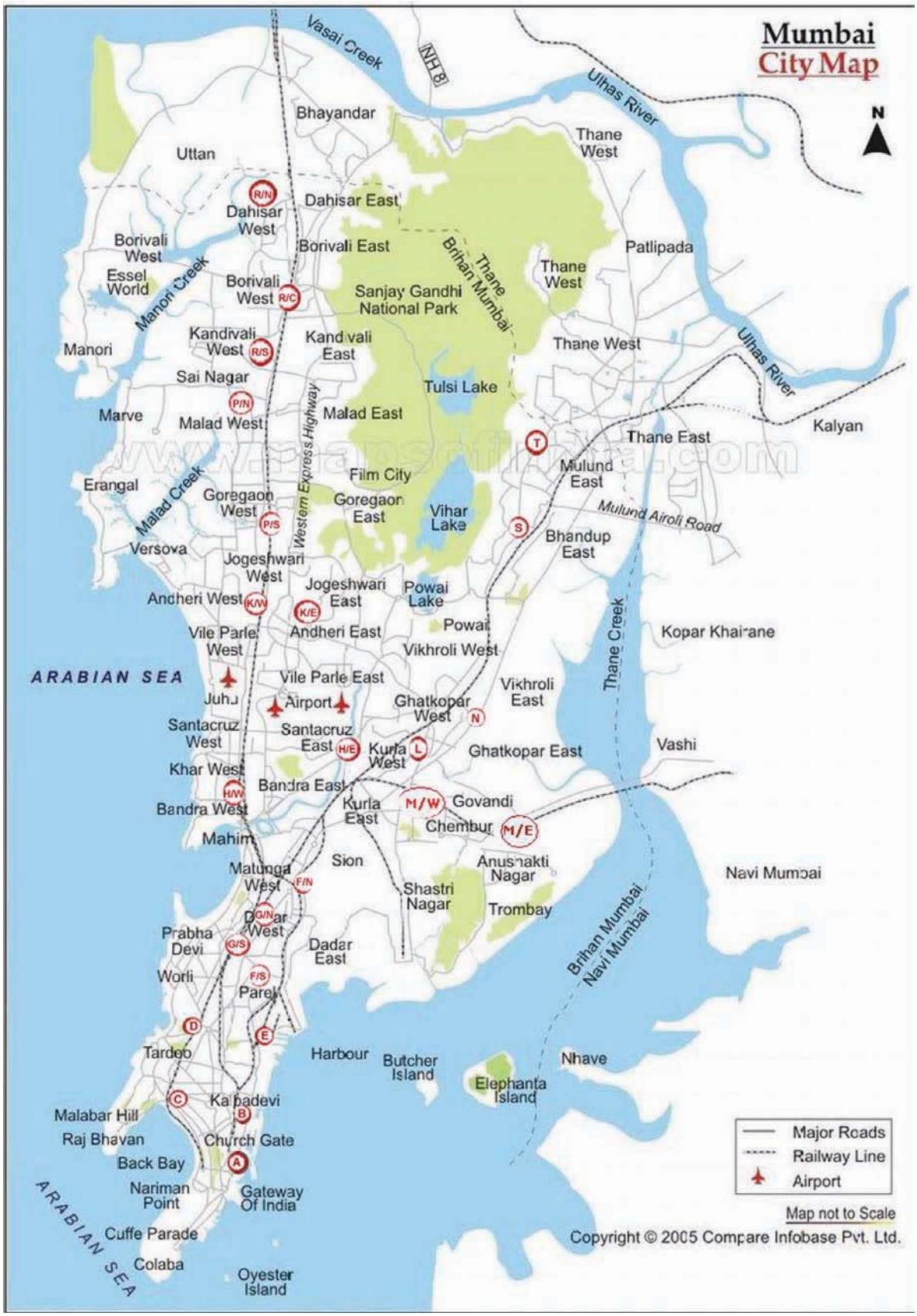

Figure 1: Map of Mumbai City Source: BMC website (Originally sourced from mapsofindia.com)
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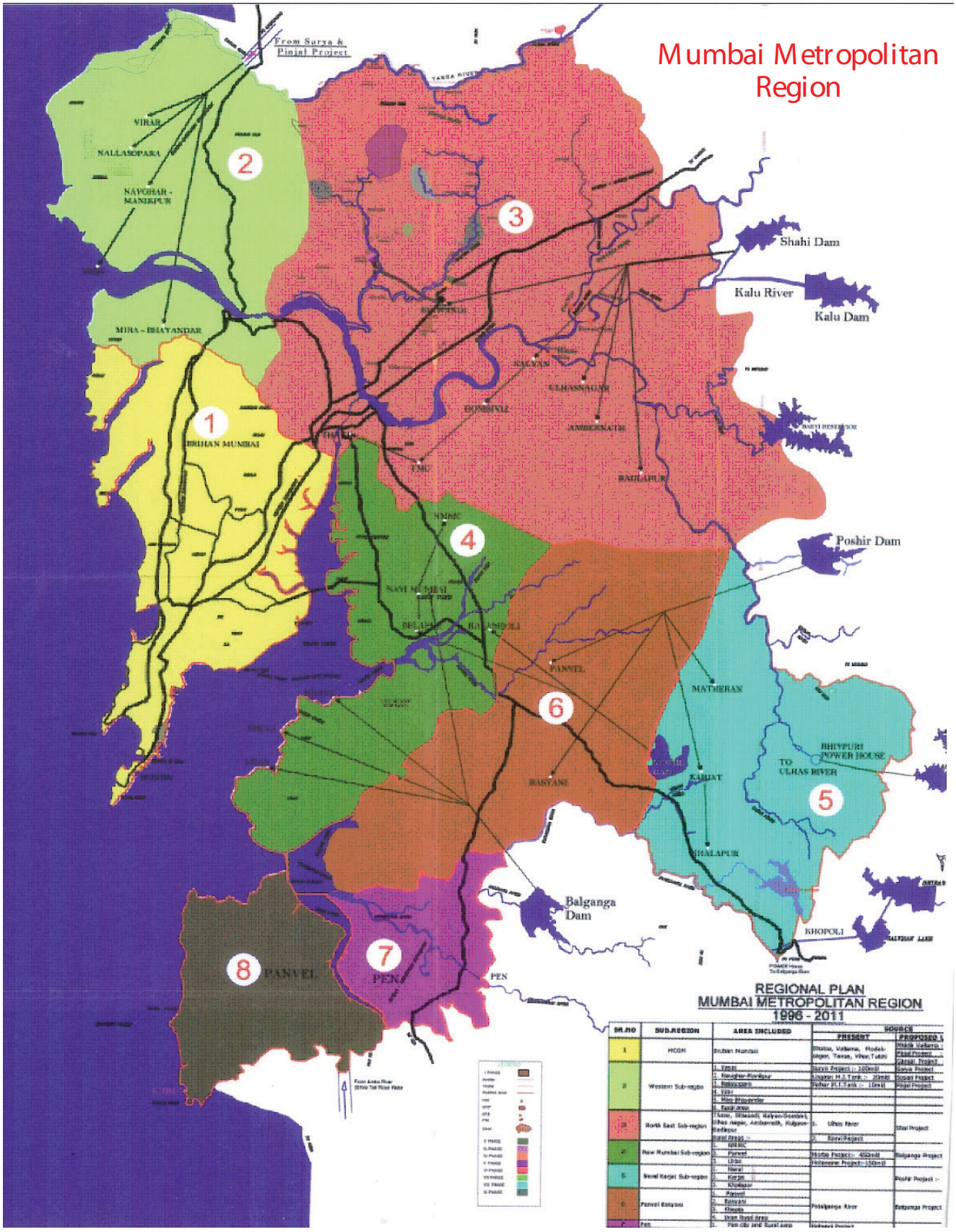


Figure 2: Map of Mumbai Metropolitan Region Source: Chitale Committee Report 1994

01 INTRODUCTION

A detailed introduction and analysis of Mumbai's current water supply scenario highlighting the critical technical, financial and socio-political issues that affect the system. The chapter concludes with a fervent appeal to the BMC and State Government to implement some tough measures for long-term sustainability of this precious natural resource.

Mumbai is a major contributor to the state and the national economy. It is widely acknowledged that the city accounts for about a third of Central Government tax revenues and contributes around six percent of India's GDP[1]. Accordingly, Mumbai deserves a commensurate level of public services. The cities of Mumbai, Navi Mumbai, Thane, Kalyan-Dombivali, Bhiwandi-Nizampur, Ulhasnagar, Mira-Bhayandar, Vasai and Virar, in the larger Mumbai Metropolitan Region (MMR), presently form an urban agglomeration of around 20 million people[2]. By 2025, its population is estimated to reach 26.4 million[3].

The population of Mumbai alone has been pegged at 12.4 million as per the provisional data of 2011 Census projections, as against 11.9 million in 2001 Census. The projections also showed that about 90 lakh or roughly 62 percent of Mumbai's residents now live in slums with limited or no access to basic civic amenities, as against 60 lakh (54 percent) recorded in 2001 Census[4]. The growing population pressures on the city and the surrounding urban areas must be met with improved provision of basic public services. The steep rate of population growth creates severe challenges for city planners.

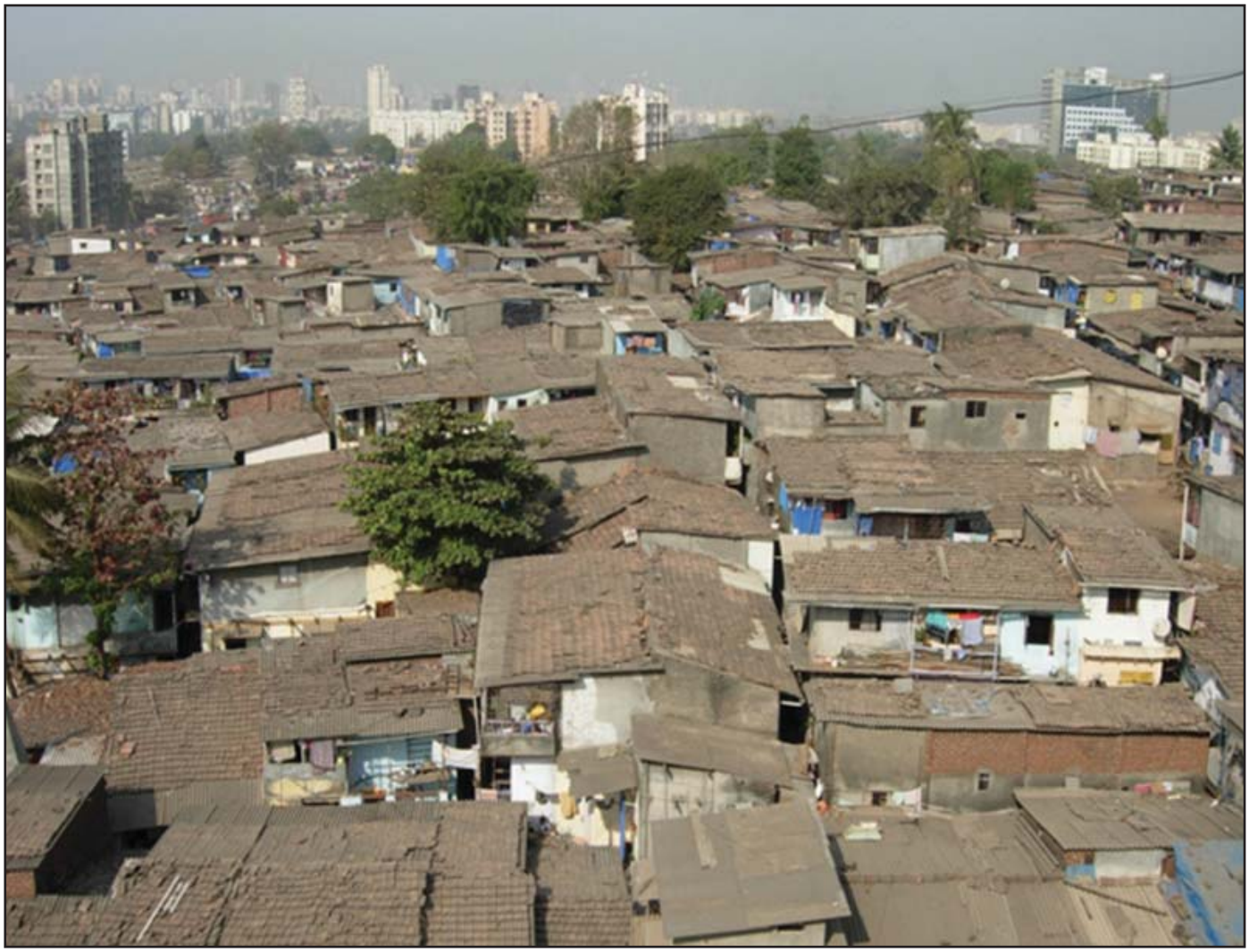


Figure 3: A SEA OF SLUMS… Uncontrolled increase in the population coupled with no planning for low-cost housing has led to proliferation of slums in Mumbai, where 62 percent of its population resides with little or no access to basic civic amenities like water and sanitation. *[Source: BMC 2010]*

Upward and outward expansion of Mumbai through high-rise constructions and improved connectivity within the Mumbai Metropolitan Region is having a big impact on the demand for water, putting added pressure on limited resources.

The rapidly growing trend of modern apartments with jet showers, bath tubs and toilets with double flush capacity tanks place added strain on the city's water. While it may be argued that the number of households currently enjoying such luxury could be just one percent of the total number of households in the city, the fact is that all new real estate developments taking place offer such water guzzling gadgets. The rate at which this high-end segment of real estate development is taking place is bound to put more pressure on the BMC's distribution system.

studies in conjunction with several consultants and specialists, and despite the fact that the quantum of water supply to the city has steadily increased over the decades, the overall situation has deteriorated. The 15 percent cut in water supply imposed in 2009-10 and subsequent civic unrest witnessed at such measures[6] prove this reality. To make matters worse for the BMC's water department, 17 major water pipeline bursts occurred in February and March— 15 in March alone[7] — resulting in water losses to the tune of several million litres

Table 1: Zone-wise population growth and projected growth in Mumbai (Million)

Year	Eastern Suburbs	Western Suburbs	City	Total
1951	0.205	0.305	2.572	3.082
1961	0.503	0.878	2.772	4.153
1971	1.095	1.705	3.072	5.872
1981	2.099	2.858	3.285	8.242
1991	2.801	3.941	3.155	9.897
2001	3.508	5.132	3.338	11.978
2011*	4.303	6.240	3.247	13.790
2021*	9.062	7.288	3.264	15.614
**Projected population growth as per Chitale Committee Report, 1994*				

[Source: MCGM White Paper, 2009]

It is tragic that while some parts of the city get more than enough water to enjoy such luxury, other parts – especially slum areas – perennially face problems like low pressure supply and acute water shortages. Unless there is a resolute and unified effort by all stakeholders for better water management and optimal use of this precious natural resource, such disparities are bound to grow along with the steady growth of the city's population, which is projected to reach nearly 16 million in 2021[5].

Despite a number of studies conducted by the BMC, as well as

nearly every other day. It is, therefore, imperative to understand and analyse the city's last water crisis, and assess the growth in patterns of water consumption. Forecasting the demand accurately will be crucial to making adequate provisions for water supply to the city's vast and growing number of consumers. ORF aims to provide credible independent research to aid evidence-based policy formulation; to identify where, and how, Mumbai's infrastructure services and public utilities can be overhauled to meet the city's 21st century needs.

We seek to provide an open forum to discuss how public policy should be recast going forward. It appears that while there is total agreement on the urgent need for reforms in public services in Mumbai among all the stakeholders, there is no clear consensus on what the long-term and sustainable solution to Mumbai's water woes can be, and how it can be achieved. In addressing this, a central part of the ORF study aims to build a platform to bring the many change agents together to brainstorm, generate a constructive debate, and bring about the desired reforms. We aim to engage the BMC, the State Government, policy-makers and influencers, citizens' groups, non-governmental organisations (NGOs) and the media in this respect.

This study, though substantive, is not comprehensive. ORF recognises the need to look more in-depth at the current and budgeted fiscal resources allocated to this sector and isolate the areas where resources can be utilised more efficiently to effectively meet growing demand.

The BMC, the richest municipal corporation in India, has an annual budget of nearly Rs. 21,000 crore[8]. In comparison, the Municipal Corporation of Delhi, one of the largest in the world in terms of area covered, has an annual budget of Rs. 1,455.55 crore for 2011-12[9]. The BMC also has 31 different funds for asset upgrading, which have almost never been used[10]. Sadly, gross mismanagement of public funds is threatening to reduce India's richest civic government to near penury, so much so, that the BMC is finding it difficult to finance some of its planned future works.[11]

The BMC is India's richest municipal corporation with an annual budget of nearly Rs. 21,000 crore.

The BMC and Water Management

The BMC's Hydraulic Engineering Department is one of its most profitable divisions, with a budgetary surplus of Rs. 1000 crore (2009-10). As such, the BMC has enough funds to finance most water projects through internal accruals. In addition to the Central Government assistance and International Aid that it gets for source augmentation and maintenance of the distribution system, the BMC collects a revenue of nearly Rs. 2775 crore annually from water and sewerage charges to citizens.[12] The water charges are broadly classified into: a) Water tax, which is collected on the basis of the rateable value of old unmetered buildings in the city, b) Water charges, collected as per billing on metered consumption, and c) Water benefit tax, which both the metered and unmetered consumers have to pay. Sewerage charges, too, are recovered under the same categories.

The BMC's Water Department is one of its most profitable divisions with a budgetary surplus of Rs. 1,000 crore.

The BMC commendably supplies an average of more than 200 litres per capita per day[13] (LPCD) to domestic consumers, which is one of the highest amongst cities in India. Yet, Mumbai faces a demand-supply gap of 900 million litres per day (MLD), with the assumed demand of 4250 MLD (as per the Chitale Committee norms of 240 LPCD for residents of planned buildings and of 135 LPCD of slum residents). The current demand of 4250 MLD is as per the assumption made in the city's water supply Master Plan prepared in 1999, which aimed at creating additional infrastructure keeping in mind the projected development and population growth. The BMC's MIS data, as of January 2010, showed that even with the 15 percent water cut imposed then, residents of planned buildings consumed 180 LPCD, while residents of slums consumed in the range of 60 to 90 LPCD of water.

A comparison with some of India's other metropolitan cities shows that BMC is doing a very good job of water provision in Mumbai, considering the enormous quantum of water it supplies and the magnitude of population it serves. The Delhi Jal Board supplied 3061.80 MLD of water in 2009 against the total requirement of 3742 MLD (as per Central Public Health and Environmental Engineering Organisation (CPHEEO) norm of 225 LPCD), with an average daily supply of 172 LPCD to domestic consumers[14]. Chennai Metro Water supplies about 645 to 650 MLD of water, out of which about 585 MLD is supplied to Chennai City, which has a population of 5.40 million[15]. The present level of water supply in Chennai is 90 LPCD, with a planned target to achieve 150 LPCD in 2026[16]. The per capita water supply in Bangalore is about 100

to 125 LPCD, which is below the National Standard of 150-200 LPCD. However, the per capita availability of water for the vast majority of poor people in Bangalore is only about 40-45 LPCD. While the Bangalore Water Supply and Sewerage Board (Bangalore Metro Water) is supplying a total of 810 MLD of water, the actual demand by its 6 million population is 900 MLD[17]. The Kolkata Municipal Corporation supplies water to the tune of 1232 MLD, but the residents are largely dependent on groundwater to meet their daily needs. Moreover, since the groundwater has been tapped without any concern for quality, a majority of the residents are exposed to health hazards by consuming water that is contaminated with excess levels of arsenic, fluoride and salinity[18].

through five key projects to be undertaken at: Middle Vaitarna, Kalu, Gargai and Pinjal. While work at Middle Vaitarna is expected to be commissioned in 2012-13, work is yet to begin at Kalu, Gargai and Pinjal. The water from Pinjal source will be shared between the BMC and MMRDA, which will use the water to meet the future water demands of the other areas in the Mumbai Metropolitan Region[19].

A number of the long-term recommendations made by the Chitale Committee in 1994 have not been seriously acted upon, with projects that should have been in advanced stages of completion by now, still languishing in an early planning phase. [The key observations, conclusions and recommendations of the committee are presented in Appendix 1.]

Table 2: Comparison of water supply situation in key Indian cities

City	Total daily supply (MLD)	Total daily demand (MLD)	Water supply (LPCD)	Total daily shortfall (MLD)
Mumbai	3350	4250	200	900
Delhi	3061.80	3743	172	681
Bangalore	810	900	100 to125	90
Chennai	585	N/A	90	N/A
Kolkata	1232	N/A	200	N/A

[Sources:Various (incl. BMC White Paper, The Hindu, Deccan Chronicle, The Indian Express, DJB, KMC etc.)]

It cannot be denied that the BMC has suitably managed to supply water to the city's residents over a sustained period of time. However, given that Mumbai has never experienced a major water crisis, the BMC has taken its Water Department for granted. Even as the pressure on Mumbai's public utilities has grown manifold, there has been no fresh recruitment in the Hydraulic Engineering Department for the last 16 years, leaving a severe shortage of experienced manpower.

The Expert Committee for water planning of Mumbai's future resources and improvement in water supply scheme was appointed in 1993 by the State Government following the failure of the monsoon in 1992, which had led to the rapid depletion of the lake levels. Set up under the Chairmanship of Dr. Madhavrao Chitale, this committee is popularly referred to as the Chitale Committee. As the crisis deepened, the situation that evolved was quite similar to the one that Mumbai faced in 2009. In addition to several demand control measures, the Chitale Committee had recommended source augmentation

There has been no fresh recruitment in the Hydraulic Engineering Department for the last 15 years.

In 2009, the BMC was once again forced to impose blanket 15 percent water cut across the city. It also cut water supply to the city's 601 public toilet facilities maintained by private trusts and NGOs[20] which was restored in August 2010 following a sharp rise in cases of malaria[21]. In December 2009, the BMC administration had even proposed drastic measures like a 100 percent zone-wise water cut once a week; which was never implemented following opposition from Corporators[22]. The crisis also prompted the BMC to consider creating additional sources for water provision like the enormously expensive desalination, without really making any concerted efforts to manage the existing water efficiently, or to initiate strict demand control measures. Following the onset of a good

The crisis maybe over, but the problem remains, as complex as ever. Recurring water crises in Mumbai every few years call for devising and implementing a long-term plan for Mumbai's water supply and demand management. Unless the water management is taken up with sincere commitment, there will be no progress made towards sustainability.

monsoon in 2010, the water cut was eased to 7 percent in August, and 100 percent supply was restored in October.

Water Sources

Starting with just 32 MLD from the Vihar Lake in 1860 for Mumbai's then population of 0.7 million, the total water supply from various schemes has now reached 3470 MLD. Out of this, 120 MLD is supplied to Thane and nearby villages. This 120 MLD includes water lost in filtration and transmission. Thus, of the total quantum of water that is drawn by the BMC from the main water sources, 3350 MLD i.e. almost 90 percent of the total water drawn is supplied for Mumbai's nearly 14 million people[23]. Water is currently supplied to Mumbai by the BMC from six main water sources – Vihar, Tulsi, Tansa, Modak Sagar, Upper Vaitarna and Bhatsa lakes.

The gradual augmentation of water supply to Mumbai from distances as far as 120 kilometres is a story less known. The history of water supply dates back to 22nd June 1845, when the then government, in response to an agitation of the 'natives' appointed a two-member committee to report about the quantity and quality of water available in Mumbai. Then, Mumbai was a group of seven islands; its population of a few thousands totally dependent on wells and tanks for water supply. This committee reported that water supply needed immediate attention. Keeping in mind the rapid expansion and future needs, the authorities responded by developing a supplemental source beyond the Bombay island. The valley at the origin of the Mithi River near the Vihar village was chosen for creating an impoundage to collect the rainwater runoffs. Three earthen dams and an overflow section in stone masonry were built, and an 810 mm main was laid from the lake to the city. The work on Mumbai's first piped water project commenced in 1856 and was completed in 1860, bringing 32 MLD water to the city[24].

Table 3: Water demand-supply growth in Mumbai since 1951 and projected growth

Year	Population	Demand (MLD)	Supply (MLD)	% of demand met
1951	2.96 Million	1200	1093	91
1961	4.15 Million	1610	1076	68
1971	5.97 Million	2275	1728	76
1981	8.22 Million	2800	2183	78
1991	9.90 Million	3306	2638	80
2001	11.97 Million	3856	3200	83
2007	13.06 Million	4150	3328	80
2011*	16.71 Million	4400	3720	86
2015*	N/A	4678	4175	90
2021*	15.61 Million	4949	5195	100
* Projected population growth as per Chitale Committee Report 1994				

[Source: BMC White Paper, 2009]

Despite source expansion, the situation may worsen in 2025 if the anticipated demand increases.

Today, Mumbai gets 3350 MLD water against a demand of 4200 MLD, a supply deficit of 850 MLD[25]. According to the Chitale Committee report, based on a 240 LPCD norm, the total demand is projected to grow to 5400 MLD in 2021.

management, the situation may remain unchanged. But if the projected demand goes up, as is predicted, the situation will worsen. Finding new sources to augment the supply, while controlling the demand, will be BMC's key challenges.

Figure 4: ENGINEERING MARVEL… Tansa Dam, built by the British in 1925. The dam's height was raised and its structure strengthened for any tectonic eventuality indigenously by BMC engineers. *[Source: www.magicalmumbai.com]*

Thus, even with all of BMC's current and future initiatives aimed at supply augmentation, the total supply is likely to catch up with the total demand only by 2021[26].

With the haphazard growth of the city, the demand for water is increasing rapidly. With some amount of resource

Over the last 50 years, total water supply to Mumbai has seen an average decadal growth of 192.7 percent. However, the total availability of water per person has actually reduced by 23.6 percent. This has happened because of an unprecedented population explosion of 300 percent, which simply cannot be kept pace with.

Table 4: Decadal water supply growth and water availability per capita per day

Year	Population (Million)	Water supply (MLD)	Availability (LPCD)
1951	2.96	1093	355
1961	4.15	1093	263
1971	5.87	1728	294
1981	8.24	2183	265
1991	9.89	2638	267
2001	11.97	3200	271

[Source: BMC White Paper, 2009]

Over the last 50 years, water supply has increased by 192.7% but water availability per person has reduced by 23.6% due to Mumbai's incredible population growth.

Although the BMC has achieved some significant milestones of securing water from far off sources, including operating Asia's largest water filtration plant at its sprawling Bhandup Complex and another at Panjrapur, and consistently maintaining world class standards in initial water quality, there are still many more challenges to overcome. The city remains guilty of high levels of water wastage, contamination and encroachment, which, unattended for all these years, have resulted in an overall poor quality of water provision to the citizens.

Planned future development of the city is extremely important in the context of the hydraulic reliability of the city's current water sources. Hydraulic reliability of a water source is based on the engineering design of a reservoir. A reservoir designed with a hydraulic reliability factor of 95 percent means that in a 100-year cycle, the reservoir will fail to provide any usable storage of water for five years. Likewise, a reservoir with a 75 percent hydraulic reliability will 'fail' for 25 years in a 100-year cycle. It is only recently that the Bureau of Indian Standards has made it mandatory for all the planned water reservoirs in India, irrespective of their purpose, to have a hydraulic dependability 100 percent. In Mumbai, only the Vihar lake, which yields about 3.50 percent of the city's total water supply, has a hydraulic reliability of 100 percent. On the other hand, the Bhatsa and Vaitarna lakes, which account for nearly 80 percent of the city's total water supply, have a hydraulic reliability factor of 75 percent, which means that they are, by design, bound to 'fail' for 25 years in a century. According to Dr. M. A. Chitale, "Since the hydraulic dependability of a water resource is variable as per its design, it can bring unbecoming crises that is hard to deal with". In a year of delayed rainfall or inadequate monsoon, the hydraulic dependability can play a very vital role for the BMC's source management and planning for the use of the reservoirs' total storage.

Figure 5: WORLD-CLASS WATER... BMC's water treatment plant at Bhandup; the largest facility in Asia.
[Source: www.degremontindia.net]

Unequal distribution of water

According to Census 2011, population of Mumbai city has fallen by 5.75 percent from 33.38 lakh in 2001, to 31.45 lakh in 2011. Population of Mumbai suburbs, on the other hand, grew to 92.32 lakh from 85.87 lakh in 2001, an increase of 8.01 percent.

The current allocation of BMC's water supply between the City, Eastern Suburbs and Western Suburbs, however, hints at inequity of distribution, as water is not allocated as per the zonal population. For example, the Eastern Suburbs which have the second largest population and a large number of industrial establishments receive 37 percent less water than the City (with nearly eight million fewer residents). This means that municipal wards in South Mumbai, which have witnessed a gradual decline in population growth as well as a near saturation in the growth of commercial activity, are being provided with much more water than the heavily populated and rapidly developing Eastern and Western suburbs. Also, as the BMC has no flow meters installed at ward boundaries, it has no precise data of ward-level water supply. This implies that the BMC does not know how much water is currently being supplied, either to residents, or businesses, which is indeed worrisome.

As flow meters are absent, the BMC does not know how much water is being supplied, or is required to be supplied to each ward in the city.

Unaccounted for Water (UFW)

Unaccounted for Water (UFW) or Non-Revenue Water (NRW) is the difference between the total water supplied and the total water billed. The BMC accepts that it currently has UFW to the tune of 20-25 percent. In reality, this figure may be as high as 30-35 percent in some areas, as only what can be measured can be managed and improved.

At present, high levels of water wastage occur through leaks and bursts, inaccurate detection, and time-consuming procedural obstacles for fixing them. Water theft either by way of breaching supply pipes or by illegal connections also contributes to high levels of water wastage resulting in loss of revenue to the BMC.

This is an enormous quantity of water lost daily – nearly 700 MLD at the 20 percent level – meaning that Mumbai wastes more water than Pune's total water supply of 650 MLD[27] every day! In other words, the amount of water lost by Mumbai daily is almost double the quantity of water (455 MLD) that will be fetched from Middle Vaitarna in 2012 - 13! It makes better economical sense to reduce such wastage rather than spending crores of Rupees on a never ending spree of source augmentation, which also has adverse environmental impact in the long run.

The Chitale Committee, while calculating Mumbai's projected demand of 5400 MLD of water in 2021, had, taken into consideration a gradual reduction of leakages to just about 12 percent from the current levels of 20-25 percent. It had also kept all non-domestic demand at a constant of 700 MLD up to 2021.

Mumbai wastes more water than Pune's total water supply of 650 MLD everyday!

Table 5: Unequal distribution of water

Zone	Population (Million)	Daily supply (MLD)	Average zonal supply
City	3.274	1140	348.19 LPCD
Eastern Suburbs	4.064	890	218.99 LPCD
Western Suburbs	5.907	1320	223.46 LPCD
Total	13.245	3350	252.92 LPCD

[Source: BMC White Paper, 2009]

Sadly, the BMC has failed to act upon most of the recommendations made by the Chitale Committee, and Mumbai still loses water to the tune of 20-25 percent of its total supply as UFW.

However, even on this score, Mumbai fares far better than some of the other Indian metropolises. The Kolkata Municipal Corporation has a UFW of a whopping 97.1 percent, which means that nearly all the water supplied is lost, leaving the people in large parts of the city heavily dependent on groundwater. The Delhi Jal Board has a UFW level of 52 percent, while in Bangalore, the UFW is 45 percent[28].

Table 6: Projected demand on the basis of reduction of leakages to 12 percent by 2021

Demand (MLD)			
	2001	**2011**	**2021**
Domestic	2841	3310	3747
Non-domestic	700	700	700
Total	3541	4010	4447
Total other uses (2%)	71	80	89
Total	3612	4090	4536
En route	90	90	90
Total	3702	4180	4626
Leakages	(@20%) 740	(@16%) 669	(@12%) 555
Total	4442	4849	5181
Other losses (plants etc.)	178	194	207
Total	4620	5043	5388 (Say 5400 MLD)

[Source: Chitale Committee Report, 1994]

Pipe bursts and leakages

A Right to Information (RTI) query filed by Shri Chetan Kothari, a city-based RTI activist, in March 2010, revealed that of all the pipeline leakages and bursts in the city in 2009, the K/West ward, comprising areas in the western parts of Vile Parle, Andheri and Jogeshwari, had 120 bursts and leakages, the maximum recorded in any area in the city. The K/East ward, the largest ward in the city covering an area of 28 sq km, including the eastern parts of Jogeshwari, Andheri, Vile Parle and Santacruz, recorded 95 leakages and bursts of varying intensities. Several leaks and bursts were also reported from the Malad-Goregaon belt and from Chembur and Mankhurd in the eastern suburbs. The data revealed that there were 1,031 complaints of burst or leaking pipes reported in 2009, meaning that the city, on an average, witnessed around three such cases every day.

In Mumbai, the sheer size, intricacy and age of the network of pipelines — some of them even a century old — seem to be the root cause of these leaks. To minimise leaks and bursts, the BMC has undertaken the crucial task of replacing its old and leak prone pipes. The BMC claims that it has already replaced or rehabilitated 300 kilometres of pipeline. This includes 161 km of pipeline replaced and 209 km of pipes that were rehabilitated from 2008-09 to 2010-11. In 2011-12, the BMC has set aside Rs. 82.05 crore for replacing 66 km pipeline, and Rs. 22.40 crore for rehabilitating 44 km pipeline. The BMC has also started work on some of the planned underground tunnels for water supply which include tunnels to carry water in the primary network from Gundavli to Bhandup via Kapurbawdi (15.1 km), Malabar Hill to Cross Maidan (3.6 km), Maroshi to Ruparel (11.85 km) and Veravli to Adarsh Nagar till Yari Road (6.1 km) — which are part of the Middle Vaitarna Project. It has also planned replacement of the 45 km pipe from Tansa that supplies water through two mains of 1,800 mm diameter each[29].

Table 7: Top 10 municipal wards in terms of pipe bursts and leaks in 2009

Ward	Leaks and bursts in 2009
K/West: Andheri, Vile Parle, Jogeshwari (West)	120
K/East: Andheri, Vile Parle, Jogeshwari (East)	95
P/South: Goregaon (West)	53
S: Bhandup	49
H/West: Khar, Bandra, Santacruz (West)	43
R/North: Borivali (West)	42
M/East: Mankhurd, Chembur (East)	41
R/South: Kandivali (West)	39
H/East: Khar, Bandra, Santacruz (East)	39
F/South: Parel	27

[Source: The Times of India, March 29, 2010]

These are steps in the right direction, because if leak detection and prevention go unattended, then bringing the additional water to the city in the future through highly capital intensive projects will only lead to more wastage of this precious resource. What is also needed is strict monitoring of the quality of work executed by the contractors who are doing these jobs for the BMC. Identifying and stopping such unchecked water loss should be the top-most priority for all water related agencies. Any lapse in this task will be disastrous for the city's future water security.

Water is wasted around the city in a number of other ways as well. For example, the lack of rainwater storage facilities within the city limits results in millions of litres of rainwater flowing into the sea each monsoon, given the average annual rainfall of 4300[30] mm the city and suburbs get each year. Given that water is a globally scarce resource, it is unacceptable to mismanage any part of public water provision. In a country like India that is bursting at its seams, it is especially important to harness every bit of available resource to productively contribute towards the growth and improvement of our nation.

Figure 6: DOWN THE DRAIN… Mumbai loses millions of liters of water through pipe bursts, a common occurrence on Mumbai's old and weak distribution network. *[Source: www.timesofindia.indiatimes.com]*

We believe that the best method to tackle the menace of water wastage for the BMC to install a modern system of reliable water meters throughout the city — at least to precisely measure water consumption by all consumers in planned buildings and bulk customers. Consumers across all categories must be made to be concerned about water wastage as much as they are about wasting electricity. It must simultaneously prepare a detailed and precise map of its underground water pipes by using Geographic Information Systems (GIS). Accurate pricing of water and metering will help to reign in wasteful uses of water as has been successfully demonstrated in Singapore[31].

Contamination

Water contamination is high as sewers and water pipelines run parallel in many parts of the city, increasing the potential of the sewerage water seeping into the water pipes through cracks and breaches. According to the BMC's annual environmental report card published in September 2010, water contamination had increased by nearly 100 percent in 2009-10 as compared to 2008-09, up from 13.80 percent in 2008-09 to 26.10 percent in 2009-10. The report card indicated higher average contamination rates across all the civic administrative wards in the city[32].

Old Habits Die Hard: **Mumbaikars are historically prone to misusing and wasting water. According to The Times of India news report dated 16.02.1934 reproduced in the annual journal (2006) published by the BMC's Municipal Engineers' Association, the then Municipal Commissioner of Bombay, reacting to complaints of water shortage, had stated: "...A good deal of water is being wasted or misused; and it is this growing habit of waste that is responsible for the shortage that is being felt at the present day. The wastage occurs chiefly through leaving taps open at night, allowing taps to run at full pressure while washing clothes or utensils and during ablutions, etc. The Commissioner desires to impress upon the public that unless this wastage is checked, the City at large will suffer; and the cooperation of the public is earnestly invited in preventing waste. It is also requested that any flagrant instances of water wastage may be brought to the notice of the Water Department."**

Figure 7: UNHEALTHY WATER... Water pipes running through open sewers and storm water drains are commonplace in Mumbai. *[Source: BMC January 2010]*

Out of 1,987 water samples collected by the BMC from across the city in February 2010, thirty-six contained the E coli bacteria, which was nearly a four-fold jump from the number of contaminated samples collected in January 2010[33]. Escherichia coli or E coli is a bacteria that causes diarrhoea and other water-borne illnesses. Maximum contamination was reported in the slum pockets of Chembur, Bandra (East) and Kurla. Contamination was also found in samples collected from parts of Byculla, Marine Lines, Vikhroli, Ghatkopar and Elphinstone Road. Instances of contamination are usually found to be the highest during the monsoon months of June to September[34]. Incidentally, the Hydraulic Engineering Department questions the credibility of these reports steadfastly maintaining that that the Health Department officials collect samples from water that is already stored, i.e. from underground sumps in buildings and other storage facilities like open drums in the slums. The quality and safety of municipal water can be judged more accurately by ensuring that the BMC's Health Department collects all the samples only from municipal taps at the beginning of the supply period. There is also need a need for greater coordination between these two departments whenever such surveys are done.

