Centre for Science and Environment

Ministry of Housing and Urban Affairs

WATER EFFICIENCY AND CONSERVATION

A PRACTITIONER'S GUIDE

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Contents

List of figures

List of tables

List of graphs

List of posters

Abbreviations

ABR	Anaerobic baffled reactor
BCM	Billion cubic metres
BMP	Best management practice
CBO	Community-based organization
CoE	Centre of Excellence
CPHEEO	Central Public Health and Environmental Engineering Organization
CSE	Centre for Science and Environment
CSP	City Sanitation Plan
ET	Evapo-transpiration
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
KL	Kilo litres
KLD	Kilo litres per day
LPCD	Litres per capita per day
MLD	Million litres per day
MoHUA	Ministry of Housing and Urban Affairs
MoWR	Ministry of Water Resources, River Development and Ganga Rejuvenation
NGO	Non-governmental organization
NMSH	National Mission on Sustainable Habitat
NRW	Non-revenue water
NWP	National Water Policy
NWM	National Water Mission
RWA	Residents welfare association
RWH	Rainwater harvesting
SDG	Sustainable Development Goal
STP	Sewage treatment plant
SWH	Storm-water harvesting
ULB	Urban local body
WEC	Water efficiency and conservation

Glossary

Aquifer	An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand or silt) from which groundwater can be extracted by means of a water well.
Battery site	A portion of land that contains separators, treaters, dehydrators, storage tanks, pumps, compressors and other surface equipment in which fluids coming from a well are separated, measured or stored.
Catchment	The area from which rainfall flows into a river, lake or reservoir.
Groundwater recharge	A hydrologic process in which water moves downward from surface water to groundwater.
Lineament	Long linear or curvilinear features that are structurally tectonically controlled and can be seen only through aerial photographs or satellite imageries.
Non-revenue water	Water that has been produced and is 'lost' before it reaches the user. Losses can be real (through leaks and also referred to as physical losses) or apparent (through, for example, theft or metering inaccuracies).
Rainwater harvesting	A process of capturing rainfall and preventing its runoff, evaporation and seepage for its efficient utilization and conservation.
Runoff	The part of precipitation, snow melt or irrigation water that flows as surface streams, rivers, drains, or sewers.
Water audit	An accounting procedure whose purpose is to accurately determine the amount of unaccounted-for water in a water-distribution system.
Water fixture	An exchangeable device that can be connected to a plumbing system to deliver and drain water.
Xeriscaping	Landscaping and gardening that reduces or eliminates the need for supplemental water from irrigation.

Executive summary

Water efficiency and conservation (WEC) creates alternative water resources, conserves existing and local resources, decreases demand for freshwater in cities and eventually stabilizes at the minimum threshold.

The National Water Mission (NWM) and the National Mission on Sustainable Habitat (NMSH) emphasize the need to conserve water, minimize waste and promote alternative technologies as well as encourage community involvement to increase water-use efficiency by 20 per cent by 2017. Centre for Science and Environment (CSE) prepared in 2017 a policy paper, 'Water Efficiency and Conservation in Urban India', in line with the Sustainable Development Goals (SDGs) for the Ministry of Housing and Urban Affairs. The 12th Five-Year Plan has provisions to create a forum for gateways to water conservation (rainwater harvesting, recycling and reuse, water conservation devices), preparing comprehensive water audit plans to offer cost-effective water-efficient technologies. In addition, the 14th Finance Commission and schemes such as Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Smart city provide for the possibility to seek funds for planned interventions. However, while these provisions recognize the need for conserving and using water efficiently, little has been done to mainstream WEC.

Planning WEC helps identify priority interventions; current water–supply gap, intended water use and quality and quantity required are accounted for. Managing demand through conservation and increase in water-use efficiency contributes to less water use for the same human benefit. WEC can also increase water supply by recycling water, minimizing leakage during conveyance and creating water-efficient landscaping. The quantity of water used varies significantly as also design and management efficiencies at various scales of plan and implementation; this leads to non-uniform scope for improvement in efficiency.

This guide is an attempt to mainstream water efficiency and conservation from policy to practice. Its thematic areas include in situ water augmentation, water efficiency and behavioural changes, with new interventions introduced and effectiveness of measures that can be implemented on different scales detailed. Its purpose is to provide guidance with regard to practising WEC for effective planning of water-secure cities.

The guide is meant to assist practitioners in the water sector to plan and implement projects at the city scale and smaller scales. It describes the process of WEC planning, with a comprehensive list of tools and techniques to initiate and implement WEC plans, programmes and practice. It shows how WEC can be strategized by looking into gaps in existing policies, plans and guidelines in India, and suggests the most suitable ways forward.

1. Introduction

Estimates of future water use have greatly exceeded actual water withdrawals. New projections have begun to incorporate new thinking and approaches only in recent years.[1]

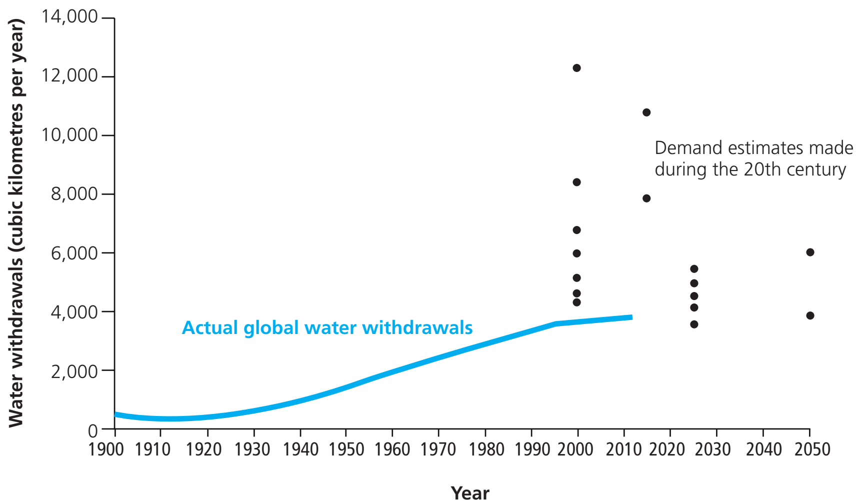
This chapter introduces the need for WEC and WEC planning. It establishes the need for this practitioner's guide and gives a preview of the contents, relevant users and methodology to use the guide.

1.1 Background

All over the world, water management—to meet projections of future demand—has conventionally been addressed by supply-side solutions. Water-supply infrastructures are built within or on the outskirts of cities from where water can be tapped. Future water use has usually been assumed to be a direct function of population size, economic wealth and per capita water use per unit of wealth. As these factors grow, traditional estimates of future demand for water are assumed to grow with them.

It has become increasingly apparent that traditional projections are often incorrect. *Graph 1: Projected global water demand and actual withdrawals* shows actual water withdrawals and projections of future water-use over the last forty years.

Graph 1: Projected global water demand and actual withdrawals



Source: Anon., 2003, Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute for Studies in Development, Environment, and Security, California.

India has 16 per cent of the world's population, 2.4 per cent of its land area and about 4 per cent of the world's water resources. Its total annual water resource potential is estimated in the range of 1870–1950 billion cubic metres (bcm), with both surface and groundwater sources accounted for. Usable water resources have been estimated to be in the range of 1030–1120 bcm of which 60–65 per cent is from surface water (690 bcm) and the remaining from groundwater sources.[2] *Table 1: Water demand for various sectors in India* shows the demand for water for various sectors and the corresponding estimated demand for

Table 1: Water demand for various sectors in India

Sector	Estimate 1 (in bcm) (Standing Sub-Committee Report MoWR)			Estimate 2 (in bcm) (NCIWRD)		
	2010	**2025**	**2050**	**2010**	**2025**	**2050**
Irrigation	688	910	1072	557	611	807
Domestic	56	73	102	43	62	111
Industry	12	23	63	37	67	81
Energy	5	15	130	19	33	70
Other (environmental losses, leakage losses etc.)	52	72	80	54	70	111
Total	**813**	**1,093**	**1,447**	**710**	**843**	**1,180**

Note: MoWR—Ministry of Water Resources, River Development and Ganga Rejuvenation; NCIWRD—National Commission on Integrated Water Resources Development.

Source: Water Use Efficiency in Urban India: A CII-USAID India Handbook, CII, 2013.

water until the year 2050. As per varying estimates, water demand for domestic consumption in India as of 2010 is 43–56 billion cubic metres annually (i.e. about 6–10 per cent of the total annual water demand).

Meeting these water demands with falling freshwater resources is increasingly a big challenge. A water-secure future for the urban sector requires solutions that converge into an integrated plan for overall sustainable water management through conservation and improving water-use efficiency.[3]

The current water model that primarily focuses on water supply is consequently unsustainable, given that increased water supply leads to more wastewater generation, which increases cost of treatment. A paradigm shift is needed to focus on management systems that involve reuse and recycle, preventing leakage losses and resource efficiency. Water resource efficiency is, therefore, critical in urban water management, both in the case of water supply and sanitation services.[4]

To address the issue of water management in a time-bound manner, CSE as a Centre of Excellence (CoE) for MoHUA in sustainable water management published a policy paper, *Water Efficiency and Conservation in Urban India in 2017*.[5] The paper was an attempt to make India a water-frugal economy through improved water quality and resource efficiency, and increased recycling, safe reuse and water-use efficiency, in line with the Sustainable Development Goals (SDGs). The National Water Mission (NWM) and the National Mission on Sustainable Habitat (NMSH) also emphasize on the need to conserve water, minimize waste and promote alternative technologies as well as encourage community involvement to increase water-use efficiency by 20 per cent.[6, 7]

Conservation planners generally believe that a long-term WEC programme can reduce water consumption by up to 20 per cent. Conservation in this range can be economically justified as it delays capital investment in facilities.[8]

Highlights of the National Water Mission, 2008

The objective of the National Water Mission is 'conservation of water, minimizing wastage and ensuring its equitable distribution both across and within States through integrated water resources development and management'.

It recommends:

- Water-use efficiency programmes, including water conservation, water recycling
- Promotion of citizens and state actions for water conservation, augmentation and preservation
- Increasing water-use efficiency by 20 per cent by 2017

Highlights of the 12th Five-Year Plan, 2012–17

- Focuses on the need to invest in water and wastewater management that is both sustainable and affordable.
- Covers recommendation for new institutions and groundwater laws.
- Recommends protection and use of local water sources before planning for long-distance transportation of water projects.
- Recommends comprehensive water audit plans to offer cost-effective and water-efficient technologies, mainly for industries.
- Suggests repair, renovation and restoration (RRR) of waterbodies.
- Provides for the creation of a forum that provides gateways on water conservation (RWH, recycling and reuse, water-conservation devices.)

Key points from policy paper *Water Efficiency and Conservation in Urban India*, 2017

A policy framework is proposed for WEC in urban areas for sustainable water management in the Indian context. This also highlights the definition of water efficiency and conservation as:

> *'Water conservation and efficiency refers to the identification, implementation, and evaluation of actions intended to meet water demand, reduce consumption and improve the efficiency of water use.'*

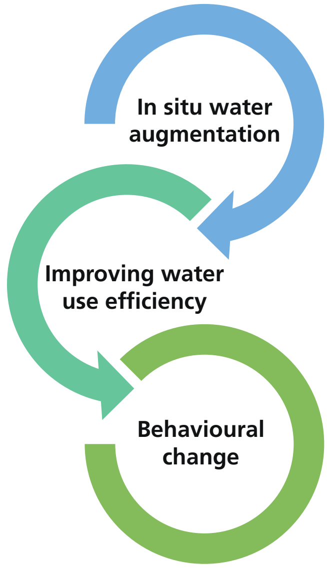
- Gives guiding principles for practitioners to use and ensure the effective and efficient collection, treatment, distribution and sustainable end-use (productivity) of potable water supply.
- Brings water conservation and efficiency together as a holistic approach, in an attempt to build on existing programme and projects, and addressing the way in which water is used in urban environments throughout the country.
- Water efficiency and conservation measures/strategies suggested in the paper are:
  - In situ water augmentation: Includes wastewater reuse, water bodies and rainwater harvesting
  - Water efficiency: Includes xeriscaping, water fixtures and reducing non-revenue water (NRW)
  - Behavioural change: Includes awareness, water pricing and social acceptability
- Best management practices (BMPs) from national and international experiences can be adopted by analysing the feasibility of different case studies which is to be applied in different Indian conditions.

