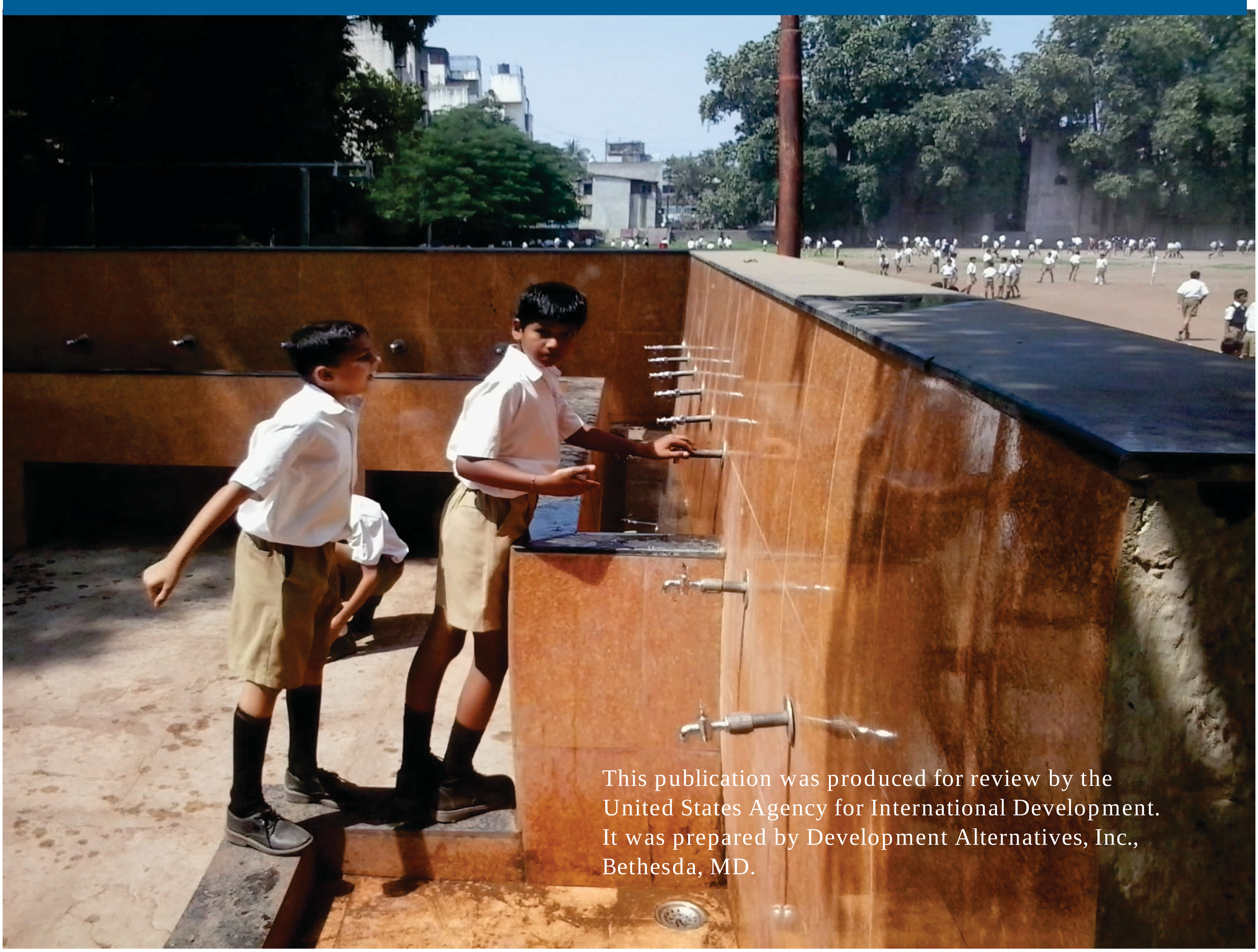
Municipal Water Use Efficiency Guideline Pune

Water Analysis, Innovations, and Systems Program

February 2013



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Municipal Water Use Efficiency Guideline: Pune

Water Analysis, Innovations, and Systems Program

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Cover photo: Water saving faucets at a Pune school. Photograph by AIILSG.

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ABBREVIATIONS AND ACRONYMS

AIILSG	All India Institute of Local Self Government
BMP	Best Management Practices (for water conservation)
BPMC	Brihan Mumbai Municipal Corporation
CPHEEO	Central Public Health Engineering and Environment Organization
CUWCC	California Urban Water Conservation Council
CIC	City Improvement Committee
CII	Confederation of Indian Industries
DAI	Development Alternatives, Inc.
ECBC	Energy Conservation Building Code
GoI	Government of India
GoM	Government of Maharashtra
gpf	Gallons per flush
gpm	Gallons per minute
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technology
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KCB	Khadki Cantonment Board
L/d	Liters per day
Lpcd	Liters per capita per day
MIDC	Maharashtra Industrial Development Corporation
MWRRA	Maharashtra Water Resources Regulatory Authority
MRTP	Maharashtra Regional and Town Planning
ML	Million liters
MLD	Million liters per day
NAPCC	National Action Plan on Climate Change
NWM	National Water Mission
NRW	Non-revenue water
PCB	Pune Cantonment Board
PMC	Pune Municipal Corporation
RWH	Rainwater harvesting
SLB	Service Level Benchmark
STP	Sewage (Wastewater) Treatment Plant, also known as water pollution control plant (WPCP)
TMCM	Thousand million cubic meters
TDR	Transfer of Development Rights
USAID	United States Agency for International Development
WAISP	Water Analysis, Innovations, and Systems Program
WC	Water Closet (also, Bathroom, Restroom, Toilet)
WF	Water Factor (Unit of water use by dishwasher or washing machine per cycle per unit load)

EXECUTIVE SUMMARY

The Water Analysis, Innovations, and Systems Program (WAISP) is a USAID-supported initiative to increase the security of potable water supply and sanitation services by building resiliency to global climate change and advancing sustainable approaches to water management. The program includes two components: (1) assessment of the water sector in India in the context of climate change, food security, and health, which was completed in June 2011, and (2) analysis of the potential and feasibility of inter-sectoral water use, primarily providing municipal wastewater for use by industry or industrial clusters in three cities—Faridabad, Jaipur, and Pune. This has been implemented by Development Alternatives, Inc. (DAI), with support from The Communities Group International, and the All India Institute of Local Self Government (AIILSG). In addition, the Confederation of Indian Industry's (CII) Triveni Water Institute is working in parallel with USAID to conduct water audits and carry the initiative forward.

The second component has included several elements, and this report consolidates all of the activities and analysis completed related to Pune:

1. Review of the water supply and sanitation infrastructure serving the city, as well as a desk analysis of the potential climate change impacts on Pune and the threats they pose to water resources in the short and long term.
2. Analysis of the legal framework related to water resources.
3. Summary presentation of primary survey research of the principal non-industrial water users in the city, totaling 502 sampling units.
4. Presentation of opportunities and recommendations to improve urban water use efficiency, including specific projects for consideration by officials and water users in Pune.
5. Compendium of selected national and international best practice case studies and references to engage stakeholders in considering the merits of various successful models.

Water scarcity is a looming threat to orderly development and growth of India's major cities, in similar fashion to most of the semi-arid and arid regions of the world. A fast growing population and increasing standards of living will combine with the effects of global climate change to exacerbate this scarcity.

National and Local Context

Water scarcity is a looming threat to orderly development and growth of India's major cities, in similar fashion to most of the semi-arid and arid regions of the world. A fast growing population and improving standard of living will combine with the effects of global climate change to exacerbate this scarcity. Fortunately, much can be accomplished to increase the efficiency of water use in India's cities in a relatively short period of time. The reason for this optimism is twofold: (a) current water use efficiency is at a very low level, and (b) international experience and advanced technology can offer proven solutions to maximize the benefits of available water supplies in the most equitable manner possible.

The Twelfth Five Year Plan (2012-2017) released by the Planning Commission, Government of India (GoI) has analyzed in detail the water situation in general and in the specific context of industries. The Plan document quotes estimates of the “2030 Water Resources Group” which indicates that if current patterns continue, about half of the water demand will be unmet by 2030, and therefore recommends a reform agenda and paradigm shift to address the challenge. This shift includes “definite targets for recycling and reuse of water by Indian industry to move in conformity with international standards” (GoI, 2012c).

The Plan document quotes estimates of the “2030 Water Resources Group” which indicates that if current patterns continue, about half of the water demand will be unmet by 2030, and therefore recommends a reform agenda and paradigm shift to address the challenge.

Given this backdrop, WAISP conducted a series of consultative meetings with USAID, CII's Triveni Water Institute, and officials within various municipalities. The guiding principles for selecting Faridabad, Jaipur, and Pune were: (1) water scarcity with high potential for growth; (2) feasible within a one year time frame; (3) enables donors and the municipalities to follow-up with longer-term initiatives based on the results; (4) interest of municipal authorities to focus on the interface across the urban built environment and industry; (5) linkages with CII's networks for follow-up.

For its part, Pune receives its water supply from three rivers (Mula, Mutha and Pawana), two lakes (Pashan and Katraj) and four dams (Khadakwasla, Panset, Warasgaon and Temghar). Lately, ground water is emerging as an important source to meet the water requirements of various sectors. The per capita water supply in the city—194 liters per capita per day (Lpcd) —is more than the Service Level Benchmark (SLB) indicator of 135 Lpcd. A recent study (Rooijen et. al., 2008) has estimated that water demand would double in 20 years from 2002 levels, and much of this increased demand will come from industries.

While sufficient water supplies are available to meet current demands, the potential long-term impacts due to climate change present yet another important variable, apart from the projected increased demand from population growth and industrial development. An analysis of the probability of likely climate events in Pune indicates that events likely to occur include wetter non-rainy seasons and more intensive storms and rainfall. Greater precipitation in non-rainy seasons and intensive rainfall during the monsoon season could result in water logging and floods, which could be aggravated by the increasingly poor drainage conditions in and around the city caused by both the topography of the city and inadequate solid waste management.

Considering the water demand-supply situation including the availability of surface water, the likely increase in rainfall in the catchment region, and Pune's groundwater resources, the vulnerability of Pune to drought events is considered low over both the short and long term periods, despite conditions in 2012. The likely increase in rainfall, on the other hand, would render the city vulnerable to water logging and floods in the long term (looking forward to the 2050s).

Water Use

A primary quantitative survey was designed to supplement the secondary data and qualitative information collected. The survey assessed the pattern of water use within the city areas across different segments of water users, including domestic and commercial (but not industrial). While it had a limited scope, the survey yielded valuable reinforcing information that, when taken in concert with other data sources, studies, and priorities, suggest trends which may be helpful to decision-makers interested in identifying opportunities for water use optimization.

The focus of the survey was on domestic water use, covering 364 households representing different areas of the city. The residential sample was divided among three sub-segments: low income (18% of the total households), middle income (68%) and high income (14%). The survey revealed that most of the households depend on municipal water supply as their principal source of water, with two-thirds depending entirely on municipal water. Nearly one-third supplement the municipal supply with their own source, usually groundwater. In addition, only 12% of the domestic connections surveyed are metered, which indicates that the utility authorities have limited data on consumption patters, which weakens their ability to manage water resources effectively, and charge appropriate consumption-based tariffs. Furthermore, while only one-tenth of the surveyed households harvest rainwater, this offers reason for optimism to improve conservation as it represents wide scope for expansion. Finally, it is notable that nearly half of the households surveyed use washing machines, and most of these are water-guzzling top-loading models, as opposed to the more efficient front-loading machines.

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Institutions and commercial establishments surveyed actually demonstrated similar trends, with most depending entirely on municipal water supplies, and very few practicing rainwater harvesting. Shopping malls reported using the largest volumes of water, though restaurants, hotels, hospitals and nursing homes also reported using large volumes of water—nearly 2 kiloliters or more a day.

Legal Framework

There are a number of laws in the state legislation like the Maharashtra Jeevan Authority Act, 1976 that relate to or affect the potential for water and wastewater recycling and reuse, and water use efficiency in particular cities. The Maharashtra

Groundwater (Regulation for Drinking Water Purposes) Act, 1993 was one of the earliest attempts in the country to directly link the regulation of access to groundwater with drinking water, and has been credited with some success. The Maharashtra State Water Policy, 2003 seeks to improve efficiency of water utilization across diverse uses, and to foster an awareness of water as a scarce resource.

Pune Municipal Corporation (PMC) has become proactive in taking water conservation measures such as banning the use of drinking water and groundwater for vehicle washing purposes at car washing centers.

The most important water legislation adopted in the past decade is the Maharashtra Water Resources Regulatory Authority Act, 2005/2011 (MWRRA Act). Among notable aspects of this new regime, the MWRRA has proposed water rights trading in a bid to promote water use efficiency within the agriculture sector. The Maharashtra Groundwater (Development and Management) Bill, 2009 also has great potential to promote water conservation.

The Pune Municipal Corporation (PMC) has become proactive in taking water conservation measures such as banning the use of drinking water and groundwater for vehicle washing purposes at car washing centers. This was a response to the drought of 2012. The PMC has also forbidden the sale of drinking water outside the city limits, which prevents private sector contractors from supplying un-served areas within the PMC and also from diverting their supply to customers outside the city willing to pay the price. Use of drinking water for the purpose of building construction is also prohibited under the Brihan Mumbai Municipal Corporation (BPMC) Act.

Besides issuing restrictive orders, PMC has also adopted forward-looking and progressive steps which encourage water and energy conservation. For instance, the PMC implemented the Eco-housing scheme, which was established in 2008 under technical assistance provided by USAID, and is the first urban local body in India to have done so. A dedicated Eco-housing Cell has been established for this purpose within the PMC. The Eco-housing Assessment Criteria, consisting of different sets of mandatory and non-mandatory criteria, has now been extended to all residential building/building complexes, and single-family residences.

The Jawaharlal Nehru National Urban Renewal Mission (JNNURM), which is a national flagship program launched in 2006 for improvement in urban infrastructure and governance encourages selected cities to undertake reforms. Pune, which was one of the cities selected for piloting the program, has initiated steps like metering all water connections, although the extent of metering remains very low, as shown by the survey. Similarly rainwater harvesting has also been on the city administration's policy agenda for nearly a decade, but with little impact on ground as yet.

Although the Municipal Corporation in Pune has taken a number of positive policy initiatives, some of them in the recent past, they do not amount to a comprehensive and mutually reinforcing framework for action. Even so, the intent clearly exists, and there is considerable scope for improving the policy environment, particularly related to the efficacy of implementation and enforcement.

Opportunities

Based on WAISP's analysis and findings, several opportunities to improve water use efficiency in Pune were identified to thereby better assure future growth of the city while meeting the competing water needs for human welfare and economic growth. WAISP considered inter-related opportunities for action, noting potential projects, technology options, as well as legal reforms. Specific projects have been proposed, such as considering recycling water used for washing bus and railway coaches in depots. The required technology would remove grease and dirt rather than full tertiary treatment to drinking water standards. Doing so at bus depots alone is estimated to save as much as 220,000 liters/day, enough to fill 32 Olympic-sized swimming pools every year. Also, there are over 100 gardens in Pune requiring irrigation, and municipal guidelines restrict the use of both groundwater and municipal drinking water for gardening. The WAISP survey suggests that alternate irrigation arrangements may generally not be in place, despite opportunities for wastewater reuse, including through on-site root zone treatment[1] and other eco-friendly options.

Specific projects have been proposed, such as considering recycling water used for washing bus and railway coaches in depots. The required technology would remove grease and dirt rather than full tertiary treatment to drinking water standards. Doing so at bus depots alone is estimated to save as much as 220,000 liters/day, enough to fill 32 Olympic-sized swimming pools every year.

In addition, opportunities for introducing legal mechanisms, such as mandatory labeling of water fixtures and appliances, and establishing maximum flow rates, are necessary to educate consumers and developers to select more appropriate equipment. Rebates, taxes, and other economic instruments can be used to encourage the use of efficient equipment, and discourage use of inefficient equipment. In addition, establishing a water demand management unit within the Pune Municipal Corporation could be highly beneficial. Such a unit could support municipal level conservation efforts through outreach campaigns, assist with enforcement, and engage users through technical assistance. Indeed, a major challenge for Pune is that, despite some local examples of development following good environmental stewardship, such principals are not visible in the mainstream.

[1] Also called “constructed wetlands,” these are man-made wastewater treatment systems designed with natural processes as found in natural wetland ecosystems, relying on plants, soil and microbial life to treat waste.

Considering that water recycling and reuse efforts are currently being undertaken on the basis of a given individual's understanding of the range of available options, a guidance manual is also recommended. Something similar to the Central Public Health Environment Engineering Organization (CPHEEO) manual, focusing on wastewater reuse, and the appropriate parameters to enable agricultural irrigation, construction activities, water for cooling towers, or for flushing in water closets, would assist and encourage more municipalities to adopt such initiatives.

Conclusion

Pune is one of the ten largest cities in India and has consistently grown over the last five decades. It has nurtured industrial-technological growth and emerged as an educational hub. The growth scenarios for the city remain very positive. Fortunately, water has not been under stress until recently because of its geographic advantages. However, projections based on changes in demography, industrial growth, and climate changes suggest a need for a stronger emphasis on strengthening water resources management to assure long-term resilience. The summer drought of 2012 already sounded alarms for many, and city administrators have taken various policy and regulatory initiatives over the last decade and more, to ensure more efficient water use and improve conservation. However, these initiatives do not add up neatly into a coherent and cohesive whole. At the same time, there are signs of high quality private initiatives. An enabling environment, therefore, exists in Pune for collaborative action between public and private sectors, which can contribute to the national goal of improving efficiency in water use by applying and scaling up technologies and pursuing legal and policy reforms.

I. INTRODUCTION

The Water Analysis, Innovations, and Systems Program (WAISP) is funded by the U.S. Agency for International Development (USAID/India). The overall goal of the program is to increase the security of potable water supply and sanitation services by building resilience to climate change and advancing sustainable approaches to multiple use water services provision for potable and productive applications.

WAISP began by conducting a water sector assessment of eight states in India, which looked specifically at water vulnerability in relation to climate change, food security, and health (available as a separate report completed June 2011). The program then carried out three city-level analyses for ways to improve water efficiency in representative cities—Faridabad, Jaipur, and Pune—which were identified as having potential for national replication.

For USAID/India, the inter-linkages between water resources and climate change, food security, and health are of paramount importance. India faces multiple challenges relating to competing uses of scarce water resources—between household and municipal consumption, agriculture, industrial, and ecosystem services. Furthermore, projected impacts of climate change indicate a higher variability in precipitation, with more frequent droughts and floods, and general stress on the hydrologic regime. Unrestricted groundwater exploitation by all sectors in the absence of adequate regulation and pricing is already severely impacting water scarce areas.

India faces multiple challenges relating to competing uses of scarce water resources—between household and municipal consumption, agriculture, industrial, and ecosystem services.

For the second program component, WAISP conducted a series of consultative meetings with USAID, the Confederation of Indian Industry's (CII) Triveni Water Institute, and officials within various municipalities. The guiding principles for selecting Faridabad, Jaipur, and Pune were: (1) water scarcity with high potential for growth; (2) feasible within a one-year time frame; (3) enables donors and the municipalities to follow-up with longer-term initiatives based on the results; (4) interest of municipal authorities to focus on the interface across the urban built environment and industry; (5) linkages with CII's networks for follow-up.

The results of WAISP's second component are presented in three separate reports, one for each city—Faridabad, Jaipur, and Pune—as a *Guideline for Water Use Efficiency*. This document represents the Guideline for Pune and includes a city profile and background, review of the water supply and sanitation infrastructure, as well as their vulnerabilities to potential climate change impacts, analysis of the legal and policy framework related to water, as well as survey results on water use trends in the city. The report concludes with a review of recommended opportunities to improve urban water use efficiency, and a reference compendium of relevant Indian and international case studies. This Guideline is designed to serve as a decision-support resource for municipal officials to better understand and address the existing and looming water resource constraints in Pune.

National Context

Water is a "State" subject in the Indian Constitution, which means that states are free to pursue their own policies regarding its use, and have exclusive power to legislate on this subject.[2] The central government provides funds to states from its budget to improve water resource management and has an advisory role in this sector, which flows from the issuance of guidelines. The Draft National Water Policy of June 2012 states: "Even while it is recognized that States have the right to frame suitable policies, laws and regulations on water, there is a felt need to evolve a broad over-arching national legal framework of general principles on water to lead the way for essential legislation on water governance in every State of the Union and devolution of necessary authority to the lower tiers of government to deal with the local water situation" (GoI, 2012a).