> ***The 'illegal' slum dwellers, who are deprived of even the most basic civic amenities, remain a key factor in the city's vote bank politics.***

This problem is exacerbated by the intermittent water supply lasting for a maximum of six hours at different times of the day, in various areas across the city. As the water pressure in the pipelines falls during off supply hours, water from the parallel sewers along with contaminated groundwater can, and does, seep into the supply pipes.

Illegal connections, patronised by politicians

There has been a consistent rise in encroachments and water theft with the unbridled expansion of slum settlements in Mumbai. Under the state government norms for the controversial slum rehabilitation scheme, slums that have not been registered by the 1995 cut-off date have been declared illegal. The BMC is prevented by law to provide water connections in these unregistered slum areas. This law was enforced in order to check the uncontrolled migration to Mumbai, with the reasoning that deprivation of basic amenities will discourage people from other states of the country to come to Mumbai.

> ***The residents of illegal slums are forced to pay more for their daily quota of water than even the city's richest who get access to 'legal' supply.***

This cut-off deadline has been advanced to 2000, indicating that such a law has not prevented such slums from proliferating. Neither has it prevented the residents of such slums from getting water, as they either steal it or buy it at much higher prices from private tanker operators. Sadly, this phenomenon has the patronage of local politicians from almost all parties. It is a paradox that while the residents of 'illegal' slums are deprived of all basic civic amenities — including municipal water and sanitation — they remain an important factor in the city's vote bank politics and politicians are often accused of blatantly deriving mileage from their deprivation.

Personal interviews with a few residents of such slums have revealed that illegal connections have been given in exchange of votes on a number of occasions. It is estimated that nearly three million people live in such unregularised slums at present and they all get their daily quota of water: either by means of water theft, or via illegal connections, which can be secured with the help of local Corporators, ward level engineers and licensed plumbers, whose nexus thrives in such areas[35]. This situation has given rise to the infamous tanker mafias, who charge exorbitant rates from illegal slum dwellers, resulting in social injustices, where the poor are forced to pay much more for their daily quota of water than the city's richest. It is a matter of shame that residents of illegal slums actually pay up to Rs. 15 for a 5 - litre jerrycan of water; and up to Rs. 18 to Rs. 20 in summer[36], while the residents with 'legal' connections across the city pay next to nothing for water.

Figure 8: SHAME, SQUALOR AND SLIME... Illegal slum dwellers in the city do not get even the most basic civic amenities like drinking water and sanitation. *[Source: Riddhi J. Chokhawala, ORF Mumbai]*

NGOs and other human rights groups in Mumbai have criticised this practice, which they say has given rise to rampant corruption and also caused the BMC substantial revenue losses. Furthermore, the daily rigmarole of travelling and queuing for water by consumers in slum settlements has resulted in the practice of those living closer to distribution points collecting additional supplies of water for resale to those who live further away, or uphill for instance. As the water cannot reach the far ends of the distribution network due to the low pressure, people living away from the water hubs are at the mercy of their neighbours. Though it could be argued that such practices are enterprising, access to clean, safe water is a fundamental right of every citizen.

In 2001, the state legislative assembly had passed the second amendment to the Maharashtra Slum Area (Improvement, Clearance and Redevelopment) Act, 1971, making penal punishment for helping and abetting construction and use of unauthorised hutments in Mumbai and other cities in Maharashtra. The stringent provisions in the amendment bill were aimed at controlling further growth of unauthorised slums in the city and providing legal protection to hutments constructed before the Slum Redevelopment Authority (SRA) cutoff date of 1st January 1995. The amendment provided deterrent action against any unauthorised or illegal structure constructed in Mumbai after 1st January 1995. Accordingly, any person constructing unauthorised dwellings or residing in such dwellings are liable to be prosecuted and imprisoned for a term of one to three years, with a fine ranging from Rs. 2,500 to Rs 5,000. It also provides for action against the competent authority or its officers, who fail to carry out the duty of demolition of such unauthorised structures, who could be held liable for punishment for dereliction of duty.

Such strong legislations have remained ineffective, considering recent reports that slums, far larger in expanse and population density than Dharavi, have come into existence in the city's northern suburbs. These include four slum settlements in areas in the Kurla-Ghatkopar belt, the Mulund-Govandi belt, the Yogi and Yeoor hill slopes stretching from Bhandup to Mulund flanking the Sanjay Gandhi National Park (SGNP) on the east and Dindoshi to the west of SGNP, which have all eclipsed Dharavi's dubious distinction of being Asia's largest slum.

A recent slum mapping exercise carried out by city-based architect P. K. Das has revealed that as many as four slums in Mumbai's northern suburbs have eclipsed in their expanse and population, the slum of Dharavi, which till recently had the dubious distinction of being Asia's largest slum.

These disturbing facts were unearthed following an extensive mapping of slums done by city-based architect and civic activist P. K. Das[37]. According to *The Times of India* report dated 6th July 2011, "While the profile of the suburban slum settlements is still to be established, the Mankhurd-Govandi sprawl that has sprung up at the base of the Deonar dumping ground is known as a "dumping ground" for the city's poor. It has the lowest human development index in the city and is constantly in the news for malnutrition deaths. Moreover, following earlier trends, the slums have come up on hill slopes and mud flats". Contrary to the 2011 Census figures which has pegged 62 percent of Mumbai's total population as living in slums, this exercise has revealed that as many as 78 percent of the city's total population resides in slums or slum-like living conditions. The unprecedented explosion of slums is one of the main reasons for the high population density in the city's suburbs, which currently stands at nearly 21,000 persons per sq km, which is the highest in Maharashtra. The magnitude of the problem could be understood clearly if one compares Mumbai's population density with the national density of 382 people per sq km and Maharashtra's average population density of 365 persons per sq km.

Mumbai, being the land of opportunities, will continue to be a migration hotspot for the entire country. However, local politicians and social NGOs must not lose sight of the heavy cost that the city is bearing due to uncontrolled migration leading to unplanned growth of the city. A separate ORF study *'Affordable Housing is imPossible'* done by Shilpa Rao, Varsha Raj and Sharmeen Contractor has closely studied the issue of slum rehabilitation and has strongly argued that affordable housing is possible in Mumbai, but for the lack of political will and proper policy formulation, implementation and accountability. Ultimately, the poor migrants themselves will be the worst sufferers if supply of water cannot match the ever-growing demand.

The very slow pace of execution of key projects that were planned nearly 15-20 years ago due to the complex mix of social, departmental, political and policy reasons has only added to the problems. This has given rise to a situation where the BMC is currently engaged only in clearing the massive backlog of infrastructure projects, without too much focus on the city's integrated and holistic future planning. It is high time that planned development of Mumbai benefits all Mumbaikars, especially the poor.

BMC – Departmental weaknesses

A key problem area pertaining to supply side issues has been identified as the staffing of the BMC's water department, which has a total workforce of around 7,000 employees[38]. Currently, the department is 40 percent under-staffed. Out of the total 12,015 posts, around 4,999 are lying vacant. Of the existing staff, only a small fraction is made up of experienced engineers. The problem has been exacerbated as no fresh recruitment has taken place in the department in the last 16 years[39].

Admirably, the department has been credited with very low levels of corruption, though ironically this phenomenon seems to discourage the retention of good talent in the Hydraulic Engineering Department, which is solely responsible for water distribution in Mumbai. The enormity of the problem comes to light from the fact that in the last four years, BMC's Hydraulic Engineering Department has seen nine different Chiefs[40]. There have been instances in the past when engineers with little or no prior experience of working in the Hydraulic Engineering Department have been posted as its chiefs. It naturally follows, that the crucial Hydraulic Engineering Department of the BMC is bereft of ownership and sustained accountability, giving rise to a 'business as usual' approach. Efforts to quickly cure the department of its organisational weaknesses will have to be taken up in earnestness to address water management issues.

In the last four years the BMC has seen nine different Chief Hydraulic Engineers. It is, therefore, natural that the department is bereft of ownership and sustained accountability.

24-hour water supply

In Mumbai, the BMC supplies water for four hours at different times across the city. However, most of the domestic consumers in buildings have access to water all through the day, thanks to the overhead storage tanks. So people living in buildings can get water at any time they need it, irrespective of the timing of municipal water supply. However, 24-hour water supply cannot be equated with the constant availability of water for some domestic consumers.

Continuous water supply (a given in many global cities across the world) can potentially solve many of Mumbai's water problems. To start with, residents who do not have proper overhead storage facilities will no longer have to collect water at odd hours; or plan their lives around the water supply schedule. It can also cut water wastage and reduce contamination, thus reducing the incidence of waterborne diseases. If there is a 24-hour supply, water will simply flow out if there's a leak; sewage will not get in. Contamination with sewage water is more likely when water pipes are empty. Also, people will not be required to store water, and this will curb the wasteful practice of emptying the unused water and refilling them with 'fresh water' each day.

International cities like Shanghai, Kuala Lumpur, Bangkok, Seoul, Hong Kong, and London all get water supply for 24 hours.

The BMC supplies water to Mumbai intermittently for no more than four to six hours a day, the same as in Delhi. Chennai, too, gets water for about six hours. However, due to the very erratic nature of the municipal water supply, residents in many areas of the city have to depend heavily on tanker water[41]. In Bangalore, residents get water for five hours. However, in many parts of the city even this five-hour supply happens every alternate day[42]! In Kolkata, the disparity is alarmingly stark, where some areas get water for 20 hours daily, while a few areas get it for less than four hours[43].

International cities like Shanghai, Kuala Lumpur, Bangkok, Seoul, Hong Kong and London have round the clock water supply. Many experts believe that already Mumbai has enough water availability to provide a 24-hour supply to its 12.4 million citizens[44].

At 100 percent water supply, BMC has enough water reserves available to provide 271 litres per person per day. Even with the water cut of 15 percent in 2009, BMC had 219 litres of water available to supply to each citizen of Mumbai. Worryingly, the quantity of water Shanghai loses in a 24-hour supply cycle is lost in four hours in Mumbai[45]. Thus, even though Mumbai does seem to have enough water availability to support a 24x7 supply, any attempt at doing so in the current scenario, without first minimising leaks, will be disastrous, as the rate of water leakages will shoot up considerably.

Undaunted by the mass opposition to the Public Private Infrastructure Advisory Fund (PPIAF) and World Bank-aided Water Distribution Improvements Project (WDIP) in the K-East ward, which aimed at privatisation of water supply, the BMC is pursuing similar reforms to provide 24-hour water supply – now across the city – under the ambitious project Sujal Mumbai Abhiyan, assisted by the World Bank. Under the Sujal Mumbai programme, the World Bank will help BMC choose a consultant for conducting a water audit and GIS mapping of the city's water network. The State Government has also approved the setting up of a Technical Procurement Committee, comprising officials from the government, the BMC, the World Bank and other experts for Sujal Mumbai Abhiyan[46]. However, after a lot of hype around the project in 2007-08, there is no concrete development made in this regard — at least nothing in the public domain.

Anomalies in the pricing of water

It is astonishing that the BMC charges a mere Rs. 3.50 per 1,000 litres (1 kilolitre) of water to domestic consumers[47], whereas one pays on an average Rs. 15 or more for a litre of bottled water. A simple calculation shows that an average consumer in Mumbai pays less than one paisa (0.0035 paisa) per litre of BMC water. In the slums, the same quantity of water is provided for Rs. 2.50. Thus, a family of five residing in a slum who might use 8,000 litres of water per month pays a water bill of around Rs. 20 per month, but pays at least Rs. 200 per month for cable TV.

Undoubtedly, the BMC is doing its bit to fulfill its social obligation. It manages to do this by having a differential tariff structure, where commercial customers' tariffs cross subsidise for lower residential rates. Provision of water by the BMC nearly for free to all the citizens has created a sense of total disregard among the consumers for this limited natural resource, as most of us do not value what is available for free.

The BMC earns 60 percent of its total revenue from its bulk consumers, to whom it supplies only eight percent of the total water. The residential buildings and societies get 67 percent of the total supply. The rest (i.e. 25 percent water) is supplied to the slums, from where the BMC collects only six percent of its total revenue[48]. However, it is important to realise that while the poor pay less for the water, they actually pay a high price for lack of proper sanitation and other related health issues.

BMC charges Rs. 3.50 per 1,000 liters of water i.e. less than 1 paisa (0.0035 paisa to be precise) for 1 litre of municipal water. We pay Rs. 15 or more for 1 litre of bottled water!

Table 8: Division of the cost of water production

Cost head	Cost
Employee salaries	Rs. 1.95
Payment to utility services	Rs. 1.55
Depreciation and asset replacement	Rs. 1.10
Repairs and maintenance	Rs. 0.30
Interest and equity payments	Rs. 0.50
Administrative expenses	Rs. 0.60
Payment to government and private parties	Rs. 0.60
Research and development	Rs. 0.60
Contingency amount	Rs. 0.10
Total	Rs. 7.30

[Source, BMC 2009]

The water department collects only 6% of its revenue from the slums, to which it provides 25% of its total water supply.

In view of high tariffs, some of the bulk customers have taken the initiative to invest in rainwater harvesting and recycling to reduce their water bills. It is imperative for the BMC to review its pricing model if it is to remain in the black. However, any tariff hike must be balanced, especially in the case of slum dwellers, by better provision of sanitation services. On the one hand, while reducing water consumption is beneficial, reduction of revenues from commercial users will reduce the BMC's ability to cross-subsidise and provide cheaper water to poorer consumers.

The Maharashtra Jeevan Pradhikaran (MJP), on the other hand, supplies water to domestic consumers in the state at nearly three times the price charged by the BMC[49]. Even the domestic consumers in rural Maharashtra pay nearly double the amount paid by the citizens of Mumbai per 1,000 litres of water. Thus, for the people in Mumbai, the real issue is inequity in the distribution of this affordable resource.

On the other hand, private water tankers in Mumbai charge anywhere between of Rs. 3,000 to Rs. 4,500 for a 10,000-litre tanker of clean drinking water. Senior officers of the BMC's Hydraulic Engineering Department commented, strictly on conditions of anonymity, said that about 15-20 percent of the city's total UFW of nearly 700 MLD is stolen by private tankers (see section on UFW on page 9). The rest is lost through leaks and pilferage. At 20 percent, this works out to a 160 MLD illegal water supply by private tankers alone. A simple calculation exposes what could potentially be one of the biggest scams thriving.

The state's rural consumers pay nearly double for water compared with the citizens of Mumbai!

Table 9: Comparative pricing of water per kilolitre of BMC and MJP

Consumer Type	BMC	MJP
Residential buildings and educational institutions	Rs. 3.50	Rs. 10.50
Slum dwellers (BMC) / Rural Areas (MJP)	Rs. 2.25	Rs. 5.25
Hospitals, maternity homes (BMC) / Schools, hospitals, Government & Semi-Government office establishments, charitable trusts (MJP)	Rs. 10.50	Rs. 19.65
Commercial establishments and BEST	Rs. 18.00	
Bulk consumers like Railways, BARC, 5-star hotels, RWITC	Rs. 38.00	
Special customers: Ordnance factories at Ozar, Ambazari, Tarapur power plant		Rs. 18.70

[Source: BMC, 2008 and MJP website]

It is estimated that Mumbai has a total fleet of around 10,000 private drinking water tankers, with an average capacity of around 10,000 litres. A single trip daily by 10,000 tankers, thus delivers 10 MLD of water. At an average charge of Rs. 4,000 per tanker, it amounts to the BMC blatantly allowing illegal profits amounting to Rs. 4 crore per day, or Rs. 1,460 crore per year! This very conservative estimate is significantly less than the total anticipated stolen water of 140 MLD (20 percent of total UFW). Thus, as most tankers make multiple trips daily, the annual illegal turnover will work out to be much more than Rs. 1,460 crore!

That a scam of this magnitude could thrive without the knowledge, or perhaps even the connivance of the BMC officers and politicians, is unbelievable and unacceptable.

The BMC officials are studying the possibility of introducing higher tariffs, including plans to introduce a telescopic tariff as charged by electricity providers. This means that consumers with high consumption levels will be charged progressively higher water tariffs, slab-wise.

While such a move might not result in any drastic reduction in actual water consumption, it could definitely lead to a reduction of water wastage through leaking bathroom and kitchen installations, as people will start valuing this essential commodity. In fact, an initial analysis of the billing data from municipal wards in south Mumbai, where the BMC has already implemented the telescopic tariff structure on a pilot basis is encouraging, hinting at reduced levels of water consumption or wastage. However, without proper and accurate metering, a telescopic tariff structure is bound to lead to avoidable anomalies and worse, public opposition.

The BMC is also considering the introduction of prepaid meters for slum dwellers, but the plan has been put on hold as a result of opposition from politicians, slum dwellers and NGOs. The BMC should explore the concept and relevance of 'Lifeline Tariffs' or progressive 'Social Tariffs', for water supply and its relevance to the city. Lifeline tariff is a pricing strategy designed to provide minimal amounts of water at low prices to households. Under a lifeline tariff, the first block of water used is provided for a nominal price, ensuring that even the poorest of the poor get at least their minimum daily quota of water. However, to do so, it will first have to establish a reliable and accurate consumption pattern of the entire city.

Traditional techniques and modern technology of water conservation

There are many traditional and modern methods for water conservation like rainwater harvesting and waste water recycling, which can easily be made operational all over the city. In 2002, the BMC first set up its Rainwater Harvesting Cell and made rainwater harvesting mandatory for every new building, measuring 1,000 sq. m. In 2007, a government notification in fact, lowered the cut-off to buildings with a plot area of 300 sq m. However, since 2002, only 1,651 buildings in the city have installed facilities to harvest rainwater[50].

Table 10: BMC's telescopic water tariff structure

Water consumption slab (LPCD)	Tariff
150 LPCD	Regular tariff
151 to 200 LPCD	Twice the regular tariff
201 to 250 LPCD	Thrice the regular tariff
251 LPCD and above	Four times the regular tariff

[Source: BMC White Paper, 2009]

The potential for rainwater harvesting in Mumbai is believed to be enormous. The BMC's Rainwater Harvesting Cell claims that Mumbai can potentially harvest up to 590 MLD of rainwater[51]. This is a significant amount of water, given the present quantum of daily BMC supply, environmentally sensitive projects like Middle Vaitarna costing several hundreds of crores of rupees will fetch only 455 MLD. While the authenticity of this claim needs to be further ascertained given the geological constraints on groundwater extraction in Mumbai, and also given the cost of constructing large-capacity storage tanks in all properties in the city, rainwater harvesting needs to be pursued earnestly. At least in such buildings which have the requisite space and resources for installing such facilities.

BMC had awarded a Rs. 620 crore contract to install 4.5 lakh water meters across the city. Sadly, after a few initial newspaper reports, there seems to be very little or no progress made on this front.

Recycling even a small fraction of the millions of litres of sewage water at least for secondary uses can potentially save large volumes of water. In the light of global issues such as Climate Change, there is a clear need to raise public awareness, to encourage behavioural change and to incentivise water conservation. Besides advocating the benefits of rainwater harvesting, the BMC should consider making waste water recycling compulsory in all new buildings in the city.

Making water metering compulsory

The total absence of consumption mapping is a huge problem, as nearly 55 percent of all water meters are not working[52]. The BMC's demand side issues like metering, better knowledge of the pipeline network and a precise study of the city's consumption pattern needs to be strengthened concurrently with the ongoing supply augmentation measures. Demand side measures like metering cost a fraction compared with supply side measures like dam construction, help reduce distribution losses and can, if implemented properly, pave the way for sustainable long-term solutions that cannot be addressed merely by periodical augmentation of water sources. In fact, source augmentation, by whichever method, is neither sustainable nor environmentally friendly

However, when compared to other large cities in the country, Mumbai scores quite admirably on this count too. In Kolkata, the total number of functional metered connections expressed as a percentage of total number of water supply connections is only 0.08 percent[53]. The Delhi Jal Board has 55 percent of its water connections metered, of which, too, a large number are faulty[54]. In contrast, Mumbai is aiming for 100 percent metering.

Currently, as part of its drive to attain universal metering, the BMC has awarded a Rs. 620 crore project to a private contractor who is required to install nearly 4.5 lakh Automatic Meter Reading (AMR) machines each costing nearly Rs. 12,000 at all its water connections across the city, including all slum connections[55]. All the currently functioning meters will also be replaced under this exercise. As per the contract terms, the company is supposed to complete the work in 18 months and undertake the maintenance of the meters for five years. However, there has been very little action after this contract was awarded. The BMC has not made public the results of the pilot project where new AMR meters were installed in a few areas in South Mumbai to evaluate their accuracy and reliability.

Conclusion

Through this study, which is a result of a broad-based, collaborative and participative approach, we at ORF Mumbai want to highlight all the critical issues of water supply and distribution management in Mumbai. The water crisis of 2009 must be utilised as an opportunity by the BMC and the state government to implement some important measures towards long-term sustainability and reducing wastage of water. Sadly, this doesn't seem to be happening with any level of seriousness. A delayed onset of monsoon will have Mumbai once again staring at another possible water crisis. But isn't it true that (rain) God helps only those who help themselves?

02 REPORT ON THE ORF MUMBAI ROUNDTABLE CONFERENCE ON WATER CRISIS IN MUMBAI

ORF Mumbai's methodology for this study involved broad-based consultations with all key stakeholders to gain a critical understanding of the ground realities.

[REPORT ON THE ORF MUMBAI ROUNDTABLE CONFERENCE ON WATER CRISIS IN MUMBAI]

Figure 9: BRAINSTORMING: Shri. Sudheendra KulKarni (at the far-end of the room) addressing the ORF roundtable conference

The ORF roundtable on water crisis in Mumbai, organised in 2010, brought to the fore a number of serious systemic problems, which have been left long unattended. The hallmark of the discussion was the emphasis on the need for institutional reforms and adoption of sound technical solutions.

Then Municipal Commissioner **Shri Swadhin Kshatriya**, in his valedictory remarks, said that as much as 300 MLD of water (10 percent of current supply) provided by the municipal corporation is easily recyclable. He admitted that the civic body had failed to keep pace with the rising demand for water. "We failed to take note of the good recommendations contained in the earlier reports", he said, referring to the landmark 1994 Chitale Committee report. He gave a hopeful and confidence-building speech on how Mumbai could, and must, explore alternative sources of procuring water, including desalination. He warned that the city should be prepared to face shortfalls due to erratic monsoons in the future, as a natural result of global warming. He mentioned the need to introduce an EcoHousing Law, which would make it mandatory for residential complexes to adopt water-saving, energy-saving and waste-management practices.

Shri V. Ranganathan, Mumbai's former Municipal Commissioner who was also the Chief Secretary of Maharashtra, set the tone for the meeting with a powerful cautionary message: "We in India mistake articulation for action". He appealed to the common sense of individuals to take practical action in changing their wasteful water habits. With a view to mitigating larger scale problems, such as: global warming and rising sea levels; he suggested the formulation of short-term, medium-term and long-term objectives achievable by citizens, companies and the BMC. He said that Mumbai was lucky to get its water from virgin sources, but in the same breath, cautioned that the inevitable economic development of these regions would also create environmental and political pressures. Stating that people come to Mumbai for work daily from towns as far away as Pune and Dahanu, he stressed that city planners must consider the huge floating population, which puts additional strain on Mumbai's water demand, and thus must be taken into account while preparing future water supply plans.

Various elected representatives such as **Shri Ram Kadam**, an MLA belonging to MNS; **Shri Ashish Shelar**, a BJP municipal Corporator; and **Shri Adolf D'Souza**, an independent Corporator, engineers of the municipal Hydraulic Department, activists and academicians participated in the roundtable, which was also attended by civic activists from reputed NGOs.

Shri Dayanand Jadhav from Triratna Pererna Mandal, a slum-based NGO that won the prestigious Urban Age Award in 2007, described his organisation's successful initiative in water conservation in public toilets in slums. The notable work of such community - based organisations have shown what can be achieved at the grassroots level. The aim now should be in replicating successful models across the city so that more communities can benefit.

Prof. Subodh Wagle, who heads the School of Habitat Studies at the Tata Institute of Social Sciences (TISS), gave his perspective on the worsening problem of water supply in urban India, with emphasis on Efficiency, Equity and the Environment as critical metrics for analysis. He warned that some of the measures being currently undertaken by the BMC may not bring the desired results as a result of: lack of coordination between the various agencies involved; high growth rate of population; and rapid and haphazard development of the suburbs. He also questioned the argument for a separate water board as a panacea for all problems, likening any autonomous body, to 'replacing the driver of a tattered vintage vehicle and expecting the new driver to drive it like an F1 racer.'

Shri Ajay Popat of ION Exchange made a compelling presentation on the use of technology for water conservation, both by households as well as bulk consumers. He said that the conventional water sources like rivers, lakes and wells etc. were all becoming affected by global warming and climatic changes. Therefore, the only way forward was to explore new technology for creating new sources through desalination and recycling.

Shri T. V. Shah, former Hydraulic Engineer, BMC, highlighted the practical problems faced by the department and sensitised the audience to the policy constraints that those in the department work within. Frequent and arbitrary changes to the Development Plan (DP) created constraints for the BMC. Earlier, the DP had a provision for only 200 tenements per hectare, and this provision was amended frequently to increase the number of tenements per hectare to 1200, he said. "The BMC plans for water provision based on the DP which is meant to be in force for 20 years… but how can the department implement its plans, if the DP itself is subjected to such drastic changes?" He also noted that the department's role in formulating technically feasible solutions has been shrinking over the years with ever fewer strictly technical staff being retained. He insisted that power, responsibility and accountability within the BMC must go hand-in-hand.

A number of speakers and participants were united in identifying political interference as a root problem in the issue of illegal water connections (including illegal booster pumps installed in middle-class and rich localities) and the resultant water theft or unaccounted for water loss from the system.

In his instructive and inspiring presentation on the successes of water management in Singapore, **Shri Ramahad Singh**, deputy director of the Public Utilities Board (PUB), Government of Singapore, described how Singapore, which imports water from neighbouring Malaysia, has achieved water security and self-sufficiency by conserving every drop of water falling from the skies. A country that used to have water rationing in the 1960s, is today able to provide 24x7 water of the highest standard and safety to every citizen, which is drinkable straight from the tap. Singapore has also achieved a

UFW rate of 4.4 percent, which is the lowest in the world. Even advanced countries like London, with a comparable 24x7 water supply, register water loss to the tune of 26 percent.

The then Municipal Commissioner Shri Kshatriya praised Singapore's achievements and expressed a keen desire to learn from the PUB. In particular, he lauded Singapore's achievement of containing water leakages to below five percent of total supply, and was eager for the BMC to also be able to effectively control leaks.

Shri Sudheendra Kulkarni, Chairman, ORF Mumbai, urged for collaborative action and concerted cooperative effort from all stakeholders, without assigning blame. "All of us – state government, corporation, citizens, the corporate sector and other stakeholders – are responsible for the present crisis. Therefore, we have a duty to act collectively and cooperatively to overcome the crisis," he said. He highlighted the importance of focussing on long-term benefits for the city as a whole, over short-term gains for any section of it. In the concluding session, he underscored the need for moving away from a vicious cycle of mismanagement, poor governance and mutual blame game to a virtuous cycle of mutual cooperation to seek equitable, integrated and sustainable solutions. "The real work to find long-term and sustainable solutions to Mumbai's water problems must actually begin with total commitment and sincerity once the crisis is effectively tackled," he emphasised.

ORF Roundtable on Water Crisis in Mumbai — List of Key Participants

1. **Shri Swadhin Kshatriya**, Commissioner, BMC
2. **Shri V. Ranganathan**, former Chief Secretary, Government of Maharashtra
3. **Shri T. V. Shah**, former Chief Hydraulic Engineer, BMC
4. **Prof. Subodh Wagle**, Dean, School of Habitat Studies, Tata Institute of Social Sciences
5. **Shri Ramahad Singh**, Deputy Director, Public Utilities Board, Government of Singapore
6. **Shri Ajay Popat**, Member, Corporate Management Council, Ion Exchange
7. **Shri Ram Kadam**, MLA
8. **Shri Ashish Shelar**, Municipal Corporator, BMC
9. **Shri Dayanand Jadhav**, Executive President, Triratna Prerna Mandal
10. **Shri Adolf D'souza**, Municipal Corporator, BMC
11. **Shri Sitaram Shelar**, YUVA
12. **Shri James John**, AGNI
13. **Shri Ravi Nair**, AGNI
14. **Shri Sudhir Badami**, Urban Activist
15. **Shri Darryl D'monte**, Journalist
16. **Sri Sandeep Acharya**, Journalist
17. **Shri Vidyadhar Date**, Journalist
18. **Shri V. G. Sahasrabudhe**, Chief Engineer (M&E), BMC
19. **Shri T. V. Shah**, former Chief Hydraulic Engineer, BMC
20. **Shri N. H. Kusnur**, All India Institute of Local Self Government
21. **Shri Janak Daftari**, Jal Sangrah
22. **Shri Bhagwan Advani**, AGNI
23. **Smt. Padmini Mirchandani**, AGNI
24. **Prof. Kavi Arya**, IIT Bombay
25. **Shri Vivek Gilani**, Environmental Engineer
26. **Smt. Seema Redkar**, Officer on Special Duty, BMC
27. **Shri Arvind Wankhede**, Dattak Vasti Sanstha Samanvay Samiti
28. **Shri Arti Gawde**, Dattak Vasti Sanstha Samanvay Samiti
29. **Srhi Dilip Kadam**, Maharashtra Navnirman Sena
30. **Shri Madhav Bhandari**, spokesperson, BJP
31. **Shri Adolf Tragler**, Slum Rehabilitation Society
32. **Shri Jagdeep Desai**, Architect
33. **Shri Ashok Datar**, Mumbai Environmental Social Group
34. **Shri Omkar Mali**, NCRA
35. **Shri Milind Jeurkar**, MWH Consulting
36. **Smt. Clara Lewis**, Journalist
37. **Shri Apoorv Jain**, ICT Mumbai
38. **Shri Sandeep Asher**, Journalist

03 RECOMMENDATIONS

The BMC and the State Government have to overcome some tough challenges to bring about sustainable and tangible reforms to water management in Mumbai. These efforts must be complemented in equal measure by the citizens. Most importantly, however, what is required is a transformation in mindset of all stakeholders – including all consumers – to recognising that the current scenario is unacceptable and unsustainable.

The following are the key recommendations obtained from the roundtable and our subsequent discussions on the issue of water management in Mumbai. We have made an attempt to classify and highlight these recommendations, which can be implemented in the near- and the long-term by each stakeholder, who plays a vital role in bringing about sustainable and tangible reforms to water management in Mumbai.

Short-term solutions: *Recommended here are some short-term measures which can be implemented by the BMC and its Hydraulic Engineering department.*

Recommendations for the Corporation

Water consumption mapping

For a densely populated city like Mumbai with a very high quantum of daily municipal water supply, it is imperative for the BMC to have a fair understanding of the city's consumption pattern. Sadly, in the case of the BMC, it only has the broad idea of how much water is conveyed to the city and released in each of its supply zones. Total absence of reliable flow meters at municipal ward boundaries render all consumption calculations as mere guess work.

Reliable consumption data can help reduce inequity, fill the demand-supply gaps and aid better planning for the future.

Having a reliable consumption map can greatly contribute to reducing the obvious inequity in the zonal supply, help the BMC in matching its supply with the consumption pattern and also greatly aid in better distribution planning in the future. For this, the BMC must immediately embark on a project (over two phases) to comprehensively map the consumption pattern of the city.

Total absence of reliable flow meters at municipal ward boundaries render all consumption calculations as mere guess work. The BMC must immediately embark on a project to comprehensively map the water use or consumption pattern of the city.

In the first phase, a sample of a minimum of 50,000 consumers — including all consumer categories across the city - must be drawn up. In the true spirit of Public-Public Partnership, the BMC must join hands with the All India Institute of Local Self Government and a well-established NGO to raise a sizeable army of 500 volunteers and give them specific training in conducting detailed household surveys, seeking accurate information about water usage. Each of these volunteers must conduct these surveys based on a detailed questionnaire (separate questionnaire for each consumer category) to get accurate information on water use for various day-to-day activities. [Sample questionnaires for consumers in buildings, slums and for bulk water consumers are provided in Appendix 3. These questionnaires provide an idea of the key aspects to be considered in order to get the most comprehensive evidence. We strongly believe that the BMC itself has the required expertise to further streamline and structure the questions.]

This exercise must be carried out under the direct supervision of BMC's Hydraulic Engineer. All ward Corporators must have the direct responsibility to oversee the survey in their respective wards, the results of which can be digitally compiled in about six months.

In the second phase, this project can borrow from the expertise of reputed organisations like the Tata Consultancy Services for developing a comprehensive, digitised consumption pattern map, which will serve as a beacon for all future planning and help iron out present inequity to a large extent. The BMC should repeat this exercise every ten years, just like the Census, and with the sincerity of the Census, to get an accurate idea of how the water is consumed in the city and plan distribution changes on the basis of changing demand.

For this, the BMC can learn from global best practices. Since 1950, the United States Geological Survey (USGS) has compiled data on amounts of water used in homes, businesses, industries, and on farms throughout the United States, and has described how that use has changed with time. Water use data are collected at five-year intervals. These data, combined with other information in the USGS Aggregate Water-Use Data System, have facilitated a unique understanding of the effects of human activity on the America's water resources. These efforts are part of the USGS National Water Use Information Programme, which was implemented in 1950 to provide uniform, current and reliable information in all types of water use all over the country. Water use estimates are used by USGS, other agencies, organisations, academic institutions, and the public for research, water management decisions, trend analysis and water-demand forecasting. The USGS has comprehensive and precise data available for each five-year period beginning 1950[56].

While the USGS database is more critical for national water planning, city-level water use and consumption patterns are established by studying the data available at the local agencies. For instance, information on water consumption comes from three member agencies of the Southern Nevada Water Authority, namely the Las Vegas Valley Water District, the City of North Las Vegas and the City of Henderson. Together, the three agencies serve more than 500,000 accounts or connections in the Las Vegas valley. Information on single-family residential properties comes from the Clark County Assessor. To draw up an accurate water use map, water used by single-family homes in valley block groups – small geographic area used by the U.S. Census Bureau – is added up. This aggregate water use is divided by the number of properties with water-using accounts to yield an approximate gallons-per-user figure for each household, giving a general, but largely reliable data of water used by homes in a neighborhood or group of neighborhoods. The system is so accurate that one can enter his residential address in the website and instantly know his or her family's average daily water use[57]. One can also know the approximate water bill for the month by entering the average daily use data by filling in a detailed but very simple online questionnaire.

In the U.S., the consumption pattern data is so systematically stored that one can just key in the residential address into the USGS website and immediately come to know his / her family's daily average water use.

To initiate such a massive data collection drive in Mumbai, the BMC can seek grants from global agencies like the UNDP or philanthropic institutions like the Bill & Melinda Gates Foundation. Incidentally, the Gates Foundation is currently funding a major project for Performance Assessment of Urban Water and Sanitation under the supervision of the CEPT University, Ahmedabad. This project is being carried out in Gujarat and Maharashtra across all Urban Local Bodies (ULBs). The Maharashtra part of the project is being spearheaded by the All India Institute of Local Self Government.

In September 2010, the BMC set up a nine-member panel of Corporators to look into the growing complaints of inequitable water distribution from the suburban residents[58]. However, given the total absence of any knowledge of actual demand, it is quite unclear as to how this panel will manage to study the inequity and suggest remedial action.

Reliable water consumption data is extremely critical for any new infrastructure development in the city, including all the Slum Redevelopment Authority (SRA) projects. The SRA was formed with the noble objective of making Mumbai slum-free, in a humane and equitable manner. However, hidden in the nobility of its intentions was a major flaw.

All slum dwellers, whose names appear in the electoral rolls as on 1st January 1995 (later extended to 2000), are considered as "legal" residents who are eligible for rehabilitation in a concrete accommodation of 225 sq ft in buildings constructed at the same site of the slum. These new houses, built by a private developer using his men, money and material, are given to each slum family for free. The developer, in turn, is allowed to recover his investment – and make a profit – by constructing other buildings in the large expanse of land thus made available in lieu of the slums for sale at the prevalent market price.

In Mumbai, where property prices are one of the highest in the world, the idea of giving out "free houses" itself is quite incomprehensible. Moreover, it gives a false impression that all slum dwellers would willingly opt for such free housing, which, given their scant area, resembles more or less of a vertical concrete slum, if they would have been given a choice to settle in better, but affordable homes of their own choice.

As per SRA records of December 2010, 1.41 lakh such free homes have been constructed across the city, each with a provision of a kitchen sink and a toilet with a flushing system. These new constructions inevitably accompany an increase in per capita water consumption, due to the provision of the aforementioned amenities, which are absent in the slums. However, the quantum of water supply to these parts remains unchanged, including supply hours and pressure.

In the process of conducting research for a concurrent project on the topic of affordable housing, ORF researchers have interviewed residents of several different SRA projects. The complaint of low pressure and inadequate water supply was unanimous among all the respondents. Given the continued absence of crucial water consumption data in the organisation of Mumbai's water supply, such glaring deficits are sure to persist. Indeed, the situation is likely to worsen as the water supply faces increasing amounts of strain from the proliferation of SRA and commercial housing projects in the city.

The BMC would be well advised to use distribution data to anticipate the patterns of demand for water, otherwise it will be forced into a permanent state of playing catch-up. This is especially true of South Mumbai, where the distribution system is the oldest and weakest. Several mega-redevelopment plans are in progress for areas like Bhendi Bazaar, Chira Bazaar and Dharavi, and it is imperative that the impact of these is incorporated into the planning of Mumbai's future water supply.