WEC planning helps identify priority conservation and efficiency interventions considering not only the present scenario from available data analysis but also accounting for the intended purpose of water use, quality and quantity required. Efforts in WEC will decrease current demand and eventually stabilize it at the minimum threshold. Water conservation also has the capacity to increase water supply through recycling water, minimum leakage during conveyance etc. Further, with WEC measures implemented, groundwater levels will increase and waterbodies rejuvenate.[9, 10] *Figure 1: WEC measures* shows proposed areas of interventions to achieve WEC for sustainable water-management in urban areas.

Several WEC measures have been practised in the past and are manifested in the vast reservoir of traditional knowledge on WEC in our country. While some of these measures are still in practice, many are fast disappearing. A well-known and -researched example is rainwater harvesting (RWH). The rise, fall and potential of India's traditional water harvesting systems is well documented in CSE's publication, *State of India's Environment—A Citizen's Report', Dying Wisdom.*[11]

Many other practices still prevail or have changed face over time. For example, according to CSE's *Roadmap for Rating System for Water Efficient Fixtures*, the use of water-efficient fixtures in buildings helps manage water demand. Water-efficient fixtures are generally used in toilets and kitchens, in flushing systems, urinals, faucets and showers. There may be varying estimates for water use per person per day, but there is little argument that toilets and bathrooms are the biggest water guzzlers in buildings. Building-water use constitutes a high percentage of the total city-water use although the nature of building-water use is governed by functions of the building, type of equipments installed etc. Generally, maximum water use—i.e. approximately 45–50 per cent—is in toilets and around 30 per cent is accounted for by washing (clothes, utensils, hands etc.).[12] This indicates the vast potential of WEC interventions.

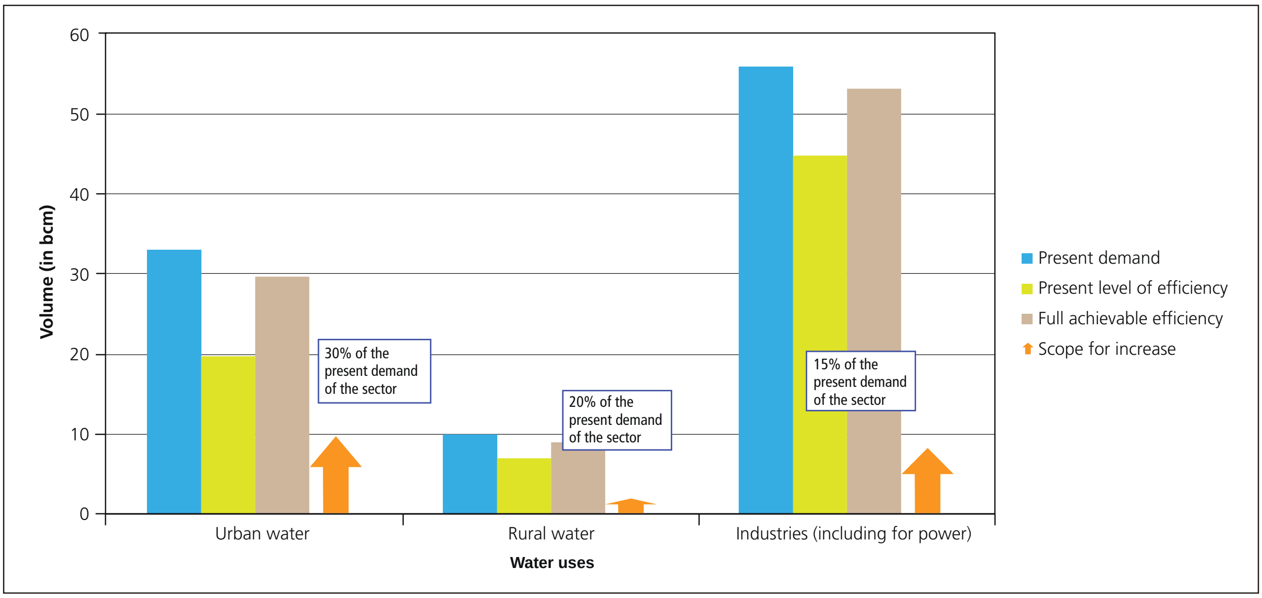
Figure 1: WEC measures



Source: CSE, 2017

The current estimate by the Central Water Commission indicates that irrigation in India demands the most water (557 bcm) and also has the most scope for improvement in water delivery and use efficiency. Water demand and scope of improvement through WEC in the industrial sector (56 bcm), urban domestic sector (33 bcm) and rural sector (10 bcm) is depicted in *Graph 2: Water demand and estimated level of achievable efficiency,* which reaffirms the potential and scope of WEC interventions for various sectors. All that is needed is a long-term committed movement to optimize the operating efficiency of systems for irrigation and the domestic and industrial sectors.[13]

Graph 2: Water demand and estimated level of achievable efficiency



Source: Adapted from: Anon., 2014, *Guidelines for Improving Water Use Efficiency in Irrigation, Domestic and Industrial Sectors*, Central Water Commission, Ministry of Water Resources.

MoHUA's national flagship programmes focusing on the urban sector, i.e. Smart cities and AMRUT, aims to improve water and sanitation in cities. The programmes aim to make 109 Smart cities and 500 AMRUT cities. Cities have the potential to save water by around 30–50 per cent per household. CSE analysis through the policy paper *Water Efficiency and Conservation in Urban India* shows that if cities with populations of over 1.5 million practise water efficiency and conservation at the municipal scale, it would reduce the demand–supply gap for water and save up to 20 per cent water.[14]

Global literature on sustainable water-use suggests that WEC is key to developing a sustainable community. It demonstrates responsible stewardship of our water resources and responsible management of our infrastructure and financial resources. By raising citizen awareness, a WEC programme can also prepare the community to respond effectively to water emergencies and accept and adapt to progressively more stringent WEC measures.[15]

Impacts of WEC are, therefore, best realized if a WEC programme involves not only municipalities and local bodies but also neighbourhoods, institutions and individuals.

1.2 Need for a guide

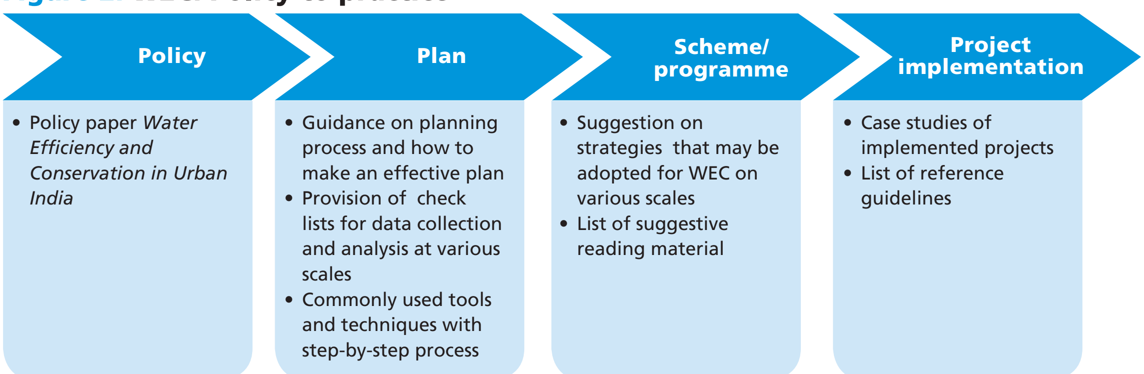
Planning water efficiency and conservation can help reduce per capita demand. Local area plans can help decision makers and water managers identify opportunities to better use community open spaces and built-up areas to lend a coherent character to areas. Local-scale planning (i.e. city/zone) provides the opportunity to devise regulations specific to an area, with watersheds such as buffer and eco-sensitive zones, where water conservation options can be taken into consideration.[16]

A WEC plan facilitates the implementation of focused WEC projects and ensures an enabling environment backed by policy guidelines. WEC projects are most impactful; policy on WEC is available in the public domain.

This document takes WEC further by providing guidance for WEC planning and effective implementation to bring water security in urban areas (see *Figure 2: WEC: Policy to practice*).

City-wide water sustainability can be achieved only if WEC is practised and implemented at all scales.[17] This guide, the first of its kind, provides insights and information for the preparation of WEC plans relevant to Indian context.

Figure 2: WEC: Policy to practice



Source: CSE, 2017.

The objectives of this practitioner's guide are:

- Objective 1: To sensitize practitioners about the concept of and need for WEC planning
- Objective 2: To provide inputs for WEC planning at different scales
- Objective 3: To present case studies of implemented projects for WEC, stakeholder involvement and implementation of plan

1.3 Target group for the guide

Table 2: Target users provides an overview of the major user groups for this guide based on involvement in formulation, evaluation and execution of the WEC plan.

The target audience comprises city officials from urban local bodies (ULBs) and development authorities such as urban planners, town planning officers, engineers, those involved in preparing and enforcing WEC plans at the city/zonal level and developing and implementing local WEC strategies as well as teachers and students of planning and environmental engineering. This guide can be incorporated in course modules of various courses recognized by the MoHUA. Further, non-state actors such as decision makers and technical staff from private organizations, and resident welfare associations can also benefit.

The reader is assumed to be a practitioner familiar with the water management paradigm in urban India and has a basic understanding of WEC.

Table 2: Target users

Government body	Target group
Development authorities State urban development agencies Town and country planners (state wise)	Urban planners: Chief Town Planner, Senior Town Planner, Junior Town Planner, Assistant Planner
Municipal corporation Municipalities Water boards Other ULBs	Engineers: Superintending Engineer, Executive Engineer, Assistant Engineer, Environment Engineer, Project Officer
Public Health Engineering Departments Water and sewerage boards Urban shelter improvement boards	Engineers
Civic bodies/NGOs	Technical staff and decision makers Planners and engineers: Representatives with background of prevailing water management system
Residence welfare associations Community-based organizations NGOs working in relevant aspects of WEC	
Planning and engineering colleges and institutes under the following courses	Students and teachers: B. Plan, BE/B. Tech (Civil)/Environmental—future engineers and planners in this sector
Post-graduate course in Environment Planning, Post-graduate course in Public Health Engineering/Environmental Engineering, short-term courses in water conservation and efficiency and related aspects	
Private organizations	Technical staff and decision makers
Consultants Private organizations	

Source: CSE, 2017.

1.4 How to use the guide

This guide shows users and implementers the benefits they can get from engaging with WEC projects implemented after proper planning. It signposts useful sources of relevant information, guides in preparing a WEC plan, provides check lists for data collection and methodology for analysis, and presents examples of good practice at various scales.

While the guide can be a useful resource for preparing a WEC plan at any scale (i.e., city, zonal, neighbourhood or individual scale), it is designed specifically for ULBs or community groups that are involved in planning and decision-making at various scales.