The Plan document quotes estimates of the "2030 Water Resources Group" which indicates that if current demand patterns continue, about half of the demand for water will be unmet by 2030, and therefore recommends a paradigm shift and reform agenda to address the challenge.

Previously, the Government of India's Approach Paper for the 12th Five Year Plan (2011) observed "It is necessary to match our use, through improvement in efficiency, with the annual replenishable water supply that the country receives. Available evidence suggests that with increased use of water, mostly on an unsustainable basis, the country is headed towards a grave water crisis" (GoI, 2011). The Approach Paper commented "…the real solution has to come from greater efficiency in water use." It also emphasizes the need to establish a National Water Commission (NWC) to monitor compliance with the national water strategy.

Following this approach, the Twelfth Five Year Plan (2012-2017) released by the Planning Commission, Government of India, has analyzed the water situation generally, and in the specific context of industry. The Plan document quotes estimates of the "2030 Water Resources Group" which indicates that if current demand patterns continue, about half of the demand for water will be unmet by 2030, and therefore recommends a paradigm shift and reform agenda to address the challenge. Inter alia this shift includes "definite targets for recycling and reuse of water by Indian industry to move in conformity with international standards" (GoI, 2012c).

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[2] However, the national Parliament has the power to legislate the regulation and development of interstate rivers.

Recycling wastewater for industrial use has been advocated as it not only helps in conserving fresh water, but also reduces the quantum of untreated wastewater discharged to common water bodies, which causes environmental degradation and compounds the disease burden. Nationally, over 70 percent of municipal wastewater is discharged untreated into rivers and waterways, with severe health implications from biological contamination. Also, while the Environmental Protection Act of 1986 mandates that all industrial effluents be treated prior to disposal, statistics indicate that toxic effluents to the tune of 40 percent go untreated into mainstream water bodies, causing chemical contamination with risks to human health, environment, and agriculture.

The agenda for reforms in the 12th Plan will have four thrust areas:

- Agenda 1: Focus on demand management, reducing intra-city inequity and on quality of water supplied
- Agenda 2: Protection of water bodies
- Agenda 3: Water supply scheme conjoined with a sewage component
- Agenda 4: Recycling and reuse of treated wastewater

Additionally, the Plan document acknowledges the need for industries to adopt international best practices to improve water use efficiency. It suggests two ways in which this can happen:

- Reducing the consumption of fresh water through alternative water efficient technologies or processes in various manufacturing activities; and
- Reusing and recycling wastewater from water intensive activities, and making the reclaimed water available for use in the secondary activities.

A recent Advisory Note from the Ministry of Urban Development recognizes the threat to both quantity and quality of water resources in the country resulting from rapid urbanization and underscores the need to collect and treat wastewater, which would contribute to managing the finite resource more effectively (GoI, 2012b). The note highlights two key emerging challenges in the water sector: first, to ensure environmental and financial sustainability; and second, to ensure equitable service provision, especially to the urban poor. The following recommendations from the Working Group on Urban Water Supply and Sanitation for the 12th Plan cited in the Note are significant:

A recent Advisory Note from the Ministry of Urban Development recognizes the threat to both quantity and quality of water resources in the country resulting from rapid urbanization and underscores the need to collect and treat wastewater, which would contribute to managing the finite resource more effectively...

The Ministry of Water Resources is also taking steps to establish the National Bureau of Water Use Efficiency... Some of the approaches under consideration include scaling up water recycling, artificial groundwater recharge, and enlarging the scope of activities for treated wastewater reuse.

- Careful assessment of the total cost of the water and sewage sector is required to ensure that projects are planned in an affordable and sustainable manner.
- Water and sewage services must be paid for in order to recover costs.
- Future investments in water supply should include elements of demand management (reducing water usage) and distribution system leakage management to help reduce intra-city inequities in both quantity and quality of water supplied.
- Building, renewing, and replenishing local water resources, including groundwater, to cut costs of water supply through investments in sewerage and in increased reuse and recycling of wastewaters.
- Building capacities at all levels, including exploring institutional and management options for improved water and sanitation provision in cities.

The broad objectives of conserving water, minimizing wastage in use, and ensuring more equitable distribution are also reiterated in the Mission statement of the National Water Mission (NWM)—one of the eight Missions created as part of the National Action Plan on Climate Change (NAPCC). The National Water Mission intends to achieve this objective through integrated water resources development and management.

The Ministry of Water Resources is also taking steps to establish the National Bureau of Water Use Efficiency. When established, the Bureau will work to reduce distribution losses (non-revenue water) in domestic utilities. The Bureau will also seek to demonstrate approaches to achieve 20% water use efficiency improvements across water uses (domestic, industrial, commercial, irrigation), and will offer incentives to achieve this level of water savings. Some of the approaches under consideration include scaling up water recycling, artificial groundwater recharge, and enlarging the scope of activities for treated wastewater reuse.

In the following sections, the characteristics of Pune City, vulnerability to the effects of climate change, hydrology, current water and sewerage conditions, water use practices, and opportunities for water conservation are presented. Recommendations for specific opportunities deserving further attention and analysis, and best management practices are offered as part of this project, based upon on-site observations, discussions with water authorities, and the results of the water use survey conducted.

Pune City Profile

Pune city, the second largest metropolitan city in Maharashtra state and the ninth largest in India (population 3.1 million in 2011), is considered the cultural capital of the state. The total area under Pune Municipal Corporation (PMC) jurisdiction in 1951 was 125 km^2. By 2001, this area had nearly doubled to 243.84 km^2. Pune's population has increased at a much higher rate, five-fold, between 1951 and 2011 to around 3,115,000. The population density increased from 3,907 to 12,775 per km^2 in the same period. Table 1 and Figure 2 show the decadal growth in population in Pune city over the last 50 years.

This population growth has largely been an outcome of increased economic activity and resulting job creation in the city. In proportionate terms, the annual growth of slum areas has been higher than the annual growth rate of the city as a whole. According to Pune Municipal Corporation data, there are 564 slums in the city, of which 353 are declared and 211 are undeclared (PMC, 2012), which house between 1.1 and 1.2 million people. The population density in slums is about six times higher than the rest of the city: 27 percent of the population resides in declared slums, within just four percent of the total city area.

Figure 1: Location of Pune in Maharashtra

Figure 2: Recent Population Trends in Pune City

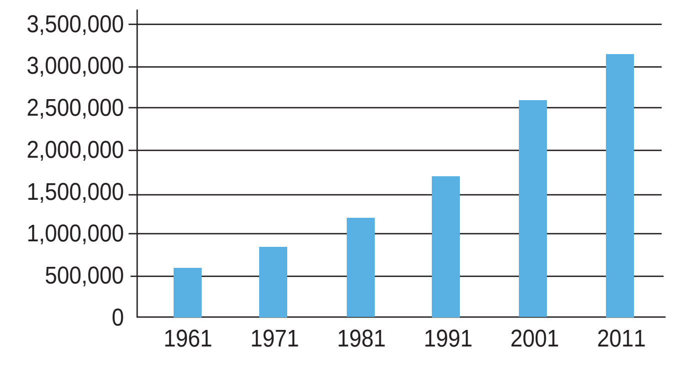


Table 1: Population Growth, Area and Density of the City of Pune

Year	Population	Decadal Change	Average Growth Rate (% per year)	Area (km^2)	Density (per sq. km.)
1961	606,777	118,358	2.4	138.98	4,366
1971	856,105	249,328	4.1	138.98	6,160
1981	1,203,363	347,258	4.1	146.95	8,189
1991	1,691,430	488,067	4.1	146.11	11,576
2001	2,538,473	847,043	5.0	243.87	10,409
2011	3,115,431	576,958	2.3	243.87	12,775

Photos: PMC, 2012

View of Pune city from Parvati Hill in 1960.

Same view of Pune city in 2011.

Industrial Development

Over the last century, Pune has transformed itself from an educational-cultural center to a major industrial hub. One of India's largest engineering conglomerates, the Kirloskar Group, first brought industry to Pune in 1945 when it established Kirloskar Oil Engines Ltd. In 1960, Maharashtra Industrial Development Corporation (MIDC) built a huge industrial estate on 4,000 acres of land at Bhosari, which attracted the growth of ancillary engineering industries in the area. The establishment of the commercial motor vehicle unit of Telco in Pimpri-Chinchwad in 1965 triggered Pune's industrialization, and for the next two decades industrial growth around Pune was largely activated by the presence of Telco, Bajaj Auto and Bajaj Tempo. This development had two major consequences: a) the development of a new satellite township—now known as Pimpri-Chinchwad Municipal Corporation, and b) the creation of new educational and employment opportunities, which attracted skilled labor from within Maharashtra as well as other parts of the country. The development of industrial estates by MIDC on the outskirts of Pune (Parvati, Hadapasar) and the declaration of the "C zones" for sales tax exemption in Pirangut and Shivapur, expanded the industrial activity map of Pune in almost all directions to Ranjangaon, Daund and Karkumbh.

The automotive sector remains prominent in Pune, with domestic and international firms manufacturing here. All segments of the automotive industry are represented, from two-wheelers and auto-rickshaws, to cars, tractors, tempos, excavators, and trucks. More recently, the Government of Maharashtra has provided liberal incentives in its Information Technology and Information Technology Enabled Services (IT & ITES) Policy, 2003. Consequently, the IT sector now employs more than 70,000 people. In addition, the Pune Food Cluster development project is an initiative funded by the World Bank to facilitate the development of the fruit and vegetable processing industries in and around Pune.

In short, the key drivers of growth in and around Pune include the auto and auto ancillary companies; educational institutions, with more than 100 technical and higher education institutions; IT companies; and a growing agro and food processing industry. There is also potential for Pune to emerge as a biotechnology hub.

2. WATER SUPPLY AND CLIMATE CHANGE VULNERABILITY

Hydrologic Setting

Pune is situated at a height of 560m above the mean sea level, near the confluence of the Mula and Mutha Rivers. Two more rivers, the Pavana and Indrayani, transverse the northwestern outskirts of the urban area. The city is surrounded by hills on the east and the south. The Sinhagad-Katraj-Dive Ghats range constitutes the southern boundary of the urban area.

Being located in the high rainfall Western Ghats, and in close proximity to many reservoirs, Pune has access to numerous surface water sources. Specifically, water sources for the city include the Rivers Mula, Mutha, Mose, and Pawana; Lake Pashan and Lake Katraj; and four dams (Khadakwasla, Panshet, Warasgaon, and Temghar). Ground water is also emerging as an important source to meet the water requirements of various sectors as per the PMC's City Sanitation Plan. There are around 399 dug wells and 4,820 bore wells in the city area.

Pune has three distinct seasons: summer, monsoon, and winter. Typical summer months are from March to May, with temperatures ranging from 35 to 39 degrees Celsius. Daytime temperatures during the winter season (November through February) hover around 29 degrees Celsius, while night temperatures dip below 10 degrees Celsius. Most rainfall occurs during the monsoon months from June to September. The mean annual rainfall in the Pune region is around 722 millimeters.

Water Supply and Delivery Infrastructure

The dams at Khadakwasla, Panshet and Temghar over the Mutha River are key sources of freshwater for the city's municipal water supply infrastructure, in addition to the Varasgaon dam on Mose River. From the climate perspective, therefore, rainfall patterns in the Pune region, as well as in the river basins, bear the most importance to the city's freshwater availability.

Table 2 shows the existing storage capacity of the four dams which provide water to the city. The balance of the water from these reservoirs is used for irrigation down and upstream of Pune city. Until recently, groundwater has not been widely used for urban water supply in Pune, although it is increasingly emerging as a supplementary source.

Table 2: Existing Water Storage Capacity of Dams in Pune City

Dams	Storage Capacity (thousand million cubic ft.)
Panshet	10.42
Varasgaon	12.82
Temghar	3.77
Khadakwasla	1.97
Total	**28.98**

The per capita water supply in the city is 194 liters per capita day (Lpcd), which is more than the Service Level Benchmark (SLB) indicator of 135 Lpcd.

The entire water supply operation of PMC is decentralized and divided into 48 water distribution zones; each zone has a specified service area, but the zones are different from the administrative wards. The transfer of water from the two principal water works is done both by pumping and by gravity, depending on available levels at the zonal reservoirs.

There are 39 storage reservoirs in the city, fed by two principal water supply sources. Of these, 11 reservoirs (sumps) with a storage capacity of 42.96 million liters (ML), provide balancing storage. The other 28 reservoirs, with a storage capacity of 177.96 ML, act as service reservoirs. The distribution network consists of pipelines varying from the largest diameter of 1,600 mm to the smallest size diameter of 80 mm. The total length of the distribution network is about 3,100 km, including 24 km of transmission lines. The total length of the roads in the city is 1,800 km. This implies that some roads may have more than one pipeline, laid at different points of time to meet demand.

Currently, the municipality supplies a net of 732 ML of water a day, after losses due to leakage and unmetered connections.[3] The per capita water supply in the city is 194 liters per capita per day (Lpcd), which is more than the Service Level Benchmark (SLB) indicator of 135 Lpcd. Table 3 shows the actual status of water supply in the Pune Municipal Corporation area.

Table 3: Water Supply Status in PMC

Details	Benchmarks	Figures	Units
Total population of Pune City		3.12	Million
Total Water Demand	135	420.58	MLD
Total Water Supplied		1,123.00	MLD
Losses 25% + 5 % NRW		337.00	MLD
NRW	20	30	Percent
Total Water Supplied to (City + Villages + PCB + KCB)		786.00	MLD
Bulk Water to Gram Panchayat +Ammunition Factory		24.00	MLD
Water Supply to City +PCB +KCB		762.00	MLD
Water Supply to PCB +KCB		30.00	MLD
Net Water Supply to City		732.00	MLD
Per Capita Water Demand	135	35	Lpcd

Note: MLD: Million liters per day; Lpcd: Liters per capita per day; NRW: non-revenue water

[3] The SLB is specified by the Central Public Health Engineering Organisation (CPHEO) and adopted by the Ministry of Urban Development, Government of India.

These demand-supply figures, however, do not tell the entire story. A study conducted in 2008 estimated that water demand would double in 20 years from 2002 levels, and much of this increased demand would come from industries. The study concludes:

> *Although urban water supply to Pune is secure, the additional water requirements will leave irrigated agricultural areas downstream of Pune with less water. Expansion of the current wastewater-irrigated area could compensate to some extent for expected losses. However, there will be a change in who has access to that water. Even if there are no long-term macroeconomic impacts, there will be losers who will need to be compensated or otherwise looked after* (Rooijen, et. al., 2008).

This points to the critical need for more holistic water resource planning at the basin level, coordinated with state and national institutions. The demand and supply situation is balanced precariously and could be disturbed by fluctuations caused by erratic rainfall in a particular season. News reports note that inadequate rainfall and reduced storage in the four dams caused challenges during 2012. A statement issued by the civic body in July 2012 directed all ongoing construction sites to control water use to prevent possible shortages. Besides this, other bulk-users such as swimming pools, hotels, and non-residential establishments were asked to install and operate meters. The city reduced the volume as well as frequency of water supply, switching to a once-a-day water supply delivery plan, down from twice a day.[4] It further considered alternate day supply after reviewing reservoir levels at the four dams.

A statement issued by the civic body in July 2012 directed all ongoing construction sites to control water use to prevent possible shortages. Besides this, other bulk-users such as swimming pools, hotels, and non-residential establishments were asked to install and operate meters.

In addition, through a series of circulars, the Corporation has tried to enforce regulations on fresh water use and has assigned specific responsibilities to line department functionaries to ensure compliance. The PMC has issued clear awareness campaign content guidelines to, and an official communication from the Municipal Commissioner in April 2012 provided directions for the following steps to respond to the water crisis this past year:

- Imposing penalties in areas where water is being wasted
- Corrective action to prevent leakages in supply lines
- Prevent vehicle washing with municipal water supply
- Prevent shops/hotels etc. from using motors to draw water from supply line
- Checking threads in pipeline to prevent leakage

[4] See *Times of India* news report 7 July 2012.

- Support use of dual flushing systems
- Encourage reuse of water from filtration plants
- Prevent use of potable municipal treated water for building construction
- Organize awareness drives among the water users to conserve water
- Establish "Help Lines" where water misuse can be reported

It should be noted, however, that while these are valuable measures, they have been instituted during what has been considered a crisis, and therefore any longer-term vision for improving water use efficiency remains somewhat of a question.

Moreover, discussions with the Municipal Commissioner suggest that the Corporation is aware of and concerned about inequities in the water supply situation. Supply varies from 40 Lpcd to 400 Lpcd across different parts of the city. The saucer-shaped topography of the city reportedly results in this inequitable supply situation—the areas at the base receive water for 12 hours, while those at the periphery receive water for only two hours. The PMC is taking concrete steps to address this issue now and over the next decade, allocating Rs. 8 billion for this purpose. A consulting firm has started work on updating the main lines and the distribution network up to the consumer end and to achieve hydraulic balance.

With respect to tariffs, the Pune Municipal Corporation recognizes three different categories of users, with the rates shown in the table below (Table 4):

1. Domestic users, which include household connections as well as government educational institutions, places of worship (temples, churches, mosques, etc), orphanages/welfare centers recognized by the government, and government accommodations such as inspection bungalows and guest houses, etc.
2. Industrial users.
3. Non-domestic users, which includes all commercial establishments not covered by (a) and (b) above, such as shops, offices and godowns (warehouse), petrol pumps, private educational institutions, cinema theaters, etc.

Table 4: Water Rates Charged by Pune Municipal Corporation

Consumption level (Liters)	Tariff by category in Indian rupees per 1000 liters		
	Domestic	Non-domestic	Industrial
Up to 15,000	1.56	4.68	11.00
> 15,000 to 40,000	3.00	8.25	13.75
> 40,000	4.00	11.00	16.50

There is a fixed monthly charge in addition to the above variable charge, which is progressively higher for increasing diameter service lines (15 mm to 150 mm). The rate varies from Rs. 20 (15mm) to Rs. 11,245 (150 mm) per month for domestic users. For non-domestic and industrial users, the fixed charges are the same except for the lowest diameter of service line.

Table 5 reflects water meter coverage, which remains very low (29.71%) as compared to the SLB indicator of 100 percent. This points to a significant need to improve the water metering in the city. What is not measured cannot properly be managed—proper rates cannot be charged, leakage levels are more difficult to quantify, and properly targeting conservation efforts becomes more challenging.

Table 5: Metering of Water Connections in PMC

Status of Metering	Number
Total number of direct service connections and stand posts	122,643
Total number of metered connections	36,456
Total number of functional metered connections	36,020
Number of metered public stand posts	436
Metering (Functional)	29.73%

Analysis of annual operating expenses for water supply and revenue generated during one year (2009-10) indicates a cost-recovery level of 70.68%. The total cost incurred during the year was Rs. 1,764.1 million, while the revenue generated through property tax and water metering was Rs. 1,246.8 million during the year.

The volume of non-revenue water (NRW) has been estimated at 30%. This includes an estimated 25% distribution loss, and 5% loss during purification processes/NRW connections (including leakages, illegal connections, and water lost during treatment). However, low metering levels calls this figure into question.

Wastewater Infrastructure

Pune's sewerage system consists of a collection network, conveyance line, pumping stations and sewage treatment plants. An underground drainage system was built as early as 1915-16. In 1997, the total main sewer length in all of the zones was approximately 146.83 kms, while currently it is 1,260.6 km in length. The total sewage generated in Pune (including villages, Pune Cantonment Board—PCB area, and Khadki Cantonment Board—KCB area) is estimated at 744 million liters per day (MLD), considering a government estimate of 80% of net water supply, with community level effluent from their own supply resources.

Out of the total 995,578 properties in the city, 971,425 properties (97.5%) are directly connected to the sewerage network. All individual, community, public, pay and use, and group toilets are connected to the underground sewerage system. Septic tanks have also been connected to the sewerage network. However, there is a need to provide toilets for 24,153 households in the slum areas. Toilets constructed for these households would need to be connected to the sewerage network in order to meet the SLB standard of 100 percent coverage.