If Mumbai demands more and improved public services, being the commercial capital of India, it must also set an example for all ULBs across the country by pioneering projects that have a far reaching impact on the sustainability of this precious and limited natural resource. An exercise devoted to drawing up the city's water consumption map will provide the right direction as to what and how many of the long-term, sustainable reforms can be achieved.

Efficient water management through organisational reform

The BMC gets enough water under normal circumstances to provide as much as 271 LPCD to the current population. Thus, the question is not about availability of water. The water department is one of the most profitable departments of the Corporation, having an annual budgetary surplus of Rs 1000 crore. The question is also certainly not about money. Therefore, the BMC must immediately do everything possible to enable its water department to mobilise all required resources to focus on efficient water management.

The staff at every ward must be provided with an inventory of all necessary equipment, safety gear, transport, radio communications etc., which are a given in all world class city utilities. Importantly, the department must set service targets and give the necessary authority to its staff and engineers to work effectively and efficiently.

Today, while the Municipal Commissioner and Additional Municipal Commissioners have the authority to sanction expenditure of up to Rs. 10 lakh, the Chief Hydraulic Engineer, who is solely responsible for water supply, is authorised to sanction expenditure of a meager amount of just Rs. 10,000. Shockingly, the water department's Assistant Engineer, who is responsible for water supply to an entire municipal ward, has the authority to sanction expenditure of a paltry Rs. 250! This means that expenditure for even the most basic works have to be sanctioned by the Standing Committee, which has more pressing issues to deal with than leaking pipes.

Archaic and illogical policies have robbed the Hydraulic Engineering Department of efficiency and given rise to an indifferent attitude. It's high time the department is cured of its organisational sickness.

Such archaic and unreasonable policies have prevented the Hydraulic Engineering department from functioning efficiently and given rise to an indifferent attitude. Given its operational constraints, the department can only function in a 'business as usual' mode instead of steadfastly pursuing its long-term objectives. It is important to note that these decisions are very much under the control of the BMC General Body, and therefore, can be easily and immediately implemented.

Efficient implementation of Sujal Mumbai Abhiyan

The BMC must speed up the work for comprehensive mapping of pipelines and leak detection currently proposed under the 'Sujal Mumbai Abhiyan' programme. Ongoing measures like universal metering, replacement and rehabilitation of old leaking pipelines etc. which are a basic necessity for any kind of water audit, and ambitious works like digging underground tunnels for water supply have to be efficiently executed.

In the 2009 winter session of the State Legislature, the then Chief Minister had acknowledged the urgent need to conduct a water audit in Mumbai. The ongoing work by contractors who have been awarded contracts worth hundreds of crores of rupees in such areas of crucial importance must be closely monitored. Till the 1980s and early 1990s, all work outsourced to private contractors was closely monitored by the BMC water department's staff. The engineers of the Hydraulic Engineering department used to be physically present on site to check the quality of work. Thus, they were directly accountable if work suffered because of poor quality. Today, the work being carried out by private contractors is not closely monitored due to insufficient manpower. This has resulted in contractors rushing through the work at the cost of quality, and at many times, even at the cost of using such standard materials, ultimately delivering poor quality of service to the consumers. There is an urgent need that all the private contractors who are currently handling all intensive projects of the BMC must be made accountable for every penny of the public money spent.

Contractors should be made accountable for every penny of public money spent.

Sadly, the spectre of corruption has raised its ugly head even in the crucial work of replacing the existing pipeline on the primary network from Gundavli to Bhandup Complex with a 15.1 km-long underground tunnel. According to a report in *The Times of India*, 'brazen profligacy' of the civic administrators and politicians has resulted in nearly doubling the project cost from Rs. 1,222 crore to Rs. 2019 crore[59]. The report also hints at favouritism by the BMC in awarding the contract. The BMC's primary water network must be treated as a matter of National security. Mumbai will have to pay a very heavy price if such critical works fall prey to corruption and sub-standard service delivery from contractors.

The primary network of the BMC, which brings water to the city from the far off sources, must be treated as a matter of National Security.

Universal water metering

Universal metering is a commendable effort which will result in regulation of water consumption. However, it may be difficult to ascertain any long-term benefit of installing costly water meters in the slums, as they are most likely to be either damaged or stolen by miscreants. In many of the low-lying slums, these electronic water meters, each costing Rs. 12,000 are likely to get damaged due to flooding, which occurs after even a small spell of rainfall. It may make more sense to meter all the connections at residential buildings and societies, and especially all bulk users, as they together account for a vast majority of the water department's total revenue. In fact, the priority should be on comprehensive metering of all the bulk consumers first.

There are also other issues which need to be resolved before major expenditure is committed to universal metering. Earlier, the BMC used to own and maintain all the water meters in the city, and a meter rent, as part of the water bill, was recovered from all consumers. There was also a provision for the consumers to buy a BMC-approved water meter and get it installed at their premises. In these cases, the consumers became owners of the meters and they were not charged any meter rent for five years. The maintenance of all meters was done by the BMC. However, this practice was gradually discontinued. Nobody in the BMC is able to reasonably explain why it was stopped.

Today, the BMC requires its consumers to buy and also maintain the meters. The BMC only conducts occasional checks to ascertain whether or not the meter is working properly. If, during one of its occasional inspections, a meter is found to be faulty, then the BMC notifies the consumer to either get it repaired or get a new meter. In most cases, consumers are not interested in doing either, because a correctly functioning meter generally means higher water bills. Thus, it is no wonder that nearly half of the water meters in the city are faulty and completely unreliable.

The BMC should immediately switch over to its earlier practice of owning and maintaining all the water meters. Metering may prove to be a sustainable exercise if the BMC narrows down on three or four quality meter manufacturers or suppliers, and tests the meters first at its own premises to ascertain their efficiency and accuracy. The expensive universal metering programme at all existing 4.5 lakh

Figure 10: SPAGHETTI PIPELINES IN SLUMS... Will expensive water meters work here? *[Source: BMC 2010]*

BMC connections in the city by relying on a private contractor for the meters' quality, efficiency and accuracy would prove to be a disaster if their meters fail on all or any of the three counts.

Banning booster pumps

Currently, thousands of buildings across the city blatantly use illegal booster pumps to draw more water from the pipes. Such unfair practices have led to gross inequity of supply across the city. The booster pumps also create pressure imbalance in the pipes, with consumers residing at the very end of the supply network getting little or, at times, no water at all. The BMC must strictly enforce a blanket ban on the use of all private booster pumps. The use of such pumps must be allowed only in elevated areas, where piped water supply cannot reach due to low pressure, and where their use has been officially permitted by the BMC.

Incidentally, the BMC uses booster pumps to supply water in several hilly areas across the city, including the official residence of the city's Municipal Commissioner at Altamount Road. Prominent areas in South Mumbai like Malabar Hill also get piped water thanks to the BMC's booster pumps. But even in such cases, there is a need to regulate the amount of water that such pumps are drawing, as careless use of such pumps also creates inequity. Many areas complain of very low pressure supply only because booster pumps suck away maximum water from the supply pipes.

The BMC has recently approved a multi-crore flow-control valve project, which had been repeatedly rejected since 2007 due to high costs. Each costing Rs. 1.5 crore, the valves are designed in such a way that they can regulate upstream and downstream pressure all along the pipeline to ensure uniform supply to all connections[60]. This includes the connections in the 'last mile' areas at the end of the network and those in hilly areas. These valves are also claimed to aid quick isolation of a pipeline in case of a burst, paving the way for faster repairs.

Provision of Rainwater Harvesting in mission mode

Traditionally, rainwater harvesting has proven very effective in rain-starved areas. Areas in North Gujarat, Western Rajasthan and Kutch, where it has been used extensively, are glorious examples of its success. There are typically two objectives of rainwater harvesting: one is to physically store the rainwater for subsequent use, and, the other, to recharge the water table of the area by channelling the rainwater runoffs into the earth. In Mumbai, which receives bountiful rainfall, the efficacy of rainwater harvesting needs to be studied in detail.

As per a study by the Central Ground Water Board (CGWB) and the Maharashtra Ground Water Surveys and Development Agency (MGWSDA), Mumbai's groundwater potential is of the order of 57 Million Cubic Meters[61]. This roughly translates to about 150 MLD — a small fraction of the total quantum of BMC's daily supply. This study had also found many samples to be unfit for human consumption due to bacterial contamination. The Chitale Committee, had, therefore, advocated the use of ground water in Mumbai only for secondary purposes like construction work and flushing of toilets. In many places, especially on the coastal areas, groundwater has been found to contain high salinity due to seawater ingress. The groundwater throughout the city has also been contaminated over the years with steady and heavy infusion of untreated sewer water, as is the case in any mega city in the world. Direct penetration of fresh rainwater into the lower strata of the earth has also been hindered as most of the available ground surface has been built over.

Today, Mumbai receives more than 3000 MLD of water, and even according to the most conservative estimates, 20 percent of it is lost through leaks. This implies that nearly 700 million litres of clean potable water is recharging Mumbai's groundwater daily.

Instead of having fixed guidelines for rainwater harvesting, the BMC should encourage site-specific solutions. A 'one size fits all' approach doesn't apply to rainwater harvesting.

Thus, a substantial amount of groundwater is replenished with fresh water, even during the non-monsoon period. Sadly, groundwater in Mumbai is also recharged daily with millions of litres of sewage water that leaks from the sewerage system, which covers only 70 percent of the city's area. In spite of this, Mumbai's water table has not shown any improvement and potential for groundwater is still about 100 MLD. A study on groundwater in Mumbai conducted by the CGWB in 2009, had recommended construction of artificial structures like recharge shafts and borewells, especially in the north-eastern part of Mumbai, which has a good potential for groundwater recharge.

According to the Chitale Committee report, groundwater potential in the city could be further increased to about 225-250 MLD if borewells were to be sunk in such areas. The committee had also recommended the BMC to establish organised Geohydrological Units of Mumbai to effectively monitor and augment groundwater levels. Currently, the Water Resources Development Training Centre of the University of Roorkee offers post-graduate degree and diploma courses in geohydrology as well as water resources. Many municipal engineers from Asia and Africa regularly enrol for these courses. The BMC should take advantage of these courses and enrol their engineers to learn this specialised field of water management, the committee had recommended.

According to standards established by the United States Geological Survey (USGS), a federal agency monitoring global ecosystems and environment, a Hydrologic Unit Code is a watershed address comprising the name and a unique 8-digit number (for example: Lower James watershed 02080206), a standardised watershed classification system[62]. Hydrologic units are watershed boundaries organised in a nested hierarchy by size. They range in size from regions, to the smaller cataloguing units, which are roughly equivalent to size and characteristics of local watersheds.

The CGWB study had also recommended rooftop rainwater harvesting as a feasible alternative to store rainwater in areas with shallow water levels, thereby supplementing the main source of water. The BMC has made rainwater harvesting mandatory, but it has made very little effort to ensure its implementation. Also, instead of encouraging site-specific solutions keeping in mind the area's prevailing conditions, requirements, availability of space to build storage tanks, and cost effectiveness, it has framed rigid guidelines and norms for rainwater harvesting. By the most conservative estimates, rainwater harvesting for collection of water for reuse in all the existing buildings in the city will prove to be a very expensive exercise, given the cost of construction of large storage tanks. It might also be impractical given the lack of open space in most premises.

If the BMC is serious about pursuing rainwater harvesting, it must first strengthen the capacity of its Rainwater Harvesting Cell and support buildings which are interested in implementing this and also possess adequate space for storage tanks. It must also develop a mechanism for conducting regular checks of rainwater harvesting facilities, as water stored in anaerobic conditions throughout the year could be prone to bacterial contamination. It must implement without any delay decisions like offering tax concessions to properties that install such water conversation facilities. But clearly, focussing only on rainwater harvesting as a means for potential source augmentation will not work, unless the BMC gives equal importance and vigorously implements other key factors like water recycling and reducing wasteful uses.

Mapping of underground pipeline network

That the BMC does not have any precise idea of where exactly its hundreds of kilometres long complex underground pipeline network runs across the underbelly of the city remains to be a matter of concern. However, there has been no serious effort to actually prepare an accurate map of the underground water utility pipelines.

Today, this is possible with technologies like the GIS. As per news reports, the BMC is in the process of preparing a GIS-based digital map for future development projects, marking each surface civic structure from a manhole to a building. But the high cost quoted for mapping the city's 40 lakh properties has resulted in the BMC omitting the crucial component of the water pipeline network from this exercise[63]. A comprehensive and accurate map of the city's underground water network must be prepared without further delay. If budgetary constraints are preventing the BMC from undertaking this crucial exercise, financial assistance must be sought from the state or the central government for this purpose.

Public awareness to underscore duties of citizens

Nowhere in the world have water reforms been possible without active people's participation. The BMC must engage with various social organisations and NGOs to create awareness through water literacy campaigns that promote saving and discourage wastage. Conducting public education campaigns on the many simple ways to make optimal use of water and penalising water wastage and water theft will go a long way in bringing about improvements in water consumption in Mumbai. The BMC should take charge of highlighting the long-term benefits of water conservation with active involvement of the citizens, and use mass media extensively for this purpose. **Cricket legend Sachin Tendulkar set an example by volunteering to become BMC's brand ambassador for water conservation**. Water conservation should also be encouraged through sustained programmes with active participation of ward-level politicians, popular film and TV stars, residential groups, schools, industry bodies like the Confederation of Indian Industries (CII), Associated Chambers of Commerce and Industry (ASSOCHAM), Indian Merchants' Chamber (IMC), Maharashtra Chamber of Housing Industries (MCHI) etc., industrial estates, hotels and restaurant associations, hospitals, the railways and academic institutions like the Tata Institute of Fundamental Research (TIFR), Tata Institute of Social Sciences (TISS) and Bhabha Atomic Research Centre (BARC).

The BMC must prepare a comprehensive GIS map of its underground pipes urgently. Else, any dreams for 24x7 water supply will only remain wishful thinking, at best.

Streamlining and standardising procedures

The BMC must streamline and standardise procedures to facilitate legitimate water connections and to reduce corruption linked to providing access to water. To begin with, water connection rights should be separate from property rights, as all people in Mumbai— irrespective of the legality of their residential status — need water. Just like electric connections, water and sanitation must be provided to all properties in the city, and all necessary water and sanitation charges recovered from them. This will also open up a new stream of revenue for the BMC.

Relief to residents of old buildings

Unlike the modern residential societies, many old chawls in the city do not have underground water storage tanks. Earlier, water used to reach up to the fourth floor of old buildings at the normal BMC water supply pressure.

The BMC should separate water rights from property rights.


Now, Sachin bats for water conservation

His endorsement is likely to drive home the point better. We are sure that Sachin's promotion of the cause of water conservation, which is a pressing issue in the city, will have a positive

Figure 11: Sachin Tendulkar's 'save water' campaign.

However, the pressure has steadily reduced with water being channelised to supply to the expanding suburbs. In 1985-86, the BMC implemented a programme that offered a subsidy to residents of such buildings to construct suction tanks and install pumps [Source: T. V. Shah, former HE, BMC]. However, only five percent of the total buildings came forward to utilise this opportunity. To provide relief to residents who continue to face this problem, the BMC must revive this scheme and publicise it through mass media to ensure maximum community participation.

Incentivising the water department staff

Whilst focussing on building the departmental capacity by establishing a special cadre of water works' engineers, the BMC must also consider schemes for incentivising the department's staff. Unlike the employees of the other departments of the BMC, the engineers and staff of the water department have to work round the clock and also have to be on duty on public holidays in case of any contingency. But there is no incentive scheme for them, as under the current HR policy framework, all BMC staff are considered equal, with equal grade-wise salaries and incentives.

Accountability and transparency

There is an urgent need to increase accountability, transparency and empowerment throughout the BMC and in particular in the Hydraulic Engineering Department. There is an urgent need for the BMC to shift its focus from treating the job of water supply as merely fulfilling a social obligation, to focussing on quality of service and accountability. This can be done by establishing measurable service benchmarks, which are totally absent in the current bureaucratic set-up.

Reviewing the pricing structure

The BMC depends heavily on its bulk consumers for its revenue collection. It generates more than 50 percent of its Rs. 700 crore annual revenue through the bulk commercial and industrial customers, which comprise only 8 percent of its total consumer base. The BMC would be in real danger of losing out on a major percentage of its revenue if all bulk water consumers in the city reduce their dependence on municipal water by institutionalising water recycling methods. If that happens, then the department might find it difficult to break even. Thus, as efforts to implement water recycling gain momentum, the BMC will need to review its price of water, which is currently supplied nearly for free. Reviewing the pricing structure might become imperative also as the BMC spends more and more on source augmentation, which will increase its water production costs manifold.

At present, the BMC incurs a cost of around Rs. 7.30 to produce a thousand litres of water. The production cost is likely to jump to Rs 13.31 once the Middle Vaitarna project completes by 2013-14. By 2021-22, if the BMC brings additional water from Gargai and Pinjal sources, the production cost is expected to escalate to Rs. 21.10. Given the usual cost overruns due to delays, the actual cost is likely to escalate much further. According to initial estimates, production cost of water through desalination, which the government is so needlessly pursuing, will be more than Rs. 70.

Mumbai's Human Development Report compiled by the BMC and UNDP in September 2009 said that the city's per capita income was around Rs. 65,361 (twice the country's average per capita income of Rs. 29,382). On the other hand, the city's poorest earned not more than Rs. 591.75 per month, or merely around Rs. 20 a day! Such poorest of the poor, the report said, amount to nearly 10 percent of Mumbai's total population, and reside mainly in slums and on pavements. But typically, in Mumbai, not all poor people live in slums, and not all people who live in areas defined as slums can be considered as poor. Given the incredible income disparity and widely different living conditions of the people in Mumbai, it is necessary for the BMC to rationalise its pricing of water and also make a separate provision for financial recovery depending on the consumers' socioeconomic profile.

Reviewing the BMC's pricing structure is inevitable as the cost of water production will increase manifold with increasing expenditure on capital intensive projects; the department might not be even be able to break even.

Re-evaluate tender contracts

With a view to building local capacity and to encourage development of indigenous technologies, the BMC should reassess its tender documents to make it easier for competent local businesses to win contracts. In line with this, the BMC should also consider reorienting the criteria for winning service contracts, shifting from the L1 (lowest bidder) principle to selecting the bidder which has the best track record of providing quality service.

Total transparency should be adhered to in the entire bidding process to put an end to the dangerous and rampant trend of favouritism in the final selection of contractors. Details of all the important contracts must be displayed on the BMC website to ensure that the entire process, right from the bidding document to the final awarding of the contract, is subject to public scrutiny.

Recommendations for BMC's Water Department

Reviving the leak detection cell

The BMC had a fully functional leak detection cell under its Hydraulic Engineering Department, which is now defunct. For a city that records 700 MLD of UFW, it is a shame that administrative negligence has allowed such an important cell to shut down. This cell must be revived at the earliest, and an all out effort must be made to ensure that it is adequately staffed and well equipped to respond to contingencies in the shortest possible time. This cell must be responsible for conducting regular checks on the entire water distribution system in the city, right from the water mains on the primary network, to the smallest service lines. The engineer in charge of such a cell must be empowered with adequate on the spot decision-making and financial freedom. This includes the freedom to mobilise resources to carry out all emergency repairs whenever required.

The spate of water pipe bursts and leaks experienced frequently across Mumbai can be prevented if the dedicated leak detection cell functions efficiently.

Contractors should not be appointed only on the basis of 'lowest bidder' criteria, but on whether they can best do the job.

In 1968, a consultancy firm appointed by the state government to prepare the technical report on the BMC's Bhatsa project also studied, for the first time ever, the leakages in system. This study had pegged water losses due to leakages in the system at 40 percent of the total supply. The BMC had then resolved to reduce the water losses to 15 percent by 1981. Concerted efforts towards this end commenced in 1971 and continued regularly for a few years. However, this exercise was gradually stopped as the instruments procured initially became unserviceable after prolonged use. Subsequent attempts at procuring new instruments for revitalising the leak detection cell also did not succeed due to non-availability of instruments suitable for Mumbai's intermittent and low pressure distribution system.

The BMC has awarded a pilot project to Tata Consultancy Services (TCS) and Selcom Unity for a period of one year that will attempt to detect leaks with the help of high-end technology sensors. The project, which was slated to begin from October 2010, will cost Rs. 4.40 crore[64]. It will be carried out zone wise. The project will use sensors and Ground Penetration Radars (GPRs) to detect leaks. In case of a leak, the sensors, placed at particular strategic points in the pipeline network, are designed to set off an alarm in case of a leak. These sensors work with the GPRs to detect the exact location of the leak, giving out its exact location on handheld devices. However, in the absence of precise underground pipeline network map, it remains to be seen how successful this exercise will actually be. After the news about this project there has not been any update on its implementation and initial findings.

It is a shame that administrative negligence in the BMC has allowed its fully functional leak detection cell to shut down! The cell must be revived at the earliest.

Making a strong plea for the revival of the leak detection cell, the Chitale Committee had considered that "*it would not be unreasonable to expect the a minimum reduction of 12 percent in loss of water due to leakages (assuming the present level of leakage at about 25 percent of total supply) would be achieved over the next 30 years if a systematic leak prevention programme is undertaken seriously.*" To achieve this, the committee had recommended special training programmes and introduction of an incentive scheme for the staff, giving the employees an annual bonus for the quantum of water saved.

Sincere leak detection and prevention will lead to an enormous increase in the availability of water. It is absolutely necessary for the BMC to do everything possible to reduce the leakages to a globally acceptable range of 10-15 percent from the current level of 20-25 percent. To maintain leak losses within this limit, continuous preventive maintenance is absolutely essential.

Capacity building

The BMC's Hydraulic Engineering department is a highly specialised and technical department. Prestigious world class projects right from the development of Tansa source in the early 1960s have been entirely designed and executed indigenously by BMC's own engineers. It is unfortunate that this once highly capable and ingenious department has been allowed to deteriorate to its present level of apathy and indifference. The complete failure of the Corporation to nurture and enhance this indigenous expertise over the years has resulted in a serious drain and dearth of experienced and capable manpower in this crucial department.

The BMC must invest more in recruitment, training and retention of its staff, and create a dedicated cadre of engineers in the Hydraulic Engineering department rather than depending solely on consultants for implementing anything new. Given the serious dearth of experienced engineers with adequate knowledge of the system, the BMC must appoint retired senior officers to train the present staff, which lacks both experience and expertise to deal with Mumbai's immensely complex water supply network. The BMC has recently started a trend of reappointing retired engineers as Officers on Special Duty (OSD) to gain from their rich experience and knowhow. While this is a healthy trend, the expertise of these experienced engineers will go waste if a dedicated cadre of engineers is not created separately for the Hydraulic Engineering Department. It makes better sense if newly recruited engineers learn the job of operating and maintaining one of the world's most complex water utilities from these OSDs.

Regulating licensed plumbers:

The BMC must develop a mechanism to regulate and inspect the work of its licensed plumbers to curtail corrupt practices. While initiating action against consumers with illegal connections, the BMC must also penalise plumbers who are part of such corrupt practices. Such action will be useful in weakening the politician-plumber-customer nexus through which illegal connections are given. The plumbers would be forced to think twice before indulging in such corrupt practices.

> ***Instead of appointing 'expert' consultants for everything, the BMC should scale up its departmental capacity and establish a dedicated cadre of engineers.***

Streamlining and standardising operating procedures

The BMC witnessed massive increase in leaks in the slum areas that were redeveloped under the World Bank sponsored Slum Improvement Programme as the contractor laid poor quality 'A' class pipes in the slums in contrast to the standard practice of BMC to use 'C' class pipes which are thicker and more durable [Source: T. V. Shah, Former H.E., BMC, 2010]. Several operating procedures have been standardised since 2000-01, but they need to be rationalised and streamlined further. Procedures for procurement of quality equipment, valves and meters must be standardised and streamlined and followed by all contractors.

Customer focus

The Hydraulic Engineering department needs to have a greater customer focus to improve service delivery and to reduce wastages. Today, the BMC website, which is primarily in English, allows the user to opt for its Marathi version by clicking a tab on the homepage. While the basic information in the Marathi version is actually in the regional language, all links that one gets redirected to from this version only open in English. For example, on the Marathi version's Water Works page, if a user wants to open the link to the checklist of documents required for a new connection, the checklist that opens in a new box is only available in the English language.

Forget clear information on key projects, the website does not even mention basic information like water supply timings in different zones. The website clearly requires many more details like the contact numbers of all ward-level water department Assistant Engineers, tips on how to report a leak or burst in the pipeline, and online copies of the various mandatory complaint forms, various application forms and all procedural details in both English and Marathi languages. Importantly, the BMC must have a dedicated 24-hour complaint cell, which can be contacted through telephone, sms and email by any citizen in case of any water-related problem.

For this, the BMC must take a leaf out of the extremely user-friendly and informative website contents of the Navi Mumbai Municipal Corporation's website, which gives all necessary public information at the click of a mouse, including the different zonal water supply timings that are not publicly available in the case of the BMC.

Recommendations for Loal Administration, State and Central Governments

Payment of outstanding dues

According to an RTI query by activist Milind Mulay, the BMC has total outstanding water dues to the tune of Rs. 741 crore to be recovered from private consumers as well as various State and Central Government agencies. Of this total outstanding amount, the State and Central Government agencies collectively owe Rs. 390 crore. The Maharashtra Housing and Area Development Authority (MHADA) tops the list with Rs 101 crore, followed by Western Railway with Rs. 57 crore. Central Railway owes Rs 28 crore. Even BMC's ward offices and its sister concern BEST owe money; with various civic departments running up unpaid bills to the tune of Rs 7 crore. Besides unpaid for water bills, the MMRDA owes the Corporation up to Rs. 78 lakh towards penalties and repair expenses of pipelines that have broken due to careless excavations by the agency across Mumbai in the past.

It is high time that the State Government and the respective Ministries of the Central Government stop continuing to abuse such crucial services. The BMC, on its part, must do everything to convince the Chief Minister and the respective Union Ministers to quickly act on this issue.

State and Central Government agencies together owe Rs. 400 crore to the BMC towards outstanding water bills.

Medium- to long-term solutions: *Following are the medium- to long-term measures which must be expedited by the BMC and the State Government.*

Recommendations for the Municipal Corporation

Initiating systemic water recycling

The BMC has seven sewage disposal stations, where all raw sewage is released into the sea after initial screening and aeration. While all these sewage disposal stations do not have enough space to build large scale sewage treatment plants, the facilities at Ghatkopar, Versova, Malad and Bhandup are ideal to set up large-scale recycling facilities. The JNNURM-funded Mumbai Sewage Disposal Project (MSDP) Stage II Priority Works has already earmarked some of these areas to set up sewage treatment and recycling plants. The MSDP also envisages setting up smaller recycling facilities at other locations in the city.

The BMC has planned recycling plants with the aim to recycle 250 million litres of water every day at Ghatkopar and Bhandup. The Ghatkopar plant will have a recycling capacity of 150 MLD and the Bhandup complex will have a capacity of 100 MLD. The BMC should speed up the work of setting up modern recycling facilities at these sites without delay and simultaneously ensure that the recycled water is efficiently distributed to all the consumers for all secondary non-potable uses. Given the millions of litres of sewage generated in Mumbai, trapping even a fraction of it for non-potable purposes can save large quantities of water. This will require critical planning and even need building of a separate distribution network to convey the recycled water to the consumers.

Waste water recycling must be mandatory for all bulk users; they should be given a 6-month deadline to comply. Non-compliance should invite strict penalty, including water cuts.

The BMC must make waste water treatment and recycling for non-potable uses mandatory, with a deadline of six months, for all its bulk water customers like industrial and commercial establishments, large-scale construction projects, the Railways, BARC, Mumbai Port Trust (MbPT), shopping malls and five star hotels in the city. If these consumers fail to comply, then the BMC should impose stiff penalties. All municipal and government offices, including the BMC Headquarters, Mantralaya and Raj Bhavan, should take the lead in installing recycling plants.

Water recycling must be made mandatory at all the public toilets in the city as well as those on all the suburban railway stations. Mumbai's estimated 65,000 public toilet seats [Source: Seema Redkar, BMC Officer on Special Duty, 2010], and the 297 toilet seats and 799 urinals on the suburban railway network provide a good opportunity for water recycling.

Water recycling must also be made compulsory for all buildings having more than ten storeys. The citizens must be given the freedom to choose a service provider from the many private companies that currently offer such turn-key services. Such service providers must be made accountable for maintenance of the facilities and for quality assurance of the recycled water.

Desalination

The state government is keen to set up desalination plants to supplement water supply to Mumbai. However, any improper or hasty decision in this regard will be a colossal waste of public funds. For example, it has cost Chennai Metro Water nearly Rs. 1000 crore to set up a 100 MLD desalination plant along with related infrastructure like pipeline for conveyance of water from the plant to the city distribution system, construction of underground and overhead tanks and pumping stations. This is

excluding the massive cost for land acquisition and power generation, two of the key overriding factors for setting up the plant.

Incidentally, the Chennai Water Desalination Ltd. (CWDL), which runs the 100 MLD-capacity desalination plant at Minjur, incurs a production cost of Rs. 23 per kilolitre, excluding all capital expenditure[65]. Chennai Metro Water purchases this water for about Rs. 49 per kilolitre (nearly 5 paisa per litre), which includes water capacity charges covering the cost for the facilities provided by CWDL, as well as variable costs like treatment, manpower and chemicals. Chennai Metro Water incurs a total expenditure of around Rs. 15 crore per month to buy this 100 MLD water[66]. The final cost of production of Rs. 49 per kilolitre incurred by Chennai Metro Water is thanks largely to the fact that the state government had allotted the land for free and there will be no cost escalation of electric power for the next 25 years.

The Minjur desalination plant consists of 8,600 sea water RO membranes, 248 pressure vessels, 23 pressure exchangers, five high-pressure pumps, 16 pressure filter vessels, electrical, automation and control systems, and a 1,200m of high-density polyethylene (HDPE) pipeline of 1,600mm diameter. Chennai Metro Water laid a 33 km pipeline with a cost of Rs. 93 crore to carry the treated fresh water from Minjur to Red Hills Lake, from where it is pumped into the city's distribution system. The project also includes infrastructure for the collection of seawater. A 110kV/22kV sub-station has been set up by the Tamil Nadu Electricity Board for uninterrupted power supply to the desalination plant with a promise that there will no revision of power tariff for the next 25 years[67].

Interestingly, countries like Israel and the United Arab Emirates which depend heavily on desalinated water, manage to keep their cost to price ratio well below Chennai's, thanks to their innovative best practices. Israel which uses the state-of-the-art, world's most cost effective desalination technology, incurs a production cost of New Israel Shekel (NIS) 3.1, which comes to approximately Rs. 39[68]. As per the latest price revision effected by the government in Israel in July 2010, the price for first 2500 litres (2.5 cubic meters) of water is NIS 7.44 (Rs. 96.72).

Figure 12: TURNING SALT TO SWEET: CPCL'S 26.26 MLD desalination plant in Kattupalli near Ennor in Tamil Nadu.
[*Source: www.cpcl.co.in*]

This works out to approximately 4 paisa per litre of drinking water in Israel. In the UAE, where a bulk of potable water is desalinated, the production cost comes to AED 7.16 (Rs. 86) per 1,000 litres, i.e. 8.60 paisa per litre of water[69].

Thus, at a time when the BMC is already committed to spending several hundreds of crores of rupees in source augmentation projects at Gargai and Pinjal, desalination could be an avoidable and wasteful option. In the panic to tide over the crisis of 2009, the state government, hastily approved three desalination plants for Mumbai — one in the island city to be set up by the BMC, and another two in the suburbs to be set up by the MMRDA for water supply to the suburbs and Mira-Bhayandar belt in Thane district. Expected to be completed by 2013, these desalination plants will produce 25 MLD of water each initially, and 100 MLD once fully operational[70]. The water is expected to be of drinking water quality as per the CPHEEO standards.

At the insistence of the state government the BMC had recently appointed a consultant to do a preliminary survey for the site selection of the proposed desalination plant for the island city. The consultant reported that the 100 MLD plant would require a land area of 25 hectares, which is not available anywhere in the city. The BMC is looking at alternatives, but the Navy, Mumbai Port Trust and Railways have denied parting with their land for the purpose. Since the BMC has not got any concessions on land acquisition or on power consumption by the state government, the final cost of production is expected to be enormously high in the region of Rs. 70 per kilolitre. Another important factor is that in the case of Chennai, the government had no alternative but to go in for desalination, given the severe lack of any other resources in or around the Tamil Nadu capital. However, that is not the case in Mumbai at all.

It would have been wiser to have first done a feasibility study to determine the economic viability of desalination, against various demand management exercises like minimising UFW through intensive and sustained leak detection and recycling,

Given the high level of pollution in the seawaters around Mumbai, the astronomical cost of land and expensive power, desalination might prove to be a white elephant. It is best avoided.

which could save up to 700 million litres of water daily. Given the high level of pollution in the sea around Mumbai and the ridiculously high cost of land, desalination, with its highly energy intensive nature might prove to be a white elephant, hurting the already cash strapped BMC badly.

Capturing storm water drain flows

It is believed that close to 25 million litres of water flows into the Arabian Sea every monsoon day. Capturing even a fraction of the storm water runoff across the city can assist groundwater recharging. The Central Government-funded Rs. 1200 crore Brihanmumbai Storm Water Drain (BRIMSTOWAD) project being implemented by the BMC currently to reduce flooding in the city during monsoons does not have any provision for this. A feasibility study needs to be carried out to identify the potential of this measure and its viability, especially considering the limits of ground water abstraction due to strong possibilities of bacterial contamination due to continuous percolation of polluted water and increased salinity due to ingress of sea water in coastal areas. Moreover, groundwater use must be explored for all non-potable purposes, for example: construction and industrial consumption, watering gardens and public playgrounds, and flushing.

Evaporation Control

Due to high average temperatures and strong sunlight, the rate of loss of water from natural lakes and manmade reservoirs through natural evaporation is very high in India. According to Central Water Commission's (CWC) assessment of evaporation losses, which was last reviewed in 1990, average annual evaporation

from reservoirs and water bodies in India varies from 150 cm to 300 cm per year. This means that at least 10 percent of the total live storage of a reservoir is lost per year. The evaporation rate is maximum during the summer months of March to May when the reservoirs are nearing their minimum drawable limits.

As per the estimated 5 to 10 percent water loss by the Chitale Committee, the BMC loses up to 300 MLD of water because of evaporation. Evaporation from Tansa lake was about 14,800 million litres in the fair weather season during 1991, which was more than 9 percent of the live storage. More than 40 percent of this loss occurred during the period of March to May. Upper Vaitarna was found to have the maximum evaporation rate of 32,000 million litres, while Bhatsa recorded evaporation loss of 12,500 million. The net evaporation loss from four of Mumbai's key water sources annually adds up to 65,000 million litres, which is equivalent of losing the total Tulsi storage eight times over. According to the Chitale Committee, at current water tariffs, this means an annual financial loss of nearly Rs. 4 crore to the BMC.

The rate of evaporation depends on several factors like the water surface area, temperature, wind effect, vapour pressure difference, atmospheric pressure and the quality of water. A report on Evaporation Control in Reservoirs published by the CWC in 2006 has suggested several measures like erecting wind breakers, covering water surface, reduction of exposed water surface, underground storage of water, integrated reservoir operation, and treatment with Water Evapo Retardant (WER) chemicals to control evaporation.

The BMC loses up to 300 MLD of water because of evaporation. The annual net evaporation loss from four of Mumbai's key sources add up to 65 million litres, which is equivalent to losing the total storage of Tulsi lake eight times over!

The CWC report has recommended implementation of these measures by all the states.

Studying the pros and cons of each of many such evaporation control measures, the Chitale Committee had recommended that the BMC should utilise the Tulsi reservoir as an experimental station to conduct various evaporation control studies. It had also mentioned that as per the then prevailing prices, such experiments at the Tulsi lake would cost Rs. 6,950 per day. So far, i.e. 17 years after the Chitale Committee recommendation, the BMC has not acted in this regard, just like many other important recommendations that remain on paper.

In the medium- to long-term, water will be brought to Mumbai from 10 different sources, including channelling of water from the Damanganga River in Gujarat to Pinjal under the National River Linking Plan (inter-basin water transfer scheme). Therefore, it is imperative for the BMC to establish reliable scientific data on evaporation losses and prepare a management strategy to reduce such losses. Given the enormous water spread of several thousands of hectares of these sources, it will be a colossal mistake to ignore water loss through evaporation, especially given the Climate Change challenges of the future.

Dredging lakes

Desilting of lakes by dredging the accumulated silt from the lake bed is necessary to ensure that their water holding capacity is retained at the maximum. But for the lone unsuccessful attempt at desilting the Tansa lake in 1978, the BMC had never seriously attempted dredging or desilting of Mumbai's primary sources of water, some of which, like Tansa, are over a century old. Dredging, however, was again seriously considered by the BMC during the water crisis in 2009.

According to a report by the Maharashtra Engineering Research Institute (MERI), Tansa lake has accumulated 9.88 percent silt. This silt accumulation is believed to have made of a layer of around 3 to 4 inches of silt on the lakebed.

Considering the total surface area of the lake of 19 sq km, this has resulted in the reduction of the lake's water holding capacity by 18,240 million litres per year, from its original storage capacity of 184,600 million litres, to 166,360 million litres. Thus, extensive desilting of Tansa alone can potentially supply an additional 35 days' water to Mumbai each year[71]. Likewise, Modak Sagar's present gross storage capacity has been reduced to 182,308 million litres as against the designed capacity of 205,689 million litres - a reduction of 23,381 million litters.