> This practitioner's guide provides an opportunity to prepare WEC plans to strategize for WEC projects at the city, neighbourhood and individual scales.
> It integrates BMPs related to various WEC projects emerging through strategic planning to achieve environmental and economic balance. The guide can thus help prepare integrated plans or guidelines for WEC that take into account existing gaps and missed opportunities.

Overview of the guide

Objective 1: To sensitize practitioners about the need and concept of WEC

This objective is covered in first two chapters. The first chapter defines the aim and objectives of the guide. It also highlights relevant users and benefits of the guide. The second chapter explains WEC concepts, and the scope and benefit of WEC planning. It also highlights different aspects of WEC. A time line showcasing various policies, guidelines and research documents with regard to WEC is also depicted (see *Table 3: Structure of this guide*).

Objective 2: To provide inputs for WEC planning approach at different scales

This is covered in Chapter 3. The chapter includes analyses of WEC planning approaches at different scales. First, the process of WEC planning is explained with suggestions to bring out a strong WEC plan and ensure effective implementation. It details variations that occur in WEC planning approaches for various scales, i.e. city-, zonal-, neighborhood-, commercial- and individual- and site-level planning.

Table 3: Structure of this guide

	Objective 1		Objective 2	Objective 3
Chapter	**Chapter 1** Introduction to practitioner's guide	**Chapter 2** Concept of WEC planning	**Chapter 3** WEC approach	**Chapter 4** WEC implementation and practices
Content highlights	• Background • Need for a practitioner's guide • Target group for this guide • How to use this practitioner's guide	• Evolving knowledge and Indian experience • What is a WEC plan? • Scope of WEC planning and interventions in India	• Planning process—step by step • Planning at various scales • Tools, techniques and check lists for WEC planning	• Stakeholder analysis • Social and ecological impacts of WEC • Best management practices

Source: CSE, 2017

Objective 3: To present case studies of implemented projects for WEC, stakeholder involvement and implementation of plan.
Chapter 4 covers this objective as it deliberates about stakeholder analyses and the importance of their role in the WEC planning process. The overall economic, social and environmental impacts are also discussed. This chapter also includes relevant case examples and best management practices.

Annexures with checklists to support WEC planning are at the end of this guide.

2. Evolving knowledge and scope for WEC planning

For sustainable water management in urban areas, WEC practices need to be implemented. To achieve optimum WEC benefits in the long run, a holistic and participatory planning approach, with clear guidance on institutional roles, responsibilities and financing to address issues, is essential.

Developing a sound WEC plan is a multi-step process that requires diligent thought and effort. This section will highlight the above as it discusses WEC concepts, evolving knowledge, experience and scope of WEC planning.

2.1 Evolving knowledge—Journey towards WEC

Water has been considered sacred throughout civilizations. India experiences both excess and scarce water because of varied rainfall and land topography. Still, it has managed to use natural water resources efficiently by integrating local water resources and technologies with community participation.

A combination of traditional techniques and community involvement used local resources and retained time-tested systems. The colonial era, however, introduced the concept of government control over surface water. Under the Indian Easement Act, 1882, landowners had virtually unlimited right to use water under their possession and this Act is still applicable. Water exploitation by way of canal and irrigation projects to increase revenue was more important than conservation during the colonial era.

In the late 1960s and early 1970s, the ecological and political costs of building large-scale water infrastructure became more apparent and the environmental movement began to challenge proposals for new dams and related environmental and social issues. Simultaneously, limitations of supply-side solutions to address water shortages in spite of huge infrastructural spending were increasingly noticed. In spite of government spending and water subsidies, there was a disintegration of this old approach, and local bodies, planners and decision-makers were urged to re-examine fundamental assumptions to seek alternative solutions[1] (see *Poster 1: The journey towards mainstreaming sustainable urban water management through WEC*). It highlights related policies, reforms, acts and guidelines and related developments since the 1970s.

It is also clear that demand-side solutions practised without the catchment and socioeconomic situation taken into consideration or an integrated water management approach followed will not contribute towards sustainable benefits.

WEC at every scale requires sound planning. With this in view, cities and organizations around the world have put forth water conservation planning guidance documents. The United States Environmental Protection Agency (USEPA) released its water conservation plan guidelines in the late 1990s. Subsequently several states and municipalities released similar guidelines.

Poster 1

The journey towards mainstreaming sustainable urban water management through WEC

1977

Water (Prevention and Control of Pollution) Cess Act

- Water as commodity
- Levy and collection of cess on water consumed for industrial activities

1992

74th Constitutional Amendment—12th Schedule

- Decentralised government including wastewater treatment

1997

CSE published book *Dying Wisdom*

- Comprehensive overview of the rise, fall and potential of India's traditional water-harvesting systems

1998

USEPA published guidelines to help utilities develop water conservation plans

2001

CSE published *Making Water Everybody's Business*

- Documentation of traditional practices, technologies and policies of water harvesting in the country

2005

Launch of JnNURM

- Reforms for revising bylaws to make RWH mandatory in all buildings and adopting water conservation systems

2006

National Environment Policy

- Recognizes that the maintenance of a healthy environment is the responsibility of every citizen

2008

National Water Mission

- Target to conserve water and minimize wastage to achieve 20 per cent water efficiency by 2017
- Integrated water resource development and management

National Mission on Sustainable Habitat

- Promotes recycling of treated wastewater/ sewage and reuse wherever possible

MoEF released *Guidelines for National Lake Conservation Plan*

- State governments to work in close partnership with the centre in protection, conservation and sustainable management of lakes

2009

Ministry of Housing and Urban Affairs

Service-level benchmark by MoHUA

- 20 per cent NRW
- 100 per cent metering and extent of water supply

2010

MoEF published EIA guidance Manual for *Building, Construction, Townships and Area Development Project*

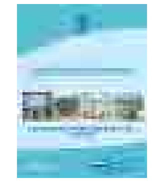
- Promotes use of water-efficient fixtures and reuse of treated wastewater

2011

CSE published *Roadmap for Rating System for Water Efficient Fixtures*

- Draft rating system for water efficient fixtures in India

2012



Non-Revenue Water Reduction Toolkit **by JnNurm**

CSE's book *Excreta Matters*

- Survey of 71 cities on water and wastewater

National Water Policy 2012

- Promotes water conservation and its efficient usage

2013

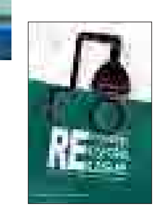
IAPMO and Indian Plumbing Association published

Rating System for Sustainable Plumbing in India

IELO published model national institutional framework on water-use efficiency

CPHEEO issued advisory on conservation and restoration of waterbodies in urban area

CSE's toolkits for practitioner



Decentralised wastewater management

Urban rainwater harvesting

2014

Fundings and capacity building for urban transformation that includes water supply, drainage, wastewater, green space and parks

2015

A mission to make cities all over the country citizen friendly and sustainable

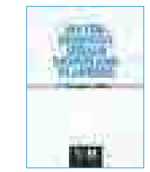
2017

CSE published policy papers on

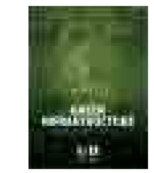
Urban Water Efficiency and Conservation

Energy Efficiency in Urban Water and Wastewater Management

CSE's practitioner guides on



Water Sensitive Urban Design and Planning



Green Infrastructure

Way Forward: Turning our cities from "water meagre" to "water frugal"

- Implementation of integrated water efficiency and conservation plan at various scales
- CSE-CoE school of water and sanitation at AAETI, Nimli to act as capacity building hub across urban centres of India

2.2 Planning for WEC

A WEC plan is a comprehensive and integrated approach to conserve water resources, reduce per capita water demand and promote efficiency of water use. It helps decision makers, implementers and users identify gaps and opportunities and pushes for significant projects that can achieve WEC in a coherent manner.

The plan is characterized by a thoughtful rationale towards water conservation that follows a holistic approach to achieve optimum water-use efficiency and conservation while linking with other plans, such as City Sanitation Plan (CSP), Faecal Sludge and Septage Management (FSSM) Plan, land use and asset management (see *Table 4: Provisions and opportunities for WEC planning and implementation*).

Table 4: Provisions and opportunities for WEC planning and implementation

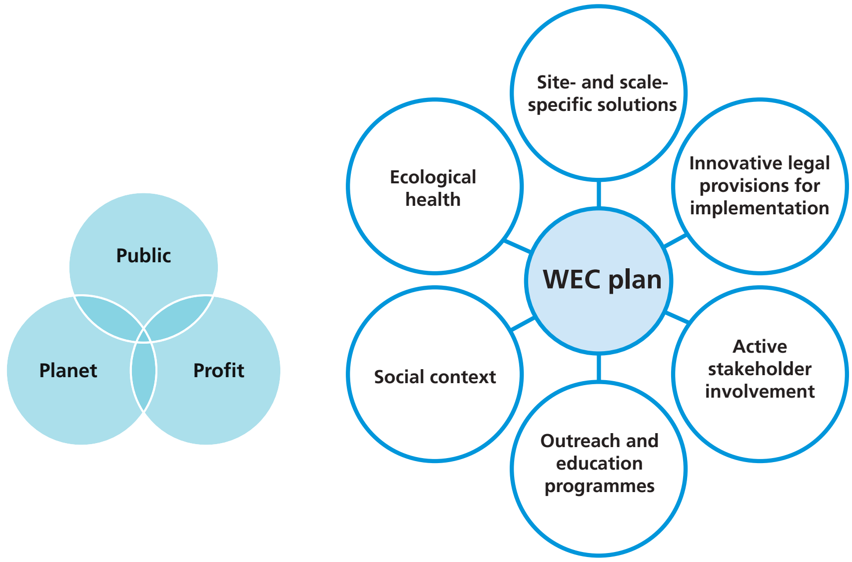
Scale	Existing documents/ provisions	Opportunities
City level: Open spaces—parks, waterbodies and road infrastructure (planning stage)	• Master plans (20 years) • City development plans (five years) • City sanitation plans • Environmental management plan	• Future locations of storm-water management facilities and proposed STPs • Waterbodies, parks, recreational areas, green areas, public and transport
Zone level (planning and designing stages)	• Zonal plan • Storm-water management, including waterbodies • ULBs scheme and sanitation schemes • Detailed Project Reports (DPRs)	• Parking lots, roads, parks, open space blocks and storm-water management facilities defined in planning documents • DPRs for water supply, sewerage including STPs, sanitation, storm-water drainage
Individual level (designing stage)	Site plan—guided by bylaws	• Water-efficient fittings, sustainable landscaping, rooftop RWH and recycle/reuse of treated wastewater • Site-specific on-site water-efficiency and conservation

Source: Suresh Kumar Rohilla, Mahreen Matto, Shivali Jainer and Chhavi Sharda 2017, Water-Sensitive Urban Design and Planning: A Practitioner's Guide, Centre for Science and Environment, New Delhi.

WEC planning is an interactive and dynamic process. Regardless of size and complexity of plan, a holistic approach with a 'watershed view' is essential. This means that using the catchment basin and its watersheds as the geographical basis for decision making is crucial. A good WEC plan integrates all aspects of water and does not solely consider linkages between drinking water, wastewater, rainwater and impacts on energy use while seeking solutions but also accounts for social, cultural and ecological considerations.[2] It gives importance to ecological health, placing it as an integral component of WEC (see *Figure 3: Considerations for a strong WEC plan*).