Nine Sewage Treatment Plants (STP) with a combined capacity of 527 MLD serve the city. The capacities of the individual plants and the method of treatment employed are shown in Table 6. At present, only 7.59% of the sewage is recycled, as against the Service Level Benchmark of 20%. Treated sewage from Bhairoba STP is being recycled for irrigation, and per flow meter records, the volume is 40 MLD.

Table 6: Sewerage Treatment Plants in Pune and their Capacity

Location of STP	Capacity (MLD)	Method of Treatment
Bhairoba	130	Activated sludge process
Erandwane	50	Modified activated sludge process
Tanajiwadi	17	Biotech with extended aeration
Bopodi	18	Extended aeration process
Naidu (Old)	90	Activated sludge process
Mundhwa	45	Sequential batch reactor process
Vitthalwadi	32	Activated sludge process
Naidu (New)	115	Activated sludge process
Baner	30	Sequential batch reactor process
Total	**527**	

The Government of India has launched a system of rating of urban sanitation services. On this basis, cities are rewarded with what is called *Nirmal Sahar Puraskar*,[5] following from the National Urban Sanitation Policy and Goals (2008). The state and local governments in urban areas are expected to plan and implement citywide holistic sanitation plans following the national policy, thereby putting in place processes that help achieve outputs pertaining to safe collection, confinement and disposal (including conveyance, treatment, and/or reuse without adverse impacts on the environment in and around the cities).

The first rating of cities with regard to sanitation performance improvements, based on a set of objective output indicators, processes and outcomes, was carried out in 2010 to establish a baseline ranking. Cities are expected to undertake this objective self-assessment from time to time using the same index. Pune ranked 66th among 423 cities, and falls in the "black" category, which means the city needs to make considerable improvement.

While the hydrologic profile of Pune is such that sufficient water supplies are available to meet current demands, the potential long-term impacts due to climate change present yet another important variable.

A multi-stakeholder City Sanitation Task Force was constituted in July 2010, headed by the Mayor and with the Commissioner of PMC as the executive head to prepare and implement the City Sanitation Plan. The plan is now at a draft stage. The Task Force has adequate representation from all sectors, including rag pickers and conservancy workers. The city has set extremely ambitious goals for itself to improve its score.

Summary of Climate Change Vunerability

Globally, the issue of sustainable freshwater availability is expected to be exacerbated by climate change (Bates, 2008), and the adverse impacts of a changing climate makes achieving development objectives all the more difficult. While the hydrologic profile of Pune is such that sufficient water supplies are available to meet current demands, the potential long-term impacts due to climate change present yet another important variable.

The Intergovernmental Panel on Climate Change (IPCC) developed a set of scenarios for greenhouse gas emissions in the future world taking into account different directions of demographic change, economic development, and technological change. Four different storylines called A1, A2, B1, and B2 were developed with different assumptions. Of these storylines, the A1 scenario family describes a future world of very rapid economic growth, global population that

[5] Literally this means "clean city award."

peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies (IPCC, 2000). The A1 scenario family further develops into three groups describing alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

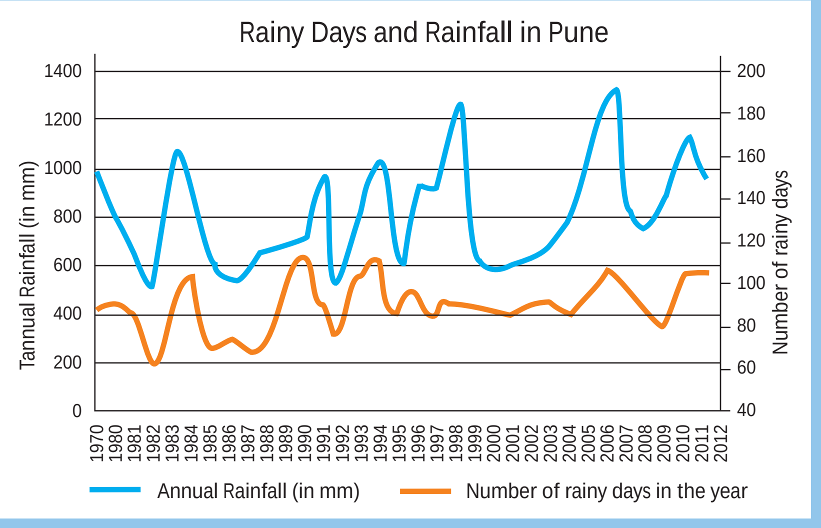
Climate change scenarios for India under the A1B scenario of emissions project a warming to the order of 0.5° to 1.5° C in the 2020s, and up to 3° C in the 2050s, against the baseline of the 1970s. Climate models further project that the maximum warming is expected over the northern parts of India and over the Himalayas (Indo-UK, 2012), with an increase in seasonal (monsoon) rainfall of 10% in the 2020s and 15%-20% in the 2050s, against the 1970s baseline. With respect to the Maharashtra region specifically, the projected percentage change in seasonal (monsoon) rainfall in the 2020s is a decrease of up to 5%, and in the 2050s, an increase of 5%-10% against the 1970s baseline. Table 7 (page 21) presents the probability of the occurrence of four possible climate change events in Pune under the A1B scenario.

It is important to note that significant variability in forecasts can occur across the different storylines, and based on different scales of analysis (such as global, regional, local). For purposes of this report, in order to assess the water resource-related vulnerabilities due to climate change,[6] climate events affecting water resources for Pune were first identified. Then, the probability of occurrence of these events in the city was determined. The probability of occurrence is the likelihood that such an event may occur, based on a scale of low/medium/high, as presented in Table 7. Upon determining the nature of the impacts from these events (Table 8), the municipality's preparedness is considered to mitigate these impacts.

[6] The IPCC 2000a publication defines vulnerability as “the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate.”

Table 7: Probability of Occurrence of Certain Climate Change Events for the City of Pune

Climate Events	Probability of Event	Rationale
Scanty rainfall in rainy season	**Medium**	Several studies report a general trend of a decrease in the number of rainy days and total amount of annual precipitation in many Asian countries.[7] From the monsoon data on the India Meteorological Department's website, the East/Central Maharashtra area has mostly received normal or excess rainfall between 2005 and 2012, with one deficient monsoon year in 2012.[8] But, there is an up to 5% decrease of monsoonal rainfall projected over the short term. Considering the recent trends and statistical projection, the probability of occurrence of scanty rainfall in the monsoon season is estimated to be medium.
Wetter non-rainy seasons	**Low**	The city of Pune and the river basins of Mula, Mutha and Pawana receive the bulk of its rainfall in the monsoon months from June to September. There has been no exclusive study or indication of an increase in off-season rainfall in the area.
Hotter summers	**Medium**	The general trend of annual average maximum and minimum temperatures of Pune since 1979 indicates that the warming in the region is minimal to now.[9] While the climate change model for India projects a warming up to 1.5^{0}C in 2020s and 2.5^{0}C in 2050s. It is expected that the probability of increasing summer temperatures is medium.
Storms and intensive rainfall	**Low**	Many studies report that the frequency of occurrence of more intense rainfall events in many parts of Asia has increased in general.[10] The climate change model for India projects a seasonal rainfall percentage increase, indicating an increase in intensity of rainfall in the monsoon months. But, the past record of rainfall in Pune area indicates a corresponding increase or decrease in number of rainy days.



[7] Zhai, 1999; Kahn, 2000; Shrestha, 2000; Lal, 2003; Ruosteenoja, 2003; Zhai, 2003; Gruza, 2003.

[8] See http://www.imd.gov.in/section/nhac/dynamic/Monsoon_frame.htm and http://www.imd.gov.in/section/nhac/dynamic/weekly_pressrelease.pdf

[9] Average annual climate values, Poona, http://www.tutiempo.net/en/Climate/POONA/430630.htm

[10] Zhai et. al., 1999; Khan, 2000; Shrestha, 2000; Lal, 2003; Ruosteenoja, 2003; Zhai, 2003; Gruza, 2003.

Impacts and Vulnerability due to Potential Climate Events on the Municipality of Pune

Table 8 presents the possible impacts from each of the water resource linked climate events for the city of Pune, with further discussion below.

Table 8: Potential Impacts and Vulnerabilities to Climate Change Events

Climate Events Related to Pune	Potential Impact	Vulnerability	
		Short-term (2020s)	Long-term (2050s)
Scanty rainfall in rainy seasons	Reduced recharge, droughts	**Low**	**Low**
Wetter non-rainy seasons	Water logging, floods	**Low**	**Medium**
Hotter summers	Reduced recharge, droughts	**Low**	**Low**
Storms and intensive rainfall	Water logging, floods, reduced recharge	**Medium**	**High**

Reduced Recharge

As per the stage of groundwater development (percentage of annual ground water draft to net annual ground water availability) assessed in 2004, Pune falls in the “safe” category with a groundwater development of 70%. (GoI, 2006a), which indicates no long term decline in pre-monsoon and post monsoon levels of groundwater in the area. Considering the current level of municipal water supply (786 MLD), the Service Level Benchmark (135 Lpcd) and the projected population by 2031 as per the City Development Plan (5.657 M), no major gaps in demand and supply are foreseen in the near future. Although groundwater is emerging as an important source of water across sectors in the city, the demand-supply balance and the availability of surface water suggests that the vulnerability of the city to reduced recharge is low in the short term and long term.

Droughts

As per the current supply situation in Pune, and the occurrence of average to above average rainfall in the region, the city is not considered vulnerable to droughts. With increasingly competing demand for water from other regions from Pune's current sources, however, the city's vulnerability to drought might increase. The likely increase in rainfall in the catchment region and Pune's groundwater resources would help in the city's preparedness for such a situation looking forward to the 2050s. On balance, the vulnerability of Pune to drought events is low over both the short and long term periods.

Water Logging and Floods

During 10 out of the last 15 years, Pune has received above average rainfall.[11] This results in an increase in rainwater runoff in both the upper watershed area of Pune that feeds the major dams, as well as the city of Pune itself. The decrease in tree cover and subsequent increase in paved area, though, has resulted in reduced water absorption to the ground, and adds to storm drain flow from runoff. This has rendered the drainage systems in some places inadequate during increased water flows. Certain areas of the city are said to be susceptible to flash floods resulting from water logging and drain clogging in the event of heavy rainfall.

The Pune Municipal Corporation has put in place Storm Water Master Plans for each basin to address this situation. Also, the building permission in the city jurisdiction requires that a property owner not alter the natural drainage pattern (AIILSG, 2010). In spite of this and other steps taken by the city administration to control flooding, because of clogged drains from improper solid waste disposal, conversion of streams to built areas, among other factors, the vulnerability of some parts of the city to water logging and floods in the short run is medium.

Models suggest that the amount of rainfall is likely to increase with changes in the climate, more so in the 2050s than in 2020s. On the upstream side, the age of the dams and the increasing rainfall patterns puts the city of Pune under risk of flooding due to uncontrolled flow from dams (such as dam bursts, which has happened in Pune). Therefore, the vulnerability of the city to water logging and flood events is likely to be higher in the long term (2050s).

During 10 out of the last 15 years, Pune has received above average rainfall... The decrease in tree cover and subsequent increase in paved area, though, has resulted in reduced water absorption to the ground, and adds to storm drain flow from runoff.

Landslides

The city is located in the midst of hilly areas in the Sahyadri mountains. The loss of tree cover on the Western Ghats due to development, and the heavy rain in the region makes these areas subject to occasional landslides. The Disaster Management Plan for Pune states that there have been a number of cases of landslides in and around Chatursshunghi area (AIILSG, 2010). More broadly, the city has grown by more than 50% in the last 20 years, implying notable land use changes (Table 9, page 24). Overall, however, the climate change vulnerability of Pune to landslides is considered low over the short and long term.

[11] See average annual climate values, Poona, http://www.tutiempo.net/en/Climate/POONA/430630.htm

Table 9: Land Use Pattern in Pune City

Land Use	1987		2007	
	Area in Km^2	%	Area in Km^2	%
Residential	50.58	36%	103.74	43%
Commercial	2.35	2%	3.93	2%
Industrial	7.26	5%	9.88	4%
Public & Semi-Public	16.60	12%	18.05	7%
Transport	22.00	16%	31.81	13%
Reserve Forest, Agricultural, River	27.84	20%	56.02	23%
Recreational	12.73	9%	20.52	8%
Total	**139.36**	**100%**	**243.95**	**100%**

Water Supply and Climate Change Conclusions

Pune city meets its water requirements from the dams upstream on the rivers Mula, Mutha and Pawana, originating in the Western Ghats. At the current rate of supply, the city can meet its projected water requirements at least in the medium term. The City Development Plan suggests that the supply and demand situation is in a delicate balance, affected by erratic seasonal rainfall (GoI, 2006c). With increasing competing uses for the city's sources of water (including from other jurisdictions), Pune should reduce its future vulnerability by increasing water use efficiency practices and expanding water recycling. The PMC has taken a number of steps to address this emerging issue, beyond the national plans which seek to encourage increased efficiencies. For example, they have introduced an Eco-housing program, which provides incentives for building developers and home buyers for developing or purchasing green buildings, which include improved water and solid waste management approaches. This program is discussed further in Section 2. Also, in institutional terms, as part of the National Water Mission, the Maharashtra Government set up a “climate change” cell under the Water Resources Department in 2010 with an aim to increase water use efficiency by 20 per cent. The cell is required to primarily assess the impact of climate change on water resources and promote conservation among citizens.

With increasing competing uses for the city's sources of water (including from other jurisdictions), Pune should reduce its future vulnerability by increasing water use efficiency practices and expanding water recycling.

At the same time, however, climate change scenarios reinforce the value of pursuing multiple measures to improve water use efficiency—such actions represent “no regrets” approaches that will optimize water resource use and build resilience. For instance, reducing non-revenue water, promoting groundwater recharge, and increasing wastewater reuse—currently only done with 8% of wastewater—all represent worthwhile measures. In addition, steps to improve solid waste management and prevent clogged storm drains will improve infrastructure conditions as well as water management.

3. LEGAL AND POLICY FRAMEWORK RELATED TO WATER USE EFFICIENCY

As stated earlier, water regulation is a "State" subject as defined in the Indian Constitution. However, there is notable national level leadership support for increased water use efficiency. The Government of India's Approach Paper for the 12th Five Year Plan recognizes this need, as does GoI's climate change initiative. Under India's National Action Plan on Climate Change (NAPCC), the National Water Mission (NWM) is one of the eight national-level strategy documents to address water management under a changing climate scenario. The NWM recommends identifying water efficiency improvement as one of the principal measures to improve resilience to the adverse impacts of climate change and has the stated goal of increasing water use efficiency by 20 percent. In addition, the Ministry of Water Resources has announced its intention to launch the National Bureau for Water Use Efficiency. The proposed methods to improve water use efficiency under the NWM are as follows:

- Label water efficient products (similar to the energy efficiency certification provided by the Bureau of Energy Efficiency).
- Minimum standards for water use for commercial buildings (similar to the Energy Conservation Building Code (ECBC) which sets minimum energy performance standards for commercial buildings). Use of water efficient fixtures can be made mandatory in all new construction and remodeling involving replacement of plumbing fixtures in government buildings and commercial complexes.
- Highlight the impacts of savings through using water efficient products so that the general public becomes conscious about adopting these products.
- In the presence of proper water tariffs, water savings can be directly linked with cost savings and thus could be an incentive to adopt water efficient fixtures.
- Provide incentives to save water using labeled products.
- Enact laws which would make it mandatory for the consumers to adopt water saving devices and also ensure strict monitoring for quality parameters.
- Assess the market potential of water saving measures product and the possibility of public private partnerships.
- Funds may be ring fenced (protecting the transfer of assets) for developing water saving measures and assisting potential stakeholders and investors.

For its part, each state government is under an obligation to provide water of a certain quantity and quality to the public. However, the state government can exercise its discretion and devolve this responsibility to urban local bodies. Provision of water to industries located within the city area—typically small and medium-sized enterprises—and disposal of effluents, come under the purview of state level industrial policies. The Municipal Corporations, of course, have their own policies relating to sites and services, which also includes water. Therefore, access to and use of water in Indian cities is guided by a complex set of policies and acts, which sometimes overlap in their jurisdiction.

Provision of water to industries located within the city area—typically small and medium-sized enterprises—and disposal of effluents, come under the purview of state level industrial policies...Therefore, access to and use of water in Indian cities is guided by a complex set of policies and acts, which sometimes overlap in their jurisdiction.

The legal and policy analysis undertaken for this Guideline found that measures to improve water efficiency have been given some due consideration over the past 15 years or so, and continue to receive greater attention, particularly in light of the 2012 drought. As a starting point, though, any effective legal framework requires (1) standards; (2) a management control tool such as licensing or permitting; (3) enforcement monitoring, complete with an established frequency as well as a reporting mechanism; and (4) meaningful sanctions, or consequences for non-compliance. This can be supplemented with well conceived incentives that encourage behavior change and provide the needed support to facilitate compliance and ensure the success of such policies.

On the whole, the analysis carried out shows that the measures in place have only been implemented half-heartedly. Furthermore, measures taken in times of drought crisis as in 2012 are not good markers for long-term and meaningful policy changes. The future is still promising, however, because of a combination of factors.

First, the present crisis may recede, but it will push the local administration to keep its focus on water conservation, reuse and efficiency. Second, new state laws, such as the groundwater legislation (or the implementation of existing laws) will ensure that the city keeps taking new steps forward. This is, for instance, the case with regard the introduction of the "polluter pays" principle in the Maharashtra Water Resources Regulatory Authority (MWRRA) Act, 2005/2011, whose implementation requires the PMC to treat effluents to standards required by the Maharashtra Pollution Control Board before releasing it. Third, union-level policy developments, such as in the context of JNNURM 2.0 will put significant pressure on the PMC to deliver more in terms of policy proposals and their implementation.

Maharashtra Municipal Legal and Policy Framework with Special Reference to Pune

There are a number of laws in Maharashtra that relate to or affect the potential for water and wastewater recycling and reuse, and water use efficiency in particular cities. At the most general level, this includes legislation like the Maharashtra Jeevan Authority Act, 1976. The supply of water for domestic purposes under the Act means supply for any purposes, except for any trade, manufacture or business; gardens or for purposes of irrigation; building purposes, including construction of streets; fountains, swimming baths, public baths or tanks or for any ornamental or mechanical purpose; watering streets; or washing vehicles where they are kept for sale or hire (section 40). If supplied by the Authority for domestic purposes, no person is to use water or allow it to be used for any other purpose, except in such circumstances or subject to such conditions as may be provided under the by-laws (section 41). The Act also prohibits any owner or occupier of any premises to which water is supplied by the Authority to cause or suffer any water to be wasted, or the service pipe or any tap or other fitting or work connected therewith to remain out of repair so as to cause wastage of water (section 43[1]).

Another piece of relevant pre-reform legislation is the Maharashtra Groundwater (Regulation for Drinking Water Purposes) Act, 1993 that constituted one of the earliest attempts in the country to directly link the regulation of access to groundwater with drinking water. Its purpose is to regulate the exploitation of groundwater for the protection of public drinking water sources, and has been credited with some success in this regard (Phansalkar, 2006).

In addition, The Maharashtra Regional and Town Planning (MRTP) Act, 1966 imposes a statutory compulsion for every municipal authority to prepare a development plan[12] for the area under its jurisdiction. What is known as the Pune Municipal Corporation was established under the Brihan Mumbai Municipal Corporation (BPMC) Act, 1949, and the Development Plan for the old city area of Pune was drafted in 1982 and sanctioned by the State Government in 1987.[13] The Development Control Rules for Pune Municipal Corporation, 1982 are a part of the Development Plan, which itself is a statutory document. Section 37 of the

...The Maharashtra Regional and Town Planning (MRTP) Act, 1966 imposes a statutory compulsion for every municipal authority to prepare a development plan for the area under its jurisdiction... The Development Control Rules for Pune Municipal Corporation, 1982 are a part of the Development Plan, which itself is a statutory document.