Extensive desilting of the Tansa lake is estimated to cost the BMC around Rs. 500 crore. This estimated cost is only for the dredging operations. Desilting of any water body without careful scientific study of its topographical, geological and hydrological factors disturbs the original lakebed and can lead to increased percolation rate resulting in heavy seepage losses through the lake bed[72]. If this happens, dredging might result in heavy long-term environmental damage, and cause more harm than good. Thus, it is critical for the BMC to conduct hydrological investigations of all the lakes to study the available yield, existing storage capacity, down-stream needs etc. before commencing any dredging operation at the lakes. If such detailed scientific data collection is carried out, the total cost of dredging is likely to increase exponentially. So really, given its perceived benefits, the critical question is whether it makes economic sense for the BMC to undertake dredging operations, especially since all the water sources for Mumbai's water supply are located in an area that receives heavy rainfall during normal monsoons. For example, in a normal monsoon year, Tansa reaches its overflow level within just 8 to 10 days of a spell of heavy rains. According to Dr. Madhavrao A. Chitale, dredging is an exercise which is more applicable to dry areas and is periodically undertaken to preserve the holding capacity of water bodies in rain deficient regions of the state like Western Maharashtra and Marathwada. Dredging of water bodies is also carried out periodically in other dry parts of the country.

Besides the astronomical financial impact, another deterrent for the BMC to undertake any large-scale dredging of the lakes is lack of space to dump the enormous quantity of earth lifted out from the lakebed. All the six sources are situated amidst thick forests, whose environment will be wrecked if they are used as dumping grounds.

Besides astronomical financial impact, another deterrent for any large-scale dredging for Mumbai's water sources is the lack of space to dump the enormous quantity of earth removed from lakebeds.

However, it is necessary for the state government to immediately act against the illegal sand dredging mafia which has been lifting tonnes of silt from the catchment areas of the lakes supplying water to Mumbai daily and selling it at a hefty premium to the construction companies thriving in the city. Despite the High Court order issued in February 2010 banning illegal mechanised sand dredging, such clandestine sand mining operations continue to thrive across the catchment areas of all the lakes supplying water to Mumbai. According to a paper by Dr. Gyan Prakash Soni, an expert in water use management from IIT Roorkee, such rampant desilting can create isolated pits of considerable size in the submergence area, which may have lower bottom levels than the main storage. Water collected in these isolated pits never reach to the main storage, it only seeps or evaporates. Such unscientific desilting practically reduces the actual usable storage, he concludes.

Recommendations for the State Government

Autonomy for the water department

Given the uniqueness of the department in terms of managing the city's complex water supply network, it cannot function as just another 'department' of the civic administration. This department needs engineers with intimate knowledge of the system. The current practice of frequent departmental transfers prevents any institutional capacity building and effective water management. This has led to several instances of persons

with no prior experience of the water department being appointed as Chief Hydraulic Engineers on the basis of the rotational and periodic promotion policy.

In 1996, the BMC general body passed a resolution to hive off the water department from the purview of the BMC and create a separate Water Board for Mumbai. This proposal is pending with the state government. Giving the water department the same autonomy as BEST is envisaged to yield similar improvements in functioning and efficiency. There is an urgent need to make a case for the revival of this proposal and to initiate a progressive dialogue among the city's political establishment to promote the idea of a separate Water Board for Mumbai.

In fact, a separate, unified, Water Board should also be considered for the entire Mumbai Metropolitan Region, including Thane, Dombivali-Kalyan, Vasai-Virar, Mira-Bhayandar, and other municipal bodies in the area. Even the Chitale Committee report had advocated an integrated regional approach for the entire Mumbai Metropolitan Region to plan for the future increase in demand of water in Mumbai's neighbouring zones. Creation of a separate Board will not be a panacea, but it is certain to become one of the focal points of attention for both the state government and the BMC, with the freedom of establishing professional management practices and taking independent decisions.

A case in point is the functioning of the water boards of Delhi, Chennai and Bangalore that are able to take independent decisions, without constant political-bureaucratic interference. [Brief details of the composition of the independent water boards of Delhi, Chennai and Bangalore are provided in the Appendix 2.]

The scope of work, the powers and procedures of a separate and autonomous Water Board for Mumbai or the entire MMR would need to be clearly defined to ensure its effectiveness.

However, given the multiple agencies like MJP, MMRDA, Maharashtra Water Resources Regulatory Authority, Water Supply Ministry, Urban Development Ministry etc. that are all involved in the planning and provision of water; the scope of work, the powers, and the procedures of such a separate water board will need to be clearly defined in its constitution to ensure its effectiveness. Otherwise, there is a real possibility of this exercise not bringing the desired results. Mumbai has suffered because of the constant one-upmanship and internal (often politically motivated) tug-of-war between the BMC and the MMRDA on several key developmental issues.

Development Plan and Development Control Rules

The BMC prepares its infrastructure master plans on the basis of the Development Plan (DP) and the Development Control Rules framed for Mumbai by the state government. Frequent amendments to these long-term plans have posed the biggest challenges to the water department of the BMC.

According to the Development Control Rules (DCR) in 1981, the floor space index (FSI) for suburban Mumbai was 1, with a provision for not more than 200 tenements per hectare. The existing Development Plan, which runs till 2013, has been subjected to a series of frequent and ill-thought out amendments. Even the city's Development Control Rules have been amended time and again. As a result, the current density of tenements has increased to 1200 per hectare, putting severe strain on all civic utilities, especially for provision of water and sanitation.

On the one hand, while the government set up the Slum Redevelopment Authority to reduce slums in the city and resettle slum residents in planned buildings; on the other hand, the Development Plan made no provision for low cost housing, leading to further proliferation of slums. The slums have become so congested that it is nearly impossible for the BMC to lay water pipes. The result is a complex mass of a spaghetti network that is a common sight in slums in the city.

Henceforth, the government should take the BMC's water department into cognizance before any future amendment to the Development Plan or Rules is made. This practice was started in 1975, but was stopped after about five years. The Development Plan and Development Control Regulations must focus on the important long-term developmental aspects of the city in an integrated manner, instead of being skewed to favour the real estate lobby.

The introduction of the Transfer of Development Right (TDR) scheme in early 1991 also paved the way for rapid development of the suburbs. The TDR scheme must be reviewed and regulated in order to ensure planned development of the suburbs. In fact, the government must rationalise the practice of rampantly doling out bonus FSI even for rehabilitation projects. TDRs are rights granted by the civic or state agency to a property developer who surrenders land to the government and, in exchange, is allowed proportionate or more development rights on land northwards and outside of the island city. Thus, a TDR that is generated mainly in areas of South Mumbai can only be deployed in the northern suburbs by the developer, who may sell that property so developed or sell the right itself, the TDR. Rampant and imprudent use of TDRs has led to severe congestion in the suburbs, putting tremendous pressure on all public infrastructures.

Inter-agency communication

Public infrastructure and services in the spheres of road, railways, communication, electric supply and water supply are currently being operated and managed by a multitude of agencies in the city like the MMRDA, Maharashtra State Road Transport Corporation (MSRTC), Western and Central Railway, BEST, Tata Power, Reliance Infrastructure etc., besides of course, the BMC. Haphazard work done by these agencies without any knowledge of the BMC water pipeline network causes major bursts and leaks across the city with regularity. It is currently mandatory for all these agencies to get the approval from the BMC before beginning any excavation work in any area in the city. But it is obvious that there is very little effort by all agencies concerned to effectively coordinate with each other to prevent such avoidable pipe leaks and bursts.

> ***Mumbai's DP must focus on developmental aspects of the city in an integrated manner, instead of being skewed to favour the powerful real estate lobby with the sole purpose to fill personal and party coffers.***

Besides such inter-agency communication, there is also an urgent need to develop strong and transparent intra-agency communication among the departments within the BMC (for example: Roads, Building and Construction, Shops and Establishments, fire brigade etc.) to ensure that there is an integrated approach to planned works.

Integrated development of the MMR to ease pressure on Mumbai

The Mumbai Metropolitan Region (MMR) is a large urban agglomeration, spread over an area of 4,355 km. Besides Mumbai city and its suburbs, and the satellite towns of Thane and Navi Mumbai, it consists of five other densely populated municipal corporations, nine municipal councils and nearly a thousand villages. The region, which includes some of India's most densely populated districts, account for nearly a fourth of the total population of the whole of Maharashtra. According to the Chitale Committee report, the projected population is expected to reach an overwhelming 34.07 million (16.67 people in Mumbai and 17.40 million in rest of MMR) by 2031.

The MMRDA, which was formed as an apex body for planning and coordination of development activities in the MMR has the following areas under its administration:

1) Mumbai city district
2) Mumbai suburban district

3) Part of Thane district:
   a. Thane city
   b. Kalyan, Bhiwandi and Ulhasnagar talukas
   c. Some part of Vasai Taluka
4) Part of Raigad district:
   a. Uran taluka
   b. Panvel, Karjat, Khalapur, Pen and a portion of Alibag Taluka

The population of the 19 municipal corporations in the region has grown by 32 percent over the past decade as compared to the overall state growth of around 16 percent. As per the provisional data of Census 2011, the population of Kharghar increased from a mere 6,000 in 2001 to 73,000 in 2011, an increase of an incredible 1,117 percent, as against the 48 percent growth rate of the rest of Navi Mumbai. Other increasing populations were in Vasai-Virar, which recorded a rise of 221 percent, followed by New Panvel, which grew by 113 percent. The overall increase in population in the MMR, with the exception of Mumbai, was 54 percent. The population in Thane city grew by 43 percent, up from 12.62 lakh in 2001 to 18 lakh in 2011. Kalyan-Dombivli and Mira-Bhayander registered a growth rate of 50 percent. In Khopoli and Karjat, the populations rose by 21 percent and 20 percent respectively. Uran, across the southern coast of Mumbai recorded 30 percent growth, while Ambernath recorded 28 percent and Pen 33 percent population growth rate.

This is a promising trend in the context of the huge problem of influx of people into Mumbai, as the Census data indicates migration to a far greater degree in satellite towns of Thane, Badlapur, Belapur, Panvel, Kalyan-Dombivali and in fast developing nodes of Navi Mumbai like Kharghar in the last decade. However, these demographic trends also clearly indicate an urgent need for the government to plan for the integrated development of the entire MMR.

The state government will have to create better social infrastructure and employment opportunities across the MMR if it is serious about reducing the population pressure on Mumbai. For this, attention should be given to good quality and affordable housing, faster and better road and rail transport interconnectivity, and comprehensive water distribution planning in the entire region. The MMRDA, which is currently preparing its Development Plan for the MMR (excluding Mumbai) for the next 15 years, has a great opportunity to create the enabling environment for this to happen.

Recommendations for the Central Government

The Centre must recognise the importance of Mumbai to India's economy and its contribution to the national exchequer and act on the following recommendations.

Speedy disbursal of funds

The Central Government must speed up the allocation of funds to all ongoing and future water supply projects in Mumbai. Many of the works envisaged under Sujal Mumbai Abhiyan like rehabilitation of the water mains in the primary network and tunnelling of water within the city are funded by the Jawaharlal Nehru National Urban Renewal Mission (JNNURM). Future projects approved for the city as per the recommendations of the Chitale Committee report will also need Central Government funding. Delays, if any, in the release of funds are bound to affect the execution of many of these crucial works.

Creation of better social infra-structure and employment opportunities across the MMR can reduce the population pressure on Mumbai. This will require good quality and affordable housing, faster and better road and rail connectivity and sustainable water planning.

At the same time, the Central Government must weigh the pros and cons of any requests from the state government to fund BMC projects like desalination, which, if done without proper benefit versus cost analysis, have the real danger of resulting in avoidable wastage of massive public funds, especially given the massive public expenditure already committed on future source augmentation projects like the Middle Vaitarna, Gargai and Pinjal.

Environmental clearance

The augmentation of water sources being planned for Mumbai like Gargai and Pinjal are currently subject to their feasibility. These projects will need environmental clearance from the Ministry of Environment and Forests (MoEF) before they can commence. There must not be any delay in giving permissions to these projects that have been planned to provide additional water as per the city's projected population growth up to 2021.

In fact, any large scale public infrastructure development like construction of a new dam or a new airport which is spread over several square kilometres of land is bound to face environmental hurdles including issues of resettlement and rehabilitation. BMC's critical source augmentation projects, which might have to face similar complex socio-environmental roadblocks, must not face a similar demise. However, such impact could be mitigated by proper planning and meticulous execution of such projects. The BMC must also agree with and implement, in letter and spirit, conditions like planting an adequate number of trees in specified areas as required for MoEF clearances that are so crucial for timely execution of the future projects.

Sustainable water management is impossible without strong political will and commitment.

Recommendations for political parties and elected representatives

Political will for water reforms

Water sector reforms in Singapore were largely possible owing to strong political will and administrative enterprise, which seem to be lacking in Mumbai. Cutting across party lines, Mumbai's political leadership – be it in the BMC, the Legislature, or the Parliament – should shun vote bank politics and focus their attention on ground-level issues. The political leadership should set an example in conservative water use. They should use their political voice to educate the party workers and the wider public on preventing water wastage and promoting water conservation. They must realise that good water management is good politics, and adopt a 'mission mode' approach to effecting water management reforms for Mumbai.

Water supply in slums

Unlike the consumers in the planned building across Mumbai, the slum dwellers do not have the luxury of getting water as per their convenience as they do not have underground storage tanks. They have to depend solely on the BMC supply, which may be erratic.

To help the slum dwellers, the BMC has constructed suction tanks and installed pumps in many slums across Mumbai. The operation and maintenance of the tank and the pump is done by the residents' associations of the respective slums. The residents have to also pay the electric bills for the usage of the pumps [Source T. V. Shah, former H.E., BMC].

This has been very beneficial for the residents, especially those, residing in slums located on elevated areas, as they could now store water and use it at their convenience.

However, in some other areas, the residents have not been able to sustain this scheme, as they have been unable to pay the electricity bills due to lack of agreement and cooperation among their associations. There have also been instances where due to the sheer neglect and lack of unity among the residents, this scheme has been usurped by local slumlords.

Such schemes could be implemented more effectively with the involvement of CBOs and local municipal Corporators. It would be wise for the municipal Corporators to spend a small amount of their development funds on such initiatives to ensure that slum dwellers are able to draw maximum benefits from such schemes. The Assistant Engineer (Hydraulic Engineering) at the ward level must also conduct periodic checks of such installations to ensure that they are being used optimally.

Recommendations for bulk consumers

Industries and commercial customers

The Rashtriya Chemicals and Fertilisers (RCF) factory at Chembur used up to 30 MLD of municipal water every day. After it implemented large scale water treatment and recycling projects and constructed large capacity rainwater harvesting tanks, it managed to reduce its municipal water consumption to just 5 MLD[73]. The Environment Management Systems at its Chembur unit have been recertified under ISO14001.

Using water saving practices and by recycling, RCF reduced its municipal water consumption from 30 MLD to just 5 MLD.

Figure 13: HELPING HAND…The BMC has constructed storage tanks and installed pumps in some slums like Govind Nagar, above, to enable the citizens to use the stored water at their convenient time. *[Source: BMC 2010]*

Internal audits and management reviews are undertaken regularly to identify if any improvements are required to be undertaken. Measures taken to conserve water have yielded not only savings but have further improved environmental management. The Effluent Treatment Plants and the Sewage Treatment Plant at Trombay have ensured that the environment in and around the unit is protected.

The Asian Paints plant at Bhandup has also managed to reduce its fresh water usage through its integrated 'Total Water Management' programme. In fact, as part of its CSR to conserve water, Asian Paints provides free expertise and knowhow to anyone interested in setting up rainwater harvesting facilities or other schemes.

These examples illustrate the potential benefit of such measures. Bulk consumers of water in the city must invest adequately for introducing such measures and make such initiatives an integral part of their work policies and mission statements.

Other public utilities and public service providers

The Central and Western Railways use about 3.85 MLD of water of which 2.34 MLD is used for washing coaches of local trains. Considerable amount of water is also used at the 109 railway stations that comprise Mumbai's Central, Western and Harbour line suburban railway network.

Railways and other transport agencies like the BEST and MSRDC must consider implementation of technologies like water recycling, and rainwater harvesting. These agencies must also explore new technologies like waterless toilets and construct ring wells, tube wells and bore wells to reduce its dependence on local municipal water supply.

The Central Railway recently introduced a high-pressure water system to clean the train coaches, believed to reduce water usage for this purpose by 60 percent. Likewise, the Western Railway, BEST and all such public service providers and utilities, including the public convenience facilities run by Sulabh International and Fumes International, should do everything possible to conserve and reuse as much water as possible.

Recommendations for housing societies

The 10-Litre Challenge

The 10-litre challenge urges citizens to reduce their daily water consumption by 10 litres. "Through various water conservation initiatives, Singapore has managed to reduce domestic water consumption from 172 litres per capita per day in 1995 to 157 litres in 2007." (Source: Government of Singapore website, 2010) Citizens of Singapore took up this 10 litre challenge in 2006 as a means to reduce their demand for water.

In Mumbai, all the citizens would have to do is save a bucket of water every day. Given the total population of Mumbai, this could result in saving of nearly 133 million litres of water per day! Nearly half of this voluminous saving can be achieved if citizens simply put one brick or a one-litre bottle (full of water) in their toilet flush tanks, to reduce their per flush water use by 10 litres.

Sensible use of water

All citizens of Mumbai must do everything possible to stop water wastage. Often water is wasted with utter disdain under the pretext of festivals like Holi. According to the BMC's Hydraulic Engineering Department, Mumbaikars used 3.5 million litres of water to indulge in Holi festivities in March 2011[74]. This, despite the BMC making fervent public appeals to the citizens to play a 'dry' Holi. Water is also wasted on other festivals like Janmashtami, where the "Govindas," out to smash the "Dahi Handis," are splashed with water all over the city.

The 10-litre challenge could result in saving of nearly 133 million litres of water per day!

Thousands of litres of potable water transported through tankers is also wasted either because of leaks in the rusted body of the tanker, leaky outlets or improperly closed and / or absent lids. Such avoidable wastage of potable water is commonly seen in a large number of private tankers. Even tankers owned by the BMC are seen with leaky bodies or taps. Such leaky tankers must be impounded and the tanker companies penalised. The traffic police must be empowered to impound such tankers.

Such unmindful wastage of water must stop immediately. It is certainly not for the BMC or the state government, but for the people themselves to show more caution to prevent such blatant water wastage. But sadly, such self-restraint is never observed when it comes to issues like saving water or, for that matter, in heeding to appeals made by the Corporation for noiseless and pollution free Diwali celebrations.

Water treatment and recycling

Water treatment and recycling facilities could be installed in all new high rise buildings and large housing societies where the costs can be divided among many residents, and would ultimately have a nominal financial effect. In fact, it has been shown by the Godrej housing society in Thane that such an investment can be recovered within a matter of 23 months!

While the BMC must make water recycling compulsory for all its commercial and industrial bulk water consumers, it must study the feasibility of installing this technology for individual houses or small buildings. Using treated water for non potable purposes will reduce the colossal wastage of drinking water used currently all over the city for flushing toilets and washing vehicles.

The old buildings which have only one sewage line for waste water disposal are not suited for such facilities, but perhaps some new alternatives can be explored in this regard.

Leaky water tankers must be impounded by the traffic police and the tanker owner penalised.

Such facilities must also be implemented at all schools and hospitals, all BMC ward offices and government buildings, including the BMC Headquarters and Mantralaya.

Rainwater harvesting

All large societies and high rise buildings which have the requisite space to store rainwater through this method must do everything possible to install such facilities at the earliest by using private help available. All residential societies and complexes that have borewells must immediately set up rainwater harvesting facilities with the objective of recharging the groundwater table around the borewells by constructing low cost precipitation tanks. This measure is bound to increase the lifespan of the borewell, and save the residents the cost of digging to greater depths of the earth when the borewell runs dry every few years.

In a welcome and much needed move, the BMC is considering offering financial incentives — including rebate in property tax and financial aid of Rs. 50,000 to Rs. 1 lakh — to housing societies that are willing to set up rainwater harvesting plants. Based on the schemes that are currently being offered by the Delhi Jal Board, this policy is likely to be implemented once the capital-value-based property tax system comes into effect in the BMC. However, for the moment, the BMC has decided to offer a concession of 2 to 5 percent on property tax bills. This new initiative is bound to attract more buildings for incorporating such water conservation methods, other than the new societies that are bound to go in for rainwater harvesting.

Eco-housing and international best practices

International best practices and the concept of eco-housing to promote sustainable resource use in water, electricity and fuel, as well as waste management must be encouraged. Just like considering ways to incentivise housing societies to scale up rainwater harvesting in the city, the BMC must explore ways to attract all major construction houses to develop large-scale eco-housing projects.

Interestingly, the Pune Municipal Corporation has launched an eco-housing programme to promote adoption of environmentally friendly practices, energy efficient products and technologies by the construction industry. The eco-housing voluntary rating and certification mechanism helps quantify the environmental performance of residential projects on the diverse parameters of site selection, environmental-friendly architecture, efficient and energy saving building materials, solar water heaters, water conservation, waste segregation etc.

Conventional brick and mortar buildings have a significant impact on resource use and cause environment degradation during their lifetime. They also significantly contribute to the spread of a city's carbon footprint. On the other hand, eco-housing incorporates environmental considerations at every stage of building construction. It offers financial benefits; environment, community and infrastructure benefits, and benefits associated with health and increased productivity as compared to conventional buildings. The amount of total incentives which could be won by such buildings depends on the level of certification that the project will earn.

Currently, the Sustainable Building Technology Centre (SBTC) serves as the apex body for the certification of eco-housing projects. The International Institute for Energy Conservation (IIEC) together with its partners – Science and Technology Park (STP) and Bhanuben Nanavati College of Architecture (BNCA) – validates all projects registered for eco-housing certification till such time as a permanent eco-housing certification agency is established at the SBTC.

The eco-housing assessment criteria for Pune city has been developed by the International Institute for Energy Conservation (IIEC) in association with The Energy Resources Institute (TERI), and Science and Technology Park (STP) under technical assistance from the United States Agency for International Development (USAID).

It's time for the BMC, too, to learn from neighbouring Pune and to think innovatively and in a futuristic manner to conserve natural resources. The BMC can also seek guidance from organisations like the Indian Green Building Council, which is currently monitoring and implementing the internationally recognised LEED certifications for green buildings in the country, to prepare green and eco-housing laws for Mumbai. LEED, or Leadership in Energy and Environmental Design, is an internationally-recognized green building certification system. Developed by the U.S. Green Building Council in March 2000, LEED provides building owners and construction companies with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

Research & Development

Exploring innovative indigenous methods along with implementation of successful and sustainable technologies to save water can provide long-term solutions for the city. While any practice which aims at reducing water wastage and encourages water conservation and optimum water usage must be looked at, actual implementation without proper analysis of its feasibility and economic viability may prove to be very ad hoc and unsustainable.

This calls for proper solutions through scientific R&D – an area that has been largely neglected to date. The issue must be looked at both in the context of municipal waste water disposal and in the context of bulk consumers and individual water consumers like housing societies. Sending departmental engineers for pursuing specialised courses and technical training programmes in various technical institutions in India

and abroad can also enable them gain new perspectives by learning new technologies and global best practices.

ORF's Future Initiatives

ORF Working Groups

ORF will form working groups to tackle the closely interlinked issues of water, sanitation, solid waste management and affordable housing.

This group will meet periodically to identify issues of immediate concern, and also to tackle the problems from a long-term perspective. The group will begin with issues related with Mumbai, but gradually expand its scope to include the MMR, urban Maharashtra and urban India. The group will study domestic and international best practices and success stories and try to generate consensus for their replication in Mumbai at the individual level and the institutional level.

4 ORF MUMBAI'S 10 KEY RECOMMENDATIONS

In the short- and long-terms, taking small but determined steps towards sustainability will become inevitable. These should have been initiated as of yesterday!

Consumption Map: Preparation a comprehensive water consumption map of Mumbai by doing a very exhaustive, expansive and meticulous door-to-door survey. This exercise must be carried out in a transparent manner with the sincerity and diligence of the Census of India.

Underground pipeline map: The BMC has no idea about where many of its underground water pipes actually are. An exercise to prepare an accurate map of these underground pipes using latest technologies must be undertaken on priority.

Flow meters: The BMC has no precise idea of how much water is going where once it's released in the distribution network. The BMC must first install reliable flow meters at all major ward inlets and outlets to measure the exact inflow.

Leaks and bursts control: The BMC must prepare a comprehensive and watertight 5-year plan focusing purely on controlling leaks and bursts. Instead of going in for hugely capital intensive source augmentation schemes, the BMC must focus sincerely on controlling the gross wastage of the precious natural resource. This exercise must be undertaken in absolute mission mode and become the single most priority area for the BMC over the next five years.

Organisational reforms: The BMC must immediately initiate organisational reforms to empower and make accountable its Hydraulic Engineering department. It must also invest in training and retention of its talent.

Recycling: Mumbai gets 3350 MLD of water daily. It also releases nearly an equal quantity of water in its sewage system. Recycling even a fraction of this enormous quantum of water to cater to some of the principal water-guzzling industries like construction, and for possible secondary or non-potable uses like gardening and toilet flushing etc. will go a long way in controlling the abuse of drinking water.

Reviewing the pricing of water: Even the poorest of the poor across the state of Maharashtra pay more than the residents of Mumbai for water, who get to enjoy this precious and limited natural resource nearly for free. Besides ensuring good health of the BMC's finances, upward revision of water prices is urgently needed to ensure sensible use and minimum wastage.

Development Plan and Development Control Rules: Frequent amendments to the Development Plan and the Development Control Regulations have posed some of the biggest challenges to the water department of the BMC. Henceforth, the government should take the BMC's water department into cognizance before any future amendment to the Development Plan or Rules is made.

Rainwater harvesting: If the BMC is serious about pursuing rainwater harvesting, it must strengthen the capacity of its Rainwater Harvesting Cell and support buildings which are willing to implement this measure. It must also develop a mechanism to conduct regular checks of rainwater harvesting facilities, as water stored in anaerobic conditions throughout the year could be prone to bacterial contamination. Further, it must show gumption to act against builders who initiate construction schemes in the city without incorporating a comprehensive rainwater harvesting mechanism in their plans.

Public awareness and involvement: Nowhere in the world have water reforms been possible without a strong focus on public awareness and public involvement. The BMC must forge a strong people-to-people partnership through sustained and targeted awareness campaigns to achieve the desired long-term sustainable results. Schools governed by various Education Boards must be encouraged to introduce water lessons to the children of the primary section.

5 CASE STUDY 1: SEWAGE TREATMENT & RECYCLING - NAVI MUMBAI SHOWS THE WAY

For some of the best practices of water supply and demand management, you do not have to look too far. NMMC has commendably initiated steps towards sustainability through the three R's of Reduce, Reuse and Recycle. The above picture shows NMMC's waste water treatment plant at Koparkhairane.

The Navi Mumbai Municipal Corporation (NMMC), which was formed in 1992, covers an area of 162 sq km. Its land area is divided in the rapidly developing nine zones of Belapur, Nerul, Turbhe, Vashi, Koparkhairane, Ghansoli, Airoli, Digha, and Dahisar. Water supply administration, along with all related operations and management was handed over to the municipal corporation by the City and Industrial Development Corporation (CIDCO) in November 1999.

The population of NMMC as per the census data of 1991 was 387,206 which increased to 703,947 in 2001, an unprecedented rise of 87.50 percent. The city's sanitation plan submitted to the Union Ministry of Urban Development (through the Water Supply and Sanitation Department of the Government of Maharashtra) in May 2011 states that the population residing within the NMMC area during 2009-10 was 11.99 lakh. Quoting the findings of its extensive Urban Health Post survey, this report has projected the total NMMC population for 2010-11 to be 12.09 lakh. Indeed, Navi Mumbai's development has had a direct impact on the population explosion in the Mumbai and suburbs, which has shown a decline in the 2011 census.

Figure 14: MAP OF NAVI MUMBAI *[Source: Google Maps]*

An overview

Prior to 1999, NMMC was purchasing water from the Maharashtra Jeevan Pradhikaran (80 MLD), the Maharashtra Industrial Development Corporation (60 MLD). The 140 MLD purchased from these two government agencies was supplied against the city's then total demand of 200 MLD, a shortfall of 60 MLD. Obviously, water shortage in many areas was a daily affair. The problem was compounded as the entire area had an old, rusty and leaky pipeline network and feeder mains. The NMMC had UFW of 52 percent at an intermittent water supply of about two hours daily. Water metering was absent and as a result, so was any kind of water and energy audit, or recovery audit. Given this scenario, coping with the future demand of this fast developing city was a major challenge for NMMC. Upgrading the pipeline network, construction of new reservoirs and monitoring of the water quality by simultaneously reducing UFW were the key tasks laid out in front of the Corporation.

Since the year 2003, following the acquisition of the Morbe dam source, NMMC has commendably managed to bring about a remarkable transformation to the city's water supply. This principal source of water for the city, developed at a cost of Rs. 553.70 crore, has an ultimate capacity of 450 MLD, adequate enough to cater to the city's projected population growth till 2031. Today, NMMC receives 270 MLD from the Morbe source. The water from Morbe is treated at the NMMC's 300 MLD capacity Water Treatment Plant (WTP) at Bhokarpada. Besides, treated water is also drawn from MIDC and CIDCO at Hetawane.

Key water sources

Source	Total supply (MLD)
Morbe Dam	270
MIDC	37
CIDCO	27

[Source: NMMC]

After checking for residual chlorine, if necessary, chlorine is added in the storage reservoirs. The NMMC supplies water to 116,727 consumers through network of over 750-km-long distribution systems with 113 service reservoirs. It, however, does not supply any water to the industries in CIDCO or MIDC areas. The current total water supply to the city is 334 MLD, which comes to 195 LPCD as per the current population.

From a state of water deficiency, today the NMMC supplies water ranging from six to 24 hours in various zones. It is the only city in the country to have sustained the 24x7 supply model – even in several of its slum areas – yet maintaining reasonable and internationally accepted levels of UFW. [One can check the supply timings and the hours of supply on the official NMMC website: (http://www.nmmconline.com/ web/guest/water-timings). Today, the UFW is in the range of 21 percent, which is quite comparable, even better than several developed countries having round-the-clock water supply. The NMMC has also outsourced operations and maintenance of its entire water supply system, ensuring high quality service delivery from the contractors. Incidentally, the NMMC charges more to its residential consumers than the BMC, but actually charges less than the BMC to its commercial and institutional consumers.

Water audit

In its 18 distribution zones, the NMMC has SCADA flow meters in 68 strategic places along the network to accurately measure the total incoming and outgoing flow of water. Besides, it has achieved 100 percent metering for all its bulk, institutional and residential consumers. These measures have enabled the NMMC to have a very reliable account of its water. They have also led to very accurate billing. Thanks to state-of-the-art GIS based metering at the consumer end, the entire billing system is highly reliable, leading to optimum accounting and recovery. The system is so designed that any consumer can get on demand a full computerised history of his billing.

Such high level of accuracy in knowing the consumption patterns through effective metering and billing have resulted in a drop in consumption from 242 LPCD to 176 LPCD. To maintain these benchmarks, the water department mandatorily carries out comprehensive energy and water audits every six months. The NMMC also mandates its officers and engineers to meet the staff of its O&M agencies every fortnight to discuss and iron out any issues or contingencies.

NMMC's water tariff per 1000 litres of water

Consumer type	Water tariff (Rs.)
Residential	4.75
Commercial	30
Institutional	11
Non-metered consumer	50 per family per month
Stand post users in slums	30 per family per month

[Source: NMMC]

These measures have made water supply in the city reliable, improved the quality of water and reduced water leakages. Water supply complaints have seen a drop by 90 percent in the last five years. The NMMC has also started policing of misuse of water by consumers and anybody found wasting water is penalised in his monthly water bill. The NMMC also offers performance bonuses to its staff for energy saving, water saving or any other beneficial acts, which are rewarded.

The NMMC has also benefited due to its interconnectivity with other organisations like the MJP, CIDCO and MIDC. During an emergency, NMMC can supply potable water to these agencies and vice versa.

Meeting future demand

Water requirement of NMMC is expected to reach 500 MLD in 2042, and the Corporation is already working on plans on source augmentation to match the future demand. Schemes undertaken by NMMC for augmentation and improvement of water supply system include gradually moving towards the full capacity of 450 MLD of the Morbe Dam, construction of ground level and elevated service reservoirs, replacement of old lines with ductile iron pipelines, system for re-chlorination of water, replacement of pumping machinery, energy conservation projects etc.

However, what has been a remarkable achievement, and a guaranteed means for effective water conservation to meet future demand, is the NMMC's focus on treating its sewage for reuse for all non-potable secondary uses.

Sewage treatment

For sustainable water management, it will become imperative for all municipal bodies in the country to begin recycling its sewage water at least for all non-potable uses. Wastewater is treated in stages to progressively improve its quality, which is mainly determined by the presence of Total Suspended Solids (TSS), Biological Oxygen Demand (BOD) and Nutrients (Nitrates and Phosphates).

Globally, sewage or other wastewater is treated using various technologies, which are best suited as per the geography and purpose. One of the most basic technologies is a Waste Stabilisation Pond (WSP) in which sewage water is allowed to degrade naturally in a series of shallow artificial basins. However, due to variable output quality, inability to manage mixed effluent and land intensity, WSPs are mainly suited in rural areas where energy and capital are scarce, but land is easily available. The WSPs are fast being replaced by more advanced technologies, specially the conventional Activated Sludge Process (ASP) for all medium to large sewage treatment plants (STP) of 30 MLD or more capacity. In ASPs the treatment comprises three stages prior to which heavy solids like wood and grit that choke the plant are removed. ASP is suitable for Indian conditions as it can effectively treat both diluted and concentrated wastewater, as well as mixed household and industrial waste. However, ASP is very energy intensive.

Figure 15: Remotely Aware… GIS-based remote-controlled water meters installed by NMMC. *[Source: NMMC]*

Yet another technology which is gaining increasing popularity is the Sequential Batch Reactor (SBR), which is also referred to as an advanced form of ASP. Since treatment takes places in a single basin, it requires up to 33-50 percent less land and has 40 percent lower civil construction expenditure than a conventional ASP plant. Due to automated controls, it consumes 35-45 percent less power than conventional ASP plants.

Figure 17: FROM BLACK TO BLUE… The NMMC's Sewage Treatment Plant at Nerul. The plant has an ultimate capacity of 100 MLD. *[Source: NMMC]*

Promotion of the use of treated water is high on the agenda of NMMC's city planners. In the days to come, such measures will enable the NMMC free up a large quantity of precious freshwater required for potable use and also manage to supply water to industry at a significant discount, relative to the current industrial and commercial tariff of Rs. 30 per kilolitre. The sale of treated water will also let the NMMC partially recover the costs of complying with the strict Central Pollution Control Board's discharge norms. In terms of environmental benefits, the increased use of treated water will reduce use of tanker water which is pumped indiscriminately from underground aquifers and transported by road.

The NMMC has two types of selling arrangements in mind. Under the first, they hope to supply treated water directly to bulk customers who would construct pipelines to their plant themselves. For example, they could supply treated water for construction of the Navi Mumbai international airport and even to the planned SEZ, which would otherwise require about 500 tankers of water per day (5 MLD approximately) at Rs. 50 per 1,000 litres.

Under the second arrangement, a private contractor would be responsible for the sale and marketing of STW to end-users. The contractor could buy the treated water from the NMMC on an 'as-is-where-is' basis. Since such contractor would be responsible for the quality to the end-user, it should preferably take up the responsibility of the STP operations as well. The NMMC is currently various possible PPP options to utilise its STP capacity to the maximum. It is also exploring the possibility of having the contractor pay for the pipelines for the conveyance of the treated water.

According to a recent study conducted by IDFC's Research Group, building a separate pipeline network to carry treated water is a highly capital intensive exercise. Constructing a one-meter diameter pipe costs Rs. 3 crore per km and current pumping costs are Re. 1 per 1,000 litres for 10 km over a normal gradient, the study states. Since NMMC does not have much large industry, most potential customers of treated water would be the shopping malls and large commercial establishments who could purchase the water for Rs. 30 per kilolitre. To encourage household consumers to use treated water for their non-potable purposes, the price of treated water will have to be kept lower than the cost of drinking water, which is Rs. 4.75 per 1,000 litres.

It also has significantly less chemical requirements and reduces manpower costs.

The NMMC is one of the first municipalities in India to treat its sewage to levels higher than the prescribed Central Pollution Control Board (CPCB) standards. Using SBR technology, with its higher output parameters, NMMC can directly sell the treated water for low-end industrial uses.

Currently, NMMC has eight STPs located at CBD Belapur, Nerul, Sanpada, Vashi, Koparkhairne and Airoli. The treatment plants at Nerul, Vashi and Airoli are re-constructed based on cyclic activated sludge process, using the SBR method. The treatment plants at Belapur, Sanpada and Koparkhairne are under re-construction. The quality of the raw and treated water is tested daily, and the quality of all treated water is in the range lower than 20/30 (BOD/SS) standards. In fact, the treated water at these plants has a BOD level of only five. Together, these STPs have a combined ultimate capacity of 424 MLD, which the corporation wants to attain over the period of the next 25 years.

The NMMC's first plant at Nerul was built in 2008 at a cost of Rs. 67.9 crore for an ultimate capacity of 100 MLD which is operated and maintained by service contractors. The NMMC pays the electricity bills directly. The current three-year O&M contract is worth Rs. 70 lakh per year, which will be bid out again when it expires.

The Nerul plant is currently treating 45 MLD of wastewater. Its operation and maintenance costs and expenditure on electricity work out to Rs. 1.30 per 1,000 litres, much lower than the costs of a conventional ASP.