A well-conceived WEC plan enables behavioural change that creates a 'conservation culture' that is an outcome of an improved awareness of the need to adopt WEC. It helps foster the recognition that wise water-use choices directly correlates to future investment—that water saved means money saved. This can be done only if the WEC plan conveys how every user and each water supplier can benefit from implementing a conservation ethic.[3]

Figure 3: Considerations for a strong WEC plan



Source: CSE, 2017.

The planning process thus requires stakeholder involvement. It may be repeated until an acceptable consensus is achieved. It is essential to involve all major stakeholders at an early stage of WEC planning. Planning processes have failed or been delayed when influential or overlooked stakeholders were involved late in the process and blocked decisions.[4]

An ideal WEC plan:

- Is tailor made and provides site- and scale-specific solutions.
- Blends innovative legal tools such as water-restriction and land-use planning bylaws with practical measures such as rebate and metering programmes.
- Makes managing demand a part of daily business rather than a stop-gap measure that is implemented and considered only an intermediate solution to increase supply. For example, measures that improve water-use efficiency without compromising on the purpose of usage such as promoting efficient systems, and operations and maintenance.
- Builds in WEC measures that are geared towards creating in situ water augmentation through rainwater capture, wastewater reclamation, reuse and recycling to better match water quality to end uses.
- Implement outreach and education programmes that go beyond information dissemination to engage and inspire citizens to permanently change behaviour.[5]

2.3 Scope of WEC planning and interventions in India

There is a growing realization at the Central and State levels of the risk that not adopting water-efficient practices and water conservation early in the planning process will cause constraints in maintaining adequate water safety and security in the long run. WEC strategies if planned correctly offer an opportunity to achieve water-frugal cities. WEC planning helps achieve a sustainable balance between water availability and demand (see *Table 5: Water-saving potential of various WEC interventions*). One or a combination of WEC interventions may be applicable at the city and smaller scales. *Annexure 1: National reference documents for implementation of various WEC measures* suggests the document which can be refered for the purpose.

Table 5: Water-saving potential of various WEC interventions

WEC intervention	Water-saving potential
In situ water augmentation through RWH (as per scale and type of catchment)	272–3,207.51 litres /sq. m of catchment area per annum (this estimate varies with agro-climatic regions ranging from western Rajasthan, where annual rainfall is as low as 302.4 mm to heavy rainfall areas/coastal areas with annual rainfall up to 3563.9 mm; assuming catchment is paved concrete)
In situ water augmentation through conservation and management of local waterbodies	Protecting and properly managing surface-water sources will augment the water supply.
In situ water augmentation through bulk use of treated wastewater from the Sewage Treatment Plants (STPs) for golf courses, public parks, botanical gardens, recreational areas, supply to industry, irrigation etc.	80 litres per 100 sq. m of urban areas (assuming 15–20 per cent of green open spaces in urban areas exists. About 3–4 litres of freshwater is saved per sq. m of green area during rainy days when native species of plants are used)
Recycling of grey water or locally reusing treated wastewater (grey and/or black) at smaller scales (as per the purpose and level of treatment, i.e. fit for purpose reuse)	Up to 40 per cent of household water consumption
Improving efficiency by NRW management of the water distribution systems	Possibility to make it less than 20 per cent (the lesser the losses, the better. The Service Level Benchmark (SLB) by MoHUA is 20 per cent of the water supplied through the system in cities.)
Improving efficiency through low flow plumbing and fixtures	80,000 litres annually for a household (assuming a family of 4, with 6 litres per flush, will mean a 20 per cent reduction in usual household consumption)
Water conservation by using native species of plants for landscaping and xeriscaping	20–25 per cent reduction in comparison to exotic species (using native species and water-efficient irrigation systems)

Source: CSE, 2017.

The following sections, with case studies, elaborate the scope of WEC planning:

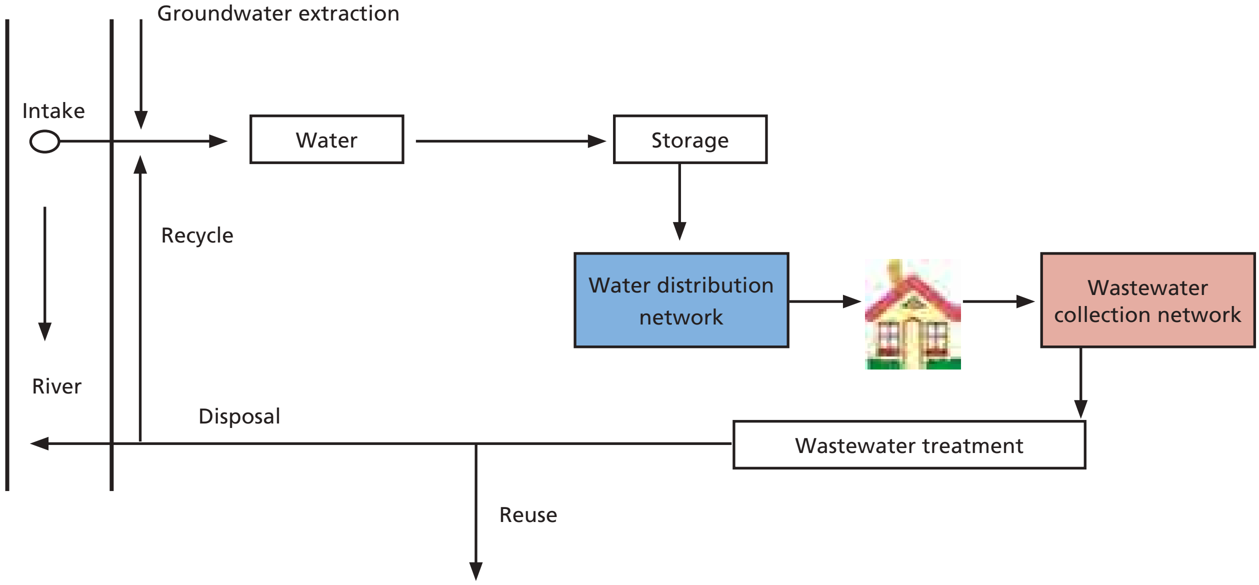
Scope of WEC at the city level

In cities, the municipality or ULBs such as water supply and sewerage boards are responsible for sourcing freshwater and its distribution, supply and maintenance for domestic, industrial and commercial purposes. In addition, these local bodies are responsible for collection, treatment and disposal of generated wastewater from domestic users through sewerage network and sewage treatment plants (see *Figure 4: Water management for a city*).

Most transmission and distribution pipelines are old and many are corroded and leaking, resulting in water loss and below-par water quality. In some metropolitan cities, leakage losses are as high as 50 per cent of pumped water.[6] Identifying system inefficiencies and taking strategic measures to improve it in addition to using local sources of water augmentation can save up to 20 per cent of the water as is the target under the NWM.[7] However, varying quantity of water utilized for different uses along with design and management efficiencies leads to non-uniform scope for improvement in efficiency.

Figure 5: Implementation of WEC interventions at city scale highlights demand drivers and key concerns that indicate that WEC at city/zonal scale is required for sustainable urban-water management. It suggests WEC opportunities at this scale.

Figure 4: Water management for a city



Source: Suresh Kumar Rohilla, Pradeep Kumar, Mahreen Matto and Chhavi Sharda 2017, *Mainstreaming Energy Efficiency in Urban Water and Wastewater Management in the Wake of Climate Change*, Centre for Science and Environment, New Delhi.

Figure 5: Implementation of WEC interventions at city scale

Demand drivers

- Water stress
- Population growth
- Urbanization and changing lifestyles
- Increased per capita water use
- Water losses in the distribution network
- Deteriorating safety of water sources
- Demand–supply gap

Key concerns

- Low water-use efficiency
- Increasing non-revenue water
- Increasing water pricing
- Increasing water footprint
- Inadequate sewage collection, treatment and reuse—deteriorating water quality
- Lack of reforms and regulations

WEC opportunities

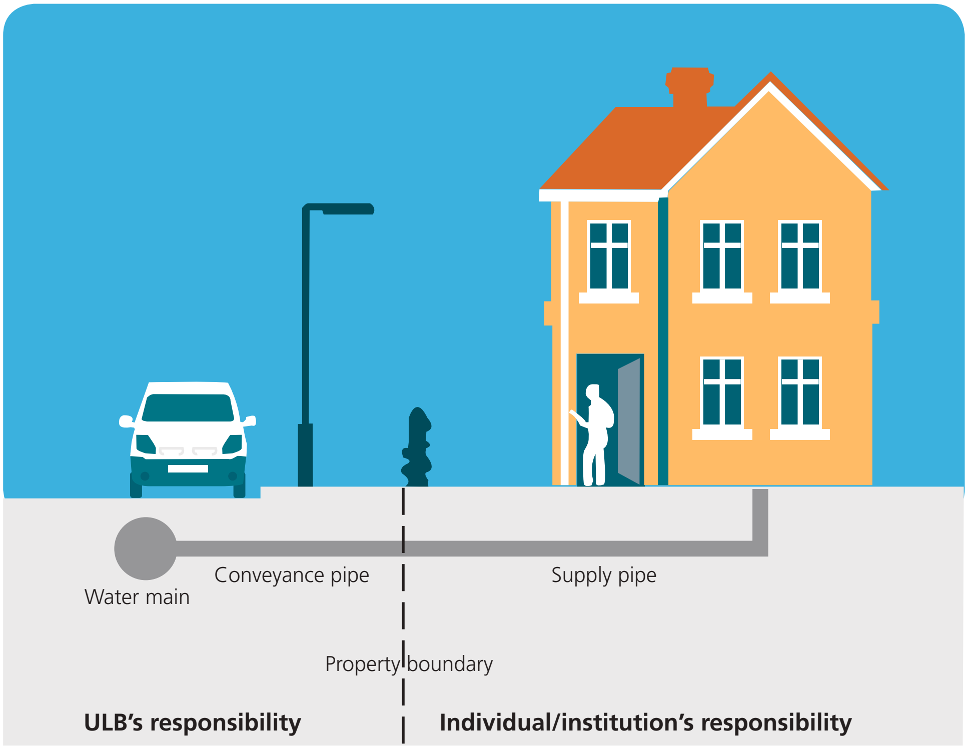
- In situ water augmentation through wastewater recycle/ reuse
- Conservation and management of local waterbodies as alternative water sources
- Identifying losses and reducing them through organized O&M
- Water-efficient landscaping
- Water pricing
- Awareness

Source: CSE, 2017.