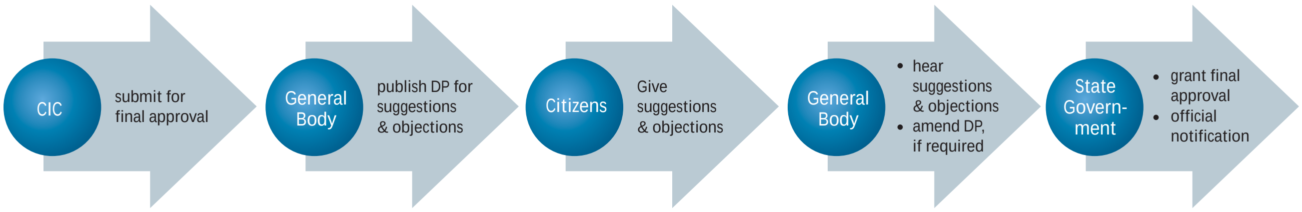
[12] The Development Plan lays out policies and proposals for the development and use of land in the city. It is meant to guide decisions on whether development permission should be granted under the Development Control Rules.

[13] See Urban Development Department, Notification No. TPS/1884/1377/CR-220/85 (iii) UD-7, 5 January, 1987.

MRTP Act allows the PMC to modify and alter the existing development control rules. Furthermore, in 2001, 23 villages were merged in the jurisdiction of the PMC limit. The Development Control Regulations of the newly merged additional area Development Plan were sanctioned by the State Government in 2007.[14]

Developments Plans have been increasingly controversial in Pune. The original Development Plan of 1987 was to expire in 1997, but a 10 year extension was granted since the execution of works was only 20 percent complete. In 2007, the civic body sought yet another extension from the state government, which gave a new deadline of December 2010. But it was only in December 2011 that the civic administration completed and submitted the draft copy of the new Development Plan (2007-2027) to the City Improvement Committee (CIC). As of November 2012, it has been approved by the CIC but it is yet to be approved by the PMC general body.

Figure 3: Procedure for Approval of Development Plan



At the state and local levels, there are a number of laws and policies in Maharashtra and Pune that are related to or affect the potential for rainwater harvesting, water and wastewater recycling and reuse, and water use efficiency. These are explored further below.

Water Conservation

The Maharashtra State Water Policy 2003 seeks to improve efficiency of water utilization across diverse uses, and to foster an awareness of water as a scarce resource. In order to promote "conservation consciousness," the Policy recommends at section 2.7.1 "education, regulation, incentives and disincentives."

Pune Municipal Corporation has become proactive in taking water conservation measures after the water crisis in 2012 due to insufficient rainfall. Some of the measures that have been taken include the following:

[14] See Urban Development Department, Notification No. TPS/1806/2125/CR-45/06/UD-13, 6 December 2007.

- In April 2012, the PMC issued directives to control water use. All establishments built, reconstructed, or renovated on or after 10 April 2012 are required to obtain certain permissions from the PMC that are linked to the fulfillment of certain conditions. For example, in order to reduce unnecessary water usage in toilets, tenants and building owners (other than commercial establishments) are required to install a dual flushing system (with 3 liter/6 liter flushes).

- The water flow pressure must be maintained at six to eight liters per minute. Further, in order to control water flow, low-flow fixtures should be installed on faucets.

- More specifically, five-star and luxury hotels have been instructed to reduce their usage of rain showers, bathtubs, and shower panels. Similarly, five-star hotels, resorts and amusement parks must install water meters to calculate the amount of water used in swimming pools and for other amusement activities.

- Another new directive is that buildings with a height of at least 24 meters from the ground level must install pressure reducing valves in their water tanks to control pressure and avoid water loss.

The PMC has also specifically addressed vehicle washing and banned the use of drinking water for the same. In July 2012, an order was passed by the Municipal Commissioner to ban the use of drinking water and groundwater for vehicle washing purposes at car washing centers. At the same time, the PMC has also forbidden the sale of drinking water outside of city limits. This is linked to the practice of private sector contractors to the municipality supplying un-served areas within the PMC diverting their cargo to more lucrative customers outside of the city.

In a related development, the PMC has imposed a ban on using drinking water for the purpose of building construction under the BPMC Act. At least one fine of Rs 3,000 has been imposed on a contractor for using drinking water for construction purposes.[15] In response, the Confederation of Real Estate Developers Associations of India of Pune Metro decided to discontinue the use of tap water at construction sites. The circular issued also notified the members about various techniques for water conservation.[16]

[15] See “Action Against Tankers Needed,” *Times of India* (Pune), 30 June 2012.

[16] See “Builders not to Use Potable Water for Construction,” *Times of India* (Pune), 24 July 2012.

Further ideas that have been mooted in response to the crisis of 2012 include stronger enforcement, such as by using Nuisance Detection Squads to check on overflowing water tanks, open public taps, illegal water connections, and illegal pumps. It remains to be seen whether such measures are maintained as long-term policy decisions rather than crisis management measures by the municipality.

Eco-Housing Program

The PMC is the first urban local body in India to have implemented the Eco-housing scheme, which was established in 2008 under technical assistance provided by USAID. A dedicated Eco-housing Cell has been established for this purpose within the PMC. The PMC has implemented the Eco-housing Assessment Criteria, which are applicable to all residential building/building complexes, and single-family residences. The mandatory and non-mandatory measures for water conservation included in the Assessment Criteria are summarized below:

Mandatory:

a) All water closets (WCs) are to have a dual flush system with a flow rate of three liters and six liters per flush
b) Install meters at every down take line
c) Plant native/indigenous species with low water requirement so as to form at least 50% of the vegetated area
d) Onsite recycled water is to be used to water lawns, fountains and other water bodies
e) Harvest, store/recharge and make provisions to utilize 100% of rainwater from the roof, as well as 60% of site runoff
f) Install a treatment system based on non-energy intensive and eco-friendly technology to treat the total volume of grey water.

Non-mandatory:

a) Maintain uniform pressure restricted to 25-30 meters/head by use of separate distribution down takes for each set of floors and use of orifice flanges or pressure reducing valves
b) All faucets and fixtures should be low flow to maintain flow rates not exceeding 8 liters per minute
c) Water meters must be installed for every household with electronic control
d) Restrict areas covered by lawn and exotic or ornamental plants to 25% of total vegetated area, as these require more water and high maintenance
e) Use sprinklers to water lawns, and drip irrigation for trees
f) Reuse collected rainwater for gardening, washings, and other building applications, and recharge excess rainwater to the ground

g) Use dual plumbing lines to separate all greywater and blackwater
h) Install an eco-friendly treatment system for combined stream of greywater and backwater
i) Install a separate plumbing line for use of treated water for flushing
j) Reuse the treated water for various building applications and gardening depending on the treatment level and meeting of prescribed standards
k) Minimize water use during construction and during curing; admixtures during concreting, use of premixed concrete/recycled water

As an incentive for participation in the eco-housing scheme, PMC started by granting a 50 percent rebate certificate on all premiums to the developer based on the star rating system. This was then changed to offer the rebate for compliance with only three elements, namely solar water heating, installation of a rainwater harvesting system, and a sewage treatment within the housing colony.

Interestingly, developments at the state level have overshadowed the local initiative. In the context of implementing the Environmental Impact Assessment Notification of 2006, the state Environmental Appraisal Committee started mandating building projects bigger than 20,000 m^2 to have a solar heating system, rainwater harvesting system, and sewage treatment facility. In view of the state-wide measures, the PMC stopped offering rebates to developers even though the property tax rebate remains in place and benefits the residents.

In the context of the water conservation measures taken in 2012, the PMC directed five-star hotels, resorts and amusement parks to install water meters to calculate the amount of water used in swimming pools and for other amusement activities.

Water Metering

There have been repeated attempts by PMC to introduce a metered water billing system in the city. Elected representatives abolished billing for domestic users on 1 April 2000, and instead domestic water users are billed on a system based on the annual rateable value of their property. In recent years, there has been further pressure on the PMC to introduce metering.

In the context of the water conservation measures taken in 2012, the PMC directed five-star hotels, resorts and amusement parks to install water meters to calculate the amount of water used in swimming pools and for other amusement activities. Further, all establishments built, reconstructed, or renovated on or after 10 April 2012 must install meters.

With regard to household meters, developments in 2012 show a renewed attempt to push this forward, due in part to state government pressure that warned the PMC that it would lose its share of funds under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) phase-II if it did not approve the water metering proposal. JNNURM mandatory reforms include 100% metering of commercial water connections that the PMC has implemented. The PMC has also started the implementation of 100% metering for new connections, but has not made much progress with regard to older connections.

In May 2012, the general body of PMC approved a proposal (pending since 2007) to introduce metered water supply for household consumers in a phased manner. As per the proposal, 150 liters of water is provided per person, and a five-member family will be considered a unit. If a family uses 150 liters water per person (750 liters in total), no extra charges would be imposed and the existing water rates would be charged. About Rs. 33 would be charged for every additional 1,000 liters. However, the general body reserves the right to alter the water charges as per requirements. The civic body is supposed to prepare a detailed project report and launch the pilot system in five areas of the city.

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Latest developments indicate that there may be a further delay in implementing the decision to install water meters for domestic connections. The Civic Standing Committee decided in mid-November 2012 to defer the decision to the end of the month after discussions with political leaders. At the time of writing this report the decision is still pending.

Rainwater Harvesting

Rainwater harvesting (RWH) has been included in an increasing array of instruments, mainly over the past decade. At a broad level, the Maharashtra State Water Policy, 2003 states that: water harvesting shall be given consideration in planning water resources. Viable projects especially in scarce groundwater areas shall be investigated and implemented to increase the surface water availability, which would also help in recharging the groundwater (section 2.7.2).

In 2002, the State Government issued a resolution approving rainwater harvesting as a means of improving water supplies (GoM, 2002). The following provisions of the resolution are relevant for urban areas:

- Necessary measures for collecting the rainwater for drinking and other purposes by adopting rooftop rainwater harvesting on all the public and government buildings in villages, towns and cities.
- Measures for collecting the rainwater for drinking and domestic use by adopting rooftop rainwater harvesting on private houses and structures.
- Measures for collecting rainwater and its direct recharge into the public drinking water sources by all possible conventional and unconventional methods.

- Other conventional measures by which drinking water can be made available (for example, water conservation measures like de-silting, and deepening of tanks/wells, check dams, etc.).

The resolution also called for rainwater harvesting and recharge structures to be adopted by all government offices and government buildings in the state, but is not mandatory across the state. However, in 2002, the Urban Development Department, GoM, directed the PMC to take steps to make rainwater harvesting mandatory for all construction, and in May of that year, the CIC recommended that the civic administration make it mandatory for builders and developers to develop RWH for all new housing schemes in the city. The General Body of PMC later passed resolution No. 573 on 21 January 2004 to create new rules for RWH in the Development Control Rules. Accordingly, the Rules were amended to make rainwater harvesting mandatory for all construction. In addition, the PMC made rooftop rainwater harvesting mandatory for all new buildings on plots larger than 300 m^2 built since 2007. The civic body gives a 10 percent concession on property tax to those who implement any two of the following three techniques: 1) solar heating 2) garbage segregation and vermin-composting, and 3) rainwater harvesting. A five percent concession is given for implementing any one technique.

The Maharashtra Groundwater (Development and Management) Bill, 2009 was passed in 2012, but is not yet notified. This important legislation specifically enjoins the state authorities to issue necessary guidelines for rainwater harvesting to recharge groundwater (section 9). With regard to urban areas falling in notified areas, the state authority is to issue directives to the concerned authorities or urban local bodies to ensure construction of appropriate RWH structures in favorable or technically suitable residential, commercial, industrial and other premises having an area of 100 m^2 or more. In addition, urban local bodies can impose necessary conditions for providing rooftop rainwater harvesting structures in the building plan in the area before approving construction, and permanent water and electricity connections can be denied until complying. This has occurred in the context of JNNURM, which promotes RWH as an optional reform. The standing committee of PMC is also considering a proposal to make rainwater harvesting compulsory before permitting bore wells in the city.

Treatment, Recycling and Reuse of Wastewater/Graywater

The Maharashtra State Water Policy envisages a role for recycling and water reuse, including reclaiming usable water from sewage after necessary effluent treatment, to augment water resources. According to the policy, this should be made mandatory for industrial use. A Government of Maharashtra resolution on Recycling and Reuse of Sewage in Urban Areas was also adopted in 2010.

The policy framework also influences the kinds of measures that are actually taken in practice even though these instruments are not binding. The Maharashtra State Water Policy 2003 includes a section 2.2.3 on "Water for Domestic and Industrial Use," which inter alia states that:

> *It shall be made obligatory for newly coming up industries to set up effluent treatment plants either collectively or individually. Effluent treatment plant installations shall be made in stages (within 5-7 years) for existing industries as well as for civic water supply schemes. Encouragement will be given for recycling or reuse of treated wastewater.*

In the Pune region, attempts have been made at various levels to promote water recycling. At a broad level, since 1997, the state Irrigation Department has been supplying 11.5 thousand million cubic meters (TMCM) of water to the PMC on the condition that it would treat 6.5 TMCM annually and recycle it as water for irrigation purposes in the irrigation canal. The PMC has failed to satisfy this condition, and at the same time, its water demand has increased over the years. The absence of a centralized system to collect treated water remains. As a result, very little treated sewage is put to effective use, and treated water is released into the river instead, along with about 25 percent of untreated sewage. Within the city, the PMC has tried to give away treated water free of cost to those wanting to use it. However, the lack of a mechanism to provide this water on demand has led to a situation where—despite the publication of advertisements appealing to individuals and industries to use treated water for non-drinking purposes, such as gardening, car washing and other uses—adoption is uncertain.

In regulatory terms, the PMC has taken several initiatives. Under the JNNURM Optional Reforms, the PMC adopted bylaws to reuse water. The PMC has also amended the Development Control Rules to make it mandatory for all builders constructing new housing societies with 150 tenements or more, or which generate more than 50,000 liters/day of sewage water, to construct sewage treatment plants to "treat the effluents to the desired levels of purity and shall thereby provide for recycling of water consumed by the said complex." Granting of the completion certificate is contingent upon the fulfillment of this condition.[17]

In September 2012, a draft proposal to incorporate graywater treatment, recycling, and reuse into the Development Plan was submitted to the CIC. The draft proposal suggests that the PMC should lay separate pipelines in housing societies to collect graywater, and connect these lines to storm water drains. This

[17] Pune Municipal Corporation, Development Control Rules, M 8/28.2 dated 6 December 2007.

water should be treated if necessary and released in the river or canal for irrigation purposes. The draft also provides that if existing housing societies want to collect graywater and use it locally, the PMC should provide Transfer of Development Rights (TDR) to societies. These societies should then be able to sell the TDR in the market and get money to lay graywater pipelines. Further, the draft suggests that the civic body should make it mandatory for new construction to have a separate system to collect graywater. However, discussions with officials suggest that the PMC has no plans to pursue such approaches currently.

Legal and Policy Conclusions

The analyses undertaken in this report confirm that the various issues under review have been given some considerations over the past 15 years and just got a boost in 2012 due to the water crisis situation affecting Pune this past year. A careful examination of all layers of the legal and regulatory framework demonstrate that, even as they work toward similar objectives, the sheer complexity of the laws and policies in place through a myriad of state and local institutions makes for overlapping and, at times, conflicting requirements. The diverse initiatives being taken do not add up to a holistic and comprehensive policy framework for advancing water recycling, water use efficiency, or cross-sectoral water use. This is, for instance, highlighted in the fact that initiatives like rainwater harvesting schemes, that cover only new development, focus on at best 2% of the city's built environment. Indeed, the bottom line is that much of the legislation is well intentioned and directed, but more needs to be done to clarify institutional responsibilities, assure enforcement, and improve incentives and disincentives for effective and operational implementation in the short and long term. PMC officials recognize this to a degree, in segmenting their responsibilities away from what falls into someone else's department. This is as expected, though it encourages uncoordinated actions and a lack of communication between different institutions concerned with water.

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What is more, the incorporation of incentives (such as rebates in property tax/urban development charges etc., efficiency labeling and star rating for manufacturers etc.), and disincentives (such as increases in water tariffs, banning fixtures and appliances below certain standards, and water service disconnection) in the regulatory framework can also provide the necessary demand impetus from domestic and commercial consumers, and supply impetus for manufacturers. However, a regulatory performance monitoring mechanism is also required. For this, the proposed national Bureau of Water Efficiency would play an important role. For issues like standards for fixtures and appliances, national regulations would be most effective, so as to avoid the problem of interstate transfer of inefficient goods.

4. WATER USE SURVEY

Survey Methodology and Scope

WAISP conducted a survey of 14 different categories of water use in Pune during October 2012 to obtain an up-to-date assessment of trends in water use practices, and in order to identify opportunities to improve water use efficiency. The survey instruments (questionnaires used by the survey team members during their in-person interviews with survey respondents) were designed separately for each category of water use. The residential sector was afforded the longest set of questions because of its large role in urban water demand and consumption. Other categories of water users were given shorter survey instruments, with varying types and numbers of questions in order to elicit the most relevant responses particular to those categories.

Most surveys, for example, asked questions about the source(s) of water supply, metering, number of people served, number and types of WCs, number of showers and faucets. Also, questions were asked about water using appliances such as washing machines, dishwashers, and desert coolers, including the type and frequency of use. Surveyors also asked about the size of gardens or landscaping (if any), and how they were irrigated. They also asked about cleaning practices around the facility and for any vehicles, as well as water storage facilities available. The surveyors asked whether rainwater harvesting was practiced, or measures for water conservation or routine water audits. For the residential surveys, teams gauged the income level of households to try to ascertain differences in water use by low, middle and high income groups.

An overall target sample size of 500 was planned and divided among the various water using categories (580 surveys were actually completed). Residential domestic users represented the largest share of respondents (364), while swim clubs, laundries, and crematoria represented the smallest number of samples. The sample size is deemed sufficient for most categories to enable data analysis and factual enumeration of responses, though responses may not be representative of the sectors for which only a few surveys were conducted. Due to time constraints, it was not possible to collect certain kinds of quantitative data, such as leakage rates or actual costs paid for water. These factors notwithstanding, information gleaned from the surveys provides insights and trends on current water use, and provides lessons and helps identify opportunities to improve water use optimization.

Table 10 provides a summary tabulation of the survey, with summary descriptive narratives of the survey data results following. These summaries inform the recommendations and opportunities presented in the next section of this report.

Table 10: Summary of Selected Results from Pune City Survey of Water Use Patterns

Water use category	Number of surveys completed	Source of water, %				Water metered?		Average water consumption, L/d	Rainwater harvesting		Water filtered?	
		Municipal	Own source	Both	Tanker	% Yes	% No		% Yes	% No	% Yes	% No
Residential	364	67	2	30	>0	12	88	NA*	10	90	64	36
Schools	67	96	3	0	1	NA	NA	NA	NA	NA	NA	NA
Religious Sites	32	100	0	0	0	3	97	256	NA	NA	NA	NA
Healthcare Fac.	27	100	0	0	0	41	59	2,465	NA	NA	50	NA
Service Stations	23	65	0	30	4	20	80	350	NA	NA	NA	NA
Hotels	20	100	0	0	0	70	30	1,903	NA	NA	NA	NA
Restaurants	12	100	0	0	0	33	67	4,250	NA	NA	50	50
Government	11	100	0	0	0	NA	NA	NA	9	91	NA	NA
Gardens, Parks	8	100	0	0	0	0	100	781	13	87	NA	NA
Transportation	5	100	0	0	0	40	60	403	NA	NA	NA	NA
Shopping Malls	4	100	0	0	0	100	0	41,100	0	100	75	25
Laundries	3	33	67	0	0	0	100	800	NA	NA	NA	NA
Crematoria	2	100	0	0	0	0	100	500	NA	NA	NA	NA
Swim Clubs	2	0	100	0	0	NA	NA	0	NA	NA	NA	NA
Total Sites Surveyed:	**580**											

***NA = Not Available; either the question was not asked, or the response was not provided.**

Survey Findings

Residential

The focus of the survey was on domestic water use, covering 364 households from residential areas representing different parts of the city. Survey areas included the core city, suburbs, and extended suburbs. Nearly two-thirds of respondents were middle-income households (68%), while the rest were high-income (14%) or low-income (18%). The majority of residences surveyed receive water from municipal supplies (67%). Water from the municipal system is available for an average of 4 hours, 22 minutes per day, and most homeowners (90%) have access to water only once per day. Furthermore, while only 9 respondents obtain water exclusively from a private source (most likely a private well), 30% of homeowners receiving municipal water also maintain an additional private water source which serves as a backup supply to improve reliability. Fully 88% of surveyed households are served through an unmetered connection. Only 43 respondents reported a meter, and of these, 12 were not functional at the time of the survey visit.