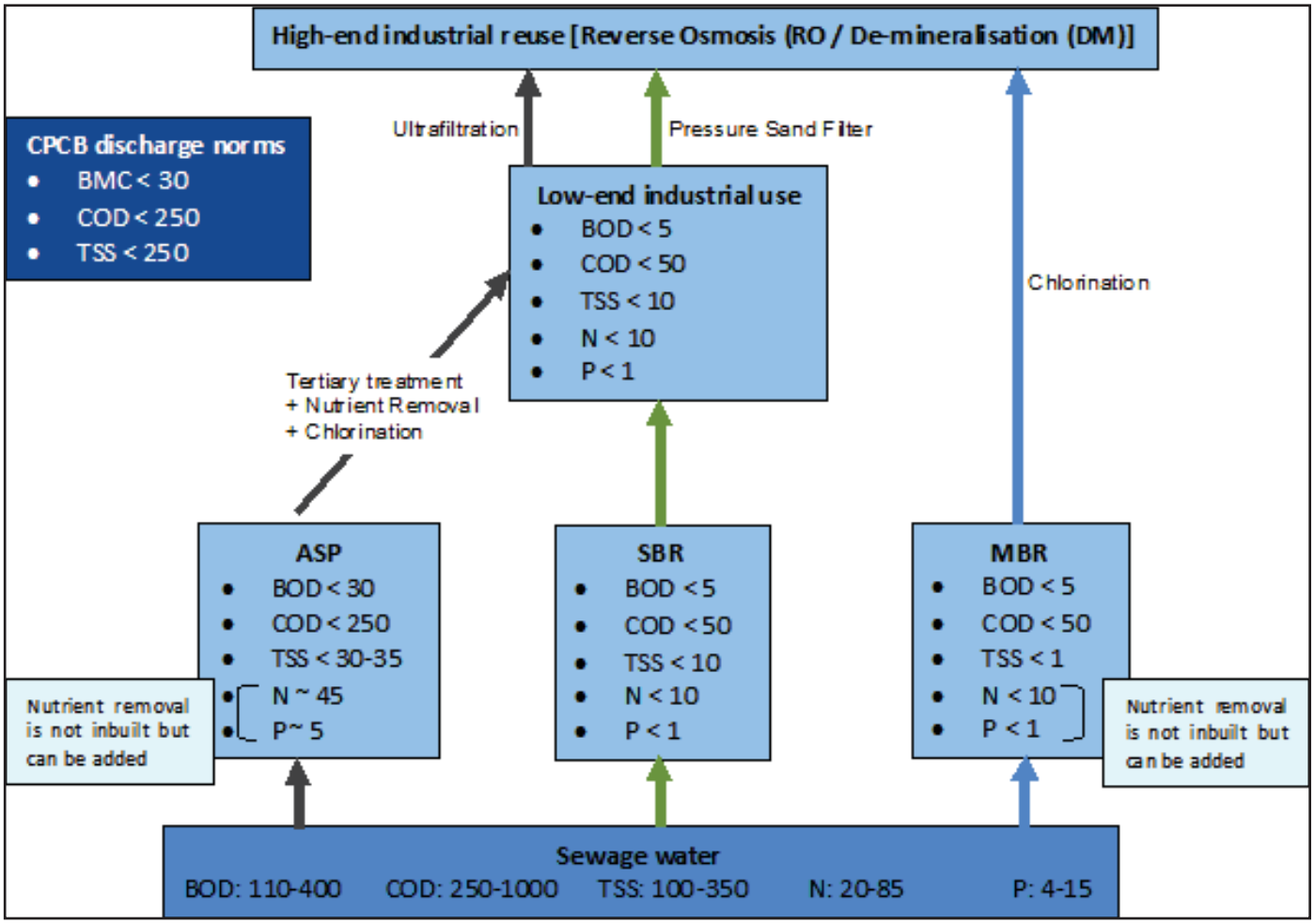


Figure 16: *[Source: IDFC Research Group Quarterly Research Note – June 2011]*

[CASE STUDY 1: SEWAGE TREATMENT & RECYCLING - NAVI MUMBAI SHOWS THE WAY]

In this regard, the NMMC has become the first municipal corporation in India to lay separate pipelines for conveyance of treated water to the Seawoods Estate Plase II, popularly known as the NRI colony off the beautiful Palm Beach Road, in Nerul. The treated water will be supplied to this colony at Rs. 2.50 per 1,000 litres.

The BMC, which has so far and quite needlessly concentrated only on augmenting water sources and is even toying with the extremely expensive idea of desalination plants, has a lot to learn from the NMMC's experience. Instead of leveraging the benefits of treating and recycling wastewater, the BMC has so far been too myopic and reluctant to forgo its revenue from the high industrial tariff on freshwater. For example, the BMC has begun construction of a 160-km pipeline from Upper Vaitarna to bring fresh water to the city. Instead, it could have easily explored the potential to meet the massive industrial demand in the city through the treatment and recycle route.

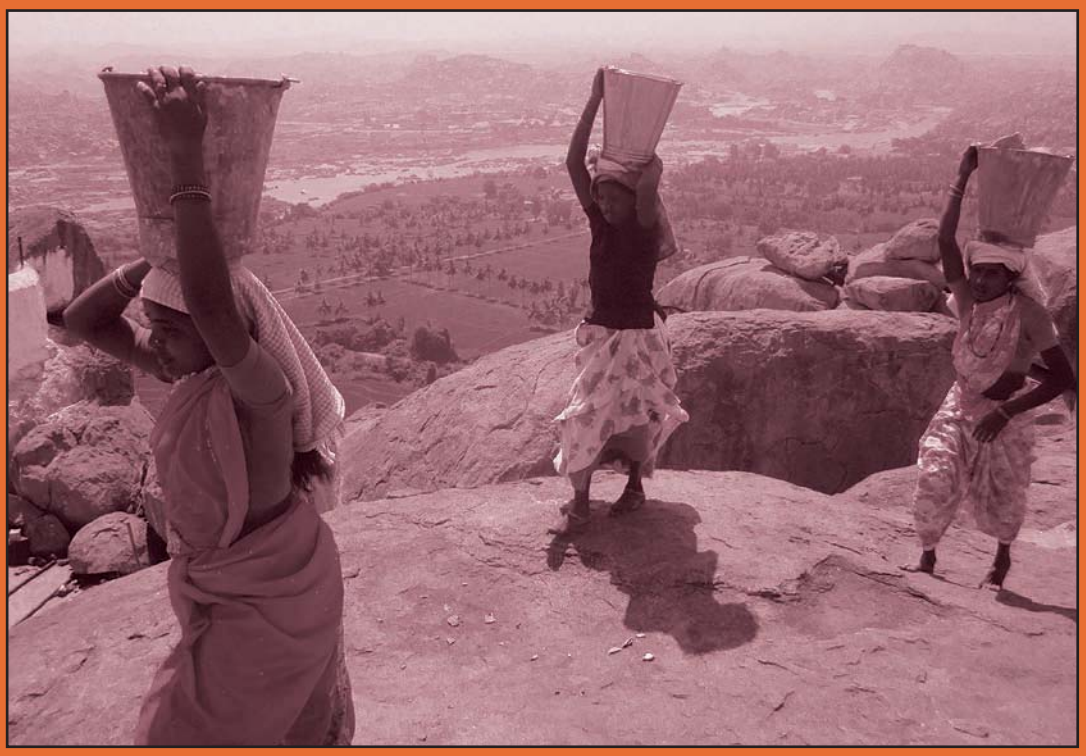
The efforts of the NMMC for improved service delivery and a futuristic sustainable approach for water management has not gone unnoticed. The corporation has won prestigious awards at the national and international levels.

2008: National Water Award constituted by Urban Development Department (Government of India), Administrative Staff College of India, Hyderabad and FCCI for successful implementation of 24x7 water supply in Navi Mumbai.

2008 and 2009: For two consecutive years, the NMMC won the National Urban Water Award conferred by President of India for "Services to Urban Poor." NMMC received this National award for two years continuously.

2009: Best City Award for Improvement in Waste Water and Sanitation Services under JNNURM.

Source: Navi Mumbai Municipal Corporation, NMMC City Sanitation Plan 2010, and partly reproduced from the IDFC Policy Group Quarterly Research Note, No. 12, June 2011



6 CASE STUDY 2: TRIRATNA PRERNA MANDAL, SANTACRUZ, MUMBAI

From managing public toilets to bringing about wide-spread and inclusive social transformation, Tritratna Prerna Mandal, a Community-based Organsation in a slum in suburban Mumbai, has reaped the real benefits of community welfare. Sensible water use is just one of its glorious achievements.

[CASE STUDY 2: TRIRATNA PRERNA MANDAL, MUMBAI]

Not many would take a second look at the decent looking, stench-free public toilet located in the narrow lane off the bustling S. V. Road, one of Mumbai's oldest arterial roads, behind the Milan Mall at Santacruz. But only a few might not raise their eyebrows in admiration if they come to know that this community toilet located in the Khotwadi slum has become the medium for an extraordinary socio-economic and environmental revolution in the entire area. An example of what an inspired slum community, with a little help and encouragement from committed BMC officials, can achieve not just for themselves, but the entire neighbourhood.

Triratna Prerna Mandal, the Community-based Organisation (CBO) that took upon itself to manage and maintain the public toilet eight years ago, has today expanded its scope of operations to organise the women in the slum to operate a micro-finance and self-help group, run study classes for school drop-outs, and also run a computer and vocational training institute for the slum youth. Besides, the CBO also maintains the adjacent Dharmaveer Sambhaji garden and playground, and regularly organises a host of seminars, public dialogues, social and cultural programmes and sports competitions, giving the slum youth a rare chance to display their talent and skills.

The commitment and drive of the men and women who run the Triratna Prerna Mandal has also won them the support of the "building residents" around Khotwadi, who have overcome the apparent social divide to time and again partner the CBO in cleanliness and greening drives and in adopting environmental best practices in urban locality management. The Mandal also regularly receives several international study groups who come down from around the world to see for themselves the magic of the toilets.

The toilet block has 21 toilet seats (14 for men and 7 for women), one fresh room for women and one toilet for the handicapped. It also has seven urinals and two bathing facilities- Together, these facilities are used by nearly 1200 to 1400 persons daily, requiring a whopping 8000 litres of water for flushing and cleaning the toilets, including the water used for bathing. Roughly, this translates to 240,000 litres of water a month, and a mind-boggling 2.88 million litres of water per year. These figures present a telling evidence of the enormous wastage of BMC's clean drinking water that we all indulge in when flushing down the toilets in our homes without ever sparing a second thought.

However, the Mandal does not use even a drop of BMC water at its toilet block. The water for all the cleaning, flushing and bathing is drawn from an ingeniously designed rainwater storage tank-cum-ringwell that is constructed adjacent to the block, resulting in saving millions of litres of water for the last several years. The rainwater harvesting facility installed by the Mandal collects rainwater directly from the roofs of the clubhouse in the Sambhaji playground and the toilet block itself (which also houses the Mandal's office and the computer training institute). The rainwater undergoes preliminary filtration and is stored in a large underground tank every monsoon. It is transferred to the ringwell whenever there is a drop in the natural recharge of the well with groundwater. This year, the Mandal is planning to increase the tank's capacity to store additional rainwater that it plans to trap from the terraces of the nearby buildings.

The Mandal's innovative best practices do not stop here. It has also installed two waterless toilets at the Sambhaji playground on an experimental basis since last three months.

"We have to realise that with the growing threat of Climate Change, water will become increasingly scarce a commodity and it is entirely up to us to see that it is used sensibly. When we learnt about the benefits of rainwater harvesting, we did some rough calculations and realised its tremendous potential for water conversation. The cost of installing the facility including the cost of construction of a tank is negligible given the long-term environmental benefits of such a facility," said Dayanand Mohite, the Mandal's President.

[CASE STUDY 2: TRIRATNA PRERNA MANDAL, MUMBAI]

Dayanand Jadhav, the Mandal's Executive President explained: "This is in line with the principles of the Mandal, which represent the essence of its name 'Triratna' (meaning three jewels), signifying by our work in the three fields of 'shikshan' (education), kreeda (sports) and sanskruti (culture). Good sanitation leads to a clean and healthier environment, which eventually paves the way for the overall community development."

Much of Triratna Prerna Mandal's success story can be attributed to the untiring efforts of Seema Redkar, a BMC Officer on Special Duty, who was part of the rollout of the World Bank's remarkable Slum Sanitation Project, which led to the formation of CBOs in slums in Mumbai. Redkar's duty was to organise meetings with the slum dwellers, and mobilise their support for an exercise, the success of which hinged on total community participation for the management and maintenance of their own toilets. Not an easy task, as it involved long and patient discourses with the residents, aimed at changing the mindsets of entire communities towards the simple but significant issues of personal hygiene and sanitation, the benefits of which they simply weren't aware of. Officers like Redkar, who work with such selfless devotion, are certainly a rare breed in the BMC, giving the citizens a hope in the otherwise corrupt and floundering civic administration.

Figure 18: TRANSFORMING LIFE... The management team of Triratna Prerna Mandal with members of an international delegation at a conference last year by the Mandal on Climate Change. In the centre in black and gold sari is Seema Redkar; to her left is Dayanand Jadhav, the Mandal's Executive President. *[Source: Triratna Prerna Mandal]*

[CASE STUDY 2: TRIRATNA PRERNA MANDAL, MUMBAI]

"While a community toilet is a basic and indispensable necessity at any slum settlement, it is bereft of any ownership. As the BMC is unable to maintain such facilities, their condition deteriorates due to gross misuse and negligence. They neither have any water connection nor proper sewage disposal, which explains the shockingly filthy state of a vast majority of such facilities across the city," Redkar pointed out.

The Triratna Prerna Mandal is perhaps the best example of the success of the programme which was implemented by the BMC in 1986. "The activists of the Mandal took this opportunity of running the toilets as a mission, with a deep sense of purpose. Importantly, they have developed a keen sense of ownership for the toilet and used it as an unlikely but effective tool to bring about an amazing socioeconomic change at the grassroots," she said.

Not too lucrative, but the success of the programme also lies in its simple business model. The BMC constructed the toilet blocks and handed them over to the CBOs under a Memorandum of Understanding for their future maintenance and management. The CBO enrolled members / users at a nominal fee which includes a one-time payment of Rs. 500, plus Rs. 120 per year from each member. The facilities are also offered as 'pay per use', at a nominal charge of Rs. 3. The sheer volume of daily turnover leaves the CBO with enough funds to hire permanent caretakers to clean the toilets, carry out minor repairs and even pay the electricity and water bills. Once such toilets started, the people in the slums realised their value, so much so, that nobody even once hesitated to pay a small sum of money for their use. The biggest beneficiaries were the women and children. The toilets gave them an opportunity to live their lives with dignity and self-respect.

The Triratna Prerna Mandal has achieved this incredible revolution without any political patronage. Sadly, such ideal models of social change are not replicated in all the other slums of the city. Instead, we have slums which have their filthy community toilets plastered with big posters of pompous local politicians who seem to be smirking at the plight of the helpless residents, who are consigned to live in an inhuman environment of unspeakable squalor.

Waterless toilets

Seema Redkar has also been instrumental in getting waterless urinals installed at the Mandal's Sambhaji playground. These toilets are currently installed on an experimental basis to test their effectiveness under extreme conditions. "We have one such urinal put for experimental use at the BMC headquarters, but it is here where their efficiency will be truly measured," she said.

According to a presentation made to the BMC officers by the company, the Kupple waterless urinals do not have any cartridge. They do not use any chemicals, and are claimed to be a 'total hygienic solution' with 'zero recurring cost'. They are laced with a nano-silver antibacterial glazing on its exterior and interior surface, which make them:

- Hydrophobic: No urine concentration on the surface
- Antibacterial: Oxidises the bacteria, whereas in conventional urinals, water provides the breeding ground for bacteria
- Anti-stain: Leaves no yellowish marks even after prolonged use.
- Completely odourless: A simple flap technology which stops the backward migration of odour.

No Odour: It is generally believed that urine has its own odour. However, urine itself normally does not bear odour. The stench is mainly because of a chemical reaction that disintegrates the urea present in the urine, releasing ammonia (odour) and carbon dioxide (heat) as byproducts. Urea is disintegrated by bacteria using an enzyme called urease. For each molecule of urea, two molecules of ammonia are produced. They multiply with the help of moisture present in the flush urinals. As waterless urinals are hydrophobic, the chemical reaction happens only inside the trap, where the trap technology stops any odour from escaping out.

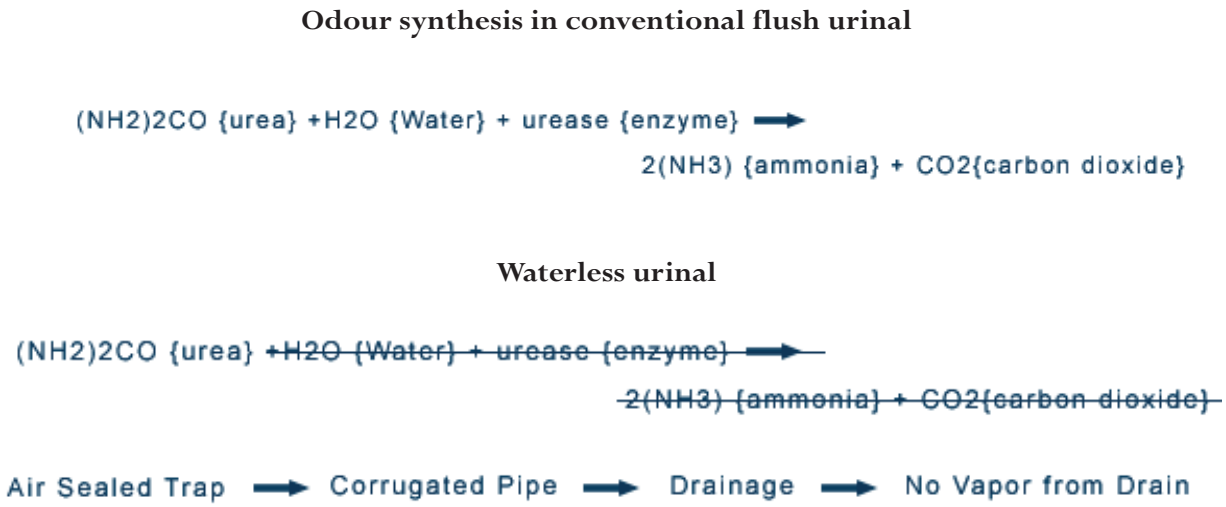


Figure 19: *[Source: Seema Redkar Officer on Special Duty]*

No Stain: Repeated use of a toilet results in the build-up of a deposit derived from urine and hard water on the surface of the toilet bowl. The hardened mineral scale is difficult to clean, especially in the case of deposits under the rim. Waterless urinals are made of vitreous china, with a special nanotechnology coating on it, which does not allow urine droplets to gather on the surface. Thus, no urine can accumulate on the surface these toilets become totally stain-free.

No Bacteria: Urine is sterile and does not contain bacteria under normal circumstances. However, conventional flush urinals are beehives of bacteria, which thrive in moist conditions. Each time any conventional urinals are flushed, the water regenerates some more bacteria. In absence of water, the chances of bacteria of bacteria formation is up to 85 percent lower in waterless toilets than in conventional urinals. Even the remaining 15 percent bacteria cannot regenerate as the urinals are coated with an antibacterial glaze. The coating is more or less of the same nature as applied on the floors and walls of drug manufacturing units.

"For the last three months that they have been installed, their performance has been satisfactory. The facility remains clean and dry and importantly, there is no stench. They neither attract flies nor do they become breeding grounds for mosquitoes," Dayanand Jadhav said.

However, with a price tag of Rs. 27,000 only for the urine pot (all construction and plumbing costs extra) these urinals are quite expensive. Good quality conventional flush urinals, on the other hand, require up to Rs. 50,000 of total expenditure. As such, the economic viability of waterless urinals needs to be worked out before scaling up their use. However, the BMC must explore their practicality, as given the volumes required; any reliable supplier is likely to earn a fair profit, even if it offers a good discount on their price. It must also explore the cost viability and effectiveness of other waterless technologies that are currently available in the market.

Source:Visits to Triratna Prerna Mandal and personal interviews with its office bearers and Seema Redkar, OSD, BMC

7

CASE STUDY 3: THE ORCHID, MUMBAI

Strict adherence to the concept of Reduce, Reuse and Recycle, through innovative measures, has enabled The Orchid, India's first ecotel, to save 60,000 litres of water per day.

[CASE STUDY 3: THE ORCHID, MUMBAI]

When The Orchid hotel first introduced the Ecotel concept in the country, there was a feeling that this was just a promotional gimmick, an idea that would gain the hotel some marketing brownie points. Having bagged 63 international and national awards since its inception in 1997, The Orchid has now become the most awarded hotel in the world for its sustainability practices, thus proving its critics wrong. Today, it is one of the only six hotels in the world to consistently maintain top-level, "five-globe" Ecotel-certified status. It is also the only ISO 14001 certified Ecotel in the world.

The five-globe criteria, established by HVS Global Hospitality Services in association with the Rocky Mountain Institute, U.S.A., which came to be accepted globally as the benchmark for Ecotels in 1994, include:

- Environmental Commitment
- Solid Waste Management
- Energy Efficiency
- Water Conservation
- Employee Environmental Education & Community Involvement

The blueprint of the Orchid took efforts to incorporate passive energy conservation in all its design and architectural aspects – right from the building materials used, to the design of the façade, interiors, plumbing, electrical and mechanical aspects, kitchen and guest comfort. The Orchid was the first hotel in the country to truly incorporate the concepts of eco-housing and water conversation.

The Orchid saves as much as 60,000 litres of water per day by strictly adhering to the concept of reduce, reuse and recycle. Besides conserving this precious natural resource, such moves have also helped the hotel save money on its water bills.

- All taps in the hotel contain aerators, which increase the water's force and reduce outflow, saving water. Using these aerators saves up to 50 percent of water. In addition, in their staff cafeteria they have taps operating on timers.

- Two other ingenious water saving devices are the Geberit Concealed Cistern which uses only 6 litres of water per flush as against 15-20 litres used in conventional flushes.

- The hotel has installed a sewage treatment plant, which recycles 50,000 litres of sewage per day, producing water which is used for all gardening, air-conditioning and all other secondary uses. For gardening, the hotel uses drip irrigation method to minimise the use of even this recycled water. The Orchid has also put this treated water to an innovative use — to reduce air pollution by installing 'air scrubbers' in the boiler outlet connected with the chimney. The boiler produces high amount of carbon dioxide fumes which passes through the scrubber and is emitted through the chimney (the fumes emitted are clear white fumes instead of the dark/black fumes usually seen). This is because when the fumes pass through the scrubber, water is sprayed and the carbon dioxide dissolves and settles down in the shower traps and clear fumes are emitted in the air. The consumption of water is 300-600 litres per hour for 1000- meter cube of gas, reducing the fume gas temperature from 250 degrees C to 50 degrees C. The water utilised in the air scrubber is recycled water from the sewage treatment plant (STP). Similar type of equipment installed in the kitchen exhaust system is called 'air washer' which works on the same principles.

- The Orchid's water purification plant uses Aquazone, a technology that employs ozone which destroys all micro organisms including bacteria, virus, spores, mould, fungi etc.

[CASE STUDY 3: THE ORCHID, MUMBAI]

The resultant water is absolutely safe, pure, fresh and healthy and free from chlorine. Aquazone water is used for for drinking, cooking, and washing fruits, vegetables, meats, poultry and seafood to destroy surface bacteria for healthier preservation.

Aquazone diffuses a controlled dosage of ozone into the drinking water, which neutralises impurities like micro-organisms and chemicals. The result is clean, fresh and healthy drinking water.

Water conservation through simple but effective measures:

- To prevent wastage, complimentary food (including fruits and dryfruits) are only provided on request to avoid wastage. Even newspapers are delivered on request, in reusable cloth bags instead of usual paper or plastic bags.
- The water flask in the guestrooms is left empty and filled after asking the guest for his preference as water already filled and kept in the flask leads to guest perception of the water being stale, which they promptly ask to be replaced. The glasses too are turned upside down and kept in the tray, thereby doing away with having to wrap each glass in a plastic bag and conse quently generating more waste for the hotel.
- The Orchid is the first and only five star property in the country to use a totally safe herbal anti-cockroach treatment. This herbal paste contains extracts from herbs and is safe as there is no use of any poisonous chemicals. No cleaning is required after the treatment is done hence there is no wastage of water, detergents etc. This paste is also applied in refrigerators, ovens, toasters, microwaves mixers, computers as it is non-toxic.

Source: The Orchid website and An Environmental Marketing System – A proposed model based on Indian experience by Sumesh Ramachandran Nair and C. Ganesh Menon

8 CASE STUDY 4: ITC MAURYA, NEW DELHI

A shining example of a water-positive facility, which generates more water than it consumes. Water consumption of 1300 kilolitres per day 10 years ago is down to 625 kilolitres per day today in this 5-star hotel in New Delhi.

[CASE STUDY 4: ITC MAURYA, NEW DELHI]

As a part of its WelcomEnviron initiatives to institutionalise the principle of 'Reduce, Reuse and Recycle', the ITC Maurya in New Delhi, a five star deluxe hotel, has started a programme, encompassing local participation, creating awareness among employees and internal conservation, through energy-saving gadgets and environment-friendly material. The hotel consumed an average of 1300 kilolitres of water, per day, ten years ago. The average consumption was down to 800 kilolitres, three years ago.

The average consumption is now down to 625 kilolitres of water per day and the hotel is trying to bring it further down to 450 kilolitres per day. There was a time when the chillers, one of the major consumption areas in the hotel, used to consume 300 kilolitres of water, which has now been brought down to 150 kilolitres.

Water positive facility

Today, ITC Maurya, which spreads across 5 acres of land, boasts of being a water-positive facility, meaning that it is able to generate more water than it consumes. The hotel has minimised consumption of water, energy and all other natural resources. It complies with all environmental legislations and the effort is not just to reduce, reuse and recycle the resources consumed by the facility, but to surpass the traditional benchmarks. The key to their strategy is sensitisation, conservation and water table enhancement.

As part of its Corporate Social Responsibility (CSR), the management has undertaken a host of measures to reduce its water consumption in the property to minimise its use of energy and other natural resources. These measures have solved some water problems not just for the property, but also for the surrounding areas.

Water consumption of 1300 kilolitres per day 10 years ago is down to 625 kilolitres per day today.

Rain water harvesting

ITC Maurya implemented a Rainwater Harvesting system backed by state-of-the-art innovative technologies. When the hotel introduced the rainwater harvesting system at an investment of about Rs 20 lakh, its seven bore wells were drawing water from 85 to 90 feet underground. In a little less than two years, the groundwater has been recharged and the bore wells today draw water from a depth of just 35 - 40 feet.

At the same time, the hotel has also reduced its dependency on bore wells, by reducing its overall water consumption. Today it depends on the water supplied by New Delhi Municipal Corporation for less than 50 percent of its total requirement. If it achieves its target of reducing water consumption to 450 litres, it will mean a 50 percent reduction in overall water consumption.

The hotel uses ETP treated recycled waters in horticulture activities, floor cleaning, fountains and cascades. These areas alone consume around 100 kilolitres of water per day. ETP treated water is also used in chillers and cooling towers, which consumes 150 kilolitres of water per day.

ITC Maurya is currently in the process of overhauling and upgrading its effluent treatment plant (ETP) and once that is accomplished, its capacity of treating effluent and sewage water will increase significantly. The surplus treated water will be used by civic bodies like NDMC maintain the greenery along the roads and flyovers in the vicinity, the parks, the Dhaula Kuan ridge area forests and other public areas in the vicinity.

Measures like inserting shower-like devices at the mouth of the water-hose to retard flow or closing half or three-fourth of the valve below the wash basin have been found to be highly effective. The hotel has invested in a sprinkler system, as the common watering practice is highly water intensive or wasteful. Importantly, these measures incur little cost.

The hotel has installed a hydro-pneumatic water distribution system, which helps in effective handling of demand-side management. In a hydro-pneumatic system, water is pumped from the supply system into a pressure tank for storage. Air in the tank is compressed by the water entering the tank. As the pressure in the tank increases, the pressure of the water, which is fed from the tank into the distribution pipes, also increases.

Another important measure the hotel has undertaken is Xeriscape. This is a form of landscaping which makes use of plants like cacti which do not need much water. Xeriscape reduces water consumption, while enabling the hotel to maintain sprawling landscaped gardens.

The ITC Maurya has been recently awarded the 'Best Eco-friendly Hotel – Special Prize' by the Ministry of Tourism, Government of India.

Water and Energy Board Game

ITC Maurya has developed a stimulating energy and water game. This engaging game gives the important message of water and energy conservation, and has proven to be a big hit among children. The board game is available in all rooms of all Maurya properties along with a Ludo set.

Hydro-pneumatic water distribution system

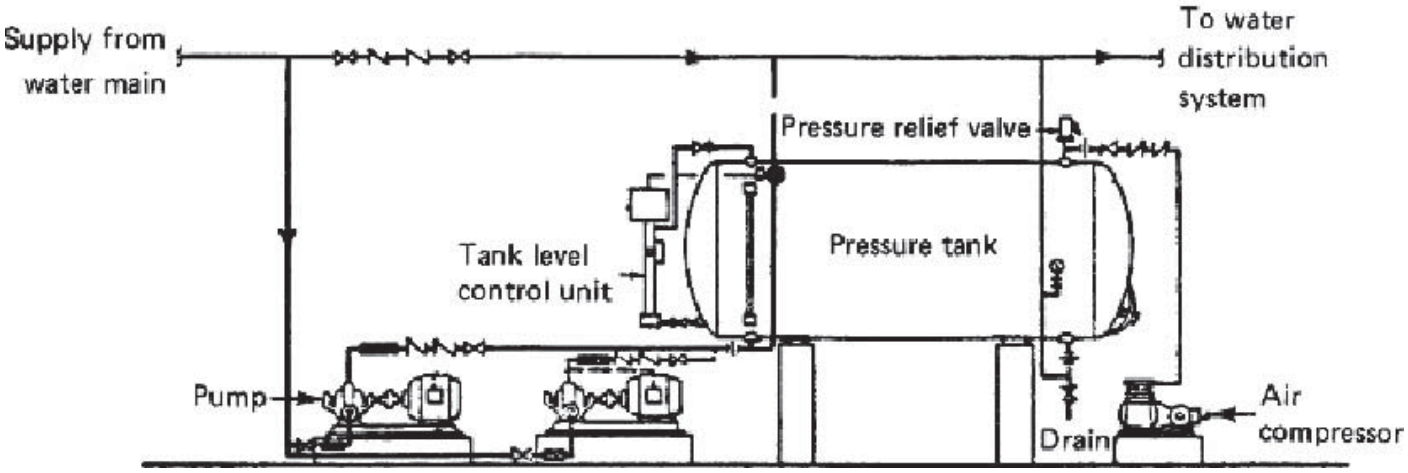


Figure 20: *[Source: http://www.itchotels.in/Hotels/itcmaurya.aspx]*

Water conservation measures
• Internal water audits are carried out to highlight high consumption areas and an action plan is formed to restrict the same
• In order to save pumping energy, the water line is bifurcated into lower head and higher head requirements
• Pressure reducing valves introduced in lines, which have low pressure requirements
• Flow restrictors/aerators are introduced in all guest rooms (washbasins & showers)
• Treated effluent discharged from ETP is utilised for horticultural purposes
• An innovative 'Snakes and Ladders' kind of a board game teaching simple ways to conserve water and energy kept in all rooms to encourage guests, especially children, to be sensitive to the use of natural resources.

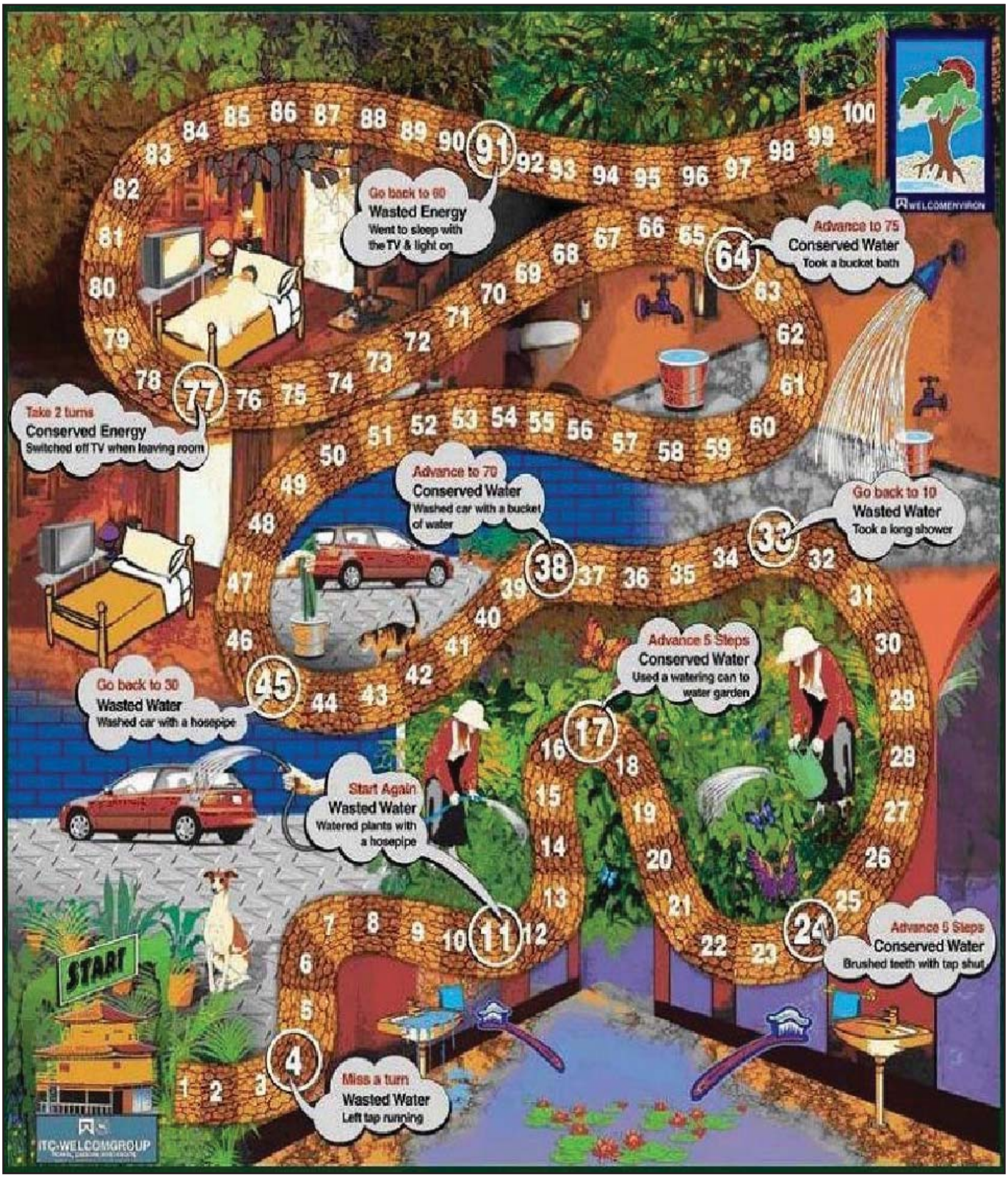


Figure 21: THE WATER AND ENERGY GAME (ABOVE) CAN BE FOUND IN ALL ITC MAURYA GUEST ROOMS.
[Source: http://www.itchotels.in/Hotels/itcmaurya.aspx]

9 CASE STUDY 5: GLEN CROFT HOUSING SOCIETY, POWAI, MUMBAI - AN ASIAN PAINTS CSR INITIATIVE

Adopting rainwater harvesting, this housing society in Powai's Hiranandani Gardens has ended the dependency of its residents on tanker water.

[CASE STUDY 5: RAINWATER HARVESTING AT GLEN CROFT HOUSING SOCIETY ~ AN ASIAN PAINTS CSR INITIATIVE]

Asian Paints, Asia's largest paints company, has built a total water management (TWM) Centre, at its Bhandup manufacturing facility, which is the first of its kind in the country. The TWM centre showcases live working models on water conservation and rainwater harvesting. For piloting the TWM concept, Asian Paints chose a high rise building – Glen Croft Co-operative Housing Society at Hiranandani Gardens, Powai. Shri Vikram Jaisinghani, Chairman, and Shri Farhan Thakur, Secretary, Glen Croft Housing Society, agreed to collaborate with them to implement a pilot scheme in Glen Croft.

An innovative and cost effective rainwater harvesting scheme was developed taking into consideration the existing infrastructure of the building. A number of options were worked upon and presentation was made by Shri Amit Doshi (Factory Manager) and Dr. Rajan Sharma (Executive – Environment) of Asian Paints to the society. The scheme was finalised and successfully implemented at Glen Croft Society by a private company, Azad Barish.

In this scheme, the top dome and terrace of the building have been used as catchment areas. The dome is the highest part of the high rise building (27 floors) and stands above the overhead water supply tanks. They have made arrangements to collect rain water from the dome and connecting it directly to the overhead tanks (flush and domestic water tanks). Since this scheme delivers water directly from the dome to the overhead water supply tanks, there is absolutely no requirement to pump water – it cascades off the dome and enters the tanks by force of gravity. This innovative scheme gives a tremendous added benefit of saving electricity along with water. The benefit of saving water and electricity ensures that, the cost of the apparatus is recovered in just one monsoon season and then is available for free. In addition, the rest of the terrace is used to collect rainwater taken through the existing down spouts (now extended using PVC water lines) to the underground flush water tank.

Glen Croft Housing Society has benefited from the scheme in this monsoon and not only has it reduced fresh water intake from BMC but it has also eliminated any dependency on the tanker water supply.

Asian Paints provides free consultation to citizens to implement rainwater harvesting and total water management solutions. The water management schemes could be designed in phases, so investments are not significant. Also a payback period can be determined for investments. Any society interested in implementing rain-water harvesting or other total water management solutions can contact Asian Paints for guidance.

[The cost benefit analysis for saving water and electricity makes certain that the investment is recovered in just one monsoon season.]

[CASE STUDY 5: RAINWATER HARVESTING AT GLEN CROFT HOUSING SOCIETY ~ AN ASIAN PAINTS CSR INITIATIVE]

What does the Asian Paints' total water management Centre do?

Total Water Management (TWM) is a method of inducing, collecting, storing and conserving roof top water runoff and local surface water runoff. It depends on end use application. The TWM centre is aimed at educating interested parties and provide them perspective on water issues. It helps people understand modalities of implementing various water conservation projects in buildings, structures and natural sources.