WEC scope at smaller scales

At relatively smaller scales, such as institutional, apartments/residential complexes or individual household, where ULBs and parastatal agencies may not be responsible for water supply after specific points, individuals through community-based organizations (CBOs) and residents welfare associations (RWAs) are responsible. At this scale, a WEC plan helps strategize not just implementation relevant to the local context but also bring awareness and clarity with regard to roles and responsibilities of government, non-government local bodies and users (see *Figure 6: Roles and responsibilities for water supply at smaller scales).*

Figure 6: Roles and responsibilities for water supply at smaller scales



Source: http://corporateresponsibility2010.unitedutilities.com/images/singlesupplypipes.PNG

Figure 7: Hierarchy of water requirements

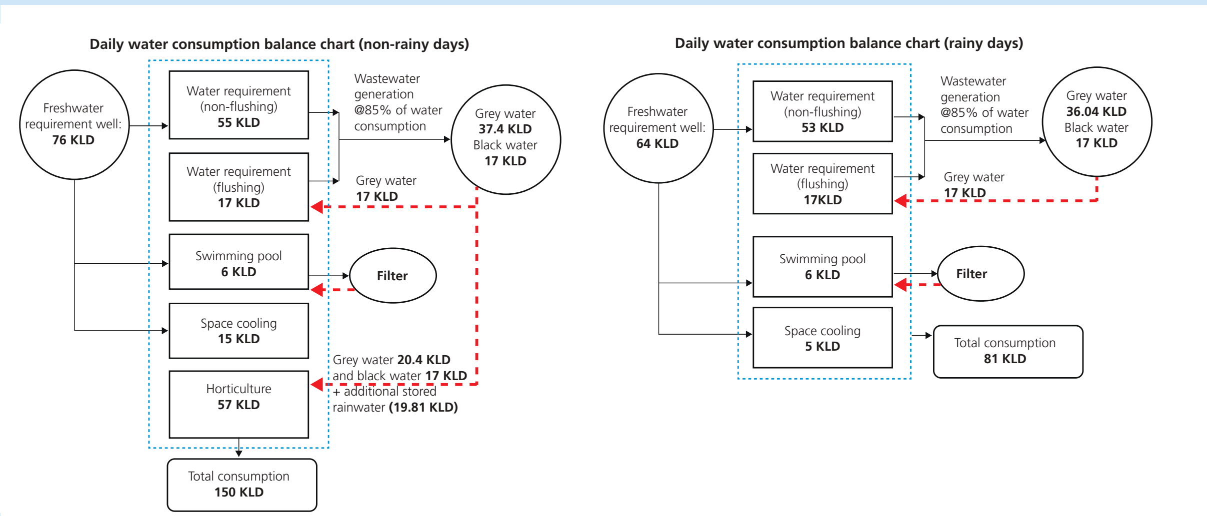
Source: WHO, 2011, Technical Notes on Drinking-water, Sanitation and Hygiene in Emergencies

The hierarchy of water requirements is given consideration in WEC planning. The hierarchy can be demonstrated by means of a pyramid (*see Figure 7: Hierarchy of water requirements*). Some uses of water are more important than others. Having a few litres of water to drink each day, for example, is more important for survival than having water for laundry, which is also needed to prevent skin diseases and meet other physiological needs. Other uses of water have health and other benefits but less urgency.[8]

CASE STUDY 1: Water efficiency and conservation at a training institute in Alwar district, Rajasthan

Background

The Anil Agarwal Environmental Training Institute (AAETI), covering 10 acres (4.04 hectares) in Nimli village, Tijara block, Alwar District in Rajasthan, is a fully residential institute for training and capacity building on thematic areas related to environment and sustainable development. The site is not connected to the municipal water supply or sewerage network. Micro and macro rain-fed channels flow through the site. Runoff from the adjacent catchment flows into the main channel, which is 134 m long and has varying width (maximum 20 m and minimum 10 m). WEC planning of the site has helped strategize various measures to achieve water conservation and efficiency, including local reuse of treated wastewater to reduce water demand.



AAETI requires a total of 150 kilolitres per day (KLD) of potable and non-potable water. About 51 per cent of this is the requirement for freshwater, to be met from groundwater. The remainder (used for instance for flushing and irrigation) will be met through available treated grey and black water.

Water sources—The site will draw about 76 KLD of groundwater every day during non-rainy season at its full capacity for all its potable purposes. Hence, annually the site will be extracting about 22,155 KL of freshwater from the ground. The AAETI campus is a planned intervention means that adequate measures have been taken to ensure that groundwater levels are not depleted or contaminated, water consumption/demand is reduced, treated wastewater is locally reused as an alternative source of water in addition to the rainwater that is harvested.

The following WEC measures are taken at the site to reduce demand for freshwater:

- In situ water augmentation
  - Water conservation through RWH/SWM—The site receives 700 mm of annual rainfall (in average 10 years). The design aims to recharge more than 25,000 KL of water annually through recharge wells, swales and check dams.

Intervention	Details	Quantity of water saved (KL/annum)
Reuse of treated wastewater	• Reuse for flushing and irrigation—wastewater generated from cafeteria and housing blocks is treated using soil biotechnology, wastewater generated from the administrative block is treated through a decentralized wastewater treatment system (combination of settler, ABR, planted filter bed and polishing pond)	9,125 (25 KLD during days when it doesn't rain)
Recharge of harvested rainwater and storm water	• Recharge well—Recharge of rainwater through rooftop RWH rainwater from all rooftop areas except from canteen's rooftop. • Tapping water from the storm water stream that flows through the site for recharge	25,000 KL
RWH for direct use	• Storage of the harvested rainwater from the canteen's rooftop into RCC tanks for usage • Space cooling • Drinking water in canteen	780 KL (freshwater requirement was reduced from 76 KLD to 64 KLD)

- Water-efficient measures

Intervention	Details
Reducing water consumption	• Usage of water efficient fittings and fixtures for toilets, bathrooms, kitchen and laboratory. • Reuse of treated wastewater for flushing
Water-efficient landscaping and evapo-transpiration (ET) controlled irrigation system	• This will reduce losses through the irrigation system • Using native plant species for landscaping

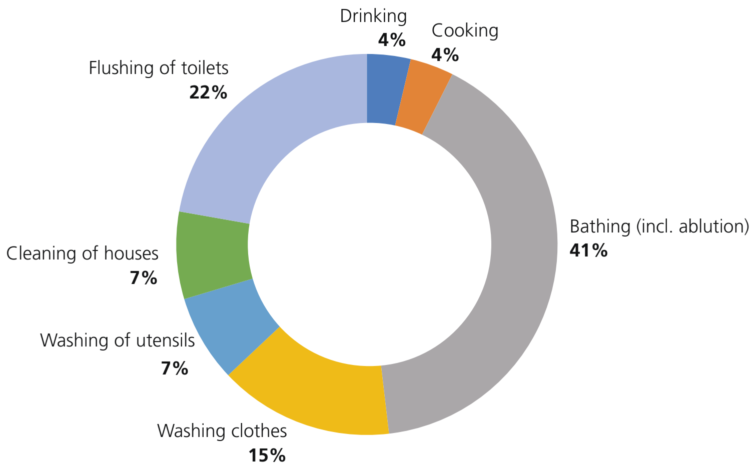
Results

- Water supply is planned at 135 litres per capita per day (lpcd). Water demand will be reduced from 135 lpcd to 86 lpcd by WEC techniques such as using water-efficient fixtures, rainwater harvesting and reusing treated wastewater.
- The site will recharge about 25,000 KL per annum through different RWH and SWM technologies in comparison with annual freshwater withdrawal of 22,155 KL.

Source: CSE, 2017.

At the individual scale, WEC can be achieved through demand-side management. *Figure 8: Average domestic water consumption in Indian households* and *Table 6: Scope of average water savings through water-efficient fixtures* show existing consumption patterns and potential savings in a household with an average family of five.

Figure 8: Average domestic water consumption in Indian households



Source: Suresh Kumar Rohilla and Sakshi Dasgupta, 2011, Roadmap for Rating System for Water Efficient Fixtures, CSE.

Table 6: Scope of average water savings through water-efficient fixtures

Purpose	Water that can be saved in litres/day	Water that can be saved in litres/week	Recommendations
Shower	200	1400	Decreasing the duration of showers and by using low-flow showers can save up to 50 per cent water. Sensor light on the shower outlet and stopping water flow after the preset duration can also save water.
Running tap in kitchen/ faucet use	106	742.5	Changing utensil-washing habits and using smart fixtures such as aerator faucets can save water by up to 50 per cent.
Laundry	14	100	While buying a new washing machine, choose one that is water efficient. Front loaders use about half the water that top loaders use. Improved washing machines use 45–20 litres per load.
Toilet	60	420	Modern dual-flush toilets use only 3–6 litres of water per flush. This is 30 per cent less than the older dual-flush cisterns and up to 9 litres less than single-flush toilets. Use water closet flush tanks with smaller volume.
Fittings	32	226.8	Have a tap that requires the user to press a handle and keep it pressed for water flow so that the tap closes and water stops the moment the handle is released. A sensor light can be installed below or above the tap or sink. When the user places hands below the tap, the sensor light operates and water flows. When the hands are moved away, the sensor closes the tap and water flow stops. Keep optimum pressure in the water supply system. Fixing leakages saves a significant amount of water.
Total	415	2889.3	

Source: Suresh Kumar Rohilla and Sakshi Dasgupta, 2011, *Roadmap for Rating System for Water Efficient Fixtures*, CSE.

Table 7: Summary of areas with major improvement potential in a building

Building type	Toilets	Showers	Sinks	Laundry	Kitchen	Heating/cooling	Landscaping	Pools	Sterilization
Residential	X	X	X						
Hotel	X	X	X	X	X	X	X	X	
Hospital	X	X	X	X		X	X		X
School	X		X		X		X		
Offices	X		X			X	X		
Shopping centre	X		X		X	X	X	X	

Source: CSE, 2017.

Interventions for efficiency in water use may be implemented in all the areas where water is used. Areas where there is scope for improvement through water-efficient fittings and fixtures may vary according to the building type. *Table 7: Summary of areas with major improvement potential in a building* lists areas with major improvement potential.

As is evident, there is scope for generating water security in urban areas without expenditure on large infrastructural projects through WEC interventions.

3. WEC approach

This section details the process for WEC planning. The approach may be customized or modified on the basis of local peculiarities to suit an area's population size, environmental challenges, demographics and planning history.

The following three scales will be used to analyse the applicability of WEC plan, programme and practices (see Table 8: *Different scales for WEC planning and implementation*).

Table 8: Different scales for WEC planning and implementation

	City/zonal scale	Neighbourhood/ institutional scale	Individual scale
Area (sq. m)	10,000–15,000	4,000–5,000	1,000–4,000
Users/population	5,000	200–5,000	5–200
Wastewater generation capacity (kilolitres per day—KLD)	500 or more	20–500	0.5–20
Land use/activity	Medium density: 200–400 persons per hectare (pph)—commercial areas, neighbourhoods, institutional and peri-urban areas	Institutional/commercial buildings	Residential buildings (plotted/four-five storeyed)

Source: CSE, 2017.

WEC planning at a larger scale (i.e. the city/zonal scale) sets guidance for plans at smaller scales. For example, large campuses such as institutions in the region (with similar geo-morphological character) could take guidance from the city/ zonal plan while strategizing and planning for WEC projects that are relevant in the local context. This would help in successful implementations that facilitate achieving maximum benefit in terms of conservation and improving water-use efficiency.

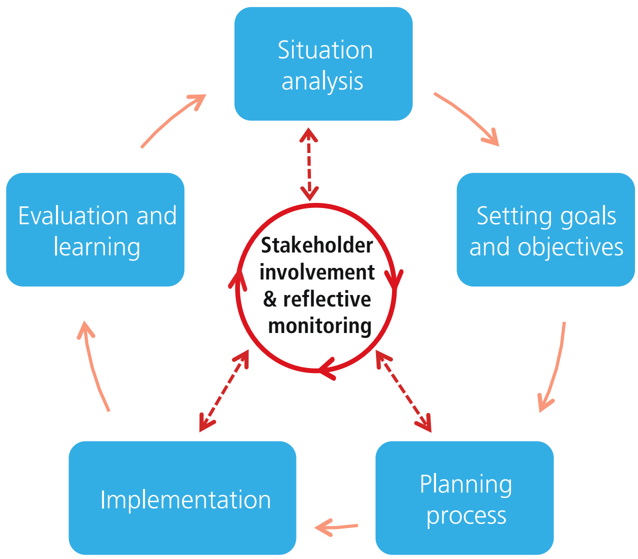
3.1 The planning process

The first step in planning is to refer to existing policies, plans and missions relevant to the sector, such as the NWM, water-related sections in the national Five-Year Plans, Three-Year Action Agenda or plans prepared by NITI Aayog. CSE's policy paper on WEC sets the core values for the planning approach specific to WEC planning that are recommended in this guide.