Measuring leakage of water from a residential storage tank

Photos: AIILSG

Household water storage in buckets

Pour flush WC

- One-third (34%) of surveyed households have two bathrooms, while the majority (231, or 64%) have just one, and 11 (3%) reported none. Half (51%) of the WCs are single flush, and 42% are pour flush, with just 7% (20) being the most efficient, dual flush.

- About two-thirds of all residences surveyed filter their water before use.

- Half of the residences surveyed have washing machines, and within the 187 homes with washing machines, eight out of ten are the less efficient top-loading models.

- Dishwashers are used by only 10% of the residences surveyed, and these are used an average of five times per week, consuming 10 L of water per load. Two-thirds of the residences surveyed cultivate a home garden. Virtually all residents water their gardens with a hand held hose or with a bucket. Sprinklers are used only by 5% of respondents, and only one respondent reported a drip irrigation system—the most advanced and the most efficient method of irrigation.

Schools

Nearly all of the 67 schools surveyed are connected to the municipal water system (96%), while of the remaining schools, two are supplied with water from their own sources and one is supplied by tanker truck.

- Schools reported between 2 and 150 WCs per site, with an average of 23 toilets per school. Nearly half of the schools are equipped with single flush toilets, while the other half have pour flush toilets. Only one school has water conserving dual flush toilets.

- The 67 schools surveyed reported between zero and 300 water faucets, with an average of 34 faucets per school, 11% of which were reported to leak at the time of the visit.

- Schools average eight showers per school, with the largest maintaining up to 310 showers.

- Most schools maintain some type of landscape, though the landscaped area varies widely among schools. The largest schools maintain up to 1,000,000 ft^2 of landscape area and 41,000 ft^2 of playground. The majority of schools (70%) water manually with a hand held hose (48%) or bucket (22%). Eleven of the remaining schools irrigate their landscape with movable sprinklers, three irrigate with fixed sprinklers, and only one reports using drip irrigation.

- Six of the 67 schools practice rainwater harvesting.

·Photos: AIILSG

School drinking water taps with automatic shut-off

School drinking water taps left open

Religious Sites

All of the surveyed sites are connected to the municipal water system. The majority of respondents report no metering.

- All religious sites surveyed maintain onsite storage, with the majority storing water in above ground tanks, and 13% using below ground tanks. Two reported leaking tanks at the time of the visit.

- Over one-third of the mosques and temples are equipped with manual, pour flush toilets. Seven of the facilities surveyed are equipped with single flush toilets.

- Although not all of the religious sites have landscaping, the largest temple reported 20,000 ft^2 of landscaping. On average, the temples maintain about 3,214 ft^2 of landscaped area per site. Most of the religious sites are watered by hand, with a hand held hose, bucket, or other.

- In religious sites, the majority of staff and worshippers reported being aware of the need for water conservation. Staff reported that, on average, the facilities are checked for water leaks twice per week.

·Photo: AIILSG

Water storage tank with leakage, overflow

Healthcare Facilities

All of the surveyed facilities are served through connections to the municipal water system. However, only 41% of them are metered.

- Eight of the 27 facilities reported conducting water audits.

- The surveyed healthcare facilities have an average of 17 toilets each. Two-thirds of the facilities are equipped with single flush toilets, but none had efficient dual flush toilets.

- An average of 1,763 liters of water per day is used for dialysis at the surveyed healthcare facilities, with one facility reporting a maximum use of 3,500 L/d.

- Half of the healthcare facilities perform some type of water treatment, with 12 treating water through granular media filtration and one through reverse osmosis membrane treatment. Of those treating their water supply, 11% reused their filter reject water.

- Seven of the healthcare facilities have landscaping, and the largest facility reports nearly 7,000 ft^2 of landscaping. All of the landscaped healthcare facilities are watered by hand with a hand held hose or bucket.

- Staff at more than half of the facilities reportedly recognize the need to conserve water, and they indicated that 41% of their patients are also aware of the importance of water conservation.

Service Stations

Nearly two-thirds of the service stations surveyed receive water through connections to the municipal water system, but only three reported having a metered connection. Seven stations receive water supplied from their own sources, and one receives water by tanker truck.

- Although 87% of surveyed service stations use water without further treatment, three service stations treat their water before use.

- More than 83% of the service stations offer manual car washes, while only 4 of the 23 provide an automated car wash. Four of the service stations re-circulate the wastewater from car washes.

- Service stations surveyed maintain between none and five WCs for employees and customers. On average there were three toilets per site. Seven of the service stations are equipped with single flush toilets, while none had more efficient dual flush toilets. Four service stations had manual, pour flush toilets.

- Some of the service stations have landscaping, with an average of 600 ft^2 of landscaped area per site. Seven of these sites are watered manually, five with a hand held hose and two with buckets.

- Fourteen service stations claim to practice water conservation by using "new technology," and twelve said they prevent water wastage. However, only one of the service stations reportedly has a plan to conserve water in the future.

Photos: Bahman Sheikh

Dual flush WC in hotel

Hotels

All 20 of the hotels surveyed are connected to the municipal water system, and 14 have a metered connection. Thirteen of the hotels filter their water before use.

- Only three hotels reported that they audit their water use.

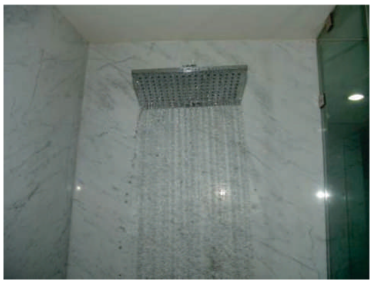
- The hotels have an average of 42 bathrooms, or about one WC per guestroom. The largest hotel had 115 bathrooms. Only one hotel is equipped with dual flush toilets, while the remaining hotels have single flush (70%) models, flush valve (25%) or pour flush (5%).

- While not all Pune hotels surveyed have landscaping, on average the hotels have about 689 ft^2 of landscaped area. Twelve hotels irrigate their landscaping manually with a hand held hose. Eight of the hotels use other irrigation methods, including one that uses movable sprinklers.

- While all of the Pune hotels surveyed provide some sort of air conditioning, the majority used some form of water-cooled refrigeration. Only five of the hotels surveyed used air-cooled systems.

- Staff at eight hotels expressed awareness of water conservation needs, whereas this was not expressed by staff at the other 12 hotels. Also, staff at five hotels indicated that their guests are aware of water conservation needs, while staff at the other 15 indicated that guests are not aware of the importance of water conservation.

- The majority of the hotels have no water conservation efforts in place.



Water-wasting "rainshower" in a 3-star hotel bathroom

Water efficient urinals in hotel

Watering with hand held hose at 5-star hotel, luxuriant runoff, waste

Restaurants

All of the restaurants surveyed receive water from the municipal water system. Four of the water connections are metered, and eight restaurants are not metered.

- Half of the restaurants use water for thawing food, while the other half do not.

- Half of the 12 restaurants sampled conduct some form of water treatment.

- Only two of the restaurants surveyed use automatic dishwashers. While the remaining 10 restaurants wash dishes by hand, only five of them claim to wash utensils under constantly flowing water.

- Restaurants reported between zero and three WCs per site, with an average of two toilets per restaurant. Eight of the 12 restaurants have single flush toilets, only one restaurant is equipped with dual flush toilets, and the remaining restaurants have WCs with pour flush valves. The restaurants surveyed also reported an average of two (2) urinals per site. Two restaurants have self-flushing urinals with electronic sensors.

- Nine of the restaurants reported that they wash the WCs regularly, and two of them do so by mopping.

- Nine of the 12 restaurants maintain irrigated landscaping, and all reported manual watering—four with a hand held hose and five with buckets.

- Two of the 12 restaurants reported some type of future water conservation plan.

Photo: Bahman Sheikh

Urinals with sensors and low-flow flush at a tourist site in India

Government Offices

All of the government offices surveyed are connected to the municipal water system. Respondents did not indicate whether or not the water service to the government offices is metered. The size of the government facilities surveyed in Pune varied widely.

- The largest office building has 50 WCs while the smallest office had only two. The 11 offices had an average of 16 WCs per building. Five of the offices are equipped with single flush toilets while the remaining six have manual pour flush toilets.

- Eight of the office buildings reported leaking faucets.

- All surveyed government offices have landscaping, with the largest facility managing 4,500 ft^2 plus 5,000 ft^2 of lawn. Landscape irrigation is almost entirely performed manually with a hand held hose (4 offices) and bucket (1).

- Four of the 11 government offices wash their vehicles with water.

- Rainwater harvesting is practiced at one of the 11 facilities.

- None of the 11 government offices maintains a program to create public awareness about the need to conserve water.

Gardens and Parks

All eight gardens and parks are connected to the municipal water system, none of which is metered.

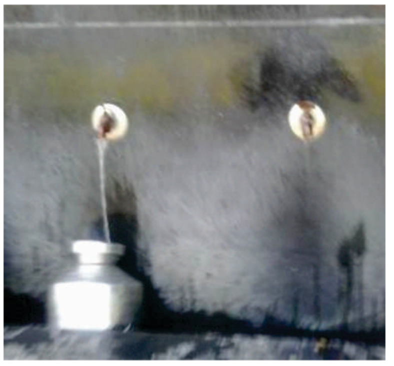
- Nearly all of the surveyed parks and gardens maintain WCs at their facilities, the largest of which has 9 toilets. The parks have an average of three WCs. The WCs are all either manual pour flush or single flush toilets; none of the gardens had efficient dual flush toilets.

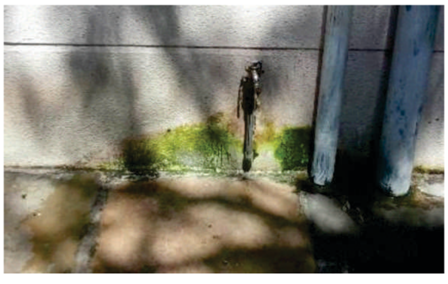
- Landscaped area at the gardens ranges in size from minuscule to nearly 8,000 ft^2. The average landscaped area per site of about 1,342 ft^2 tends to be comprised mostly of grass (43%) with smaller areas dedicated to trees (24%) and shrubs (15%). Half of the gardens and parks are irrigated with movable sprinklers, while two of the gardens (25%) are watered by hand held hose and one uses buckets. The remaining site uses efficient drip irrigation technology.

- Only one of the gardens augments their water supply with rainwater.

- One of the eight gardens reported having modern equipment and one takes steps to prevent water waste. None of the garden/park sites claimed to have water conservation plans in place.

Below: Leaking hose bids in Pune.





All Photos: AIILSG

Transport Facilities

All five transportation hubs surveyed receive water from the municipal water system, however, only two of them are metered. Leaks were reported from the storage tanks at three transport facilities. Water is available for drinking and hand washing at all of the five transportation hubs. The transportation centers also provided water to food stalls. One of the five hubs provides water for the coaches as well.

- All transportation hubs provide toilet facilities, with the largest having up to 15 WCs. On average, transportation hubs maintain eight WCs per site. Three of the five hubs have single flush toilets, and the remaining two hubs have flush valve WCs. Two transport centers reported using measures to save water in their urinals.

- All five hubs use sweepers to clean floors.

- Four of the five transportation centers wash WCs daily, while the remaining hub only sweeps the WCs.

- One out of five transportation hubs reported some type of water conservation measure.

Shopping Malls

All four of the shopping malls surveyed have a metered connection to the municipal water system.

- Three malls reportedly treat water, with two of the three providing granular media filtration and one mall providing no treatment.

- Shopping malls report between 13 and 65 WCs per site, with an average of 31 toilets per shopping mall. Three of the four malls are equipped with single flush toilets.

- Half of the malls maintain their floors by sweeping, while the other half mop to clean floors. The frequency of cleaning varies from twice per day in three malls, to once per day in one mall.

- All four surveyed shopping malls are air conditioned, with air cooled through the use of cooling towers.

- Three of the four shopping malls have landscaping and irrigate an average of 500 ft^2 per site. Half of the malls irrigate with a hand held hose, and the other half with movable sprinklers.

- Rainwater harvesting is not practiced at any of the four shopping malls.

- One mall reported to be recycling water.

Other Categories

Of the remaining categories, the small survey samples suggested the following:

- Two of the three laundries surveyed are equipped with a top-loading washing machine that used 200 L/load of laundry. The other establishment washes laundry by hand and reports its rate of water use at 40 L/load. All three laundries disposed wastewater to the sewer, and none reuse water. One laundry facility had a plan in place to reduce wastewater discharge in the future, and one indicated plans to conserve water in the future.

Photo: AIILSG

Open-air laundry (dhobhi ghat).

- Both crematoria surveyed reported metered municipal water supplies, and leaking faucets. One crematorium has a single flush toilet, and the other a pour flush toilet. Both crematoria irrigate their landscaped areas with a hand held hose.

- Of the two swim clubs surveyed, both reported their own private water source. In one club, shower wastewater is reused for landscape irrigation. Neither club reported a water conservation plan, though one indicated efforts to prevent water wastage.

5. OPPORTUNITIES AND RECOMMENDATIONS FOR WATER USE EFFICIENCY

Water Conservation Opportunities

Across developing countries worldwide, the cost-benefit of water conservation practices can rarely be calculated on the basis of the exceedingly low tariffs charged, which often do not recover operations and maintenance costs. Even so, it is generally less costly and more sustainable to pursue efficiency measures than solely invest in new supply infrastructure. Below we present numerous water conservation approaches and concepts based on the survey result outcomes, as well as global best practices.

Rainwater Harvesting

Our survey found that only 10% of households practice rainwater harvesting, indicating a wide scope of opportunities to increase this practice. Moreover, because fully 30% of respondents indicated that they rely on both municipal and private water sources, RWH represents a potentially worthwhile alternative to supplement supplies at the user level. At the same time, because the monsoon rains are restricted to a few months per year in Pune, investments at the household, colony, or municipal level require more in-depth analysis regarding issues such as storage capacity, catchment areas, as well as water quality maintenance and water use applications. The city should establish design criteria for planning and constructing rainwater harvesting systems that maximize their benefit to the community with affordable costs and public health protection. One option would be for the city to provide a connection line to collect rainwater from colonies in order to directly recharge groundwater. Alternatively, investments in decentralized storage capacity could supplement water available for irrigation, cooling, toilet flushing, and other uses.

Photo: Bahman Sheikh

Scale model of a community level rainwater harvesting system

Rainwater harvesting storage tank

Photo: US Dept. of Agriculture

Again, an analysis by the government is warranted to calculate the cost effectiveness and examine a variety of conditions such as catchment size, area served, demand for water, type of demand to be met, etc. Unfortunately, however, the traditional cost-benefit comparisons are not adequate to the task because of the artificially low value price of water.

Permeable Pavement

Pune has grown considerably over the last 20 years, from 146 km^2 to 244 km^2 in 2011. An unfortunate consequence of this expanding urbanization is that the ground surface becomes increasingly covered with impermeable features, such as asphalt parking areas, sidewalks, and streets. This results in grossly reduced natural groundwater recharge during rainfall events. Instead, the rainfall causes flooding and forms pools of water that eventually evaporate into the atmosphere, or end up as runoff into surface rivulets and drains away from the city.

Groundwater being an increasingly important source of water supply for Pune, a key water saving action would be gradual replacement of paved surfaces with appropriate permeable pavement materials and water absorbing/infiltration construction. This would complement rainwater harvesting efforts, and could be pursued by the municipality on its own initiative, or through public-private partnership schemes. Public parking surfaces and walkways in parks and other public places would be the first candidates for such conversion. It is also worth analyzing whether a municipal requirement for private properties to install permeable pavement would facilitate such investments by private builders and developers.

Water Audits

Our survey showed that few end-users truly monitor and measure their water consumption. Only 30% of health care facilities and 15% of hotels surveyed actually audit water use, and therefore understand their consumption patterns and water needs. This demonstrates an extremely low level understanding of water requirements by urban end users. In fact, water audits are very useful to identify waste and water losses in a home, government facility, company, industry, or other establishment.

Source: Microsoft images

In a parallel effort supported by USAID/India, CII's Triveni Water Institute is conducting numerous water audits. A thorough water audit analyzes a facility's water use and identifies measures to optimize its use. Audits review domestic, sanitary, landscaping, and process water use. The audits can be a service performed free of charge by a water authority and can save the owners money by reducing water consumption and its associated costs when metered. It can also save the utility money by ultimately reducing demand, and thereby preventing the need to invest in expanding the supply infrastructure. Water audits can also be conducted by the facility owner, NGOs or private contractors, and can be combined with an energy or full environmental audit to optimize potential efficiency gains. One tool available is from the American Water Works Association, which offers free water audit software at: http://www.awwa.org/files/science/WaterLoss/WaterAudit.xls. Ultimately, however, a water audit is only useful if the beneficiary implements key recommendations.

Water Metering

Authorities in Pune have been debating the issue of metering for many years. While they are taking steps to make metering universal, the pace is slow and lacks the requisite local support. Metering rates are extraordinarily low in Pune. The city estimates metering to be just under 30%, and among our surveyed households, just 12% are metered, and only one of the 32 religious centers. In our survey, only hotels, at 70%, demonstrate progress toward metering. It is clear that efforts are needed to explain the purpose and benefits of metering to all stakeholders in Pune to provide a clear understanding and gain acceptance. The reality is that utilities cannot effectively serve their customers if starved of financial resources. In fact, service quality suffers and water losses increase without adequate investment enabled by consumption-based tariffs. Universal metering of water accounts, regular and accurate reading and billing, and assertive collection on accounts is essential to city-wide water conservation and effective water management. Metering and billing are the most effective methods of sending the message of water conservation to all customer categories so that water is valued, as well as its service delivery. The most technologically advanced water metering now is automated and remotely read—“smart” meters with wireless telemetering equipment for centralized data collection. This type of metering bypasses manual readings, eliminates errors, and enables rapid feedback to customers about their water use behavior, enables early leak detection, and affords opportunities for water and cost savings.

Water Fixtures and Appliances

During site visits to the water fixture wholesale market in Pune, as well as meetings with builders and developers, it was apparent that awareness about water conserving fixtures and appliances is extremely weak. Such equipment is either not available or otherwise not easily factored into purchasing decisions, which are generally made against price and aesthetics alone. None of the fixtures sold on the market had a flow rate or discharge maximum rating, complicating consumers' ability to consider efficiency in their purchasing decisions. On one extreme, “rain shower” showerheads sold in the bathroom fixtures market and observed in hotel bathrooms are obviously highly wasteful of water. While viewed by the more affluent residents as a luxury, these showerheads place an unnecessary strain upon the community's water supply. The survey showed that the average low-income home has one WC and one to three faucets, while middle income homes have one to two WCs and three to six faucets per household, and high income homes have an average of two to three WCs and an average of seven faucets. Dual flush toilets show virtually no penetration—even among the high income bracket, only 15% of respondents had dual flush toilets, and the figure was just 2% in the middle income group. With respect to appliances, while the high income group showed a 25% penetration of efficient front loading washing machines, the vast majority of residents in Pune use the less efficient top loading models.

Photos: AIILSG

Variety of fixtures sold at wholesale market.

It is further worth noting that 32% of the surveyed schools and 55% of the surveyed government offices use pour flush toilets, which tend to be less hygienic. Modernizing these with waterless urinals, dual flush toilets, as well as low-flow faucet aerators would show leadership by the Pune government in retrofitting facilities with efficient technologies. Also, publicizing such initiatives with brochures, student and government staff education and outreach, coupled with water savings metrics, would provide an important demonstration effect of the importance of water conservation.

Therefore, the adoption and enforcement of standard-flow fixtures and appliances would be a highly effective method of enabling long-term efficient water use in homes, businesses, hotels, institutions, etc. The difficulty in widespread adoption and use of such technology is often due to (a) relatively higher initial investment cost, (b) lack of local familiarity and resistance to change, and (c) lack of maintenance budgets and skills. A list of standard flow-rated fixtures and appliances is provided in the *National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances,* available from the California Urban Water Conservation Council (CUWCC) website at <http://www.cuwcc.org/WorkArea/showcontent.aspx?id=13966> (a few of the standards for fixtures and appliances from that source are shown in the table below). In addition, the Indian Plumbing Association is working with the American Plumbing Association to establish guidelines for flow rates in fixtures, and this initiative should be encouraged to improve water use optimization.