- Information on Water Supply systems
- Issues of Tanker Water Supply
- Methods and issues with storage of Water
- Issues and ideal process of Water Distribution
- Rain Water Harvesting (RWH)

By visiting the TWM centre all the above concepts can be understood with the help of following working models:

- RWH Model for High Rise Building
- RWH Model for Industrial complex
- RWH Model for Commercial Building
- RWH Model for Bungalows
- Tanker Water Model
- Water Collection and Pumping Model

Asian Paints also conducts guided tours of its TWM Centre at its Bhandup factory. The tour enables interested people to understand the various concepts of total water management. All you have to do is register at TWM by emailing your request to jal@asianpaints.com.

Source: Asian Paints website and personal interviews with residents of Glen Croft Society

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CASE STUDY 6: PUBLIC UTILITIES BOARD, SINGAPORE

From a scenario of severe water crisis in the 1960s, this city-state has emerged the world's most water efficient country. An ideal lesson in how strong political will can combine with meticulous planning and execution to bring about the desired transformation through sustainable best practices.

[CASE STUDY 6: PUBLIC UTILITIES BOARD, SINGAPORE]

After it obtained independence in 1965, Singapore faced the challenge of water scarcity and vulnerability. Limited land for catchments to collect and store sufficient rainwater and total absence of groundwater only compounded the problem, so much so, that the government had to impose severe rationing on water consumption. However, the country adopted an integrated and innovative approach to water management, which, together with careful planning and hard work of more than 40 years enabled it to overcome the water constraints and obtain sustainable and cost-effective water management solutions.

Today, its entire population enjoys access to modern sanitation and high-quality piped water on a 24-hour basis, 365-days-a-year. In recent years, Singapore succeeded in using innovation to enlarge its water supply, by turning used water and seawater into safe drinking water, in addition to adding reclaimed water and desalinated water into its inventory of water resources.

In particular, Singapore's achievement in reclaiming water (which is branded as NEWater) has made it stand out globally. The success of NEWater shows that high-quality reclaimed water can be produced for human consumption and non-domestic use. Singapore's used water technology could help solve the grave issue of lack of potable water faced by several countries around the world. Its experience with sustainable water management offers several lessons for other cities in Asia and otherwise.

The country's water utility, Public Utilities Board (PUB) Singapore, is owned by the government. The Singapore experience shows that a public-owned water utility can be as efficient as any well-managed corporate. PUB is an outstanding example

Singapore Government treats water as an issue of National Security.

Singapore's used water technology could help solve the grave issue of lack of potable water faced by several countries in the world. The BMC can greatly benefit from its experience.

of a successful public-owned utility that is efficient and has effectively tapped the expertise of the corporate sector to lower costs and improve the quality of its services.

Political and Government Commitment

The Government of Singapore treats water as an issue of National Security. Without high commitment from its leaders to put water and sanitation high on the country's agenda, Singapore would not have been able to make heavy investments in the infrastructure and technology needed to achieve sustainability in water supply, especially right after independence in 1965, when the country was still poor and had pressing economic, social and security development needs. Singapore's founding father, Prime Minister Mr. Lee Kuan Lew was instrumental in ensuring that the country overcame its vulnerability in water and achieved water sustainability.

At the same time, the Singapore government does not tolerate corruption. Anti-corruption regulations are strictly enforced in letter and spirit. This eliminates the problem of corruption in the water sector adversely affecting investments in water infrastructure and hampering efficiency and achievement in water management.

Integrated water management

Efficient water management requires close and efficient inter-agency cooperation, and the PUB works in close collaboration with the Urban Redevelopment Authority (URA), Singapore's national land use planning authority, in this regard. URA prepares long-term strategic plans and details local area plans,

for physical development. It then coordinates and guides efforts, among relevant public sector agencies such as PUB, to implement these plans. The result is that all public agencies in Singapore work collaboratively, with established communication regarding each other's works.

Singapore's approach to water management is integrated and holistic – from supply management (including catchment management), demand management (including water pricing and public education campaigns), waste water management, storm water management, R&D, outsourcing and Public Private Partnerships.

Supply management

The Four National Taps: PUB has diversified the country's water sources and established a long-term water supply strategy known as the Four National Taps, which comprise water from local catchments, imported water, reclaimed water and desalinated water.

Local catchments: In 2009, 60 percent of Singapore's land area was already used as water catchments. By using cutting-edge membrane technology, PUB aims to reclaim water from surface runoffs at fringe catchments around the island and this could further increase Singapore's water catchments from 60 percent to 90 percent of its land area. To ensure that water in the catchments is not polluted, the government has resettled all farms and squatters and relocated polluting industries away from these areas. Singapore has strict legislations to enforce heavy penalties against polluters. Besides, gross pollutant traps are installed in various locations (such as drains and canals) across the island to keep water resources clean by trapping debris and litter. Earth control measures, particularly for construction sites, are put in place to improve the quality of storm runoffs into waterways, minimizing the presence of silt in the water reservoirs after storms.

Imported water: Singapore meets 40 percent of its water needs through imported water from its immediate neighbour, Malaysia, as per two bilateral agreements. These agreements will expire in 2061, and they have not been extended beyond the expiry period.

Hence over the last decade, Singapore has been conscientiously tapping other sources of water to increase its water security after 2011. In particular, Singapore has stepped up efforts to produce more reclaimed water.

Reclaimed water: Since 1997, 100 percent of Singapore was served by a modern sanitation system. All used water is collected and treated. Singapore began to use advanced dual-membrane (micro-filtration and reverse osmosis) and ultra-violet technologies to produce reclaimed water (branded NEWater) on a commercial scale since 2003.

NEWater: Used water is purified and treated to drinking standards to form NEWater. A small amount of NEWater is pumped into reservoirs for indirect potable use – the NEWater is mixed with raw water in reservoirs to pick up essential minerals that the human body needs but it lacks due to its purity, before being further treated at the waterworks to become drinking quality water. The amount of NEWater introduced into raw water reservoirs constituted about one percent of Singapore's daily water consumption in 2004 and this will be progressively increased to 2.5 percent in 2011.

The bulk of NEWater is supplied to industrial and commercial customers for direct non-potable use such as water fabrication in the semiconductor sector, landscaping, fire sprinkler systems, and air-conditioner cooling towers. Since NEWater is purer than tap water it is ideal for use in industrial manufacturing processes that need ultra-pure water.

Changing the public perception: To enhance the public acceptance of NEWater, PUB placed strong emphasis on public education before launching the product in 2003. It embarked on an intensive, multi-lingual campaign that emphasised the high quality of NEWater. Advertisements, exhibits, leaflets, pamphlets and posters in Singapore's four official languages were used, explaining in simple terms how NEWater was produced. A documentary on the technology and experience of other countries in the use of reclaimed water was broadcast on the local and national television. Exhibitions of NEWater were held at community and school events. PUB conducted briefings and seminars for various stakeholder groups like the media,

community, political leaders and business and industrial leaders. PUB also established a NEWater Visitor Centre where people could learn about the product, its production process and its role in Singapore's water strategy through guided tours, exhibits, video shows, virtual guide and interactive games. PUB also distributed free samples of NEWater at the Visitor Centre and during community and national events so that the people could try out the product to help them overcome the psychological barrier towards consuming reclaimed water.

A product like NEWater could be potentially controversial due to its sources. But through a well-timed and properly-executed public education campaign that emphasized on NEWater's high quality and its use in other countries, Singapore effectively helped create positive perceptions among its people towards the product and succeeded in convincing them to accept recycled water as a source of potable water. Today, NEWater which is produced at its four plants meets 15 percent of Singapore's water needs. The first phase of the country's fifth and largest NEWater plant at Changi is already functional, and by end of the year, the plant will enable Singapore to serve 30 percent of its total water needs.

Public-Private Partnerships work well: Of the five NEWater plants, two of the largest were developed using the PPP approach. The design, construction, operation and maintenance of the two plants were undertaken by private parties, under Design-Build-Own-Operate agreements. This arrangement enabled PUB to leverage the expertise of the private sector to keep production capacity at the cutting-edge and at a low cost. This also allowed purchase of NEWater from the operator at a competitive price, enabling PUB to levy a lower-than-expected tariff for NEWater.

Singapore embarked on an intensive, multi-lingual campaign that emphasised on the high quality of NEWater. This well-timed and properly executed public education campaign effectively shaped perceptions among the people for NEWater.

Wastewater management: Wastewater management is an integral part of Singapore's water policy. Used water is collected through a network of underground sewers that leads to sewage treatment plants, which in Singapore, are known as Water Reclamation Plants (WRPs). This used water network is separate from the storm water collection system, where storm water and surface runoffs are collected in open drains and channeled into rivers and reservoirs. The separation of the systems prevent used water from polluting sources and waterways and stops storm water from entering the used water network and causing overflows.

Legislation and strict enforcement ensures that used water is properly managed and pollution is minimized. For instance, it is mandatory for all premises in Singapore to be connected to public sewers. Developers of housing and industrial estates have to incorporate a central used water facility to collect and convey used water into the public used water system. Proposals for development are scrutinised to ensure that they do not encroach upon the public used water system, averting a potential damage to it.

Used water is first treated according to international discharge standards at the WRPs. Much of the secondary-treated used water is then piped into the NEWater plants as feed water for the production of NEWater. Treated effluent that is not used is discharged into the sea.

Singapore has continued to evaluate the efficiency and cost effectiveness of its wastewater infrastructure. A Deep Tunnel Sewerage System (DTSS) was conceived as a long-term solution to meet Singapore's needs for used water collection, treatment and disposal through the 21st century. The first phase of DTSS was completed in 2008, and the second phase will be implemented over the next 20 years. As the DTSS will be made fully operational, Singapore will gradually phase out its WRPs. This will free the land occupied by WRPs and its pumping stations for other developments.

Besides, Singapore regularly rehabilitates aged and leaking public sewers to minimise incidence of sewer water contaminating canals, waterways and reservoirs.

Desalination: Desalinated water is the fourth source of water supply for Singapore. Constructed in 2005 at a cost of Singapore $200 million (approximately US $155 million), the SingSpring desalination plant was Singapore's first PP project, developed through a DBOO arrangement with a private company, to supply desalinated water to Singapore up to 20 years. The plant can produce 30 million gallons (135 MLD) of water per day, using the reverse osmosis process. However as desalination is costlier to Singapore than producing NEWater, the emphasis is more on enhancing NEWater production to meet the country's future water needs.

Singapore has just 4.4% UFW, which is the lowest in the world among countries having 24-hour fully pressurised municipal water supply.

Minimising Unaccounted for Water (UFW): Singapore has increased its water supply by cutting down on its UFW. The UFW rate declined from 9.5 percent of total water production in 1990 to just 4.4 percent, the lowest in the world. Singapore prohibits illegal connections and this is strictly enforced. PUB also reduces UFW by controlling the number of the leaks in its transmission and distribution network. PUB has banned the use of unlined cast iron and galvanised iron pipes since 1980, and much of the network is today constructed using high quality corrosion-resistant materials like copper, stainless steel and ductile iron. PUB has strict monitoring of its pipe-laying work to ensure that all its new pipelines are virtually 'watertight'. For its existing networks, Singapore has implemented the pipelines' replacement programmes to upgrade and renew the existing works. PUB has a comprehensive system that detects leaks, which helps to fix leaking pipes efficiently.

Demand management

In 1965, Singapore's population was 1.9 million and domestic demand for potable water was 75 LPCD. By 2008, the population had increased by about 2.5 times to 4.8 million, whereas domestic demand for potable water had increased by more than five times to 156 LPCD. Domestic consumption constituted 59 percent of the total consumption of potable water in 2008. In 1981 PUB established the Water Conservation Unit, which is responsible for managing water demand as well as promoting water conservation among the public and non-domestic consumers. It uses water pricing, mandatory requirements and public education to manage water demand. Due to such practices, domestic water consumption per capita per day declined steadily over the period 2005 to 2008. In 2008, residents of Singapore used 156 LPCD of water, which was 16 litres (or 9 percent) less a day than in 1995.

Water pricing: In Singapore, all connections are metered to precisely register water usage. Customers are billed for the actual water they consume. There is no free water in Singapore. Singapore's water tariff structure comprises a water tariff, Water Conservation Tax (WCT), sanitary appliance fee and waterborne fee. These tariffs effectively recover the full cost of water production and supply. The higher cost of water is justified given the scarcity of water and the resultant higher incremental costs of additional supplies like desalination – which is more expensive than using local catchment water as desalination is energy-intensive. While the water tariff goes to the PUB, the WCT is channeled into the government consolidated fund managed by the Finance Ministry, which is used to fund national water projects. As water tariffs reflect the true cost of water production, supply and treatment, revenue is ploughed back into R&D to identify innovative and more efficient ways of treating and distributing water and construct water supply sources to meet future demand.

In July 1997, the Singapore government progressively increased tariffs of potable water and the WCT over three years to reinforce upon domestic consumers the idea of water being a precious and strategic resource. 'Waterborne' fees were also raised to recover the cost of wastewater treatment and high cost of new sewerage facilities. The move was meant to avoid indirectly subsidising the usage of water. Water tariffs have remained unchanged since 2000.

[CASE STUDY 6: PUBLIC UTILITIES BOARD, SINGAPORE]

Singapore does not artificially lower the price of water across the board as a means to subsidise the poor, and thereby also avoids subsidising those who can actually afford to pay for their water consumption. Instead, the government provides direct and targeted financial assistance, in the form of 'Utilities Save' (U-Save) rebates to low income households. The amount of rebate that a household receives depends on the type of public housing that it resides in, with households living in smaller apartments receiving larger rebates. During the economic downturn in 2009, the Singapore government announced additional rebates giving the total rebate of Singapore $ 125 million to the poor households. Moreover, the low-income households receive help from the PUB in other ways. PUB has set aside Singapore $ 600,000 to implement a nation-wide programme from April 2009 to install water-saving devices in needy households with above-average water consumption, in order to help these families reduce water consumption and water bills.

Mandatory requirements: Since 1983, PUB has made it mandatory to install water-saving devices (such as constant flow regulators and self-closing delayed action taps) in all non-domestic premises and common amenities areas of all private high-rise residential apartments. Besides it limits the maximum allowable flow rates at water fittings for all domestic and non-domestic premises. In 2003, the maximum allowable flow rates were reduced by 25-33 percent.

Public education and water conservation programmes: PUB launched its first nation-wide "Water is precious" campaign in 1970. This campaign continued into the 1990s, and many more innovative programmes are being implemented even now. Some of the water conservation and public education initiatives introduced by PUB in recent years include:

There is no free water in Singapore. Instead of subsidies, the poor are offered direct and targeted financial assistance.

Water efficient homes: Launched in 2003, the water efficient homes programme was designed by PUB but run by organisations at the community level. PUB provided do-it-yourself water-saving kits free of charge for community organisations to distribute to all households across Singapore. It also set up mobile exhibitions to demonstrate to citizens on how to install water-saving devices and their benefits.

10-litre challenge: This programme was introduced in 2006 to encourage the citizens to reduce their daily water consumption by 10 litres.

Water efficiency labeling scheme: This scheme involves labelling products sold to inform consumers how water efficient they are, so that consumers can make informed choices before purchasing from them. From July 2009, it is mandatory for taps, flushing cisterns and urinals sold in Singapore to be labelled.

Friends of water programme and watermark awards: Implemented in 2006, Friends of Water aims to inculcate a greater sense of ownership among people to care for water. Watermark Awards, introduced in 2007, are given to 'Friends of Waters' who make significant contributions in water conservation, raising awareness about water issues and keeping Singapore's waterways clean.

Water efficiency fund: The fund encourages industries to try out water saving tactics and promote water conservation in the community. Corporations which have creative and innovative ideas on how to reduce water use could apply for financial support to carry out initiatives, such as doing feasibility studies, trials with new water-saving technology or implementation of community level water conservation campaigns.

10% challenge: The 10% Challenge was introduced in 2008 to challenge non domestic customers to improve water efficiency and reduce their monthly water consumption by 10 percent.

[CASE STUDY 6: PUBLIC UTILITIES BOARD, SINGAPORE]

Water reliability and water quality

Citizens in Singapore enjoy a reliable, 24-hour supply of potable water daily, throughout the year. PUB's water network is designed in loops with alternative feeds to its customers. This ensures that water supply remains intact even if one source is unavailable, as another source can be fed into the same network. It is safe to drink Singapore's water straight from the tap. More than 80,000 tests are conducted monthly, based on more than 290 parameters, surpassing the 130 tests specified by the United States Environmental Protection Agency and WHO. Independent checks are conducted by the National Environment Agency, a statutory board. In addition, PUB's management of water quality is reviewed twice a year by an independent external audit panel comprising foreign and local experts.

PUB requires building owners conducting works on pipes to engage licensed water service plumbers who must ensure that the water supply system is sterilised before being put back into service. Besides, town councils and management corporations of buildings are required to engage a licensed water service plumber at least once a year to inspect, and where necessary, to clean and disinfect water tanks and certify that the tanks are fit for drinking water storage. The plumber is required to submit his certification and water sample test reports to PUB, which then conducts spot checks and water sample testing to ensure that the tanks are properly maintained and that the plumber has not committed any foul play.

Human Resource Management

PUB has good HR policies. This is essential for utilities to attract, nurture and retain talent so that the utility has a capable staff to carry out its responsibilities. Staff salaries at PUB are benchmarked against the salaries of the Singapore Civil Services, which are in turn benchmarked against the remuneration packages of the private sector. In 2004, PUB moved from fixed salary structure to a performance-based structure that rewards better performers with higher incentives and bonuses. Promotions are based on work performance and potential, further motivating staff to perform. PUB has programmes to identify and develop employees' talents. It encourages its staff to further upgrade their skills through sponsorship of postgraduate studies, leadership programmes and other courses. It spends 4 percent of its annual payroll on training. Employees are also given exposure to best practices through challenging overseas knowledge exchanges to develop their potential. This has helped PUB in attracting and retaining talent; its present attrition rate is 1.2 percent compared to 11.9 percent in other public sector organisations in Singapore. To nurture the next generation of water leaders, PUB offers scholarships to students who have strong academic achievements and passion for the environment, to pursue higher studies in water-related and other relevant streams like Environmental Engineering and Economics.

Singapore conducts more than 80,000 water quality tests monthly based on 209 parameters, surpassing about 130 specified by the U.S. Environmental Protection Agency and the WHO.

Engaging the community

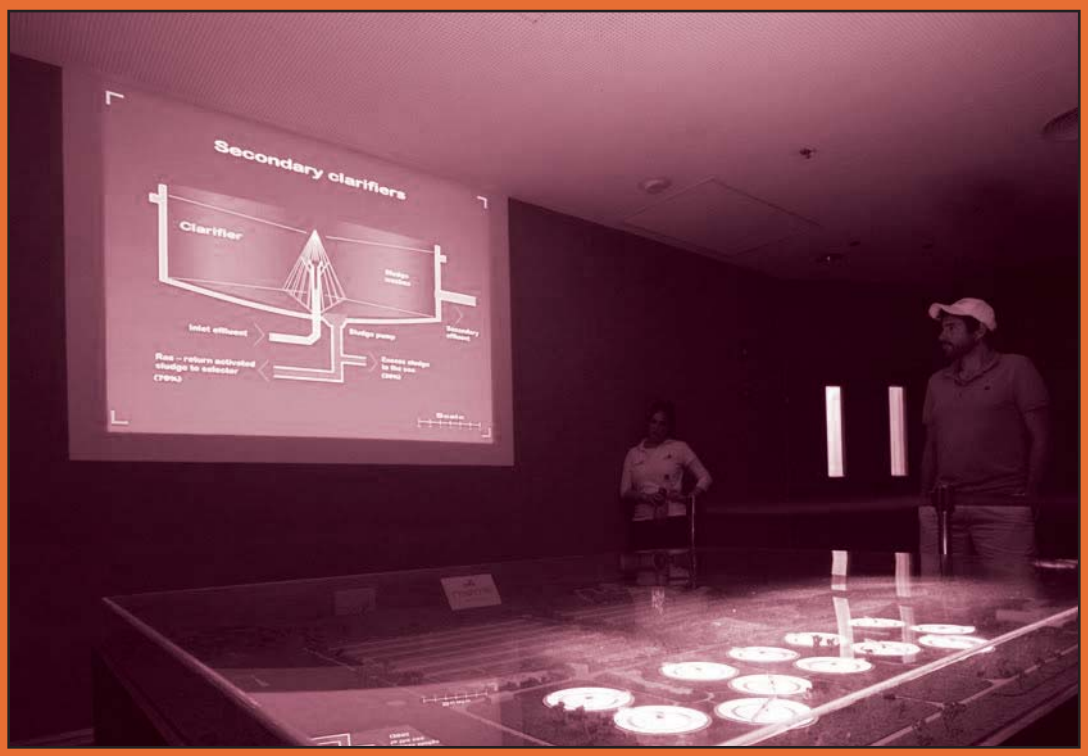
PUB has actively engaged the public to achieve its policy objectives. For instance, it implemented the Active, Beautiful and Clean (ABC) Waters Programme in 2006. The ABC programme, carried out in collaboration with the National Parks Board, aims to transform Singapore's reservoirs and waterways beyond their functional uses, into beautiful and clean streams, rivers and lakes, creating new community spaces for people to enjoy recreational activities. By bringing the public closer to water it creates a sense of ownership and helps people conserve and value water as they enjoy it.

Source: Reproduced from 'The Singapore Experience' paper submitted by Tan Dheon Kheong, Research Fellow at the Institute of Water Policy, Lee Kuan Yew School of Public Policy, at the Final Workshop on Good Practices for Urban Water Management in Asia, December 2009. For more information, please visit:

http://www.pub.gov.sg/Pages/default.aspx

http://www.pub.gov.sg/LongTermWaterPlans/index.html

http://www.pub.gov.sg/conserve/Pages/default.aspx



11 CASE STUDY 7: MEKOROT, ISRAEL

This semi-arid and desert-like country with very limited fresh water sources recycles 75% of all wastewater for irrigation. Mekorot provides 80% of the country's drinking water, the rest provided by operating some of world's most efficient desalination technologies.

[CASE STUDY 7: MEKOROT, ISRAEL]

Mekorot, in Hebrew, means source. Israel's national water company began operations as the "impossible dream" of Israel's pioneering leaders, a decade prior to the establishment of the state. Today, Mekorot is one of the world's most advanced water companies, a leader in water resource management, desalination, wastewater treatment and recycling, effluent reuse, rain enhancement, water quality, water security and project engineering.

Through continuous research, experimentation and field innovation, the company provides a reliable supply of high-quality water to a rapidly growing population, despite the region's limited freshwater resources, arid climate and difficult geographical and political realities.

Mekorot supplies 80 percent of Israel's drinking water and 70 percent of its entire water supply, operating 3,000 installations across the country. It recycles 75 percent of Irael's wastewater for irrigation, and the target is to increase recycling of wastewater to 95 percent.

Water resource management

Mekorot's expertise derives from decades of innovation in the face of severe challenges, including limited freshwater resources, climates ranging from semi-arid to desert, a rapidly growing population and difficult geopolitical realities. Mekorot has overcome these challenges by developing cutting-edge processes that have succeeded in maximising the utilisation of Israel's water resources, automating its treatment and delivering it efficiently to domestic, industrial and agricultural users.

Water Supply

Over a period of 70 years, Mekorot has implemented a range of novel systems and methods to supply water with high reliability and safety. Mekorot supplies water to approximately 5,000 intermediate water providers, including municipalities, regional associations, large agricultural settlements and bulk industrial consumers.

Water quality and security

Mekorot has established a nationwide, state-of-the-art network of water quality laboratories and sophisticated monitoring programmes. These services are outsourced to partners.

Desalination

One of the world's desalination pioneers, Mekorot today operates 31 desalination plants treating nearly a million cubic meters of seawater and brackish water every day. Its advanced R&D, experience and know-how have resulted in desalination plants with an impressive level of water economy and automation while reducing their energy consumption and membrane usage. These efficiencies have enabled Mekorot to achieve the world's lowest cost desalination technology. Its desalination expertise ranges from plant design, construction, project management, operations, training and maintenance.

Wastewater treatment and reclamation

The systems established by Mekorot have given Israel the world's highest water reclamation rate. The company's eight water purification plants treat 40 percent of all Israel's purified sewage water, and its nine reclamation plants enable 70 percent of the effluent to be reused for agriculture, freeing drinking water for domestic and industrial use.

Flow Catchment

Mekorot has developed innovative technologies for the capture of floodwater in desert regions.

Rain enhancement

Mekorot's proprietary cloud seeding technologies and programmes have succeeded in augmenting Israel's rainfall by approximately 13-18 percent annually.

Model-based operational planning

Mekorot has developed sophisticated mathematical models and (Supervisory Control And Data Acquisition) SCADA control systems that enable it to optimise the full range of its operations and planning activities.

Advanced engineering and infrastructure capabilities

Mekorot's engineering subsidiary, Electro-Mechanical Services (EMS), carries out major infrastructure projects such as Israel's flagship National Water Carrier and its state-of-the-art 5th Pipeline to Jerusalem. To share its expertise with companies around the world, Mekorot has established a professional services framework under which it provides planning, technological consultation, engineering, operation, maintenance, project management and implementation services. International partners that have benefited from these services include Siemens, FENTOS, CYII, Melbourne Water, Sydney Water, the Government of India, KIWA Research Institute and others.

Entrepreneurship

To extend its technological leadership and continuously improve the quality of the water it provides, Mekorot actively promotes the development of innovative new water technologies. Through its WaTech™ initiative, Mekorot provides entrepreneurs in all water-related business areas with platforms for beta and commercial testing and supports them with a broad range of technological analysis and consultation services. It also assists them in their efforts to reach out to global markets, strategic partners and capital. Nationwide, flexible systems of conduits and controls unify and enable mobility between Israel's main water basins (Sea of Galilee, mountain aquifer, coastal aquifer, local rivers, desalinated water and reclaimed water). "Smart" systems automate operations while allowing remote control of all facilities. Centralised monitoring and planning systems facilitate a "top-down" approach to planning, operation and development.

Mekorot has internally-developed modeling and management tools, including:

1. Management of water supply to Jerusalem and the Jordan Valley
2. Management of the central filtration system
3. Optimisation of water supply to desalination plants
4. Remote control pump specification tests
5. Optimal real-time models for operation of pumping stations

It has developed mathematical models for optimisation of complex operations including decision support systems:

1. Mathematical models for planning of water systems
2. Forecasting of Sea of Galilee levels
3. Hydrological models for optimal operations
4. Forecasting of weather and water demand
5. Hydrological research
6. Usage of SCADA control systems

Mekorot designed these tools and systems to address its environmental challenges like chronic water shortages and continuously rising demand, complex structure of local aquifers, multiple types of water resources, distance of water sources from demand centers and complex security issues, given the regional instability.

Israel's sources of potable water

- Surface water: From Sea of Galilee-Lake Kineret, approxi mately 30 percent of Israel's drinking water supply, 2.42 lakh million litres in 2006
- Ground water: Approximately 36 percent of the drinking water delivered by Mekorot; 7 lakh MLD pumped per day (coastal aquifer along the length of Israel's coastline; moun tain aquifer inland; ~2,800 wells). Pumping strictly controlled to prevent contamination by ingress of sea-water; recovery done via 150 recharge wells
- Natural springs: 34 percent of the drinking water supply
- Desalination: 31 plants with treatment capacity of about 1 million cu.m. (1000 MLD) per day.
- Reservoirs: A number of reservoirs are maintained for flood water collection and aquifer recharge. Most of these are located in South Israel.

Districts

Mekorot's water supply system is divided into Northern, Central and Southern Regions and Jordan district. A mechanical equipment unit serves all districts, constructing water infrastructure and other capital projects throughout the country. The Jordan district controls the operation of the National Water Carrier (NWC).

The National Water Carrier: Mekorot's Flagship Infrastructure Project

The NWC is a visionary infrastructure project that Mekorot constructed over a two-decade period in the 1950s and 1960s, with construction completed in 1964. A single water network linking most of the regional water projects throughout the country, the NWC is able to convey 4.5 lakh million litres water per year. The NWC was intended originally to supply irrigation water to the central and southern regions of Israel, but since the early 1990s has been supplying more than half of the country's drinking water. The concept behind the NWC was to combine Israel's three fresh water sources: the Sea of Galilee and its catchment basin, the mountain aquifer and the coastal aquifer to provide water to Israel's arid southern region.

In practice, the Sea of Galilee has become the NWC's primary natural reservoir, and provides water to Israel's dense population centers as well as to the South. In addition, the NWC water is used to recharge aquifers and groundwater to reduce the significant loss of water through evaporation of its surface reservoirs. The Sea of Galilee is a lake that covers 168 sq km and contains 4 billion cu.m. (4000 billion litres) water.

Figure 22: Map of water supply in Israel [*Source: Mekorot*]

[CASE STUDY 7: MEKOROT, ISRAEL]

It receives the majority of its water – approximately 5.2 lakh million litres – from the Jordan River. Total inflow from the lake's catchment basin is approximately 8.5 lakh million litres per year. Some 300 million cu.m. (3 lakh million litres) of water evaporate from the lake each year, and the remainder is available for pumping. Of this amount, approximately 400 million cu.m. (4 lakh million litres) per year is pumped into the NWC. The route of the NWC covers mountains, streams and rocky terrain, challenges that were overcome by digging tunnels and constructing inverted siphons. For 35 km of its route, the water travels through open canals. Water enters the NWC through a pipeline submerged in the Northern part of the lake, and flows to a pumping station. The pumping station, located in a mountain cavern, contains 30000 hp pumps that force the water into pressure pipes. The pressure pipes raise the water from 213 mt below sea level to 44 mt above sea level.

Construction and excavation of the giant station was one of the most complex tasks of the NWC project. The water is discharged into the 17 kilometer Jordan Canal, and from there into the Tsalmon Canal, an operational reservoir with a capacity of 1 lakh million litres. The Tsalmon Pumping Station lifts water another 115 meters into the 17 kilometer Beit Netofa canal, bringing it to the Eshkol reservoirs, which contains sludge removal, chlorination and water testing facilities. From this facility, water enters an 86-km-long pipeline to the Yarkon-Negev system at Rosh Ha'ayin. Part of the route includes several tunnels that are remarkable engineering feats. Several additional pumping stations have also been constructed to increase the capacity of the NWC and enable additional sources of water to be conveyed by the NWC from the Rishon Lezion area southward.

Key Components of Mekorot's Water Supply System

Annual water supply	1.5 billion cubic meters (70% of national consumption and 80% of drinking water) Wastewater reuse: 60% of treated wastewater Sewage treatment: 40% of overall sewage
Customers	4,800 municipalities, local councils, agricultural settlements, kibbutzim and regional associations, who in turn supply water to Israel's citizens, farmers and industries
Employees	2,150
Founded	1937
Ownership	Fully owned by the State of Israel
Financial information	Sales – more than US$700 million per year Shareholders' equity – US$ 500 million Balance sheet total – more than US$3 billion
Physical plant	Production and supply facilities: 3,000 Control centers: 8 Water pipes: 10,500 kilometers Desalination plants: 31 A 100 million cu m. a year seawater desalination plant is under construction in Ashdod that will be operational in 2011 Sewage treatment plants: 6 Reused wastewater projects: 10 Filtration plants: 8, including a 500 million cu. m. a year filtration plant at the Eshkol facility Pumping units: 1,822 Pumping stations: 659 Reservoirs: 91 Wells: 1,042 Tanks: 637 (500cu.m. and above) Reclamation projects: 10 Water quality laboratories: 6
Water testing	Water samples taken: 40,000 annually Laboratory analysis: 190,000 annually

[CASE STUDY 7: MEKOROT, ISRAEL]

The Saline Carrier was built by Mekorot in the 1960s to 'catch' the flow of saline springs flowing into the Sea of Galilee in order to lower its salinity. Rather than allow the saline water to enter the Sea of Galilee, the Saline Carrier carries it to the Jordan River at a point south of the lake, enabling it to flow into the Dead Sea. The Saline Carrier is 22 kilometers in length and conveys 22 million cu.m. (22,000 million litres) per year. Its usage has cut the salinity of the lake by half.

Additional steps taken to lower the NWC's salinity include diluting of the water in the carrier with well water, together with maintenance of an optimum level of the lake.

Significant energy is required to operate the NWC, primarily to lift the water from 209-213 mt below sea level to an elevation of 150 mt above sea level. In fact, the NWC consumes approximately 100 megawatts per hour, or 4 percent of all electricity produced in Israel. Savings in electrical consumption have been achieved by employing innovative technologies and by operating during minimum electricity tariff hours. To increase irrigation water available for the Negev, Mekorot established the Third Pipeline. The water for this pipeline is created through the treatment of effluents at the Dan Region treatment plant. The Third Pipeline carries 110 million cu.m. (11 lakh million litres) of water per year.

Highlights of Mekorot's flagships facilities:

- The Central Filtration Plant - one of the largest and most complex of its kind in the world. The plant comprises several systems designed to produce the highest quality water with an annual capacity of more than 500 million cu. m. (5 lakh million litres).
- The Dan Region Wastewater Treatment Plant (Shafdan) – the largest and most advanced of its type in the Middle East. Mekorot is responsible for the operation of this facility which treats about 130 million cu. m. (1.3 lakh million litres) of wastewater annually and guarantees a high quality effluent.
- The National Water Carrier - delivers fresh water from Israel's North, with its fairly abundant rainfall and water sources, to dry southern parts of the country. The National Water Carrier overcomes significant technical challenges, traversing a wide range of terrains and comprising a network of aqueducts, tunnels, reservoirs and pumping stations. It transports about 400 million cubic meters of water a year.

Israel's water achievements:

- Israel, with a 75 percent water recycling rate, is the world's No. 1 water recycler.
- Israeli-invented drip irrigation helped achieve 70-80 percent of water efficiency in agriculture – the highest rate in the world.
- Israel has achieved the highest ratio of crop yield per water unit.
- Israel is home to the world's largest Seawater Reverse Osmosis desalination plant, annually producing 100M cu.m. (1 lakh million litres) at a low cost of ~$0.65 per 1,000 litres of water – the most cost-efficient of its kind in the world.
- Israel creates 25 percent of its consumed water.
- Israel's total water consumption has remained the same since the 1960s, despite a growing population and rising water requirements.

Source: Haaretz newspaper reports and partly reproduced from Mekorot, Israel's National Company website: http://www.mekorot.co.il/eng/Pages/default.aspx

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CASE STUDY 8: SHANGHAI WATER CORPORATION, CHINA

Shanghai, China's commercial capital, is comparable to Mumbai in many ways, especially in terms of size and population. This once "pollution-induced water shortage city" is an example of sustainable water supply and demand management today.

[CASE STUDY 8: SHANGHAI WATER CORPORATION, CHINA]

Covering an area of 6340.5 square km, Shanghai is about 100 km wide from east to west and 120 km long from north to south. According to estimates, Shanghai's population is expected to reach 23 million when the census results are announced later this year. Of this 14 million comprise the registered population, while another 9 million is the floating population (about 2 million visitors on a short stay, and 7 million people who stayed in Shanghai for a minimum of 6 months at a stretch).

A recent news report in the China Daily, quoting statistics available with China's National Population and Family Planning Commission, has said that during the past decade, the city's population density has risen from 2,588 people for each square kilometer in 2000 to 3,600 for each sq km in 2010. The report also quoted experts warning that Shanghai should make population management a top priority, or else risk losing its ability for steady development.

Considering the severe pressure of a rapidly growing population on its public services and infrastructure, Shanghai faces a similar urban conundrum like Mumbai. However, the dream of converting Mumbai into a Shanghai seems like a pipedream when one compares the efficiency of the public infrastructure and services in these two of the world's most populous cities.

Actually, Mumbai seems to be Shanghai's poor cousin considering the tremendous progress made by Shanghai in terms of supplying 24x7 high pressure supply to all its citizens, by initiating bold steps towards both supply and demand side efficiency. The municipal government of Shanghai has even roped in a private player to manage and distribute water in the Pudong region, one of the world's major business hubs, which gets its water from the Pudong Veolia Water Supply Corporation (PVWC). Set up as a PPP joint venture, the PVWC works under the legal framework of the Shanghai Water Authority (SWA), which was created by the Chinese government in 2000 [A detailed note 'PPP in Pudong' on the PVWC, reproduced from a paper submitted by the company at the Expo Zaragoza, Spain, is given at the end of this section]. Interestingly, municipal governments in as many as 180 city municipalities across communist China have 'outsourced' their water distribution and management operations to private service providers.

Geographically, Shanghai has abundant water resources. It has two perennial main perennial sources: the Huangpu River and water from the Yangtze estuarine region. It also has five medium size sources: Jiading Shugou, Pudong Yanghe River, Nanhui Daye River, Chongming Nanheng River, Inner rivers.

However, according to SWA, due to human activities (living, industry and agriculture etc.), almost all surface water has been polluted in different degrees. The water quality, including that of Huangpu River, which is the city's main source, cannot meet the WHO drinking water quality standards. Besides, the deteriorating quality of water in Taihu Basin and the Yangtze River flowing through Shanghai, coupled with the heavy ingress of sea water upstream, has made the real source of water less and less consumable, causing Shanghai to be a "pollution-induced water shortage city".

Following a simple but effective model of decentralised water supply management, the Shanghai Water Authority governs four companies managing water services in its various zones. These companies are:

1. Shanghai Water Supply Shinan Co. Ltd.
2. Shanghai Water Supply Shebei Co. Ltd.
3. Shanghai Water Supply Minhang Co. Ltd.
4. Shanghai Pudong Veolia Water Supply Co. Ltd.

All the four zonal companies are directly responsible for all works including upgrading and maintenance of the water supply pipeline network, repairs, water service, meter installation, maintenance and reading, and billing and recovery. The companies have separate New Installation Service Development Centres which are responsible for all new connections.

Together, these four companies service a population of nearly 20 million with a daily supply of nearly 9000 MLD of water. With an average 24x7 water supply within a pressure range 98.31 percent to 99 percent, the total UFW recorded in Shanghai is to the tune of 18 percent.