Since urban water management is a state subject, state governments may, to mainstream WEC, adopt and define a state's policy in accordance with the national policies. For sustainable and effective water management, WEC planning should, however, be local. Before any planning process is formulated, the following steps have to be carried out:

1. Defining system boundaries, i.e. scope and scale for the planning process
2. Identifying stakeholders
3. Identifying threats, challenges and opportunities to water-resource sustainability

Figure 9: Stages of WEC for sustainable water management



Source: CSE, 2017.

Setting objectives for WEC gives direction to a plan, programme or scheme and its implementations at the city/zonal or smaller scale. *Figure 9: Stages of WEC for sustainable water management* summarizes the process that leads to effective WEC planning and implementation to achieve sustainable water management and highlights the role of reflective monitoring through active stakeholder involvement.

Planning offers the opportunity to tie different initiatives together to transform land use for extensive development and rapid provision of infrastructure. Organizational structure with requisite managerial capacity and financial budgetary process can be built around planning and can lend itself to a platform to arbitrate global and local changes. At the local level (regional, city, zonal) there is the opportunity to devise regulations specific to the area, such as buffer and eco-sensitive zones, where options to conserve water can be considered. For example, floodplain buffers can act as regional recharge zones.[1]

It is important to understand the various steps involved in implementing a successful plan to be able to demonstrate one (see *Table 9: Step-by-step process for WEC planning*).

Stage 1: Evaluation of the system and self-assessment

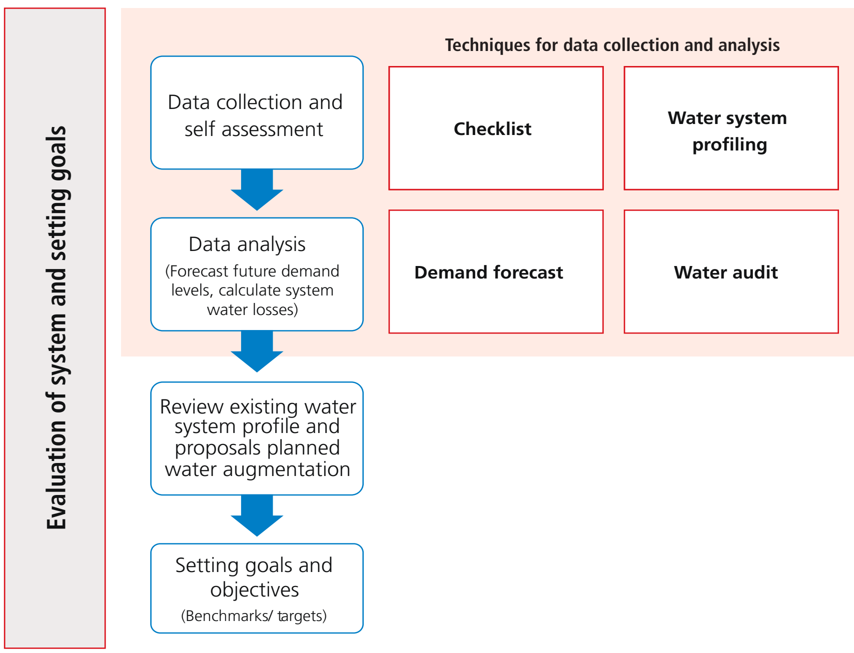
Evaluation of the system of water management for the study area is the starting point for planning. It involves collecting data and analysing it to identify gaps and opportunities in the system. Self-assessment overlaps with evaluating the system post first iteration of the planning process. The major difference between them is that self-assessment is the initial step for implementation of any efficiency plan to achieve already set goals or targets. *Figure 10: Process for evaluation of system and setting goals* gives an overview of the activities involved and lists out relevant techniques.

Table 9: Step-by-step process for WEC planning

Stage	Steps involved
Stage 1: Evaluating the system and self-assessment	Data collection and self-assessment • Describe the service area • Profile the water system • Generate spatial maps • Survey reports
	Data analysis • Review detailed demand forecast • Describe present water demand level • Spatial analysis of water resources and groundwater aquifer • Forecast future demand level • Identify gaps
	Review existing water systems and proposals for planned water augmentation
Stage 2: Setting goals and objectives	Evaluate effectiveness of existing conservation measures • Match water-efficiency goals to needs • Set realistic goals or targets
	Define conservation potential
Stage 3: Plan (Developing WEC measures, and designing the plan)	Identify conservation measures • Estimate potential savings from efficiency measures • Screen for applicability, feasibility and acceptability
	Determine feasible measures
Stage 4: Developing strategy for implementation	Select and package conservation measures • Review goals and objectives
	Combine overall estimated savings • Estimate benefits • Estimate cost of efficiency
	Optimize demand forecasts • Finalize plan

Source: CSE, 2017 and *Water Conservation Programmes—A Planning Manual*, 1st Edition, American Water Works Association, 2006.

Figure 10: Process for evaluation of system and setting goals



Source: CSE, 2017.

Data collection and self-assessment

The first stage is the collection and compilation of data. Relevant and existing data (spatial and non-spatial) of the area of interest needs to be generated by means of primary and secondary sources (see *Table 10: Overview for data collection at various scales*).

Information required for WEC intervention is often recorded by different agencies or service providers and requires synergistic action from different government and non-government bodies (refer to *Annexure 2* for a suggestive checklist for data collection at various scales).

The following collected data helps address critical questions that leads to better understanding:[2]

- What problems are to be solved?
- What are the driving forces for future development? What can be expected in the future?
- What WEC systems or measures are in place (if they exist)? What is the level of WEC efficiency achieved?
- What are the current water losses?

Table 10: Overview for data collection at various scales

Developing WEC plan at city/zonal scale		Developing WEC plan for neighbourhoods/commercial complexes	Developing WEC plan for individual/ buildings
WHO takes the initiative?	ULBs responsible for water supply, water boards—operators, managers and other engineers of water board consultants	Technical personnel from RWA or CBOs, annual maintenance contractors/operators, water consultants	Residents, building management, technical personnel from the RWAs or CBOs, annual maintenance contractors/operators, water consultants
WHAT is the starting point for data collection?	Gather and assess relevant information about: • Ecological systems • Water source, supply, distribution, treatment and redistribution systems • Water users and end-uses of water • Water revenue This is the foundation upon which a WEC plan is built	Gather and assess relevant information about: • Localized ecological systems, • Water users, water usage, metered or unmetered supply, • Water source, tariff • Information regarding existing WEC measures practised and their status This is the foundation upon which WEC plan is designed in consultation with users and relevant stakeholders	Gather and assess relevant information about: • Area available, type of building • Water users, water usage, metered/ unmetered supply, tariff • Water source, information regarding • Existing WEC measures practised and their status This is the foundation for WEC planning and initiatives
HOW to collect data?	Collect data from water metres, water utility records, billing records, municipal planning documents, existing reports from neighbouring municipalities or national level studies	Collect data from water meters, water utility records, billings records and municipal planning documents or conduct a water audit/survey. Involve stakeholders—practitioners, beneficiaries and managers/governing authority/civic bodies etc.	Collect data from water meters, water utility records, billings records and municipal planning documents or conduct a water audit/survey

Source: Adapted from Wong, J., S. Porter-Bopp, O.M. Brandes, and L. Edwards, 2009. *Water Conservation Planning Guide for British Columbia's Communities*. Victoria: POLIS Project on Ecological Governance at the University of Victoria with the Ministry of Community and Rural Development.

A water system profile enables creation of an overview of the water system. It provides an outline of the water system, which includes water sources, water supply, distribution till end-use wastewater treatment and disposal. Collected data is used to calculate average daily demand and create a profile of the water system (see *Technical Box 1: Calculating average daily demand*).

Technical Box 1: Calculating average daily water demand

To estimate metered water use:

Average daily demand = Total annual water production/365 days

To estimate unmetered water use:

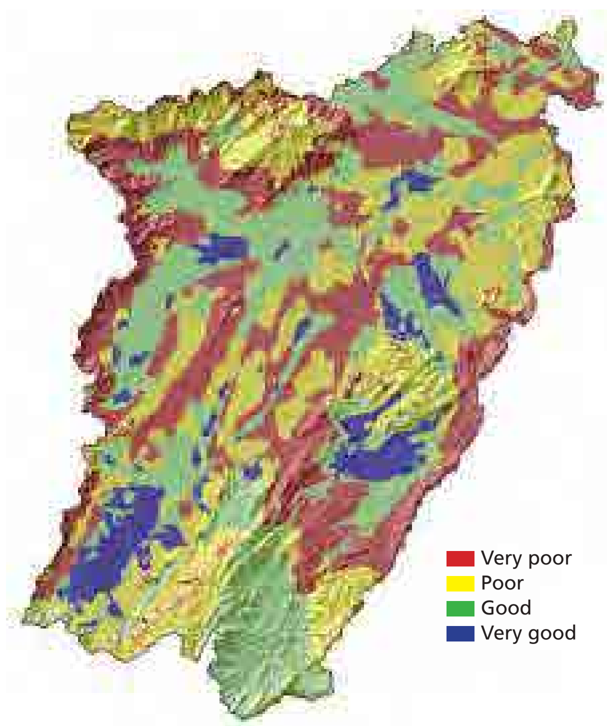
Average daily demand = Pump rate x run time x efficiency of pump*

* Efficiency of pump decreases annually

Profiling water systems helps identify where WEC initiatives should be directed. For example, detecting and repairing leaks can be a valuable initiative as the recovery of the lost water becomes a source of 'new water'. Data collected in this step is used to make demand projections. Inclusion of a map that shows the spatial layout of all components of water system along with the geography of the area is also beneficial. For example, spatial data on drainage, density, lineament, geology, geomorphology, land cover/land use and slopes in the form of maps needs to be collected to identify artificial recharge zones by delineating variations in groundwater potential in the selected area. This is done by using remote-sensed imagery and GIS techniques for analysis.

Figure 11: Groundwater potential map of Theni district, Tamil Nadu maps groundwater potential zones for the study area. The map is prepared by integrating the various layers and analysing them. The groundwater potential zone of this study area is divided into four grades, namely very good, good, poor and very poor.

Figure 11: Groundwater potential map of Theni district, Tamil Nadu

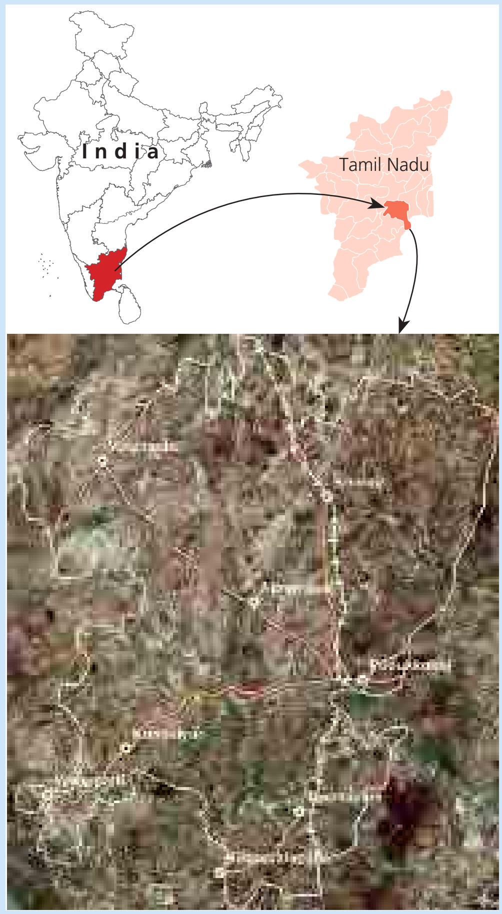


Source: N.S. Mangesh, N. Chandrsekar, John Prince Soundranayagam, 2012, Delineation of groundwater potential zones in Theni district, Tamil Nadu using remote sensing, GIS and MIF technique.