Table 11: Water Conserving Standards for Fixtures and Appliances

Fixtures / Appliances	Standard (English)	SI System
Residential or Commercial Toilets	1.6 gpf	6 Lpf
Residential or Commercial Faucets	2.2 gpm at 60 psi	8 Lpm at 4 bar
Residential or Commercial Showerheads	2.5 gpm at 80 psi	9.5 Lpm at 5.5 bar
Residential Dishwasher Water Factor (WF)	$\leq$ 6.5 gal/cycle/ft^3	$\leq$ 1.0 L/cycle/Kg
Residential or Commercial Clotheswasher WF	$\leq$ 9.5 gal/cycle/ft^3	$\leq$ 1.3 L/cycle/Kg
Commercial Urinals	1.0 gpf	4 Lpf
Pre-Rinse Spray Valve	$\leq$ 1.6 gpm	$\leq$ 6 Lpm

Public Outreach

Public awareness regarding the need to conserve water is the first step in gaining the public's cooperation to save water for the entire community. It is clear that water conservation awareness increased in Pune just prior to the survey simply because of the 2012 drought conditions. However, many end user categories indicated that “a majority” are aware of the need for conservation, so somewhere over half of respondents. There is room to improve, particularly since behavioral characteristics of the population with regard to water use can have a huge impact on water use efficiency. An outreach program is needed to inform the public about water conservation, its value as a vital resource, and the power of the individual citizen to have a significant impact on its conservation. The Eco-housing initiative initiated through the Pune Municipal Corporation represents one step toward this effort. However, stronger efforts are needed to encourage builders to adopt the principles of Eco-housing, and a dialog with builders is necessary to scale up this program. Also, broader efforts using specialized professional firms with proven experience in public outreach programs would be highly recommended to ensure the success of public awareness for the need for efficient water use. In fact, while Pune has less than 5% green buildings, it seems that Pune has the financial and technological resources available to have a much larger impact. Therefore, more demonstration projects and awareness campaigns, as well as effectively leveraging the NGO sector and universities could offer a great deal to scale up water efficiency.

Modern Irrigation Methods

Our survey indicates that manual irrigation is generally the most common method used in Pune. The vast majority of all household income group levels use either a bucket or hand held hose to irrigate. Public parks and gardens fare slightly better, with half of surveyed parks using sprinklers, and one actually using drip irrigation methods (the rest use manual methods). Unfortunately, hand held hose irrigation is inefficient, non-uniform, and results in water wastage. Some areas are over-watered, flooded, and result in runoff, while other areas remain under-irrigated. As noted, the best available technology today is drip irrigation, with many international and local suppliers and designers for small and large applications. Landscape irrigation with drip systems would save considerable volumes of water over hand watering and sprinkler systems.

Water Reclamation and Reuse Opportunities

Centralized Wastewater Reclamation

Water recycling from a central treatment plant is now an established practice in many metropolitan regions of the world. Pune is no exception. As indicated in Section 2 above, Pune lacks infrastructure to make use of treated wastewater, despite looking at ways to provide such water to interested end users. As a result, very little treated sewage is put to effective use, while it could be used to meet non-potable water demand—irrigation of parks and gardens, use in cooling towers and desert coolers, and toilet flushing, for example. As the city continues to grow, the challenge will compound. With appropriate levels of treatment and disinfection, reuse of highly treated wastewater effluent even for potable purposes, will become inevitable. An application by the Pune Marigold Society has an outstanding request to the city for direct potable reuse given their advanced reverse osmosis wastewater treatment; this is meant to supplement drinking water during periods of extreme water scarcity and as a way to avoid tanker truck water with its inferior quality and higher cost (see Annex 1 Case Studies). This model can be replicated with other societies and should be encouraged. Potable reuse is already serving the capital city of Windhoeck, Namibia, Singapore, and even in Bangalore. Indirect potable reuse is practiced in the United States at Virginia's Occoquan Reservoir Augmentation, El Paso ground water recharge in Texas, California's Orange County ground water replenishment system, among others.

Decentralized (Satellite) Water Recycling

Areas of Pune that are not currently connected to the piped sewage system would be candidates to establish decentralized water recycling systems. Each of these satellite plants would serve a cluster of homes, businesses, and institutional buildings with a collection system that would bring all wastewater to one location for treatment and disinfection—adequate for the intended use of the reclaimed water. Because of the proximity of the treatment system to points of use of the incoming wastewater, only a small distribution system will be needed to bring recycled water to the points of demand. Opportunities for decentralized water recycling are abundant in Pune and should be studied in comparison with the centralized options.

Moreover, Pune offers a tax rebate for establishing a Sewage Treatment Plant availed by new developments. If STPs can be designed within green areas by societies, then more decentralized systems can be adopted. In addition, root zone and other eco-friendly treatment solutions could be considered. One specific water reuse opportunity observed through the surveys and site visits across Pune includes the following:

- ***Decentralized Sewage Treatment and Parks Irrigation***
  Pune has over 100 gardens, and while municipal guidelines restrict the use of groundwater and municipal drinking water for gardening, the small WAISP survey suggests that alternate irrigation water arrangements may generally not be in place. Some green areas, like the Rajiv Gandhi Zoo, are 165 acres, while at least three gardens are between 11 and 30 acres, and at least another 27 are between three to eight acres. Each of these gardens offers the opportunity to consider root zone treatment and other eco-friendly options, which is not power intensive and would enable water recycling for irrigation.

Graywater Reuse

Residential graywater reuse is gaining widespread acceptance in many arid and semi-arid regions of the world (Sheikh, 2010). Because graywater is untreated wastewater—albeit excluding WC wastewater—its use for irrigation outside the house must be undertaken only with the greatest care to prevent human exposure. Authorities should develop a guide similar to the Central Public Health Engineering and Environment Organization (CPHEEO) manual, focusing on waste water reuse and the appropriate parameters to enable agriculture, irrigation, construction activities, water for cooling towers, or flushing in water closets, as this would assist and encourage more graywater initiatives.

While graywater reuse saves water and money for the homeowner, it also reduces the amount of wastewater flowing to the central treatment plant, thus reducing the treatment burden. It would be advisable for Pune authorities to determine which water recycling option is the most important for the community and to set policies with regard to graywater accordingly. Two specific opportunities observed through the surveys and site visits across Pune include:

- ***Bus Depots***
  The Pune-Mumbai link is one of the busiest highways in the country, with frequent bus service not only to Mumbai, but also other cities. Pune has nine bus depots, and buses are washed at four of these. Additional wash facilities are provided for buses reporting for Regional Transport Office checks. These include the Natawadi Bus Depot, Swargate Bus Depot, Katraj Bus Depot, Kothurd Bus Depot, and Central Work Shop. While our survey was unable to obtain precise figures on buses washed and liters of water used per bus, the team calculated approximate water use based on data collected for similar purposes elsewhere. Therefore, assuming that an average of 200 buses are washed at each of the four depots, and 200 liters are required per wash, then each depot consumes approximately 40,000 liters of recyclable water. Buses requiring regional transport office clearance apparently need twice the amount of water, and 100 buses are cleaned daily, consuming another 40,000 liters of water. Therefore the combined potential of these depots is in the range of 200,000 liters/day. By the same token, Maharashtra State Road Transport Corporation bus depots at Sivaji Nagar St. Stand and Swargate St. Stand represent another potential 20,000 liters/day for water recycling. These would add another 20,000 liters/day for potential recycling, based on 100 buses at 200 liters each. Since grease and dirt would be the major contaminants in the effluent, treatment costs should be lower than sewage treatment units.

- ***Pune Railway Station***
  Pune Railway Station washes coaches, and this water can similarly be recycled. Approximate water recycling figures assume, in this case, that 100 coaches are washed daily, and the approximate amount of water required per coach is 230 liters. This would represent some 23,000 liters of water/day. Since grease and dirt would be the major contaminants in the effluent, treatment costs should be lower than sewage treatment units.

Taken together, these two recycling opportunities could save an estimated amount of water equivalent to fill nearly 15 Olympic sized swimming pools every year. Indeed, while only four of the 23 service stations surveyed are reusing their vehicle wash water, the fact remains that this practice is occurring presently in Pune and can be replicated.

Opportunities for Legal and Economic Instruments

While several legal and policy mechanisms are in place to encourage water conservation, policy makers should more thoughtfully consider specific instruments that will genuinely drive behavior change. This requires as much analysis regarding the type of mechanism as it does the level of incentive or penalty—otherwise customers will maintain the status quo.

One major area of consideration for officials in Pune (and indeed, nationally), relates to plumbing fixtures and appliances. As noted previously, even vendors of plumbing fixtures are not aware of the flow rates of the products they sell. These are purchased on the basis of aesthetics and price alone, since consumers have no information about their water efficiency. This offers many opportunities to improve water conservation:

- Labeling requirements for water fixtures and appliances can be the first step toward establishing standards for flow rates. This will begin to educate consumers and developers, and encourage vendors to stock these items. Rebates, taxes, and other economic instruments can be used to encourage or require efficient equipment, and discourage use of inefficient equipment and models, but these must be carefully designed in order to truly change behavior. Moreover, as lifestyles change and appliances like washing machines become more ubiquitous, promoting water efficient appliances is very important, particularly since they tend to be more expensive. Fully half of survey respondents have a washing machine already, and 85% of these have a less efficient front loading machine, though users have no clarity on the water consumption per cycle. Conservation campaigns, cost-based water tariffs, and rebates or tax incentives will encourage more families to select more efficient appliances. Similarly, studies indicate that 40 liters of the 135 Lpcd (30%) are used just for flushing toilets. The WAISP survey found that only a tiny fraction of households has dual flush systems. Making these mandatory and providing incentives for their use, or disincentives for single flush systems, would have an important water conservation impact.

As noted previously, kitchen faucets generate graywater that can be reused within the household, for gardening, toilets, or in desert coolers. Technical and/or financial support to families to establish graywater reuse systems would facilitate more widespread adoption. In addition, as Pune continues to grow and tries to accommodate more dense new developments, the government could require such growth to include recycling and reuse initiatives in the design, even based on the Eco-housing program.

- Another important institutional measure would be to consider establishing a water demand management unit within the Maharashtra Jeevan Pradhikaran or local body. Such a unit could support municipal level conservation efforts through outreach campaigns, assist with enforcement, and engage users through technical assistance relating to fixtures, rainwater harvesting, graywater reuse, and other household or colony-level conservation initiatives.

While India lags behind other countries in introducing water efficient technologies and enacting laws making them mandatory, the country would not start from scratch. The Bureau of Indian Standards (BIS) is the premier agency in India assigned the task of developing standards, marking, quality certification, and quality control on a wide range of products and processes. A few BIS standards prescribe guidelines and certify sanitary products like cisterns, commodes, faucets, etc.[18] While BIS standards are not binding, they can serve as a starting point toward achieving such standards. The energy Standards and Labeling Program of the Ministry of Power, GoI which was launched in 2006 provides a good lesson in this regard. It currently applies to 12 appliances, four of them mandatory since January 2010.

Moreover, voluntary standards such as from green rating certification programs like the Indian Green Building Council (IGBC) Green Homes, Leadership in Energy and Environmental Design (LEED) India, and Green Rating for Integrated Habitat Assessment (GRIHA), also provide important model approaches from which to consider minimum requirements. Many opportunities, then, exist to improve water conservation through legal and policy reforms.

[18] *See*, for example, IS 774:2004 – standard for flushing cistern for water closets and urinals (non-plastic) cisterns; IS 2326:1987 – automatic flushing cisterns for urinals and IS 7231:1994 – specification for plastic flushing cisterns for water closets and urinals.

ANNEX 1: BEST PRACTICE CASE STUDIES

This section comprises a number of best practice case studies and reference materials for further review by water sector stakeholders. These cases represent examples from India and from around the world, and were selected on the basis of the relevance to the Indian context in the pursuit of urban water use efficiency.

Select Indian Case Studies

1. Pune Marigold Housing Society: Direct Potable Reuse

Location: Marigold Cooperative Housing Society is a residential housing complex of 100 high-end apartments in Pune city located in Kalyani Nagar. The society occupies approximately one-fourth of a larger property of around 46 acres, including a large decorative lake that receives runoff from surrounding areas and wastewater effluent from the building's treatment system. The rest of the area is still being developed. The housing society's area includes 10,000 m^2 of lawns and gardens.


Photo: Bahman Sheikh

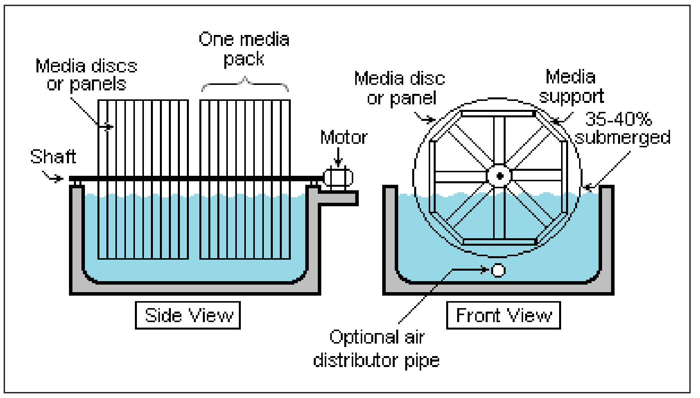
Aeration Tank

The Problem: For five years, residents of Marigold Cooperative Housing Society put up with the stink from a drain that flows along the property into a river and was a rich breeding ground for mosquitoes. The residents of Marigold Society also did not want to further pollute the river with the overflow from their septic tanks.

The Intervention: The Society decided to solve the problem by creating a bypass system for the drain first. Then they installed a system for secondary treatment for nearly 100,000 L/d of septic tank effluent using a patented "Nature-cell" rotating biological contactor (RBC) with a three hour residence time. The RBC process involves allowing the wastewater to come in contact with a biological medium in order to remove pollutants in the wastewater before discharge of the treated wastewater to the environment.

The RBC (Figure 4) consists of a large diameter steel or corrugated plastic media centered around a horizontal shaft placed in a concrete tank. The media is slowly rotated (1.5 rpm) and at any given time during the rotation about 40% of media surface area is in the waste water. Organisms in the waste water attach and multiply on the rotating media until they form a thin layer of biomass. This shaggy fixed film growth presents a very large very active population for the biological degradation of organic pollutants. During rotation, the media carries the biomass and a film of waste water into the air where oxygen is absorbed. The dissolved oxygen and organic materials in the waste water diffuse into the biomass and are metabolized. The radial and concentric passages in the media allow unrestricted entry of the waste water and air throughout the unit's total surface area for continued growth of the biomass.

Figure 4: Schematic Diagram of a Typical Rotating Biological Contractor (Reproduced from Wikipedia)



Excess biomass shears off at a steady rate as the media rotates these solids and are carried through the RBC system for subsequent removal in a conventional clarifier. The RBC process does not require recycling, and unlike the activated sludge, can withstand shock loadings or variance in volumes. This process requires only 25% of the energy cost of the activated sludge process and the quality of the sludge enables it to settle even in shallow secondary clarifiers.

Water released after secondary treatment

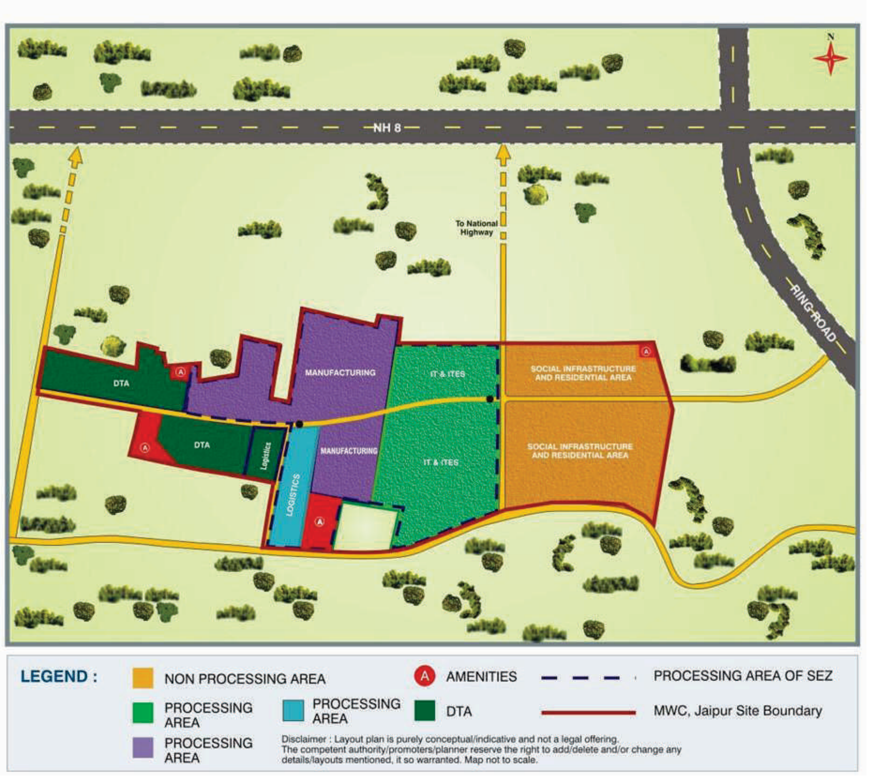
Improvements in the System: While the original intention of the residents was to prevent pollution of the river body, repeated water cuts during summers forced the residents to buy water from the commercial water tankers. The water quality of the tanker water did not meet potable standards, and mixing this water with the Municipal supply was not the solution. The residents then decided to treat their secondary treated water to the tertiary stage by membrane filtration. They opted for the 100 picometer (Polymecide Membrane) membrane which has a pore size 150 times smaller than the smallest E. coli. New Water Singapore uses a 15 pico membrane which has a pore size only 100 times smaller than the smallest E. coli. The reverse osmosis unit can treat 3000 liters per hour and the treated water then passes through an ultraviolet (UV) unit and is chlorinated prior to storage. The Society has carried out repeated testing of the treated water which meets potable standards and is currently seeking permission from Pune Municipal Corporation to use it for potable purposes.

This type of water recycling uses the most advanced practice and best technology available world-wide—emulating similar technologies currently in use in Singapore, Australia, and the United States (Orange County Groundwater Replenishment System in California, Occoquan reservoir augmentation in Virginia, City of El Paso, Texas, and others). It is anticipated that in the future, more critical water shortages will make adoption of this type of water recycling on a large scale a viable option.

Photos: Bahman Sheikh

Membrane filters for tertiary treatment

2. Mahindra World City (Special Economic Zone), Jaipur



Layout of Mahindra World City.
Source: MWC publication.

Location: Mahindra World City (MWC), Jaipur is the largest public-private partnership project in Rajasthan, and is expected to create large scale industrial development and employment[19] in the state. It is a 74% / 26% joint venture between Mahindra group firm *Mahindra Lifespaces* and Rajasthan Industrial and Investment Corporation (RIICO). The total project area is 3,000 acres, which is demarcated as Special Economic Zone (SEZ) under the SEZ Act of Government of India (2005). The multi-product SEZ will have three zones: IT (750 acres), light engineering, including auto and auto component (250 acres), handicraft (250 acres), besides zones for apparel, gems and jewelry, logistics and warehousing. A domestic tariff area for ancillaries to support export units and 714 acres of residential and social infrastructure has also been earmarked. At the time of report, approximately one-third (1,000 acres) have been developed and 41 industries have invested in the project. The project is located approximately 20 kilometers away from the centre of Jaipur city.

Mahindra Group's Eco-friendly Philosophy: The Mahindra group has a stated policy of adopting ecologically sound principles of sustainable growth. A group publication titled “Sustainability Review” (2011) states their commitment to contribute to the national goal of combating climate change by aligning their operations with the National Action Plan on Climate Change (NAPCC). Mahindra Group has also made it a point to embed green features in all new building projects. It has retrofitted its office in Mumbai (Mahindra Towers) to ensure that it is energy-efficient. Mahindra World City (MWC) has developed an in-house team of engineers and architects as certified energy saving analysts. The Management Development Centre of the Mahindra Group at Nasik, Maharashtra

[19] Twenty companies have signed up for these zones, who will invest more than Rs 1,000 crore, employ 75,000 people and generate exports of Rs 35 billion within four years.

has adopted rainwater harvesting technology and converted all existing urinals into "waterless urinals" using bio-blocks. Water audits are carried out in all its Divisions.