The drainage operations, including sewage treatment, and related billing are managed and maintained by the Shanghai Urban Drainage Corporation. The Shanghai Water Supply Planning, Design and Research Institute is dedicated to blue line marking for river course and planning, and augmentation of water system and adjustment programmes for long-term planning, given the very rapid expansion of the city and its population. The institute is also engaged in all the public engagement and awareness programmes aimed at long-term sustainable water management.

Pricing of water

The pricing of water across all consumer types is fixed with the sole idea of covering the maximum operational cost incurred by the water utilities. As such, a domestic consumer in Shanghai, where the per capita consumption is 155 LPCD, pays nearly Rs. 20 for 1000 litres (2.8 Yuan per cubic meter) of

Map of areas of Shanghai covered by various water utilities

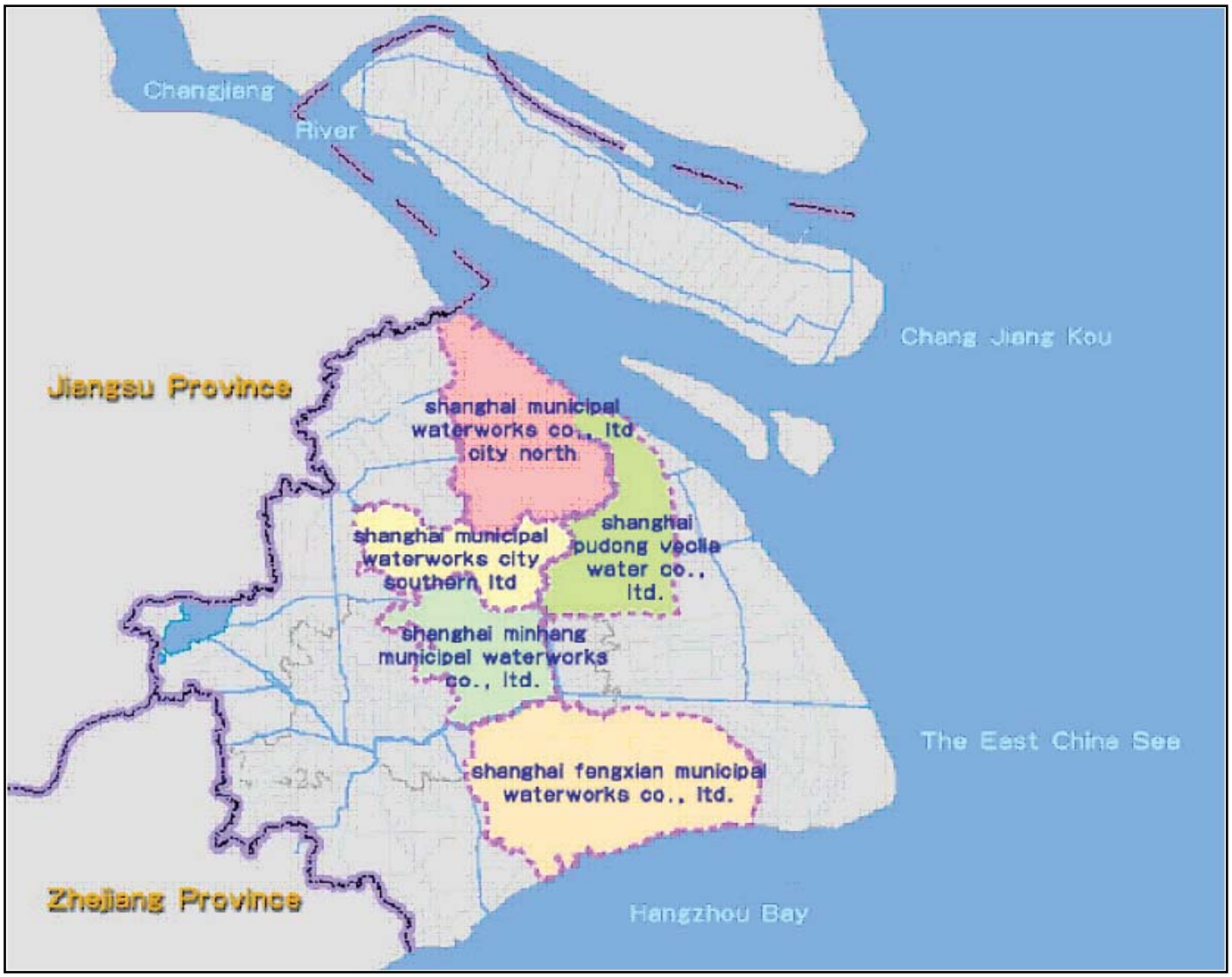

Figure 23: Map of water distribution in Shanghai *[Source: Shanghai Water Authority]*

water, with a slab-wise increase for higher use. This includes including 1.63 Yuan supply fee and another 1.3 Yuan as sewage treatment cost. In effect, a typical family of three (at 155 LPCD consumption) will incur a basic cost of around Rs. 300 per month for their water usage. Water for industrial and commercial use is charged within a price band of 5 Yuan to 16 Yuan per 1000 litres. High pricing of water has certainly driven the residents to value water and keep wastage to the minimum.

The city's water prices climbed to 2.30 Yuan from 1.84 yuan June 2009 and the second step of a water price adjustment plan which was approved by the Shanghai Development and Reform Commission, the city's top planning body, further increasing the price by 22 percent, was enforced in November 2010. The commission, along with the SWA, held a public hearing in April 2009 on the water price plan and decided to hike the price in two stages following claims by residents that the proposed increase was too high to be implemented in one go.

The drastic decision to enforce the price hikes was taken following huge losses reported by local water companies, which suffered a deficit of about 460 million yuan in 2009 and had already committed investments for future upgrading of the water services to put a collective additional cost burden of 552 million yuan till 2012.

Such pricing has contributed to better quality tap water for Shanghai residents with water companies being able to upgrade their facilities and services. A part of the revenue is also used to supplement the construction cost of the 17 billion yuan new reservoir, which will replace the Huangpu River as the city's the principle source of water in 2012.

PPP in Pudong

Pudong, one of the largest business districts in the world, is a fast growing new city with increasing demand for clean and safe drinking water. To effectively cater to the ever rising demand, the Shanghai Municipal Government entered into a 50-year Public-Private Partnership (PPP) with the Paris-based Veolia Water to draw up a full concession contract which came into effect in 2002. Through this contract, Veolia Water bagged a 50 percent stake in the Pudong Water Corporation, a state-owned company at that time. This was the first time that a private foreign water operator was roped in by China to manage its local water company.

The PVWC today serves a population of nearly 3 million spread over an area of 480 sq km having nearly one million water meters. The company has 1210 employees, manages six water treatment plants and eight pumping stations, maintains and upgrades a 3300 km pipe network and produces an average of 1500 MLD of water per day. The Shanghai Municipal Government is present in the joint venture via the Shanghai Chengtou Group, an infrastructure development, operations and investment group owned by the municipal government.

Best practices introduced from 2002-2008

In the first decade of the 21st Century, Pudong witnessed rapid expansion both in terms of infrastructure and population, which was effectively supplemented by an increased and efficient coverage of the water supply services.

	2002	2007	Increase
Service Area (sq km)	319	480	+50%
Network length (km)	1975	3300	+67%
No. of water meters	573000	970000	+69%
Population served (million)	1.8	3	+58%

[Source: Paper on Best Practices in Water Supply in Pudong, Shanghai, presented at Zaragoza Water Expo, 2008]

Water Quality

The establishment of the PVWC's Water Quality Center has continually reinforced water quality management and control and is now capable of testing more than 110 drinking water parameters. The company has made substantial investments into equipment and employees to upgrade the water treatment processes.

Its testing programme includes a provision of a minimum of 35 network points checked weekly; raw and treated water sampled and tested daily, and 80,000 random sample analyses performed per year.

Water production

New developments at the PVWC-managed Linjiang Water Treatment Plant represent the best of the company's forward-looking approach to water technology and treatment. In July 2006, the Linjiang Water Treatment Plant extended its water supply capacity of 400,000 cubic metres per day to 600,000 cubic metres with a plant extension equipped to meet the tightened regulations and growing demand in the Pudong New Area while achieving a significant reduction of land use, an important condition in the high-developing urban area of Shanghai.

As economic growth continues at a phenomenal pace in Shanghai, water demand is expected to grow six percent per year over the next 5-10 years. In order to ensure stable and reliable water supply to an increasing population, apart from the extension of Linjiang Water Treatment Plant, a new water treatment plant, Jinhai, in the center of Pudong District, has started providing an additional 400,000 cubic metres of water daily to the district in September 2010.

Network management

Development of the Pudong's pipeline network has been rapid over the last few years from 1750 km in 2002 to 3300 km in 2008. Most of the urban areas in Pudong district are now served by the PVWC.

To optimise the network and control NRW, the company has introduced a new state-of-the-art metering technology and set up management tools to maintain and repair the network. NRW level has been reduce to 27 percent in 2007 from more than 35 percent in 2002.

The company aims to reduce water losses by continuing a downward trend of at least two percent per year, to reach an efficiency target of 19 percent by 2012.

GIS, Hydraulic model and SCADA are among the tools used by the Control Center which help coordinate operations at the various water treatment plants and pumping stations to optimise the distribution system.

Network optimisation with Hydraulic Modeling

The PVWC completed a sophisticated hydraulic model of the pipeline network for its service area within 18 months from the start of the joint venture. The hydraulic model optimises the design of the network by simulating network conditions, providing operation parameters of the pipe network system (pressure, flow, quality) through analog operations.

Steady NRW reduction in Pudong

	2002	2003	2004	2005	2006	2007
Network efficiency (%)	65	66.5	67.1	68.2	70.2	72.5
Loss index (cu mt/ km/ day)	-	159.2	148.1	135.5	121.8	101.2

[Source: Paper on Best Practices in Water Supply in Pudong, Shanghai, presented at Zaragoza Water Expo, 2008]

This enables the company to verify the effectiveness of emergency handling operations by simulating model schemes beforehand. Based on information from the hydraulic model, pumping stations now optimize energy use, and operators carry out immediate and accurate reaction to emergencies and problems in the distribution system. Additionally the hydraulic model facilitates network zoning, validation of projects and helps identify influence areas.

GIS mapping

From more than 5,000 paper maps showing partial sections of the pipelines, PVWC has completely digitalised its GIS-based network maps, charting 3,300 km of pipelines and thousands of valves, fire hydrants and other special equipments. The work has been completed in less than 18 months, providing a powerful management tool. The maps are kept updated by a dedicated small team consisting of six draftsmen and two engineers.

Figure 23: REMOTE CONTROL… GIS maps of the utility pipes in PVWC's control room give real-time information and data.
[Source: Paper on Best Practises in Water Supply in Pudong, Shanghai, presented at Zaragoza Water Expo, 2008]

Pipelines and valve information, data on sensitive customers and relevant information are stored on the system and available for the operational staff. Water cut operations, in case of leaks and bursts are efficiently managed using this system, reducing intervention time. The company aims to improve response capability and be on the ground within two hours of identifying pipe breaks. The location of each valve and meter is identified precisely on the map helping to ensure efficiency of the repairing works as well minimizing water services damage or suspension in the case of emergency situations. To further improve assets management, a major step in progress is to categorise pipes into families, whereby types of pipes with higher risk of bursts can be monitored and handled effectively.

Customer service

The PVWC conducts comprehensive customer satisfaction surveys annually for all its industrial, commercial and residential consumers. Based on the analysis of these annual surveys, the company has devised action plans to improve areas of services in line with customer expectations.

Since January 2005 the company provides efficient communication services to its customers through the Customer Call Centre working 24 hours a day, 365 days a year. The centre links customers to the company through a sophisticated communication and service platform.

After-sales service management whereby information from the hotline is integrated into a complete profile for each customer

- Average waiting time: six seconds; less than one percent of lost calls
- Instant access to the billing system and database through an IVRS facility
- Automatic distribution and coordination of work orders to the relevant departments, work teams and customer service agencies, enabling efficient operational flow and reaction capacity to all kinds of customer needs
- Provision of an interface with a supportive information system in order to facilitate quick access of relevant information by the telephone operator, who is seamlessly connected to the Water Quality and Control Center to minimise response time.
- ATM and other network technologies used to transmit user repair report information to the relevant departments. Averaging 800 phones calls per day in 2008, the company aims to encourage more customers to make use of the services provided at the Customer Call Center.
- The PVWC also supports communications through emails, SMS, fax and post
- Call back procedure to ensure needs of customers are met and an annual audit of customer satisfaction.

Accounts management

As the number of large industrial and commercial customers has grown significantly over the years, the company has established an agency dedicated solely to serving the 6,000 big customers who although comprise less than one percent of total customers, represent almost 60 percent of the distribution volume. These key accounts enjoy specific services for professional needs such as consumption analysis, remote reading and alarms.

Human Resources

The PVWC's human resources strategy has been developed specially on the three axes of 1) health & safety, 2) training and 3) salary reform.

After 5 years, 2/3rd of the production capacity, all the pumping stations, network, customer service and pipeline works sections have been certified OHSAS 18.001 as the culmination of a process of continuous improvement in health and safety conditions for the employees.

Training has been a priority in the development process of the staff. Through the Competency Based Training approach, which is based on identifying training needs through competencies required for each position and identifying gaps between actual and required capability, an intense training programme has been gradually implemented. An average of 46 hours of training per employee each year, covering more than 90 percent of the employees has been achieved in 2006 and 2007 and it is the minimum target for next five years.

With the aim of encouraging individual, team and company performance, the salary system has been reformed as per a process jointly developed with the Labor Union and the structure of basic salaries, allowances, variable salaries, performance evaluation and procedures is regularly updated.

In spite of the increasing activity and service area, the number of employees has remained stable, with increased productivity because of training, technology and better organisation. Without lying off any employee, the staff profile has been gradually improving, even attracting a good number of young university graduates and technicians to make a career at the PVWC.

Community participation

The company has been actively involved with the local community. Specially focused on environmental education, numerous activities are organized around subjects like water resources and environmental protection. School visits to the facilities, cooperation with local universities and exchange with the communities about a wide range of water issues allows the company to be in contact with its consumers and contribute to general environmental awareness.

Innovation is promoted at all levels of the company through "Golden Ideas" awards, and several research cooperation agreements with local universities. Subjects like water treatment optimisation, health and safety equipments, and energy savings have been the focus of such research projects.

Sources: Various newspaper reports in The Shanghai Daily, Shanghai Water Authority, Veolia Water Company, Pudong Veolia Water Corporation, Paper on Best Practices in Water Supply in Shanghai, presented at Zaragoza Water Expo, 2008.

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APPENDIX 1: KEY OBSERVATIONS AND RECOMMENDATIONS OF CHITALE COMMITTEE REPORT, 1994

The Expert Committee under the chairmanship of Dr. Madhavrao A. Chitale submitted its findings and recommendations in December 1994. Seventeen years later, most of the recommendations are gathering dust.

APPENDIX 1: KEY OBSERVATIONS AND RECOMMENDATIONS OF CHITALE COMMITTEE REPORT, 1994

Chitale Committee Report, December 1994

Dr. Madhavrao Chitale

Normally in Mumbai, the monsoon sets in around June and lasts till September. In the four monsoon months, various catchment areas around the city get their annual water quota replenished, and the lakes which supply water to the city start overflowing. However, in 1992, the rains played truant resulting in rapid and sharp depletion of water levels in the lakes leading to a water crisis in Mumbai. Just like in 2009, the situation in 1992 caused a panic. The BMC imposed severe water supply cuts. Concerned at growing public outcry, the state government appointed an expert committee under the chairmanship of Dr. Madhavrao Chitale, Secretary General, International Commission on Irrigation and Drainage.

The expert committee report, which came to be known as the Chitale Committee Report, recommended several measures to fulfill all the water requirement of the city till 2021. One of the most comprehensive studies ever on Mumbai till date, this report has set the benchmark for all future water planning by the state government and the BMC. Had the BMC and the state government acted with due urgency on these recommendations, Mumbai would not be facing the present water problems.

Presented below briefly are the key observations, conclusions and recommendations made by the Chitale Committee in December 1994.

Observations

• Mumbai's water supply system is mostly demand driven and no efforts have been made for demand management as such. As future sources of water are going to be relatively costlier, conscious efforts need to be made to satisfy the demand.

• Though the waste water disposal system was in existence in Mumbai for nearly a century, it was not updated to take care of the additional water being received through water source augmentation schemes. Priority was given for augmentation of water sources, whereas disposal of waste water was not attended to on a systematic basis. Even on the organisation side, there has not yet been any integration of these two activities.

• The BMC's perspective being limited to city's water supply, it only concentrates on source development for the city. Regional and multi-purpose development of these sources were not thought of. In view of the increasing demand of water for local needs in Mumbai's neighbouring zones it is necessary to have an integrated regional approach. This will help more balanced growth of the entire region.

• The BMC must undertake a review of the expected demand and actual supply of water every 10 years and take corrective steps, if necessary, well in time.

• Incremental improvements to the distribution system according to the changing patterns of demand have taken place in an ad hoc manner. A systematic distribution improvement scheme will have to be drawn up and pursued as a separate project by itself to bring the full benefits of the additional supply of water to the city's residents.

Key Recommendations:

• **Source augmentation:** The sources of Middle Vaitarna (potential 455 MLD), Gargai (potential 455 MLD), Pinjal (potential 800 MLD), Kalu (potential 590 MLD) and Shai (potential of 1000 MLD) were identified for Mumbai. As per the recommended timeframe of the projects, the Middle Vaitarna should have been completed in 2003 and Gargai in 2009. However, the Middle Vaitarna project is now likely to be commissioned in 2013, while the Gargai site is being evaluated for scientific and technical feasibility.

[APPENDIX 1: KEY OBSERVATIONS AND RECOMMENDATIONS OF CHITALE COMMITTEE REPORT, 1994]

• **Alternative sources:** The committee also recommended exploring the possibility of groundwater use, reuse and recycling of waste water, evaporation control and intensive and sustained leak detection and prevention measures. If these can be attained by 2021, the present dependency on surface water sources will reduce, and the surplus water could be used for future contingency years, when the monsoon fails.

• **Groundwater:** As the available groundwater in Mumbai may not be fit for human consumption, it must be systematically harnessed for the purposes of construction work, watering lawns and parks and flushing. In 1994, the committee had estimated a cost of Rs. 2 crore only for developing groundwater as a source to its full potential.

• **Leak detection and prevention:** It will not be unreasonable to expect that a minimum reduction of 13 percent in UFW (assuming the 1994 level of UFW of 25 percent) would be achieved over the next 30 years if a systematic leak prevention programme is taken up seriously. The present setup of departmental leak detection needs to be strengthened and staff should be suitably incentivised against the quantum of water saved through their efforts.

• **Recycling:** A reduction of just 15 percent fresh water intake by industries and commercial establishments by resorting to water recycling could mean a reduction in their demand by about 100 MLD, which would amount to 2.7 percent of the expected demand in the year 2021. For domestic waste water recycling, the BMC must set a target of meeting at least 2 percent of the demand in 2021 through just this measure. The necessary incentives to adopt recycling and reuse of water for domestic consumption need to be introduced without any delay.

• **Management setup:** There is a need for a separate central planning, design and monitoring authority which must be in charge of both Water Supply and Sewerage Disposal wings. The BMC must also establish a Dam Safety Cell. Young engineers from the BMC must be encouraged and incentivised to take up advanced geo-hydrological courses to understand the groundwater potential in Mumbai. The BMC must have a recruitment plan to attract bright youngsters to the department.

• **Citizens' involvement:** The BMC must begin creating awareness among the citizens about the high cost of water and encourage their involvement in water management to reduce demand. The BMC must publish an annual report of its water supply and sewage disposal and set aside a week every year in the months of April or May to organise public meetings in every ward in order to explain different ways for water conservation. The BMC must spare at least 0.5 percent of its budget for future projects and 1 percent of its budget for operations and maintenance and for public awareness and education campaigns. An enlightened citizenship is the main anchor of any demand management exercise, and hence the need for adequate attention to the relevant measures.

14 APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS

Models of autonomous water boards have been working with varying degrees of success in several cities in India.

[APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS]

Office organisation and distribution of work:

The Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), an independent institution, was constituted vide a government order issued by the Rural Development and Local Administration Department in 1975. The CMWSS Act was notified and the provisions of the Act were brought into force in 1978. The Board is attending to the growing needs of and for planned development and appropriate regulation of water supply and sewerage services in the Chennai metropolitan area with particular reference to the protection of public health and for all matters connected therewith.

Under Section 20 of the CMWSSB Act, an employee of any local authority, i.e. Chennai Municipal Corporation, Ground Water Division of the Public Works Department, Tamil Nadu Water Supply and Drainage Board, in Chennai Metropolitan Area who is serving in connection with Water Supply and Sewerage System may be transferred to the services of the Board. Accordingly, persons who were working in the local authority were transferred and absorbed in this Board.

The administration of Chennai Metropolitan Water Supply and Sewerage Board is governed by the Board of Directors, headed by the Managing Director (MD). The policies and directions of the Board are carried out through the MD. The MD is the chief executive authority of the Board who is a Grade I Officer and is in charge of the day to day administration of the Board and exercises supervision and control over the employees of the Board. The MD is assisted by the following Heads of Department:

- Executive Director
- Finance Director
- Engineering Director
- Four Chief Engineers having different functions
- General Manager

Functions of the key departments of the Board:

The Materials Department: Executive Director is an IAS Officer and he is also a whole-time Director and member of all Statutory Committees in the board and the Executive Director is in charge of the Materials Department and Contracts and Monitoring Wing. All purchases, inventory control, disposal etc. are being attended to by Materials Department and all contracts are settled by C&M Wing. The Executive Director is assisted by a Superintending Engineer in the C&M Wing and by Purchase Manager and Inventory Control Manager in the Materials Department. The Data Processing Manager (Grade IV) functions directly under the control of Executive Director and he assists Executive Director in computing the financial data and feeding the analysis of the Board.

Finance Department: The Finance Director is the head of this department. This department is responsible for financial administration and matters relating to finance and audit. This department carries out works like preparation of budget and budgetary control, collection of revenue, payroll particulars of all staff, analysis of cost etc. The Finance Director is assisted by the Chief Controller of Finance & Controller of Finance.

The Internal Auditor functions directly under the control of Finance Director and assists him in conducting Internal Audit and settlement of audit objections.

APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS

Engineering Department: Engineering Director is the Head of the Department who is a Grade II Officer. The Engineering Director is in charge of P&D Wing and Training and Data Centre. The Engineering Director is assisted by one Superintending Engineer and one Director (all Grade III Officers) each in P&D Wing and T&D Centre. The Construction Water Supply Wing is headed by a Chief Engineer and he is assisted by two Superintending Engineers. The Chennai City River Conservation Project is headed by a Chief Engineer and he is assisted by one Superintending Engineer.

The Construction Sewerage Wing is headed by a Chief Engineer and he is assisted by two Superintending Engineers.

Operation & Maintenance Wing: The Chief Engineer (O&M) is the Head of this Department who is a Grade II Officer and is in charge for Water Resources, Supply transmission, Street mains, new services, Leak surveys, Pumping Station maintenance, Sewerage collection and disposals of Street sewers, sewer blocks etc. The C.E (O&M) is assisted by 5 SEs and a Hydro-geologist. The Eleven Area Engineers who are in charge of Water Supply and Sewerage disposal for entire city and PRH Engineer and Well Field Engineer are working under the control of 4 SEs who assists the C.E.(O&M).

Personnel & Administration Department: This Department is headed by General Manager who is also the Secretary to the Board. He is a Grade III Officer. A District Revenue Officer is holding the post.

The P&A Department is responsible for the following functions.

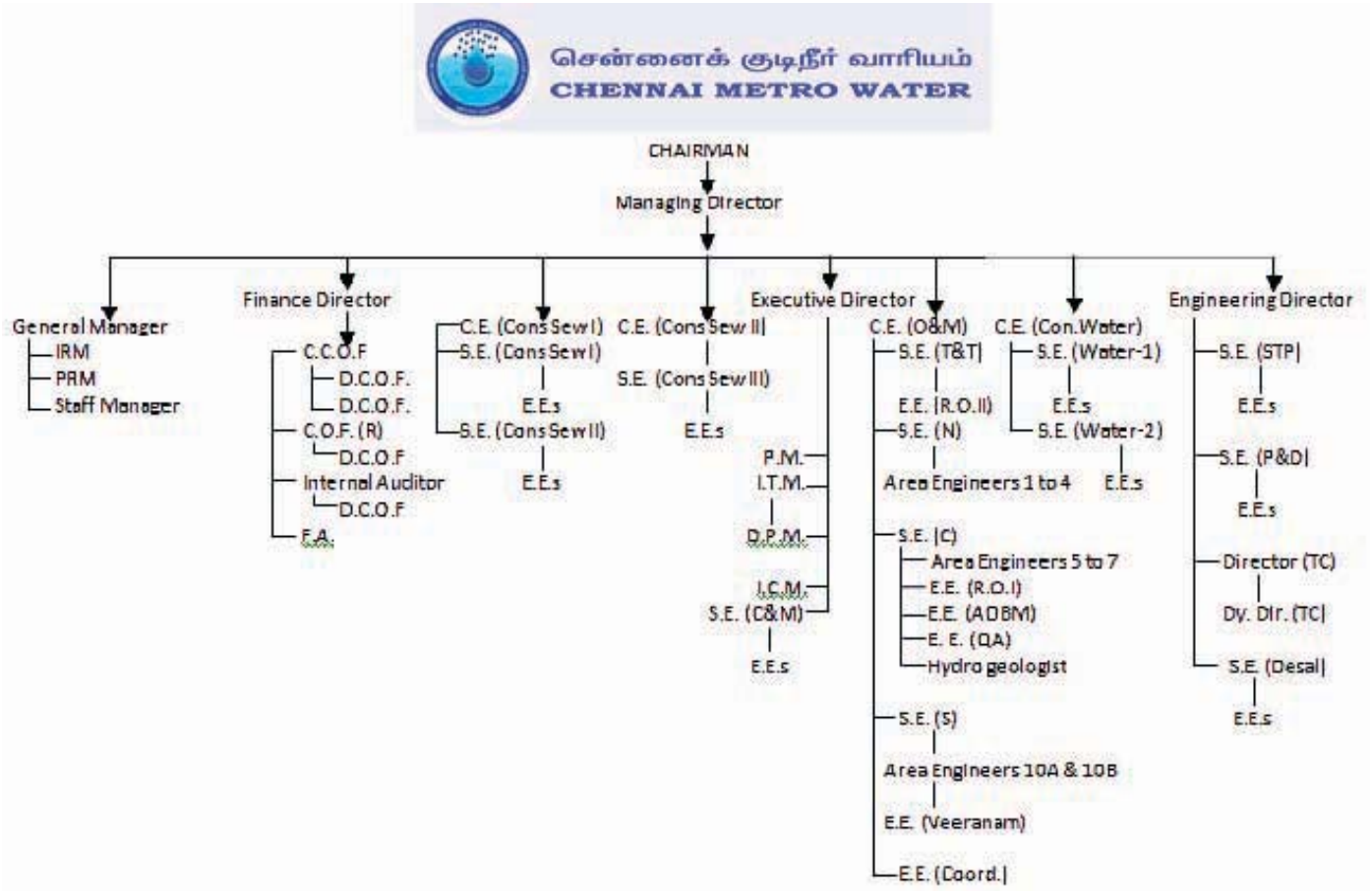
- Recruitment of personnel for various services under the board
- Employees records, disciplinary proceedings etc.
- Man power development
- Industrial relations
- Public relations
- Office services
- Legal matters

The General Manager is assisted by the Public Relations Manager, Deputy General Manager, Staff Manager and Standing Legal Adviser.

There is a separate legal cell to deal with the court cases. This cell is directly under the control of General Manager.

Training and Data Centre: This centre is headed by Director, Training Centre, who is the Member Secretary of the Governing Council. The Director functions under the control of Engineering Director. He is assisted by a Deputy Director of the centre. The centre conducts various refresher training classes for the Board employees and also for the employees of other government departments sponsored by CPHEEO, Government of India.

[APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS]



Abbreviations:

C.E.: Chief Engineer
C.C.O.F.: Chief Controller of Finance
C.O.F. (R): Controller of Finance (Revenue)
F.A.: Financial Analyst
S.E.: Superintending Engineer
I.R.M.: Industrial Relations Manager
I.T.M.: Information Technology Manager
D. P. M.: Date Processing Manager
D.C.O.F.: Deputy Controller of Finance
I.A.: Internal Auditor
P.M.: Purchase Manager
I.C.M.: Inventory Control Manager
E.E.: Executive Engineer
R.O. (I): Regional Office I
R.O. (II): Regional Office II
S.E. (P&D): Superintending Engineer (Planning & Design)
Dy. Dir.: Deputy Director
TC: Training Centre
O&M: Operation and Maintenance
T&T: Treatment and Transmission
S: South
N: North
C: Central
STP: Sewage Treatment Plant
Sew: Sewerage
Desal: Desalination
AOBM: Administration Office Building Maintenance
QA: Quality Assurance

APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS

Delhi Jal Board

The Delhi Jal Board (DJB) was constituted through an Act of the Delhi Legislative Assembly on 6th April 1998. It has been meeting the needs of potable water in the National Capital Region of Delhi for more than five decades. The DJB has been able to supply pure and wholesome filtered water to the capital city of India which has grown phenomenally to the present population of more than 160 lakh.

The DJB is responsible for the production and distribution of potable water after treating raw water from various sources like the river Yamuna, Bhakhra storage, Upper Ganga canal and groundwater and also provides treatment and disposal of waste water. It provides water in bulk to the New Delhi Municipal Corporation (NDMC) and Cantonment areas. Sewage from these areas is also collected for treatment and disposal by DJB.

The DJB is committed to the augmentation of water supply in Delhi and has taken many steps towards this goal. It has ensured average availability of 50 gallons (225 litres) per capita per day of filtered water through an efficient network of water treatment plants, booster pumping stations and about 9000 km of water mains and distribution system.

Supply of potable/ filtered water

The installed capacity of Water Treatment Plants is 631 million gallons per day (≈ 2839 MLD) and by optimisation through Tubewells, Ranney Wells etc., about 3061 MLD potable water is being supplied by the DJB. It is expected that by the end of the 11th Five Year Plan i.e. 2011 water requirement in Delhi shall be 3745 MLD.

The DJB is committed to augmentation of water supply in Delhi and has taken many steps in this direction. The 40 MGD (≈ 180 MLD) water treatment plant at Nangloi has been commissioned. The work of construction of 20 MGD (≈ 90 MLD) water treatment plant at Bawana is in the final stage of completion. The work for construction of 140 MGD (≈ 630 MLD) water treatment plant at Sonia Vihar in trans-Yamuna Area has started and is likely to be completed within two years. Simultaneously, UP Jal Nigam has also started the work of laying a raw water conduit from Murad Nagar to Sonia Vihar. On completion and commissioning of these water treatment plants the filtered water supply in Delhi will improve.

With a view to rationalise the distribution of water the DJB has drawn up an elaborate plan for construction of Under Ground Reservoirs and Booster Pumping Stations (UGR/ BPS). During the year 2001 the UGR/ BPS at Dakshin Puri, Farid Puri, Shadi Pur, Mangol Puri and Chittaranjan Park have been completed and commissioned. The work on 13 underground reservoirs and booster pumping stations is in progress.

Initiatives in the field of water conservation

The DJB is active in the field of water conservation and has a separate Leak Detection Cell for detecting leakages in the system. A special campaign for public awareness on water conservation has also been successfully implemented through extensive media coverage. Special stress has been laid on replacement of old water lines and during the year about 208 km of old eroded water lines have been replaced in different parts of Delhi.

[APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS]

Rapid urbanisation has put tremendous pressure on the existing civic services including supply of drinking water in Delhi. This has resulted in a drastic decrease of the ground water table in Delhi. This could be avoided through a simple, economical and eco-friendly method of rainwater harvesting. The DJB has decided to implement rainwater harvesting schemes in all its buildings / installations including the DJB Headquarters at Karol Bagh. In addition, Resident Welfare Associations (RWAs) are also being in its implementation.

Bhagidari Scheme is being implemented by the DJB in which more than 100 RWAs are actively participating. The scheme covers the following subjects:

1. Rain water harvesting
2. Distribution of water through tankers.
3. Replacement of old /leaking service pipes.
4. Water bill payment and collection.
5. Curbing wastage of water.

Quality Assurance

Water supplied by the DJB conforms to the standards laid down by the Urban Development Ministry, Government of India. Quality assurance measures are taken right from the raw water stage up to the consumers' end. The water supplied from ranney wells and tube wells is also tested regularly. Water samples are collected daily from the distribution system i.e. individual taps and public hydrants etc. located in different parts of the city to ensure that safe drinking water reaches the consumers. Efforts are also being made to achieve ISO 9002 certification for which the DJB is in touch with Bureau of India Standards. In order to avoid contamination of water due to service lines passing through drain sewers, 10789 cases were identified and notices were issued to consumers for shifting their water lines. 3687 such connections were removed and 4899 consumers shifted their service lines themselves.

Treatment and disposal of waste water

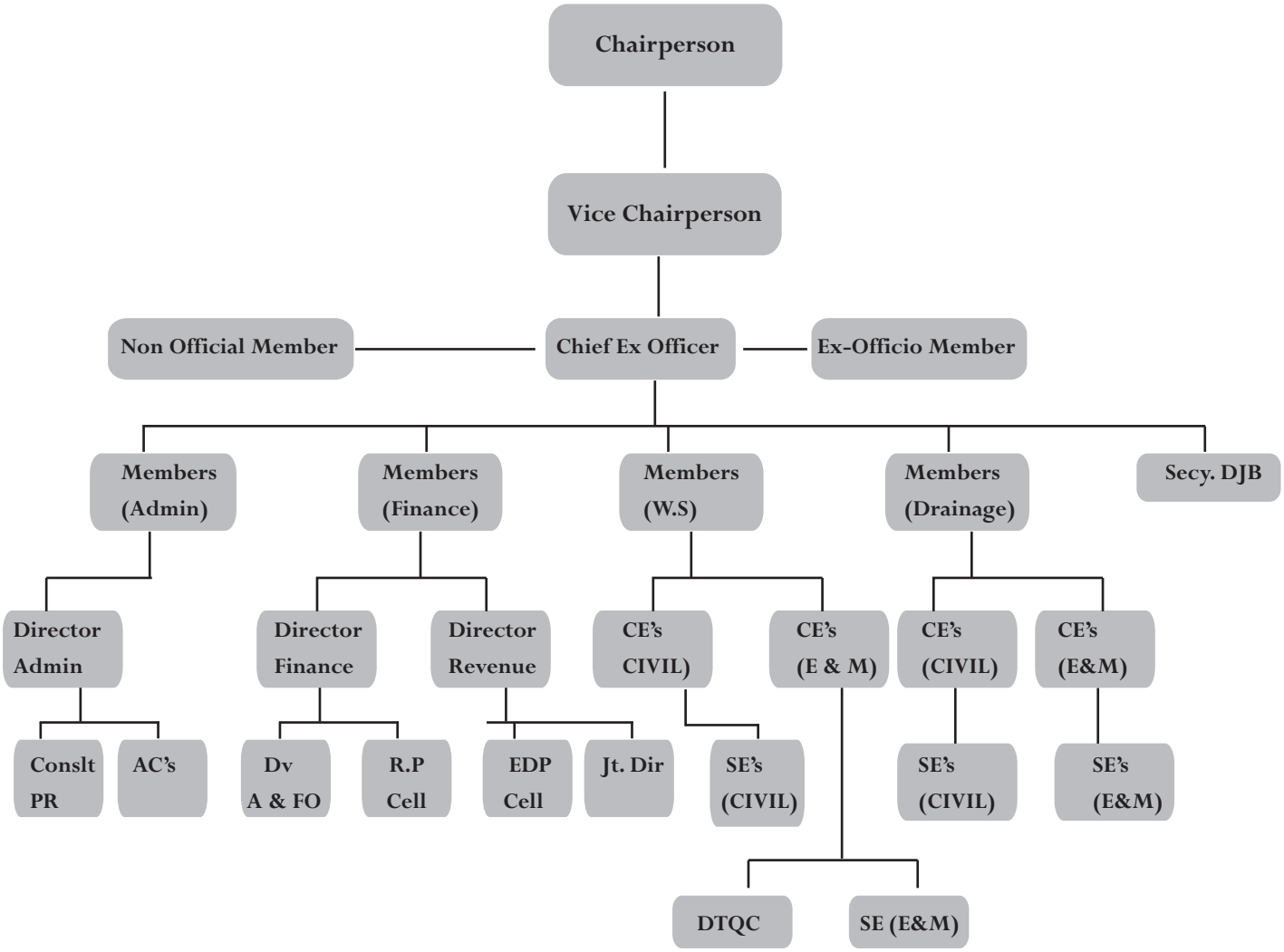
The DJB is responsible for treatment and disposal of waste water through a network of about 5600 km of internal, peripheral and trunk-sewers. The capacity of STP has been raised from 376.4 MGD (1700 MLD) to 402.4 MGD (1810 MLD) during the year 2000-2001. This capacity is further proposed to be increased to 512.4 MGD (2300 MLD). Out of 17 STPs under construction the work on 12 has been completed and the work on the remaining 5 STPs is under progress. The DJB has provided sewage facilities in all the approved colonies. Out of 567 unauthorised / regularised colonies, 414 colonies have been provided with sewage system and we have laid sewer lines in all re-settlement colonies. Sewer lines have also been laid in 93 urban villages.

Sources of Revenue

1. Water charges
2. Scavenging tax
3. Gas charges and
4. Development charges

Through strenuous efforts and dedication of the staff the DJB has been able to achieve substantial increase in the collection of revenue over the years. The revenue collection was Rs. 21162.41 Lakh in 2000-2001. Delhi Jal Board has provided about 13.47 lakh water connections across the city till 1st April 2001.

APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS



[APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS]

Bangalore Water Supply and Sewerage Board (BWSSB)

The Bangalore Water Supply and Sewerage Board (BWSSB) was constituted under the act of the Karnataka state legislature by notification no. PLM/15/MNY/64 dated 30th September 1964 and the board came into existence on 2nd October 1964. With the formation of the Board the entire system of water supply was transferred to the board on 1st December 1964 and sanitation on 21st December 1964.

The Organisation:

The chairman and other six members of the Board are appointed by the state government. The members selected are usually among persons having in depth experience in administration, public health engineering, accounts, commercial and financial matters connected with public utility undertakings preferably pertaining to drinking water management and disposal of waste water undertakings.

Prior to the formation of the Board, the task of providing water supply to the city was with the Bangalore City Corporation in the Cantonment area and Public Works Department (PWD) in the city area. The cost of maintenance was charged to the corporation which was purchasing the water in bulk from the PWD. The head works was under the control of PWD. From 14th August 1961 the entire distribution system except the head works was transferred to BCC for its maintenance.

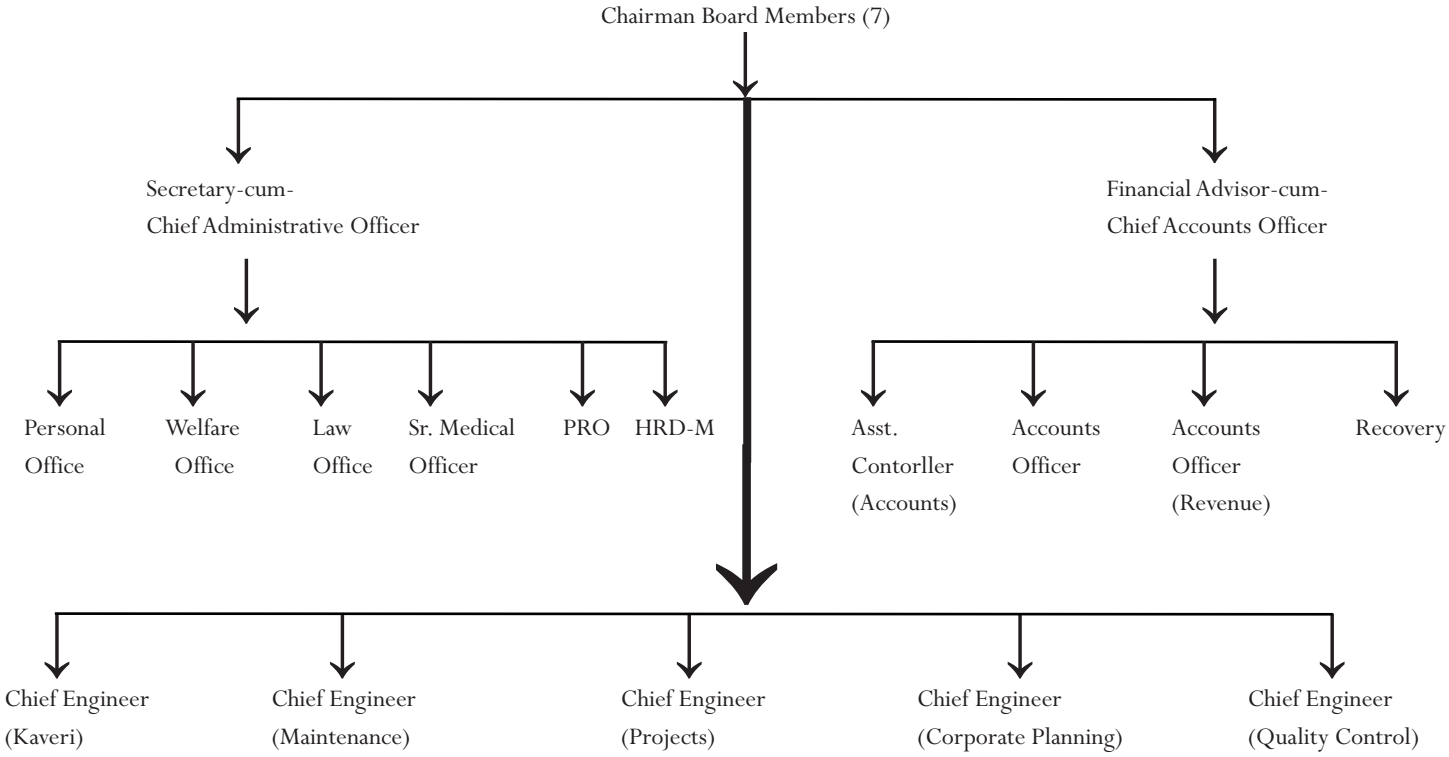
A World Bank team which came for first hand appraisal of the project insisted upon the need for creating an autonomous Board for handling the Cauvery Water Supply Scheme on commercial lines which was accepted by the Government.

Key functions of the Board

1. Investigating adequacy of water supply for domestic purpose in Bangalore Metropolitan area.
2. Preparation and implementation of plans and schemes for supply of water for domestic purposes within the Bangalore Metropolitan area to the required standards.
3. Preparation and implementation of plans and schemes for proper sewerage and disposal of sewage of the Bangalore Metropolitan area.
4. Levy & collection of water charges on "no loss no profit basis."

APPENDIX 2: BRIEF DETAILS OF COMPOSITION OF CHENNAI, DELHI AND BANGALORE WATER BOARDS

BANGALORE WATER SUPPLY AND SEWERAGE BOARD



• Each of the Chief Engineers is assisted in various works by Assistant Chief Engineers, who supervise the Excutive Engineers, who in turn, are superior to the zonal Assistant Engineers.

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APPENDIX 3: SAMPLE QUESTIONNAIRES FOR CONSUMPTION PATTERN SURVEY

It is imperative for the BMC to precisely know how much water it supplies to the city and how much is consumed in what proportion in which area. For this, a meticulous consumption pattern map of the city needs to be established. This must be an exercise that must be repeated at every 10-year interval with the seriousness of the Census of India.

Sample questions for residents of buildings, Page #1

Name of Surveyor:							
Ward:							
Address:							
Family name:							
1.	Total number of people in your household:	Total :	Adults :	Children (under 15):			
2.	What is the normal method of bathing in your household?	Shower	Bucket and Mug	Bath Tub	Other - please specify:		
2a.	How many baths / showers are taken each day in your household?	Total :	Baths (with bucket and mug) :	Showers :			
2b.	How much water is used for bathing each time?	No. of buckets x capacity :	Length of time in shower x flow rate (litres per minute) :				
2c.	If you have a bath tub - how many times is it used each week?	times per week					
3.	What are the standard toilet facilities in your house?	WC with flush tank	Indian style with flush tank	Indian style without flush tank	Communal Urinal	None	Other - please specify:
3a.	How much water is used to flush toilets each day?	Litres of water used per flush x number of flushes on average per person per day:					
4.	How many taps are present in your house?	taps					
4a.	How many of the taps are prone to leaking?	taps prone to leaking					
4b.	How many times each day does each household member: shave, brush teeth, wash hands & face etc.?	Shave:	Brush teeth:	Wash hands:	Wash face:	Other - please specify:	Total:
4c.	What method does each household member use to: shave, brush teeth, wash hands & face etc.?	Tap:	Mug:	Bucket:	Other - please specify:		
4d.	How much water is used by each member for these uses?	Shaving:	Brushing teeth:	Washing hands:	Washing face:	Other - please specify:	Total:
4e.	If using a tap for each use, how many minutes on average does the water run?	minutes					
5.	How much water is used in cooking for the whole family on a daily basis?	litres					
5a.	What is your standard source of drinking water?	Water Purifier	Bottled water	Boiled tap water	Raw tap water	Other - please specify:	
5b.	How much water does each member of family consume for drinking daily?	litres					
6.	Which method is used for washing dishes?	Handwash using tap	Handwash using bucket / basin	Dishwashing Machine	Other - please specify:		

Sample questions for residents of buildings, page #2

6a.	How many times are dishes washed by hand each day	times per day				
6b.	If using a tap, how many minutes does the water run during each wash load?	minutes				
6c.	If you have a Dishwashing Machine, how many times is it used each week?	times per week				
6d.	How many litres of water does your method of dish washing use per load?	litres of water used per load				
7.	What is the normal method of washing clothes in your household?	Handwash by tap	Handwash by bucket	Washing Machine	Given to Dhobiwalla	Other - please specify:
7a.	How many loads of washing are done by your household per week?	loads of washing per week				
7b.	How many litres of water does your method of washing clothes use per load?	litres of water used per load				
8.	How many litres of water are used per day for cleaning your house?	Floors (including balconies):	Counter surfaces etc:	Bathrooms / Toilets:		
9.	Do you keep a garden or plants?	Garden with lawn and plants	Potted plants on balcony	None	Other - please specify:	
9a.	How often do you water your plants?	Everyday	Once in 2 days	Once a week	Other - please specify:	
9b.	What method do your normally use to water your plants?	Bucket and Mug	Hose	Other - please specify:		
9c.	How much water (in litres) do you use to water your plants?	No. of buckets x capacity:	Number of minutes with the hose x flow:	Other - please specify:		
10.	How many vehicles does your household own?	Car:	Motorcycle:	Van / SUV:		
10a.	How often do you wash your vehicle?	Everyday	Once in 2 days	Once a week	Other - please specify:	
10b.	What method do your normally use to wash your vehicle?	Bucket and Mug	Hose	Other - please specify:		
10c.	How much water (in litres) do you use to wash each vehicle?	No. of buckets x capacity:	Number of minutes with the hose x flow:	Other - please specify:		
11.	What is your standard source of water supply?	Municipal Supply	Tanker	Borewell	Other - please specify:	
11a.	If you get water from a tanker - how frequently do you get a tanker delivery?	Once a month	Twice a month	Once a week	Twice a week	Other - please specify:
11b.	Are there any rainwater harvesting schemes in your building?	No	Yes - please give details:			

On a scale of 1-5 how would you rate the quality of the water from your taps?	1 - Excellent	2 - Good	3 - Average	4 - Poor	5 - Very poor	Rating:
Please tell us about the colour of the water you get from the taps:	Regularly discoloured	Occasionally discoloured	Rarely discoloured	Never discoloured	Other - please specify:	
Please tell us about the smell of the water you get from the taps:	Regularly smelling bad	Occasionally smelling bad	Rarely smelling bad	Never any bad smells	Other - please specify:	

Sample questions for residents of slums, Page 1

Name of Surveyor:							
Ward:							
Address:							
1.	**Total number of people in your household:**	**Total :**	**Adults :**	**Children (under 15):**			
2.	**What is the normal method of bathing in your houshold?**	**Shower**	**Bucket and Mug**	**Communal tap**	**Other - please specify:**		
2a.	**How many baths / showers are taken each day in your household?**	**Total :**	**Baths (with bucket and mug) :**	**Showers or other:**			
2b.	**How much water is used for bathing each time?**	**No. of buckets x capacity :**	**Length of time in shower or under tap x flow rate (litres per minute) :**				
3.	**What are the standard toilet facilities in your home / area?**	**WC with flush tank**	**Indian style with flush tank**	**Indian style without flush tank**	**Communal Urinal/toilet**	**None - open defecation**	**Other - please specify:**
3a.	**How much water is used to flush toilets each day?**	**Litres of water used per flush x number of flushes on average per person per day:**					
4.	**How many taps are present in your house?**	**taps**					
4a.	**How many of the taps are prone to leaking?**	**taps prone to leaking**					
4b.	**How many times each day does each household member: shave, brush teeth, wash hands & face etc.?**	**Shave:**	**Brush teeth:**	**Wash hands:**	**Wash face:**	**Other - please specify:**	**Total:**
4c.	**What method does each household member use to: shave, brush teeth, wash hands & face etc.?**	**Tap:**	**Mug:**	**Bucket:**	**Other - please specify:**		
4d.	**How much water is used by each member for these uses?**	**Shaving:**	**Brushing teeth:**	**Washing hands:**	**Washing face:**	**Other - please specify:**	**Total:**
4e.	**If using a tap for each use, how many minutes on average does the water run?**	**minutes**					
5.	**How much water is used in cooking for the whole family on a daily basis?**	**litres**					
5a.	**What is your standard source of drinking water?**	**Water Purifier**	**Bottled water**	**Boiled tap water**	**Raw tap water**	**Other - please specify:**	
5b.	**How much water does each member of family consume for drinking daily?**	**litres**					

Sample questions for residents of slums, Page 2

6.	Which method is used for washing dishes?	Handwashing using bucket and mug	Handwashing using tap	Other - please specify:		
6a.	How many times are dishes washed by hand each day?	times per day				
6b.	If using a tap, how many minutes does the water run during each wash load?	minutes				
6c.	How many litres of water does your method of dish washing use per load?	litres of water used per load				
7.	What is the normal method of washing clothes in your household?	Handwashing using bucket and mug	Handwashing using tap	Other - please specify:		
7a.	How many loads of washing are done by your household per week?	loads of washing per week				
7b.	How many litres of water does your method of washing clothes use per load?	litres of water used per load				
8.	How many litres of water are used per day for cleaning your home?	Floors:	Counter surfaces etc:	Wet corners:		
9.	Do you keep a plot of land or plants?	Small plot of land	Potted plants	None	Other - please specify:	
9a.	How often do you water your plants?	Everyday	Once in 2 days	Once a week	Other - please specify:	
9b.	What method do your normally use to water your plants?	Bucket and Mug	Hose	Other - please specify:		
9c.	How much water (in litres) do you use to water your plants?	No. of buckets x capacity:	Number of minutes with the hose x flow:	Other - please specify:		
10.	If you own a vehicle - how much water do you use to clean it?	No. of vehicles x no. of buckets x capacity of bucket x number of times washed per week:				
11.	What is your standard source of water supply?	Municipal Supply	Tanker	Communal tap	Borewell	Other - please specify:
11a.	If you get water from a tanker - how frequently do you get a tanker delivery?	Once a month	Twice a month	Once a week	Twice a week	Other - please specify:
11b.	If you use a communal tap - how far is it from your house?	metres				
11c.	How long do you wait in line to collect water from the communal tap?	minutes				
11d.	What method /vessel do you use to transport water from the communal tap?	Bucket	Kodam?	Plastic basin	Jerry can	Other - please specify:
11e.	How much water are you able to collect on each trip to the communal tap?	litres				

Sample questions for residents of slums, Page 3

12.	Are there any rainwater harvesting schemes in your area?	No	Yes - please give details:				
	On a scale of 1-5 how would you rate the quality of the water from your taps?	1 - Excellent	2 - Good	3 - Average	4 - Poor	5 - Very poor	Rating:
	Please tell us about the colour of the water you get from the taps:	Regularly discoloured	Occasionally discoloured	Rarely discoloured	Never discoloured	Other - please specify:	
	Please tell us about the smell of the water you get from the taps:	Regularly smelling bad	Occasionally smelling bad	Rarely smelling bad	Never any bad smells	Other - please specify:	

Sample questions for commercial customers, Page 1

Name of Surveyor:							
Ward:							
Address:							
Organisation / Company name:							
Business / Function							
1.	Total number of people in your organisation:	Total :					
2.	What are the standard toilet facilities in your office?	WC with flush tank	Indian style with flush tank	Indian style without flush tank	Communal Urinal	None	Other - please specify:
2a.	How much water is used to flush toilets each day?	Litres of water used per flush x number of flushes on average per person per day:					
3a.	How many taps are present in your office?	taps					
3b.	How many of the taps are prone to leaking?	taps prone to leaking					
3c.	How much water from taps is used daily?	litres					
4a.	What is your standard source of drinking water?	Water Purifier	Bottled water	Boiled tap water	Raw tap water	Other - please specify:	
4b.	How much water drinking water does your organistion procure on a monthly basis?	litres					
4c.	If you have a canteen on your premises, how much water is used in cooking and cleaning there per week?	Cooking:	Cleaning:				
5.	How many litres of water does your organisaton use for its commercial purposes per week?	litres of water used per week					
6.	How many litres of water are used per week for cleaning your premises?	Floors (including balconies):	Counter surfaces etc:	Bathrooms / Toilets:			
7a.	Do you keep a garden or plants at your premises?	Garden with lawn and plants	Potted plants on balcony	None	Other - please specify:		
7b.	How often do you water the plants?	Everyday	Once in 2 days	Once a week	Other - please specify:		
7c.	What method do your normally use to water your plants?	Bucket and Mug	Hose	Other - please specify:			

Sample questions for commercial customers, Page 2

8a.	How many commercial vehicles does your organisation own?	Car:	Motorcycle:	Van / Trucks:		
8b.	How often do you wash your vehicles?	Everyday	Once in 2 days	Once a week	Other - please specify:	
8c.	What method do your normally use to wash your vehicles?	Bucket and Mug Hose	Other - please specify:			
8d.	How much water (in litres) do you use to wash each vehicle?	No. of buckets x capacity:	Number of minutes with the hose x flow:	Other - please specify:		
9a.	What is your standard source of water supply?	Municipal Supply	Tanker Borewell	Other - please specify:		
9b.	If you get water from a tanker - how frequently do you get a tanker delivery?	Once a month	Twice a month	Once a week	Twice a week	Other - please specify:
10.	Are there any rainwater harvesting schemes in your building?	No	Yes - please give details:			
	On a scale of 1-5 how would you rate the quality of the water from your taps?	1 - Excellent	2 - Good	3 - Average	4 - Poor	5 - Very poor	Rating:
	Please tell us about the colour of the water you get from the taps:	Regularly discoloured	Occasionally discoloured	Rarely discoloured	Never discoloured	Other - please specify:
	Please tell us about the smell of the water you get from the taps:	Regularly smelling bad	Occasionally smelling bad	Rarely smelling bad	Never any bad smells	Other - please specify:

16 REFERENCES

1. The Financial Express, 2008, http://www.financialexpress.com/printer/news/266636/
2. Census, 2001, http://censusindia.gov.in/Census_Data_2001/Census_Newsletters/Newsletter_Links/eci5.htm
3. NESCAP Population and Urbanisation Trends, 2008, http://www.unescap.org/ttdw/Publications/TPTS_pubs/pub_2157/review2001_ch2.pdf
4. 62% population lives in slums: Census, Hindustan Times, 17th December 2010, http://www.hindustantimes.com/62-of-Mumbai-lives-in-slums-Census/Article1-614027.aspx#
5. Chitale Committee Report, 2004
6. http://www.expressindia.com/latest-news/Mumbais-water-woes-claim-life-as-police-cane-protesters/549505/1/
7. http://www.dnaindia.com/mumbai/report_another-pipeline-burst-in-mumbai-15th-in-march-alone_1363910
8. BMC, Budget 2011-12
9. The Hindu, 12th March 2011, http//www/thehindu.com/todays-paper/tp-national/to-newdelhi/article1530810.ece
10. BMC, Budget 2010-11
11. BMC's cash crunch to affect your life, Hindustan Times, 5th December 2009, http://www.hindustantimes.com/BMC-s-cash-crunch-could-affect-your-life/Article1-483180.aspx
12. BMC, Budget 2011-12
13. BMC White Paper, 2009
14. Economic Survey of Delhi, 2008-09, http://delhiplanning.nic.in/Economic%20Survey/ES2007-08/C13.PDF
15. Deccan Chronicle, 6th January 2010 and Chennai Metro Water, 2009
16. Chennai Metropolitan Development Authority, 2009, http://www.cmdachennai.gov.in/SMPS/B_Proceedings.pdf
17. Bangalore Water Supply and Sewerage Board, 2010, http://www.bwssb.org/help_faq.html
18. Mint, 18th April 2009 and various studies on groundwater contamination in West Bengal
19. Water Supply for MMR – Review and Planning, MMRDA, May 2009
20. The Times of India, 30th January 2010, http://timesofindia.indiatimes.com/city/mumbai/Civic-body-cuts-water-supply-to-public-toilets/articleshow/5515075.cms
21. DNA, 2nd August 2010, http://www.dnaindia.com/mumbai/report_bmc-restores-water-supply-to-public-toilets_1418022
22. Business Standard, 19th December 2009, http://www.business-standard.com/india/news/mcgm%5Cs-100-zone-wise-water-cut-move-to-be-discussedmonday/380088/
23. BMC White Paper, 2009
24. Chitale Committee Report, December 1994
25. The Indian Express, 2nd January 2009, http://www.expressindia.com/latest-news/mumbais-water-woes-are-here-to-stay/405634/
26. BMC White Paper, 2009
27. The Times of India, 6th July 2011, http://articles.timesofindia.indiatimes.com/2011-07-6/mumbai/29743095_1_largest-slum-dharavi-nivara-hakk-sangharsh-samiti
28. Pune Municipal Corporation, 2011
29. Delhi Jal Board and Bangalore Water Supply and Sewerage Board, 2009
30. BMC, Budget 2011-12
31. Regional Meteorological Centre, average annual rainfall recorded at Colaba and Santacruz
32. Public Utilities Board, Government of Singapore, 2010
33. The Hindu, 17th September 2010, http://www.thehindu.com/news/states/other-states/article674299.ece
34. The Times of India, 9th March 2010, http://lite.epaper.timesofindia.com/getpage.aspx?articles=yes&pageid=2&max=true&articleid=Ar00200&sectid=1edid=&edlabel=TOIM&mydateHid=09-03-2010&pubname=Times+of+India+-+Mumbai+-+Times+City&title=Water+samples+tell+shocking+story&edname=&publabel=TOI
35. BMC, 2009
36. Mumbai Mirror, 12th November 2009, http://www.mumbaimirror.com/printarticle.aspx?page=comments&action=translate&sectid=2&contentid=20091112200911120351515467bbfe9b1&subsite=
37. Mumbai Mirror, 7th December 2009, http://www.mumbaimirror.com/printarticle.aspx?page=comments&action=translate&sectid=2&contentid=20091207200912070323073 5c0a65948&subsite=
38. Asian Development Bank—Benchmarking and Data Book of Utilities in India: http://www.adb.org/documents/reports/Benchmarking-DataBook/Part3.pdf

39. BMC, 2009
40. BMC, 2009
41. The Hindu, 8th August 2009, http://www.hindu.com/2009/08/08/stories/2009080859750300.htm
42. The Hindu, 8th March 2009, http://www.hinduonnet.com/2009/03/06/stories/2009030660370300.htm
43. Business Standard, 24th December, 2009 http://www.business-standard.com/india/news/kolkata-assumes-domestic-water-supply-is-free/380556/
44. Hindustan Times, 7th December, 2007, http://www.hindustantimes.com/The-Mumbai-Project-24-hour-water-supply-It-s-no-pipedream/Article1-261739.aspx
45. Hindustan Times, 7th December, 2007, http://www.hindustantimes.com/news/specials/bombay/Main%20article18.shtml
46. The Indian Express, 8th August 2008, http://www.expressindia.com/latest-news/bmc-gets-wb-help-for-sujal-mumbai-and-water-audit/346516/
47. BMC White Paper, 2009
48. BMC, 2009
49. MJP water supply tariff structure, http://mahajeevan.com/Finance/Water_Tariffs/Water_Tariffs2007.asp
50. The Indian Express, 7th June 2010, http://www.expressindia.com/latest-news/900-houses-in-7-yrs-751-more-in-1-yr-rainwater-harvesting-picks-up/630310/
51. The Times of India, 5th May, 2003, http://articles.timesofindia.indiatimes.com/2003-05-05/mumbai/27281123_1_rain-water-water-harvesting-rainwater
52. BMC, 2009
53. Kolkata Municipal Corporation, 2009
54. Delhi Jal Board, 2009
55. http://indiaearnings.moneycontrol.com/sub_india/corpannoun.php?sel_comp=UI17
56. Water use in the United States http://water.usgs.gov/watuse/
57. Residential Water Use http://www.lasvegassun.com/water/map/
58. The Times of India, 18th September 2010, http://articles.timesofindia.indiatimes.com/2010-09-18/mumbai/28216278_1_civic-panel-water-distribution-corporator
59. The Times of India, 25th March 2010, http://articles.timesofindia.indiatimes.com/2010-03-25/mumbai/28132174_1_tunnel-project-senior-bmc-officials-financial-crunch
60. The Indian Express, 15th September 2010, http://www.expressindia.com/latest-news/for-equal-water-distribution-bmc-plans-multicrore-valve-project/681663/
61. Report of the Expert Committee (Chitale Committee Report), December 1994
62. USGS Hydrological Tutorial, http://mwis.waterdata.usgs.gov/tutorial/huc_drf.html
63. The Indian Express, 22nd March 2010, http://www.indianexpress.com/news/underground-utilities-out-of-gisbased-digit/593794/
64. DNA, 27th August 2010, http://www.dnaindia.com./mumbai/report_bmc-to-initiate-pilot-project-from-oct-to-plug-water-leakages_1429439
65. The Hindu, 23rd September 2010, http://www.thehindu.com/news/cities/Chennai/article777454.ece
66. The New Indian Express, 23rd September 2010, http://expressbuzz.com/cities/chennai/government-buying-rs-15-cr-worth-water-for-city/209259.html
67. Minjur Desalination Plant, Chennai, Tamil Nadu http://www.water-technology.net/projects/minjurdesalination/
68. Israel increases rates for desalinated water, 16th January 2010, http://www.circleofblue.org/waternews/2010/world/israel-increases-rates-to-pay-for-desalinated-water/
69. Emirates 247 News, 8th August 2010, http://www.emirates247.com/news/emirates/uae-spends-dh11-8-billion-on-desalination-2010-08-08-1.276189
70. DNA, 7th September 2010, Shubhangi Khapre, http://www.dnaindia.com/mumbai/report_govt-sets-deadline-for-desalination-plants_1434493
71. DNA, 30th April 2010, http://www.dnaindia.com/mumbai/report_bmc-desilts-tansa-to-save-water-for-mumbai_1377190
72. Gyan Prakash Soni, IIT Roorkee, Myths and Realities about Desilting, Indiawaterportal.org
73. RCF—The 10 Principles of Global Impact
74. The Times of India, 2nd March 2011, http://www.mid-day.com/news/2010/mar/020310-holi-mumbaikars-water-wasted-tankers.htm

LIST OF ABBREVIATIONS

AMR: Automatic Meter Reading
ASSOCHAM: Associated Chambers of Commerce and Industries of India
BARC: Bhabha Atomic Research Centre
BEST: Brihanmumbai Electric Supply and Transport Corporation
BRIMSTOWAD: Brihanmumbai Storm Water Drain Project
CGWB: Central Ground Water Board
CII: Confederation of Indian Industries
CPHEEO: Central Public Health and Environmental Engineering Organisation
CSR: Corporate Social Responsibility
DP: Development Plan
DTSS: Deep Tunnel Sewage System
ETP: Effluent Treatment Plant
FSI: Floor Space Index
GIS: Geographic Information System
H.E.: Hydraulic Engineer
IMC: Indian Merchants' Chamber
JNNURM: Jawaharlal Nehru National Urban Renewal Mission
LPCD: Litres per capita per day
MCGM: Municipal Corporation of Greater Mumbai
MCHI: Maharashtra Chambers of Housing Industries
MGWSDA: Maharashtra Ground Water Surveys and Development Authority
MJP: Maharashtra Jeevan Pradhikaran
MLD: Million litres per day
MMRDA: Mumbai Metropolitan Regional Development Authority
MoEF: Ministry of Environment and Forests
MSDP: Mumbai Sewage Disposal Project
MSRTC: Maharashtra State Road Transport Corporation
NRW: Non-revenue water
OSD: Officer on Special Duty
PPIAF: Public Private Infrastructure Advisory Facility
PUB: Public Utilities Board, Singapore
RCF: Rashtriya Chemicals and Fertilizers
SCADA: Supervisory Control and Data Acquisition
SGNP: Sanjay Gandhi National Park
SRA: Slum Redevelopment Authority
TDR: Transfer of Development Right
TIFR: Tata Institute of Fundamental Research
TISS: Tata Institute of Social Sciences
UFW: Unaccounted for water
WCT: Water Conservation Tax
WDIP: Water Distribution Improvement Project
WRP: Water Reclamation Plant

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OBSERVER RESEARCH FOUNDATION MUMBAI

Ideas and Action for a Better India

Observer Research Foundation (ORF) is a leading non-partisan Indian Think Tank that seeks to influence public policy formulation. It was established in New Delhi in 1990 by the late Shri R. K. Mishra, a widely respected public figure, who envisaged it as a broad-based intellectual platform pulsating with ideas needed for India's nation-building.

In its journey of twenty years, ORF, pursuing its mission of 'Building Bridges for a Global India', has brought together leading Indian policy makers, academics, public figures, social activists and business leaders to discuss various issues of national importance. ORF scholars have made significant contributions toward improving government policies. ORF has produced a large body of critically acclaimed publications.

Until recently, ORF's activities were based mainly in New Delhi. Beginning 2010, ORF Mumbai has been established to pursue the Foundation's vision in India's business and finance capital. It has started research and advocacy in six broad areas:Education, Public Health, Inclusive Development, Urban Renewal, Youth Development, and Promotion of India's Priceless Artistic and Cultural Heritage.

ORF Mumbai's mission statement is: Ideas and Action for a Better India. It will champion the cause of balanced socio-economic development and a better quality of life for all Indians. It will also work towards strengthening India's democratic institutions to become more responsible, responsive and sensitive to common people's needs and concerns, especially those of most vulnerable sections of the society.

Besides conducting diligent research in its above six core areas, ORF Mumbai also pursues wide-ranging initiatives like:

- Maharashtra@50 Study Centre
- Forum for India-China Citizens' Dialogue
- India-Israel Innovation Initiative
- Centre for the Study of India's Ancient Knowledge Traditions
- Gurus of Science Series

[ORF MUMBAI'S OTHER AREAS OF INTEREST]

Maharashtra @ 50 Study Centre

Maharashtra is one of the leading states of India. With a population over 10 crore, every development that takes place in the state — positive or negative — markedly impacts India's development and destiny. Therefore, attaining deep knowledge of all the major issues, challenges, achievements, failures and emerging trends is necessary from the point of view of the progress of Maharashtra as well as the nation. The overriding purpose of the Centre is to create hope in place of pessimism, clarity in place of confusion, consensus in place of discord, and cooperative action for ambitious, integrative goals in place of confrontational pursuit of sectional interests.

Forum for India-China Citizens' Dialogue

ORF Mumbai believes that in the changing world order, friendship between India and China is not an option. It is a mutual necessity. Moreover, it is an essential factor for peace and stability in Asia and the world. Obviously, diplomatic efforts are not alone enough to restore India-China relations to the desired level of affinity. The imperative need, to create mutual understanding and cooperation between our two countries, demands closer and vastly increased people-to-people contacts. It is against this backdrop that ORF Mumbai has taken the initiative to establish the Forum for India-China Citizens' Dialogue. This is a non-partisan, non-governmental platform for all those who believe in, and are willing to contribute to, the cause of promoting fraternal and cooperative relations between the peoples of India and China.

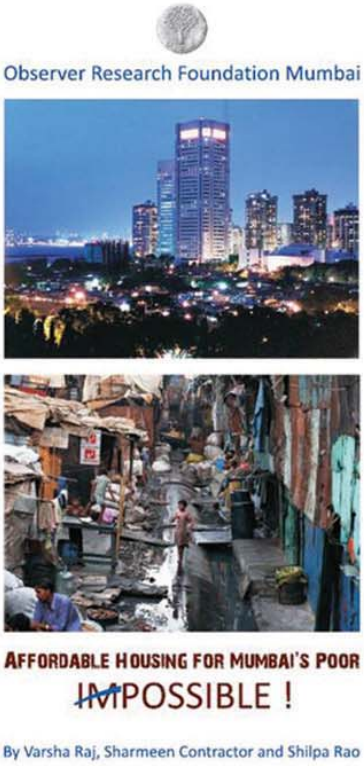
Centre for the Study of Indian Knowledge Traditions

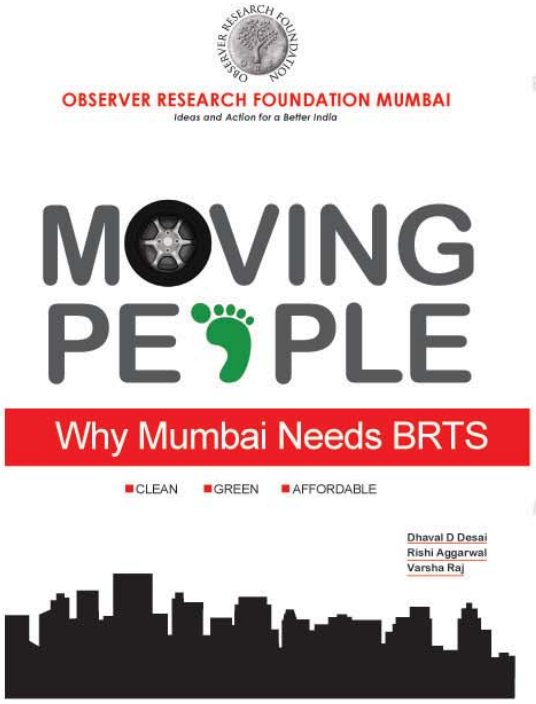
ORF Mumbai's Centre for the Study of Indian Knowledge Traditions seeks to promote the rich reservoir of knowledge and wisdom in Samskrit and other Indian languages, especially focusing on their enormous contemporary relevance. The Centre aims at studying India's knowledge traditions not from a purely academic perspective, but from the point of view of their contemporary relevance and usefulness. It is the endeavour of the Centre to highlight how these traditions can enlighten and benefit our institutions of governance, political establishment and civil society initiatives.

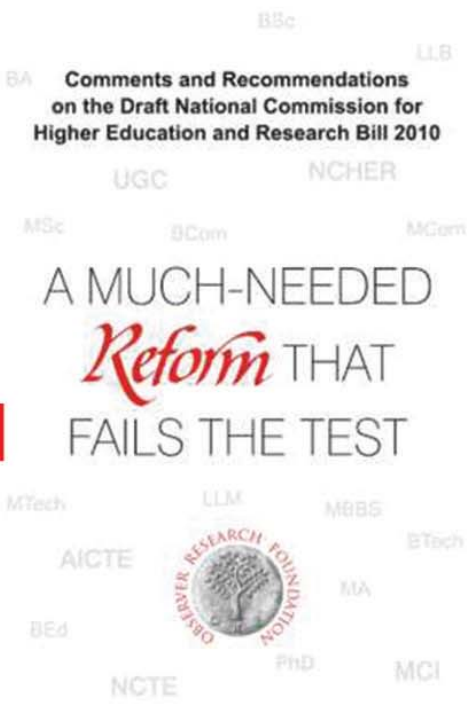
India-Israel Innovation Initiative

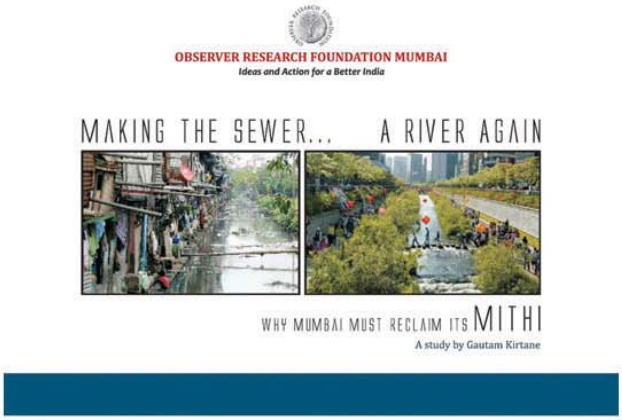
Israel has emerged as a powerhouse in innovation and hi-tech industries in the recent past. India, on the other hand, is growing at more than 8 percent and, together with China, has become an engine of global economic growth. India and Israel share common values of democracy and entrepreneurship. Both are knowledge-driven societies. The economies of both are complementary to each other. In the last two decades, Indo-Israel cooperation has grown exponentially, with bilateral trade expected to soon cross USD 5 billion. This special relationship has a long way to go, particularly in the field of joint R&D and innovation. Against this backdrop, and to mark the beginning of the 20th year of diplomatic relations between our two countries, ORF Mumbai has mooted the idea of India-Israel Innovation Initiative. This is an alliance comprising academia, public and private sector companies, and think tanks from India and Israel, for deeper engagement with the subject of innovation-led cooperation between the two countries.

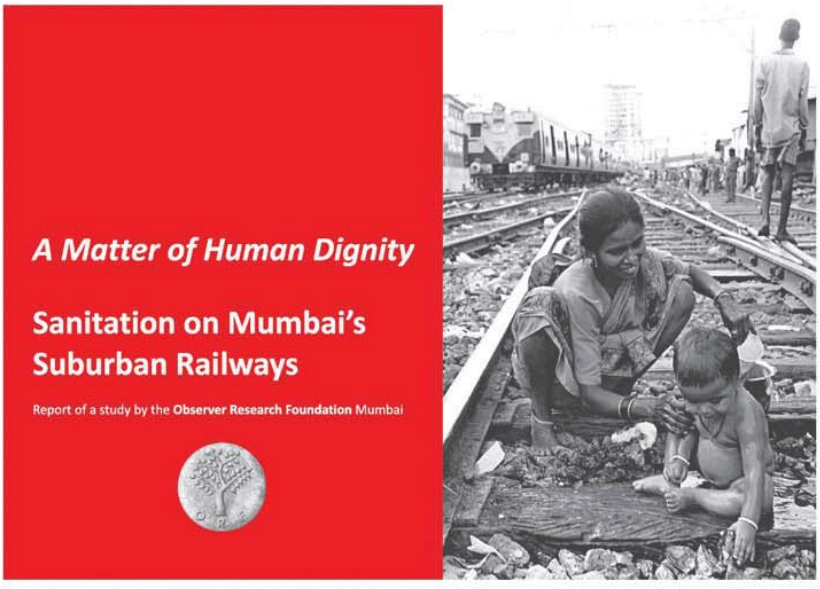
[ORF MUMBAI PUBLICATIONS]











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NKM International House, 5th Floor, 178, Backbay Reclamation,
Babubhai Chinai Marg, Nariman Point, Mumbai - 400 020, India
Telephone: +91 22 6131 3800 | Website: www.orfonline.org

Contact: Dhaval D Desai | Email: dhaval.desai@orfonline.org