CASE STUDY 2: Feasibility study to identify zones for setting up artificial recharge systems, Tamil Nadu, India

Background

An area of nearly 2,084 sq. km in the state Tamil Nadu was selected for feasibility data collection and analysis. The area experiences different climates depending on the altitude. Summer, rainy and winter seasons are prominent and fall from April to June, September to December, and January to March respectively. The average mean rainfall for the past 70 years (1927–96) is around 733 mm.



Remote sense image was analysed and overlayed with different thematic layers for the study area. Primary and secondary sources, such as IRS 1C/1D geo-coded data, and a survey of India topographic sheets on a 1:50,000 scale were used to identify rainwater harvesting structures in the study area. From the IRS 1C/1D LISS III geo-coded photographic products, four thematic maps were prepared, such as structural trend line, lineament, geomorphology and land-use/land-cover maps. From the survey of India topographic sheets, three thematic maps were prepared, i.e. drainage, slope and tank maps. Data collected from the public works department reports, two thematic maps were prepared, i.e. water-level map and depth-to-bed rock map. Sub-surface geological data and geophysical data were collected to understand the water resources scenario. Sample field checks were also carried out for confirmation of details obtained from remote-sensed data. GIS databases were generated for all thematic layers; these databases were integrated and analysis was carried out to check feasibility of artificial recharge structures.

The feasibility study was done to identify intervention areas:

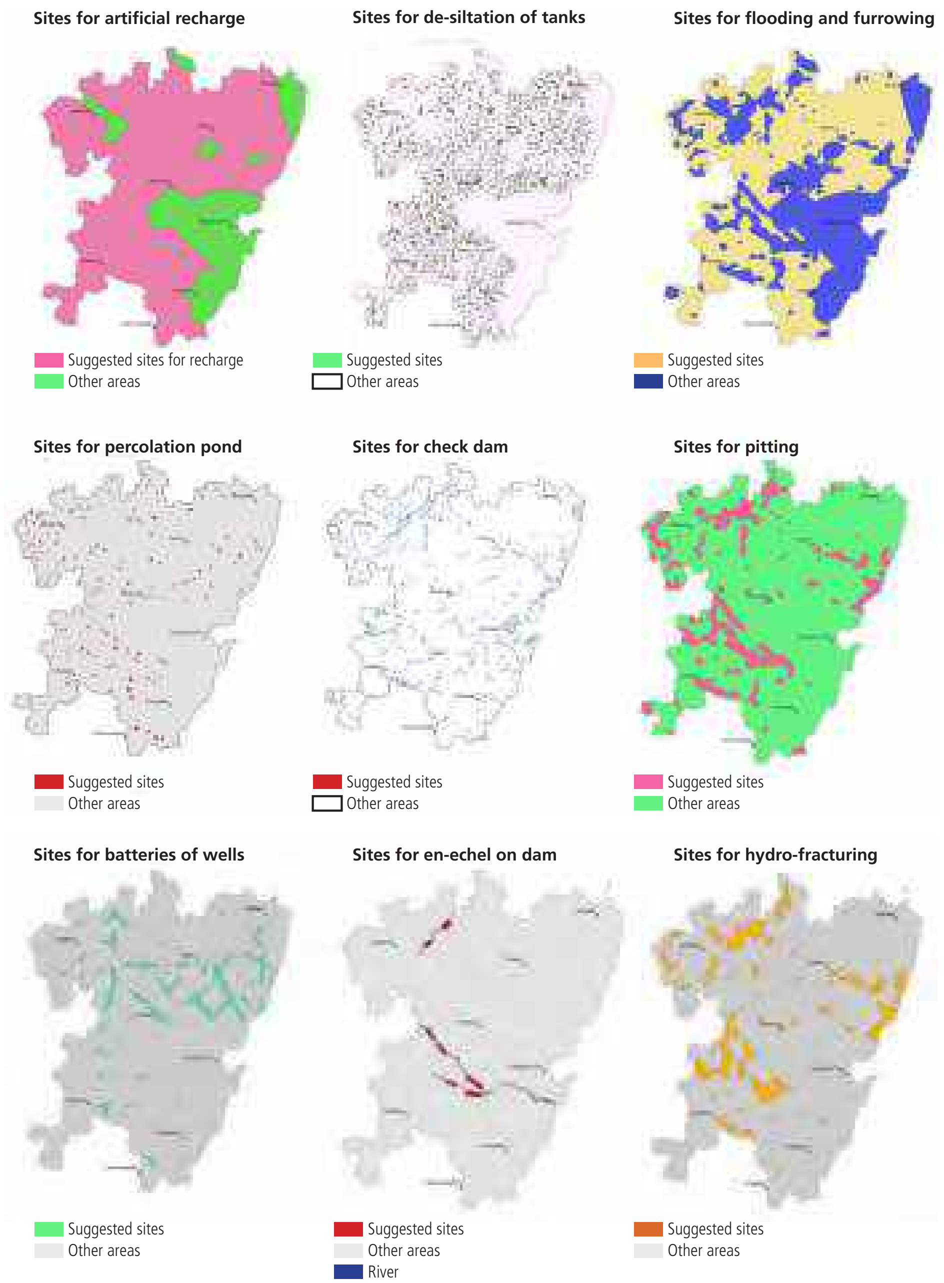
- Sites for de-siltation of tanks: The map of existing tanks was superposed over the map with suitable areas for artificial recharge. Wherever such already available tanks fell in selected zones they have been recommended for de-siltation.
- Sites for flooding and furrowing: Areas with plain slope and low drainage density are best for artificial recharge through flooding and furrowing. To identify such sites, the map showing sites for artificial recharge was overlaid on drainage-density and slope maps. Areas where plain slope and low-drainage density coincided with artificial recharge sites were recommended for artificial recharge through flooding and furrowing.
- Sites for percolation ponds: For percolation ponds, the area must have shallow slopes and micro-drainage catchments. In the first stage, therefore, such zones were buffered out with these terrain conditions. This map was superposed over the priority-area map. Regions where the two areas coincided were recommended for percolation ponds.
- Sites for check dam: The drainage map was analysed for drainage convergence and meeting points, and only drainages satisfying aforementioned conditions were filtered out and a GIS map generated. This map was superposed over the site selected for artificial recharge and the coinciding areas were recommended for check dams.
- Sites for pitting: From the drainage density prepared for the study area, areas with maximum density were identified. These areas were overlaid on the map showing suitable sites for artificial recharge. Regions where areas with maximum drainage density were found within positive areas of recharge were recommended for recharge pits.
- Battery site of wells: From the shape of the lineament density contours, the linearity maxima axes were drawn along the crest of the contours of elliptical shapes with maximum value in the core and successive lesser values encircling them. The GIS map was generated showing these lineament density maxima axes. This map was superposed over the map showing artificial recharge sites. Regions where the lineament density maxima axes fell within the recharge areas sites were recommended for batteries of wells.
- Sites for check dams: From the drainage map, broad and straight drainages were identified in the study area and the GIS map was generated accordingly. The GIS map was superposed over the map showing sites for artificial recharge. Regions where such

broad and straight drainages were found within such selected sites for artificial recharge were recommended for parallel and continuous check-dams.

- Sites for hydro-fracturing: With the positive areas for artificial recharge sites, the zones of coincidence of lineament density maxima and drainage density maxima were recommended for hydro-fracturing.

Results

The study indicates the feasibility and potential of various RWH/SWH techniques that would lead to WEC.



Source: P. Venkata Ramireddy, G.V. Padma and N. Balayerikala Reddy, 2015, A Geospatial Approach—Identification of Groundwater Recharge Zones and Artificial Recharge Structures for Part of Tamil Nadu, India.

Technical Box 2: Feasibility study for identification of artificial recharge zone

1. Applications of remote sensing and GIS for exploration of groundwater potential zones are carried out by a number of researchers around the world, and it was found that the involved factors in determining the groundwater potential zones were different, and hence the results varied accordingly.
2. The identification of artificial recharge sites is interdependent on various parameters such as geomorphology, lithology, lineament density, slope and soil. By using remote sensing technology, thematic data is integrated for evaluation of groundwater potential zones for any area.
3. Primary and secondary data is required to be collected from Survey of India (SOI) topographic data and satellite geological data. Both the data are to be assembled together in the GIS platform. The spatial data can be assembled in digital format.
4. The data sources like satellite and topographic data and other secondary data can be used for generation of various spatial parameters. The specific purposes maps are often referred as 'thematic' maps because they contain information about a single object or theme to make the thematic data easy to understand.
5. Various thematic maps can be prepared by visual interpretation of satellite imagery and SOI top sheet. All the thematic maps are preferred to be prepared at a 1:250,000 or 1:50,000 scale. The following are the maps which are required for the spatial identification of potential recharge areas.
   - *Drainage and drainage density map:* The drainage map to be prepared from the satellite images with inputs from the topographical map. The drainage density map can be prepared in Arc MAP, and can be classified into different classes varying from very low to very high density. The zones of high drainage density will have poor groundwater prospects and gradually the zones of lower and lower drainage density zones will have better groundwater prospects.
   - *Lineament and lineament density map:* In geology, these are usually faults, joints or boundaries between stratigraphic formations. All these linear features can be interpreted from the satellite data. Lineaments are any linear features that can be picked out as lines (appearing as such or evident because of contrasts in terrain or ground cover on either side) in aerial or space imagery.
   - *Geology map:* For most of the cities the geology map can be prepared by using already existing geological data from the geological survey of India map.
   - *Geomorphology map:* Groundwater mainly occurs in the colluvium cover and especially secondary pore spaces created by the jointing, fracturing, fissuring and weakening of rocks. Groundwater potentiality is very promising in alluvial areas photo recognition techniques can be used for preparation of geomorphology map using Landsat satellite data.
   - *Land use/land cover:* The land-use/land-cover study is to identify and map the various types of land-use/land-cover classes in the area by visual interpretation. Classification of land use of the specified area can be done using remotely sensed data. Land use map are prepared from satellite data using the photo recognition elements such as tone, texture, drainage, structural fabric and relief found in the image and comparing it with topographic sheet.
6. Groundwater potential zones thus can be generated through the integration and analysis of various thematic maps and data.

Source: Application of Remote Sensing and GIS for Artificial Recharge Zone in Sivaganga District, Tamil Nadu, India, 2010

Once the data is collected and the second iteration of the efficiency plan is being implemented, it is beneficial to do a self-assessment. Self-assessment is generally carried out by the planning committee/planner/consultant who will be involved in the planning process. It is done to be well-informed about the current situation and predict the future commitment level and feasibility to work on a WEC programme (see *Annexure 3* for a suggestive checklist for self-assessment. This becomes critical especially for implementing efficiency measures to be achieved in the long term and require active stakeholder participation and reflective learning and may require consequential redefining of strategy.

The key questions that a self-assessment would answer are:

- What is the present and estimated demand–supply gap?
- What contextual considerations need to be addressed?
- How are the knowledge, decision making and commitment of the stakeholders involved?

Data analysis

There are several techniques for data analysis. Generally, forecasting the demand gives an estimate of potential water future by providing projections. These projections help determine what intensity of change is needed to ensure a sustainable water future. It helps in visualization and understanding the possible water future with the present course and rate of growth in demand and consumption pattern. These forecasts can be prepared by extrapolating current demands over the next five, 10, 20 and 50 years. Considerations to changing demographic trends might affect the projections.