As a part of its sustainability road map it sets very clear targets for reducing resource consumption. The target for 2012 was reduction of energy use by 2% against which the various Divisions had achieved 7.8% reduction as per the above energy audit report. The group reports special projects which have adopted the 3R (Reduce / Reuse / Recycle) methodology for reduction in specific water consumption and packaging waste. The MWC is one such project.

Photo: Dipak Roy

Sprinklers in the nursery

Water Use Practices in MWC: The SEZ project, when fully operational, will meet two-thirds of its water needs by using recycled water for all non-drinking usage. It will recycle its water as well as take treated sewage water from Jaipur and use it after tertiary treatment. The project has committed to adopt the following practices during the construction phase as per the communication from State Level Environment Impact Assessment Authority, Rajasthan:[20]

Construction Phase:

- Storm water control and its reuse as per CGWB and BIS standards for various applications
- Water demand during construction reduced by the use of pre-mixed concrete, curing agents and other best practices
- Separation of grey and blackwater done by the use of dual plumping line for separation of grey and blackwater.
- Treatment of 100% grey water by decentralized treatment
- Fixtures for showers , toilet flushing and drinking shall be of low flow either by use of aerators or pressure reducing devices or sensor-based controls

Operation Phase:

Rain water harvesting for roof run-off and surface run-off to be complied as per GoI guidelines. Before recharging, surface run-off to be pre-treated to remove suspended matter, oil and grease.

[20] Letter dated 18 Nov 2010 from Rajasthan State EIA Authority on environmental clearance as per EIA Notification, 2006)

Work in Progress: As mentioned earlier, only one-third of the project area has been developed thus far. Therefore, this is very much work in progress. The Public Health Engineering Department (PHED) of Government of Rajasthan was to install the pipeline from the Sewerage Treatment Plant at Delawas (nearly 20 km away) for carrying treated sewerage water for reuse. However, the PHED has not been able to meet its commitment because no provision was made in its budget. In March 2011, it was finally decided that RIICO as a partner would provide the budget while PHED would lay the pipeline. The work is yet to be completed.

Reduction of potable water consumption is being considered by the MWC through the use of grey water from Central Sewage Treatment Plant for flushing and landscaping, low flow water faucets within the homes, rainwater/storm water management system and use of Xeriscape[21] in Landscape (so that the landscape will be drought tolerant and will consumes less water). Water saving is also done with the use of timer-based water sprinklers, drip irrigation system, moisture sensors, pressure regulating devices for water control and water meters etc.

Validation by Independent Agencies: The University of West Minister has conducted an International Eco-City Initiative: Global Eco City Survey in 2011, which includes the MWC in its profile (Joss, 2011). Because of all the efforts that it has made, Mahindra World City, Jaipur, has been identified as one of 16 projects globally, which are being supported by the Clinton Climate Initiative (CCI), a foundation for sustainable development promoted by former US President Bill Clinton.

3. Case Study in Lake Restoration with Private Participation: Man Sagar Lake, Jaipur, India

Introduction: Man Sagar Lake was created as an artificial lake in the 16th Century during the Moghul period, by Raja Man Singh of Amber. He erected a dam 700 meters long, 40 meters wide, and 15 meters high south-east of Amber. In 1727 Jaipur was established as a planned city on the periphery of Amber, and the southern fringe of the lake. Its ruler, Maharaja Sawai Pratap Singh, built a palace garden for entertainment in the middle of the lake during the 18th Century. It was called Jal Mahal, which literally means "Palace on water". The lake would receive water from the adjoining hills as well as the city.

[21] A landscaping approach that incorporates water conservation techniques, such as low water consuming plants and vegetation, efficient irrigation methods, decorative hard surfaces, etc.


Photo: Down to Earth

Man Sagar Lake before intervention

The area of the lake has been estimated between 310[22] acres and 343[23] acres by different sources. The average depth of the lake was reported to range between 2.18 meters during peak monsoon to 1.62[24] meters during the dry season, before any interventions took place in the 1990s. Two main drains carry water from the drainage area which includes the adjoining Nahargarh hills as well as the city area: I) the Bramhapuri Nalla coming from the north-western flank of Jaipur city and entering into the southern region of the lake, and ii) the Nagtalai Nalla, coming from the eastern region of the city and entering into the south-eastern region of the lake. The catchment of the lake has been estimated to be around 23.5 sq km, of which approximately 40% is constituted of urban area, while the north-western hill slopes constitute the remaining area.

Challenge: As the city grew, water quality in the lake began to deteriorate. City authorities diverted most of the city's raw sewage to the lake in the 1960s, along with nearly half of the city's run-off. As a result, the lake became silt rich with a heavy organic load, which only grew with the city's population. Eventually, solid waste generated in the city was also dumped into the lake, and by the 1990s, there was very little water during the year except during the monsoon months. During the rest of the year, since the lake was mostly dry, it was used as an open defection ground, for grazing animals, and partly as a play ground by children.

The Bramhapuri Nalla releases about 30 MLD of sewage daily, which is now treated in a sewage treatment plant (STP) built by the Jaipur Municipal Corporation (JMC) in year 2007-2008. However, the capacity of this plant is 27 MLD, which means a part of the sewage flows untreated. The Nagtalai Nalla currently releases about 8 MLD into the lake, all of it untreated sewage.

[22] This was reported in the Detailed Project Report prepared by PDCOR – an infrastructure project development company jointly promoted by Government of Rajasthan (GoR) and Infrastructure Leasing and Finance Services Limited (IL&FS) which was commissioned by the Tourism Department of GoR to prepare a tourism project on the site.

[23] Maximum spread during monsoon in report by Bharat Lal Seth in "Down to Earth," 15 September 2012

[24] Central Pollution Control Board, 2003.

Restoration Approach: As far back as the 1980s, the Government of Rajasthan (GoR) had earmarked the land around the lake for tourism development in its Master Plan. During the late 1990s, the Tourism department of GoR engaged PDCOR Limited,[25] to prepare proposals for tourism development projects in Rajasthan. PDCOR developed one such proposal with a focus on the Man Sagar Lake. A number of plans were made to rejuvenate the lake until about 2000; however, these were unsuccessful due to a paucity of funds and the lack of incentives to undertake restorations (CSE). In 2002 the Ministry of Environment and Forests (MoEF) within the Government of India (GoI) prioritized the task of restoring the lake under the National Lake Conservation Plan. The MoEF identified the Jaipur Development Authority (JDA) as the nodal agency for the task and sanctioned a budget of Rs 247.2 Million for the project. The GoI share was Rs 173 million in this budget, while GoR was to contribute the remainder.


Photo: Down to Earth

Man Sagar Lake after rehabilitation

This commitment from GoI enabled decisive advances in the restoration effort. Among them, the Sewerage Treatment Plant serving the Bramhapuri Nalla was upgraded. (The Nagtalai Nalla sewage is diverted into artificial wetland treatment system). In addition, a two kilometer tourist trail was built as well as a one kilometer-long promenade. Even so, the budget provided under the National Lake Conservation Plan was insufficient to undertake a more comprehensive plan for developing the area and assure long-term operation and maintenance. Therefore, a tender was released in 2004 to engage private participation in response to which four consortia submitted bids. The project was awarded to Jal Mahal Resorts Private Limited (JMRPL), led by Kothari Builders, giving them a 99 year lease agreement at an agreed annual lease amount of Rs. 25.2 million, with a built-in provision for 10% increase every three years. "The objective behind private sector participation was to ensure funds to operate and maintain the pollution abatement infrastructure" (Seth, 2012).

[25] PDCOR is a company jointly promoted by the GoR and private sector to facilitate infrastructure investments in Rajasthan.

Results: The following summarizes the interventions undertaken to improve the quantity and quality of water in the lake and improve the habitat, and the corresponding results.


Photo: Bahman Sheikh

Newly laid garden in the center of the restored monument

1. The lake bed has been dredged to a depth of 3 to 3.5 meters in 2008, as a result of which the water holding capacity of the lake has increased.

2. Both of the main drains into the lake (Bramhapuri and Nagtalai) have been by-passed by creating a new masonry drain of approximately 1.5 km, so that sewage cannot flow directly into the lake.

3. The STP run by the JMC with a capacity of 27 MLD which uses extended aeration technology has been upgraded. In addition, a Tertiary Treatment Plant (TTP) has been established by the JDA close to the STP, with a capacity of 7.8 MLD.

4. At three locations, JMRPL created 21 enclosures of constructed wetlands, covering an area of 40,000 m^2, providing further, natural treatment of the water coming out of the STP/TTP before discharging to the lake.

5. The storm water that enters the lake (estimated 7,050 million liters per annum) is estimated to carry about 200 tons of silt into the lake annually. The suspended load in the water entering the two *nallas* is calculated at 100 milligrams per liter and is constituted of both organic and inorganic material. JMPRL has created a sedimentation basin within the lake below the embankment where nearly 60% of this silt gets trapped, thus substantially reducing the silt load in the lake.

6. The improved water holding capacity of the lake, combined with the treated wastewater discharged, has turned the Man Sagar Lake into a perennial water body.

7. Selected aquatic vegetation has been introduced from the same region (Keoladeo National Park at Bharatpur) for beautification and to ensure that pollutants get absorbed.

8. As a result of the interventions, the water quality has reportedly improved substantially: In July 2005 and 2006 when the MoEF tested the water quality for biochemical oxygen demand (BOD), it was in the range of 115 to 210[26] milligrams per liter, well over the standard for quality of water for bathing. After interventions, the water quality has been recorded with a BOD of less than 30 mg/liter, the stipulated discharge norm as per the Central Pollution Control Board.

[26] Data on water quality improvement have been reproduced from "Down to Earth" CSE Webnet of 15 September 2012 (Author: Bharat Lal Seth).

In conclusion, the restoration of the Jal Mahal Project provides an example of a potentially effective public-private partnership for water reuse, improved wastewater treatment, as well as tourism development. Importantly, it provides a revenue model to ensure long-term maintenance. The lease itself, however, is under litigation within the Indian Supreme Court, where the scope of restoration vs. what could be defined as new construction is in dispute. Notwithstanding this situation, the model has proved effective in accomplishing the above noted results.

International Case Study References

1. Australian Water Savings Experience during an 11-Year Drought

During the years 1998-2010, Australia underwent a severe sustained period of drought, considered to be a harbinger of global climate change. Water supplies were so stressed that one state, New South Wales built a huge direct potable reuse system. All over the country, communities adopted water conservation measures in all water using sectors. Overall residential water use dropped from 315 Lpcd to 213 Lpcd over the nine-year period 2000 to 2009 (Cahill et al., 2011). This impressive (>30% percent) reduction in per capita water use was achieved with a nation-wide campaign of water conservation behavior change and institutional revisions in how water was managed. Three actions contributing to Australia's reduced water use are (1) adoption of outdoor water restrictions, (2) ultra-low flush WCs, and (3) water pricing policies. Another important factor in the conservation effort's success is tracking water use with accurate, quantitative data. This enables the communities to document and therefore manage water use according to goals and what the data indicates about progress toward those goals.

2. United States Department of Housing and Urban Development Water Conservation Benchmarking Tool

The United States Department of Housing and Urban Development (USHUD) developed a useful benchmarking tool for residential buildings to compare their water conservation efforts against established benchmarks as a means of monitoring progress and measuring success along the way to achieve their desired conservation goals. In order to develop the water consumption benchmarking tool, water consumption data was collected through voluntary release of information from thousands of buildings in nearly 350 public housing units nationwide. Regression analyses were performed on these datasets to see which of over 30 characteristics were most closely linked to water conservation. The benchmarking models were then developed by quantifying the effects of the building traits that most commonly correlated with water utilization. The benchmarking tool that resulted from this exercise is Excel-based and quite adaptable to various types of buildings for assessment of their water use characteristics and determination of best practices to reduce water demand. The Excel-based tool can be downloaded from: http://portal.hud.gov/hudportal/documents/huddoc?id=DOC_26031.xls

3. California Urban Water Conservation Council

California's climate and water supply characteristics are similar to Rajasthan's, although there are vast differences in demographic and other characteristics. Over the last 25 years, the California Urban Water Conservation Council (CUWCC) has worked closely with water authorities throughout the State of California for adoption of Best Management Practices (BMPs), each of which is designed for a specific action with an implementation path to reduce water demand. Over this period, residential water demand has dropped by ten percent—not as impressive as the Australian case, but significant with room for greater progress in the future. Much can be learned from this experience and the tools made available by CUWCC. Most of these experiences and technical resources are available on the website of the Council: http://www.cuwcc.org/

4. California Best Management Practices

In the early 1990s, a large number of retail water providers in the State of California in the United States signed agreements among themselves committing to water demand reductions using the most effective water conservation methods available. The list of these water conservation BMPs include:

1. Water survey programs for single-family residential and multi-family residential customers
2. Residential plumbing retrofit
3. System water audits, leak detection and repair
4. Metering with commodity rates for all new connections and retrofit of existing connections
5. Large landscape conservation programs and incentives
6. High-efficiency clothes washing machine financial incentive programs
7. Public information programs
8. School education programs
9. Conservation programs for commercial, industrial, and institutional (CII) accounts
10. Wholesale agency assistance programs
11. Retail conservation pricing
12. Conservation coordinator
13. Water waste prohibition
14. Residential ultra low flush toilet (ULFT) replacement programs

Over the last 21 years, these BMPs have been refined and have borne fruit so that water use levels have declined or remained unchanged in spite of significant population increases in the service areas of the BMP signatories. Detailed implementation and monitoring protocols for each of these 14 BMPs is available at the website of the California Urban Water Conservation Council: http://www.cuwcc.org/bmps.aspx?ekmensel=b86195de_24_0_7794_2

Photo: Bahman Sheikh

Automatic sprinkler system in use

5. Water Saver Home

The CUWCC has developed a useful tool for the homeowner to inventory their own water use characteristics and compare them with best practices for water conservation and to make effective changes for water (and money) savings is the H2OUSE—Water Saver Home, accessed at: http://www.h2ouse.org/. An example, showing the benefit of a simple lawn sprinkler water use audit, from one of the many water savings tips in this website follows:

An automatic sprinkler system is almost always the largest user of water. If you're looking for a way to save water it makes sense to focus on the big uses. It doesn't get any bigger than the sprinkler system.

From a horticultural standpoint, over-irrigation occurs much too often. However, it is most prevalent in the cooler fall months when summer irrigation schedules have not been revised to meet the current weather conditions. Over-irrigation causes three basic problems; it:

- pushes water beyond the root zone and is wasted. This occurs most notably in the case of turf grass.
- causes excessive run-off, which contributes to non-point source environmental pollution.
- generally degrades plant health.

There are a number of ways to reduce outdoor water use and automatic irrigation and all of these recommendations are explored in great detail in this web site.

Saving water outdoors depends on a number of factors including the type of plant material, the soil, landscaping practices, climate, irrigation system efficiency, etc. It can all be a bit overwhelming. Many water utilities offer free landscape audits. An audit is a great opportunity to meet with a local expert and discuss ways to improve efficiency on your specific landscape.

6. East Bay Municipal Water District's Watersmart Guidebook

East Bay Municipal Water District (EBMUD) is a retail water and sewerage provider for a large population on the eastern side of San Francisco Bay in California, USA. This water authority is one of the most aggressive in the United States in promoting water conservation. In 2008, EBMUD prepared and published a highly practical publication, entitled “Watersmart Guidebook”, with 242 pages of text, graphics, photos and charts providing its new business customers and their consultants with a wealth of up-to-date material for saving water. While the guidebook is primarily intended for new businesses seeking approvals within the EBMUD service area, the guidebook can assist other water agencies wanting to emulate similar approaches to water savings. The guidebook is freely available to anyone at: http://ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.

Examples of Regulations Advancing Water Efficient Technologies and Labeling

The following section provides some international examples of regulations that promote the adoption and implementation of water efficient technologies, as well as recommended general best practice measures.

- **United States:** The Energy Policy Act of 1992 (Public Law 102-486) *inter alia* addresses water efficiency on a national scale and mandates the use of water-efficient fixtures. It is mandatory for new buildings to install domestic water efficient devices, and regulations define maximum water use standards for plumbing fixtures. In January 2008, Congress enacted new laws to limit the water use of dishwashers and washing machines.

  As part of the U.S. government's goal to lead the nation by example in improving energy and water efficiency, Executive Order 13123, Greening the Government through Efficient Energy Management (1999), directs government agencies to reduce their potable water consumption. This order calls on the government to implement all cost-effective water conservation measures in Federal facilities by 2010. The order also required Federal agencies to determine their baseline water use in fiscal year 2000, and report on their usage every two years. Agencies must also implement at least four of 10 cost-effective Best Management Practices (BMPs) for water conservation at up to 80 percent of their facilities by 2010.

- **Australia:** All Australian states have regulations relating to dual flush and low volume toilets for new houses and replacement products, and the same for aerators and flow regulators for showerheads and kitchen faucets. Suppliers are now under pressure to adopt a subsidized retrofit scheme for the installed base of old style single flush toilets, as is done in various states and cities in the United States.

- **United Kingdom:** Following amendments to Part G of Building Regulations, from 6 April 2010, all new homes will have to meet a water efficiency standard of 125 liters of water per person per day. The government has also introduced an Enhanced Capital Allowance (ECA) scheme for water efficient plants and machinery.

Labeling water efficient fixtures enables consumers to make informed choices on the water efficiency of a product when purchasing. It also helps to raise public awareness regarding water conservation and encourages more water efficient products on the market, and saves money over time when water is priced and billed properly. Several countries have well-established schemes to label water efficient fixtures and services.

- **United States:** WaterSense (http://www.epa.gov/watersense/) is a voluntary partnership program by the United States Environment Protection Agency (USEPA) with various companies, which was launched in June 2006, and is designed to encourage water efficiency in the country. WaterSense labeled products meet EPA's specifications for water efficiency and performance and are typically about 20 percent more water efficient compared to corresponding conventional products. WaterSense has many resources available, including the National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances, available at: http://www.epa.gov/WaterSense/docs/matrix508.pdf

- **Australia:** The national government's Water Efficiency Labeling and Standards (WELS) Scheme is responsible for the WELS water efficiency star ratings on products. The Smart Approved WaterMark is another simple identification label, which is applied to water efficient outdoor products in order to assist consumers to make informed choices.

- **New Zealand:** The water efficiency labeling regulations are modeled on the Australian WELS scheme. However, unlike the Australian scheme, there is no government mandated registration scheme and no minimum performance requirements are imposed.

- **United Kingdom:** The Bathroom Manufacturers Association (BMA), a leading trade association for manufacturers of bathroom products, promotes Water Efficient Product Labeling.

- **Singapore:** In 2006, the Public Utilities Board (PUB), the national water agency, introduced the Water Efficiency Labeling Scheme (WELS), a voluntary program, which covers faucets, showerheads, dual flush low capacity flushing cisterns, urinals and urinal flush valves, as well as clothes washing machines. The scheme became mandatory for water fixtures in July 2009.

- **China:** There are no federal laws that set standards for plumbing equipment. However, large cities such as Beijing, Tianjin and Shanghai have taken measures to promote domestic water saving, including subsidizing water-saving faucets or toilets and establishing education programs.

- **Israel:** The Water Authority has announced further measures to reduce water consumption, including the distribution of 1.2 million household devices to reduce the flow of water from faucets. It plans to issue a tender for the purchase and distribution of the devices, which are currently mandatory only in new buildings.

Reference Examples of Water Reclamation and Reuse

Aertgeerts, R., & Angelakis, A. (Eds). (2003).
State of the Art Report: Health risks in aquifer recharge using reclaimed water.
Geneva, World Health Organization.
Retrieved from: http://whqlibdoc.who.int/hq/2003/who_sde_wsh_03.08.pdf

As competing demands place pressures on water supplies in India and elsewhere, a body of literature has developed around experiences and projects built to recharge depleted aquifers with treated municipal wastewater. The World Health Organization's *State of the Art Report: Health Risks in Aquifer Recharge Using Reclaimed Water* examines the many facets associated with safe groundwater recharge with reclaimed water. Importantly, these guidelines include regulatory considerations to safeguard public health, an examination of the range of treatment levels and options prior to aquifer recharge, methods to assess health risks, and public perceptions and outreach strategy considerations to assure public acceptability. Moreover, the document includes case histories, including an example of soil aquifer treatment in Morocco for aquifer recharge, as well as an example of advanced wastewater treatment prior to groundwater recharge in the United States.

Brown, C. (2000).
***Water conservation in the professional car wash industry.* United States, International Car Wash Association.**
Retrieved from: http://www.carwash.org/docs/default-document-library/water-conservation-in-the-professional-car-wash-industry-.pdf?sfvrsn=0

Following water use restrictions imposed in eastern United States during the summer of 1999, the International Car Wash Association commissioned a survey of conservation techniques used in the car wash industry and constituted a think tank of industry experts to examine the means for designing water efficiency standards and advance policy discussion on water conservation and reclamation in the industry. The report finds significant saving in water use in professional car washes where conversation equipment, including a reclaim system is used. The needs of the car wash operator –conserve water, reduce discharge, meet regulatory requirements, or some combination thereof – dictate the selection of the installed reclaim system. The report includes a list of steps developed by industry associations for use by professional car washes during droughts and water shortages. The report also discusses cost components for retrofitting existing car washes. Moreover the document highlights two programs developed through industry and utility cooperation to promote water conservation, and with applicability in other locations: the Conservation Certification Program developed by the San Antonio Water System, Texas, together with the Southwest Carwash Association. And the Seattle Public Utilities, Washington, conservation grants to professional car wash operators to install reclaim systems at their facilities. These examples will be of interest to decision makers at municipalities and utilities. This document presents an example of how industry groups can get in front of policy discussions on water conservation and reclaim, to represent the interests of their constituents.

Bryck, J., Prasad, R., Lindley, T., Davis, S., Carpenter, G. (2008).
***National database of water reuse facilities summary report*. United States, WateReuse Foundation.**
Retrieved from: http://www.watereuse.org/files/s/docs/02-004-01.pdf

This project reports presents the design and management of a national database of reuse facilities, using a web-enabled application. Intended for use by water practitioners, the database was developed to advance the implementation and disseminate information on water reuse. The report details each step of the database design process: developing the survey instrument, designing and beta testing the web-enabled database, collecting state data on utilities, reaching out to state water utilities to complete the online survey to populate the database, producing reports, installing the final database application on a server for continual use. The report includes as annexures, a copy of the survey instrument, as well as, examples of two standard reports that the database produces: a summary of utility and reclaimed water facility, and a summary of reclaimed water use by end use category. This document is useful reference for national and state agencies that plan to develop relational databases for water utilities.

Department of Water Affairs. (2010).
***Strategy and Guideline Development for National Groundwater Planning Requirements. The Atlantis Water Resource Management Scheme: 30 Years of Artificial Groundwater Recharge*. P RSA 000/00/11609/10-Activity 17 (ARS.1). Republic of South Africa.**
Retrieved from: http://www.artificialrecharge.co.za/casestudies/Atlantis_final_10August2010_reduced%20dpi.pdf

This report produced by the Department of Water Affairs, Republic of South Africa, provides information about the Atlantis Water Resource Management scheme for the planned town of Atlantis (now a part of the metropolitan area of Cape Town), South Africa. The scheme, which evolved over a 30 year period, diverts treated domestic effluent and domestic storm water to two infiltration basins up-gradient of well fields to recharge the aquifer. From here it is abstracted and recycled for municipal use. The scheme diverts industrial effluent and industrial storm water to the coast down-gradient of the main aquifer to coastal recharge basins to raise the water table and prevent seawater intrusion. The report tracks the evolution of the scheme from its inception during the town planning stage in 1970, to the integrated scheme as it now exists. The report documents the efforts of engineers and scientists to design the integrated scheme, including technical and operational issues addressed over time. Finally the report draws lessons from the thirty years of operations, management and monitoring and makes recommendations for the need for integrated management to ensure the scheme's long- term sustainability. This report is useful reference for engineering and scientists to understand technical, operational and management challenges associated with the development and operations of an integrated water resources management system.

Economic Analysis Task Force for Water Recycling in California. (2011). Guidelines *for Preparing Economic Analysis for Water Recycling Projects.* California, State Water Resources Control Board.
Retrieved from:
http://www.swrcb.ca.gov/water_issues/programs/grants_loans/water_recycling/docs/econ_tskfrce/eagd.pdf

This document produced by the California State Water Resources Control Board provides guidance on conducting economic and financial analysis of water recycling projects. The guidance considers water recycling as a part of integrated resources management and recommends that planners, utilities and local governments begin by establishing baseline forecasts of land use, population, institutional, legal and other requirements; and establish clear water supply objectives and alternatives prior to the analysis. Economic analysis considers and quantifies societal cost and benefits of a project over a selected time horizon. Risk and sensitivity analysis form part of the economic analysis and quantify the effect of uncertainties in parameters and events. A financial analysis emphasizes the financial viability of a project and its ability to generate sufficient revenues to cover construction and operations costs. Such costs may be allocated across purposes and beneficiaries. The analysis is useful for designing capital financing mechanisms, estimating debt service requirements for a portfolio of funding sources, and identifying need for additional leverage. This document is a useful template for utilities and cities on how to work through an economic and financial analysis for a water recycling facility. Such analysis may be used for applying for grants and loans, as well as for evaluating alternatives for recycling projects.

Environment and Natural Resources Committee. (2009).
Inquiry into Melbourne's Future Water Supply. **Australia, Parliament of Victoria, Paper No. 174 Session 2006-2009.**
Retrieved from: http://www.watereuse.org/files/images/Inquiry_into_Melbourne_s_Future_Water_0609.pdf

The Victorian Parliamentary Environment and Natural Resources Committee, constituted under the Parliamentary Committees Act 2003, as amended, produced this parliamentary report on the merits of supplementing Melbourne's water supply. Amongst other findings, the report recommends: mandating simple low cost water efficient fixtures; establishing an environmental sustainability assessment and rating system that includes water use efficiency and conservation; revising planning provisions and building regulations to promote storm water harvesting; and, setting and enforcing new recycling and reuse targets for treated wastewater. The committee also recommends that a groundwater management strategy be developed. This parliamentary report serves as an example for policy makers in India and other countries on undertaking a comprehensive assessment of a water supply system, vis-à-vis options to supplement water supply; and to deliberate and translate findings into actionable policy directives.

Environment Protection and Heritage Council (EPHC), Natural Resource Management Ministerial Council (NRMMC), & Australian Health Ministers' Conference (AHMC). (2006).
Australian Guidelines For Water Recycling: Managing Health and Environmental Risks (Phase 1). **Retrieved from:**
http://www.scew.gov.au/archive/water/pubs/wq_agwr_gl__managing_health_environmental_risks_phase1_final_200611.pdf

Produced by the Environment Protection and Heritage Council, Natural Resource Management Ministerial Council, and Australian Health Ministers' Conference; these Australian guidelines on water recycling address—safe and sustainable—supply, use and regulation of recycled water schemes. These comprehensive national guidelines provide a consistent approach across Australian state and territory governments, and are intended to be implemented in collaboration with relevant health and environment authorities. The guidelines present a risk management framework that emphasizes management of recycled water schemes, as compared to simply using post-treatment testing. The framework recommends an analysis of health and environmental hazards, and critical control points, so as to undertake preventive measures that reduce risks to an acceptable low level. The elements of the risk management framework are grouped under the following categories: commitment to responsible use and management of recycled water; system analysis and management; supporting requirements (employee training, community, research and development, documentation and reporting); review (evaluation and audit). The document discusses risks from the use of water recycling from a sewage treatment plant and from graywater, and characterizes both maximum as well as residual risk. Preventive measures to reduce risk include treatment processes and reduced exposure, either by using at the site of use or restricting use. Monitoring establishes baselines, and is needed to validate systems and operations. Validation of system effectiveness is essential because of the potential health risks associated with recycled water. The risk management framework emphasizes consultations and communication, to ensure stakeholder support. The document includes case studies of recycling of treated water from sewage treatment plants for irrigation of commercial crop, golf courses, municipal landscaped areas; and, on the use of graywater in toilet flushing and outdoor uses. Policy makers in India and other countries will find the risk management framework presented in these guidelines as useful reference for developing similar approaches for water recycling schemes, to address health and environmental risks.

Federal Energy Management Program. (2011).
***Methodology for Use of Reclaimed Water at Federal Locations.* U.S. Department of Energy. Retrieved from:**
http://www1.eere.energy.gov/femp/pdfs/reclaimed_water_use.pdf

The U.S. Federal Government requires reduction of water consumption at Federal sites and under Executive Order 13514 directs Federal agencies to implement water reuse strategies consistent with state laws that reduce water consumption. This fact sheet, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information to Federal agencies on the process of initiating a water reuse project using reclaimed water. This fact sheet distills information from the 2004 EPA Guidelines for Water Reuse, to identify six key steps: (i) Understand state laws and contact state regulatory agencies. The use of reclaimed wastewater in the U.S. is regulated by state and local laws, and varies across states. (ii) Classify project type, to determine necessary water quality standards and treatment options; (iii) decide whether to purchase reclaimed water from local municipal wastewater treatment plant or produce reclaimed water on-site, based upon considerations such as conveying costs, population, reuse purpose and quantity required, etc.; (iv) secure permits; (v) work with an experienced contractor; and, (vi) communicate and educate people that will be exposed to the system. The fact sheet also includes two brief case studies of water reclamation projects at Federal facilities. This fact sheet would be a handy reference for staff at government facilities on the steps involved in starting a water reuse project.

Federal Energy Management Program. (2011).
NASA's Marshall Space Flight Center saves water with high efficiency toilet and urinal program: BMP 6 – toilets and urinals. **U.S. Department of Energy.**
Retrieved from:
http://www1.eere.energy.gov/femp/pdfs/nasa-msfc_watercs1_.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the success of a water efficiency program that included the development and installation of innovative high-efficiency toilet and urinal fixtures, at NASA's Marshall Space Flight Center (MSFC). High-efficiency fixtures are fixtures that exceed the current standards for toilets and urinals as set under the Energy Policy Act of 1992. The facility engineering team examined performance and operating standards of high-efficiency fixtures, together with the operational constraints related to replacement at the aged building, to develop tailored design specifications suited to the facility's old fragile plumbing. The team then tested these innovative high-efficiency fixtures at a demonstration project and measured results. MSFC is now retrofitting these high-efficiency fixtures at identified buildings across the flight center. The MSFC water efficiency program comprises: water metering, leak detection and repair, water management of cooling towers, water reuse for limited irrigation, native landscaping, and staff outreach. This case study demonstrates the successful use of innovative high-efficiency fixtures for replacement at a Federal facility with aging infrastructure.

Federal Energy Management Program. (2009).
Huntington Veterans Affairs Medical Center: BMP 7 - faucets and showerheads. **U.S. Department of Energy.**
Retrieved from:
http://www1.eere.energy.gov/femp/pdfs/huntingtonva_watercs.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the performance and economics of a water efficiency program that retrofit 178 faucets and 33 showerheads at the Huntington Veterans Affairs (VA) Medical Center in 2007. The medical center used in-house staff to replace the old faucets and showerheads with newer, water efficient models, which incorporated antimicrobial technology. These improvements save the medical center more than 1.5 million gallons of water each year. In addition the medical center also converted 87 toilets with water efficient, dual flush toilets. This case is an example of the water savings that can be achieved through the use of new, improved fixtures in buildings.

Federal Energy Management Program. (2009).
Water reclamation and reuse at Fort Carson: BMP 14 – alternate water sources. **U.S. Department of Energy.**
Retrieved from: http://www1.eere.energy.gov/femp/pdfs/water_fortcarson.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the performance, economics and success of a water conservation program comprising water reclamation and reuse at the U.S. Army's Fort Carson. For over three decades, the base has used treated effluent from its wastewater treatment plant, to irrigate 180 acres of their golf course. Effluent is also reused as process water required in the operations of the wastewater treatment plant. In addition, over the past two decades, the base has successfully operated a vehicle wash facility that uses recycled water through a closed loop system. Through this water conservation program, the base saves approximately 303 million gallons of water annually. This case study demonstrates the potential for municipalities in India and elsewhere for water and cost savings through water reclamation and reuse.

Golf Course Superintendents Association of America (GCSAA) and The Environmental Institute for Golf (EIFG). (2009).
Golf Course Environmental Profile, Volume II, Water Use and Conservation Practices in U.S. Golf Courses. **GCSAA.**
Retrieved from:
http://www.gcsaa.org/_common/templates/course/environment/EnvironmentLandingPageLayout.aspx?id=3544

This report produced by the golf course industry in the U.S. presents findings from a survey of over 2500 golf courses in the U.S. on water use and conservation practices. This survey was intended to establish a baseline for comparison with future findings. While the survey identified no difference between private and public golf course in the use of recycled water, it found that a higher number of the larger courses with higher maintenance budgets, used recycled water for irrigation. This report is an example of the role industry groups can play in promoting water use and conservation at their facilities.

Koeller, J. & Brown, C. (2006).
Evaluation of potential best management practices: Vehicle Wash Systems.
California, California Urban Water Conservation Council.
Retrieved from the CUWCC website: http://www.cuwcc.org/products/pbmp-reports.aspx

This report published by the California Urban Water Conservation Council provides an evaluation of a range of water savings practices in vehicle wash systems within the State of California. The study starts by examining water savings opportunity in different vehicle wash systems: conveyor carwashes; in-bay carwashes; self-service carwashes; and truck, bus and fleet washes. This is followed by a technical discussion of water reclaim and conservation practices and processes, used by businesses during each step of the operation of the different vehicle wash systems. Of particular interest to decision makers at municipalities and utilities in India and elsewhere, will be the discussion of approaches, such as, carwash business certification by utilities, and the use of municipal ordinances and state regulations on vehicle wash businesses to achieve water efficiency, as currently deployed by cities and states in the United States.

National Research Council. (2012).
Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater. **Washington, D.C.: The National Academies Press.**
Retrieved from: http://nas-sites.org/waterreuse/

This comprehensive study by The National Research Council assesses the potential for reclamation and reuse of municipal wastewater to expand and enhance water supply alternatives in the United States. The report reviews the suitability of water—quality and quality—of processed wastewater and considers a range of reuse applications, including drinking water, non-potable urban uses, irrigation, industrial process water, groundwater recharge and ecological enhancement. Moreover the report assesses the current state of technology in wastewater treatment and production of reclaimed water, and compares the performance, cost, energy use and environmental performance of a portfolio of treatment options and discusses risk exposure to microbial and chemical contaminants from drinking reclaimed water. In emphasizing the need for quality assurance, the study recognizes the significance of developing new monitoring and attenuation technologies. Using U.S. and international case studies, the report identifies technical, economic, institutional and social issues associated with the increased adoption of water reuse, and the available legislative tools to address the same. Finally the report considers current barriers to implementation and proposes areas for research to advance the safe, reliable and cost-effective reuse of municipal wastewater. This document is a timely and valuable guide for India and other countries, which will need to assess and address these issues with the increasing reuse of municipal wastewater.

New Mexico Office of the State Engineer. (1999).
***A Water Conservation Guide for Commercial, Institutional and Industrial Users.* New Mexico. Retrieved from:**
http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf

This manual, produced by the New Mexico Office of the State Engineer, provides step-by-step guidance on how to design and establish a water conservation plan, including water conservation guidelines for specific uses: domestic, landscaping, cooling and heating, and industry. The manual recommends that a water conservation plan be part of an integrated approach, address technical and human elements, be based upon accurate data, and follow a logical sequence of events. The water audit must assess not just how much water is being used, but also how and by whom, and that water quality is matched to the reuse application. The plan must consider true cost of water and use life-cycle costing to evaluate water conservation options. This manual is a useful resource for water utility engineers and water systems operators at commercial, institutional and industrial facilities.

State of California. (2009).
***Regulations related to recycled water updated from Titles 22 and 17 California Code of Regulations.* California, Department of Public Health.**
Retrieved from:
http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Lawbook/RWregulations-01-2009.pdf

The California Department of Public Health produced this publication as an aid to its staff regarding Titles 17 and 22 published codes. Requirements under Title 17, Division 1, Chapter 5, address the protection of drinking water supplies from contamination. The regulation assigns responsibility to the water supplier to implement a cross-connection control program, and includes detailed criteria for approval, construction, location, type, testing and maintenance of backflow preventers. (A cross-connection is a connection between a potable water system and an unapproved water system). Requirements under Title 22, Division 4, Chapters 1, 2 and 3 requirements, focus upon environmental protection and present water recycling criteria. These criteria address only recycled water from sources that contain domestic waste and specify required levels of treatment by the intended use of the recycled water (irrigation, impoundments, cooling, other), as well as, specific conditions for the area of recycled water use. The criteria also address: design and operation requirements for dual plumbed recycled water systems; use of reclaimed water for groundwater recharge; and, design, reliability, and operations and maintenance requirements for water reclamation plants. These California codes address the concerns of public health and environmental protection pertaining to the use of recycled water and are a source of reference for policy makers and those responsible for designing standards and regulations in India and elsewhere.

U.S. Environmental Protection Agency (EPA). (2012).
Guidelines *for Water Reuse.* 600/R-12/618. Washington, D.C., United States. U.S. Environmental Protection Agency and U.S. Agency for International Development.
Retrieved from: http://www.waterreuseguidelines.org/

The Guidelines for Water Reuse debuted in 1980, and were updated in 1992 and 2004. This national guidance, produced as a collaborative effort between the EPA and USAID, updates and builds upon the *2004 Guidelines for Water Reuse* with the purpose of facilitating the further development of water reclamation and reuse practices. In the U.S. water reuse is regulated by states. This document inventories state water reuse regulations and discusses regional variations of water reuse practices in the U.S. Using illustrations from U.S. and international experiences, the document discusses: steps that should be considered for water reuse in the planning and management of an integrated water resources plan; types of reuse applications; advances in wastewater treatment technologies relevant to water reuse; funding decisions related to the development and operations of sustainable water system; and, best practices for involving communities in planning projects. The document discusses a portfolio of wastewater treatment options and recognizes that the cost of wastewater treatment can be balanced with the desired level of water quality for the purpose of reuse. Moreover, the document includes over a hundred U.S. and international case studies of water reuse for various applications, as well as an inventory of recent water reuse research projects and reports. Given the context of urbanization and associated population increases and land use changes and the dynamics of changes in local climate patterns, this document will serve as an authoritative reference for India and other countries on water reclamation and reuse practices.

World Health Organization (WHO). (2006).
WHO guidelines for the safe use of wastewater, excreta and greywater, Volume 1: Policy and regulatory aspects **(3rd ed.). Geneva, World Health Organization.**
Retrieved from: http://whqlibdoc.who.int/publications/2006/9241546824_eng.pdf

This four-set volume of WHO guidelines is recognized by UN-Water—the coordinating body of UN agencies and programs working on water issues—as representing the position of the United Nations system on the issues of wastewater, excreta and graywater use and health. Volume 1 gives policy makers an overview of the benefits and risks of such use and provides guidance on the development of a conducive policy environment, regulations and institutional arrangements. The guidelines recommend that policy to addresses primary health concerns related to such use may be designed around the subject of food security or environmental protection. The widespread—formal and informal—use of wastewater, excreta and graywater in agriculture and aquaculture can contribute to nutrient and water recycling; however international policy implications on trade of safe food products and any implication of negative health impact need to be addressed.

These guidelines are based on a risk analysis approach similar to the methodology underlying the development of food safety standards that provide adequate health protection and facilitate trade in food. The guidelines recommend that the planning and development of projects include a health impact assessment or an environmental impact assessment with a health component. And that public health policy for interventions ensures the most cost effective measures or combination thereof. The guidance outlines a step-by-step process for policy formulation and adjustment and introduces the concept of intersectoral collaboration, including mechanisms to promote collaboration and integration at the national and local levels to achieve effective institutional arrangements across sectors. The guidance for developing regulations to ensure safe use identifies and discusses the following essential functions: identification of associated primary health hazards; generating evidence for health risks and the effectiveness of protection measures to manage them; establishing health-based targets to manage health risks, implementing health protection measures to achieve the targets; and monitoring and system assessments.

This document also includes a brief synthesis Volumes 2, 3 and 4 of this set, which focus upon technical information on health risk assessment, protection measures, and monitoring and evaluation. As water scarcity increasingly drives interest in the wastewater, excreta and graywater use in agriculture and aquaculture, this document offers useful guidance for policy makers on the design of policy, regulation and institutional arrangements.

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