Technical Box 3: Water demand forecasting

Obtaining projected population for a city to calculate water demand using empirical method: Based on decadal population, future population is projected as per incremental increase method. For higher growth rate this method is considered suitable. It uses the following formula for estimation:

$$P' = P + nX + n\,(n+1)\,Y$$

P' = Projected population; P = Present population
n = No. of decades
X = Average of increment in population between previous decades
Y = Average incremental increase of X
If a city 'ABC' has a population 1,131,548 in the year 2011:

Population projection by incremental increase method			
Year	**Population**	**Increment (A)**	**Incremental increment**
1941	140,227		
1951	203,659	(A1) 63,432	
1961	295,375	(A2) 91,716	(A2 – A1 =) 28,284
1971	442,481	147,106	55,390
1981	649,085	206,604	59,498
1991	764,586	115,501	-91,103
2001	956,107	191,521	76,020
2011	1,131,548	175,441	-16,080
	Average	**141,617**	**18,668**

Prediction for the next five decades is on the basis of formula above and subsequent water demand for domestic and non-domestic purposes is calculated using 135 lpcd as standard for the projected population plus fire demand (for fire demand supply rate would be $\sqrt{P}$ (P is population in thousands)

Estimated population projection for city 'ABC'		
Year	**Population**	**Water demand (MLD)**
2021	1,310,501	176.9
2031	1,526,790	206.1
2041	1,780,415	240.3
2051	2,071,376	279.6
2061	2,399,673	323.9

Source: CSE, 2017.

Additional questions that need to be considered during estimation are as given below: [3]

- Can current water source(s) meet future demand?
- Describe the possible impacts that climate change could have (if known research is available). How could it affect the watershed and hydrology of the region? For example, increased severity of extreme weather events, droughts, floods and storms.
- How will these potential effects impact the current and future population?
- Based on the potential impacts to water supply and built and natural infrastructure, does continued growth make sense?

Technical Box 4: Water auditing

1. Identifying all water sources. Volume of input is determined by metering the source. All sources that are utilized within the system should be added to give the annual water supplied.

<table>
<tr><td rowspan="9">The annual volume input into the water supply system</td><td rowspan="4">Authorized consumption</td><td rowspan="2">Billed authorized consumption of water</td><td>Billed metered consumption (including water exported)</td><td rowspan="2">Revenue water</td></tr>
<tr><td>Billed unmetered consumption</td></tr>
<tr><td rowspan="2">Unbilled authorized consumption</td><td>Unbilled metered consumption</td><td rowspan="7">Volume of non-revenue water</td></tr>
<tr><td>Unbilled unmetered consumption</td></tr>
<tr><td rowspan="5">Water loss</td><td rowspan="2">Apparent losses</td><td>Unauthorized consumptions</td></tr>
<tr><td>Customer metering inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on transmission and distribution mains</td></tr>
<tr><td>Leakage and overflows at storage tanks</td></tr>
<tr><td>Leakage on service connections up to point customer meter</td></tr>
</table>

2. Compile the billing records and calculate volume of revenue water. This constitutes of the billed metered and the billed unmetered consumption.

Revenue water = Billed metered consumption + billed unmetered consumption

3. Calculate authorized consumption which consists of revenue water and unbilled authorized consumption
4. Evaluate water losses

Water loss = System input – authorized consumption

Water losses consist of apparent losses and real losses.

5. Identify apparent losses
   - Apparent losses are those that come out from systemic data handling errors. Apparent losses consist of unauthorized consumptions and user metering inaccuracies.
   - This accounts for the water used but not being paid for and inaccuracies in metering.
6. Understand the real losses for the system.
   For a city/zonal scale, the real losses consist of water through the distribution network, storage or if there is overflow from the storage reservoir/ overhead tanks.
   - Leakage on transmission and distribution mains—these are visible leaks that are reported and can be easily repaired
   - Leakage and overflows at storage tanks
   - Leakage on service connections up to point customer meter

Source: Anon., 2009, Water Conservation Planning Guide for British Columbia's Communities—The POLIS Project on Ecological Governance. British Columbia

Forecasting future demand and its comparison with current available water resources with future plans for water augmentation at any of the scales taken into consideration would help identify gaps.

Review water system profile and proposals of planned water augmentation
Once the existing data system profile is available, it needs to be reviewed along planned or in-process water augmentation projects for a city. The source of funding for sanctioned projects, expected expenses, quantum of expected water augmentation, operations and maintenance requirements etc. are supplementary information that will support preparation of an effective plan or guideline for cities.

Stage 2: Setting goals and objectives
Any WEC plan, programme or initiative guided by policy gets direction from the vision statement. A plan defines the pathway and is the key to achieving the vision.

The vision for a WEC plan could be to achieve sustainable water management in city 'ABC'. To work towards the vision, goals are defined. Any goal is further broken into projects with specific objectives. Any goal should be SMART, the acronym used to guide goal setting. To make sure goals are clear and reachable, each goal should be:[4]

- Specific (simple, sensible, significant)—What exactly is to be achieved?
- Measurable (meaningful, motivating)—Establish clear definitions to help measure the extent to which the goal is reached
- Achievable (agreed, attainable)—What steps can be taken to reach the goal? Outline steps.
- Relevant (reasonable, realistic, resourced, result-based)—Does the goal relate to the vision? How does it help in achieving the vision?
- Time bound—How long will it take to reach the goal?

Vision: Achieve sustainability of water resources for the next 50 years in city 'ABC'

Goals
- Improve water-use efficiency through water distribution network by 20 per cent
- Conservation and maintenance of all 10 lakes in the city
- Monitor and limit groundwater exploitation
- Reuse of treated wastewater

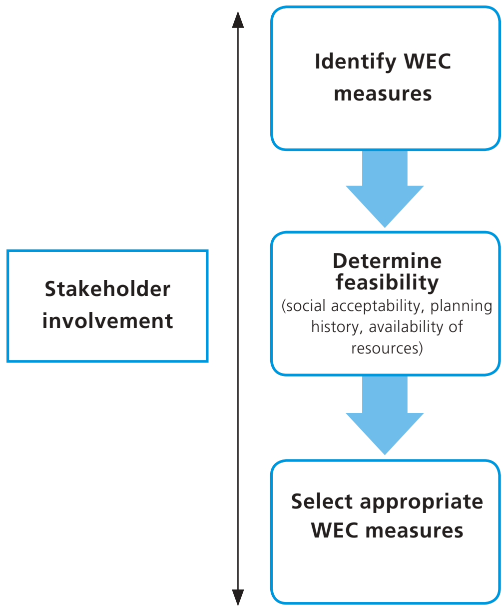
Objectives
- Bulk metering and monitoring
- Consumption-based tariff
- Rejuvenate lake
- Authorization, metering and monitoring of ground water pumping
- Mainstream decentralized wastewater treatment for local reuse of treated water in public parks, horticulture
- Bulk uses of treated wastewater from STP

Stage 3: Designing a plan
A comprehensive integrated WEC planning requires thinking beyond the physical components of the water system and taking into account the broader context of the watershed. Consider the following:

- Are water sources shared beyond the area of interest?
- Are community-based environmental stewardship groups active? What kind of projects are they taking up?
- Does water consumption impact recreational uses?

WEC planning aims to implement efforts towards efficiency and conservation to decrease current demand and stabilize at the minimum threshold (see *Figure 12: Process for designing a plan)*. Planning takes collected data, its analysis, vision statement, set goals and objectives into consideration to identify the best-suited WEC measures for this purpose.

Figure 12: Process for designing a plan



Source: CSE, 2017.

Identifying WEC measures

Water consumption and local conditions vary with scale of consideration (city or smaller), region, social acceptance etc. Hence suitable measures that facilitate WEC will also change as per the local context. In spite of WEC planning being case specific, there are general rules of the thumb that can be considered.

For cities, any water conservation could be achieved when in situ water augmentation is sought, i.e. when efforts are made to create alternative water resources at the site itself. The following measures are suggested for in situ water augmentation depending on the scale of implementation:

Rainwater harvesting—Collect rainwater or runoff for use

RWH systems use the principle of conserving water where it falls. It involves collecting and storing rainwater at surface or in sub-surface aquifer before it loses its quality as surface run-off or is lost by evaporation. Implementation of rainwater/storm-water harvesting (SWH) for either direct usage or to recharge the sub-surface aquifer requires taking measures that maintains the water clean by not allowing polluting activities to take place in the catchment.[5] This decreases the overall reliance of the city on water storage dams and distribution system. In any WEC plan, RWH/SWH measure should be taken to:

- Overcome the inadequacy of surface water to meet our demands
- Maintain water balance of the aquifer or increasing groundwater level

Collected rainwater can be planned for use in various potable or non-potable activities (after prior filtration); water in excess of the collected or unused water could be used to recharge the aquifer.[6] Possible RWH options at various scales:

Individual scale	Rooftop RWH for usage in floor cleaning, car washing, drinking etc.
Neighbourhood scale	Runoff harvesting from paved and unpaved areas for maintaining public parks, fire protection etc.
City/zonal scale	SWH and maintaining quality inflow into the waterbodies, maintenance of rain gardens etc.

Waterbody conservation

Conserving waterbodies helps conserve water for drier periods of the year, protects buffer zones of the catchment that in turn prevents flooding and ensures groundwater recharge. A healthy waterbody directly means an alternative local source of water that might facilitate reduction of load on the conventional water supply system in future. In addition, water bodies play a major role in natural hydrological cycle and offers healty recreational spaces.[7]

The conservation or revival of waterbodies includes several strategies and steps, including:

- Prevention of domestic/industrial sewage into the waterbody. Treated effluent, as per the effluent standard of the State Pollution Control Board, may be allowed to be disposed off into waterbodies.
- Waterbodies in urban areas should be identified and notified in municipal land-use records as municipal assets mentioning their area and particular location.[8]
- The shoreline of the waterbodies should be properly fenced to protect it from encroachment. A well-planned awareness campaign should be conducted in the localities to highlight benefits of waterbodies. If there is any encroachment of the banks, affected people need to be resettled/ relocated after consultation with them.

Reuse of treated wastewater

Reuse of treated wastewater is closely associated with the objective of water conservation. It offers the opportunity to save freshwater.[9] There is a saving in associated financial resources as overall water consumption decreases. In any WEC plan, this would reduce water demand for non-potable purposes. Reuse of treated wastewater facilitates:

- Reduction of household water consumption and increase in resilience to water scarcity.
- Reduction in costs and energy spent for water supply as less is required simultaneously, helps in avoiding untreated wastewater discharge into the environment.[10]
- Decentralized wastewater treatment by natural techniques, thus reducing the city’s expenses on large-scale infrastructure, energy required for treatment.

Possible reuse options at various scales:

Individual scale	Reusing or recycling water in flushing, gardening, washing cars etc.
Neighbourhood scale	Treated wastewater can be used for aesthetic uses such as fountains, washing of streets, fire protection, maintaining landscapes, flushing etc.
City/zonal scale	Bulk reuse of treated wastewater includes supply to horticulture department for maintenance of roadside plantations and institutional landscapes, golf courses, botanical gardens, use in construction, irrigation of parks, gardens and peri-urban agricultural fields, discharging into lakes and waterbodies to replenish water.

Note: Reuse and discharge norms set by SPCB and CPCB at state and national level, respectively should be followed.

Employing water-efficient measures at various scales: Water-efficiency measures reduce the amount of water required to produce a good or service. An efficiency measure is a direct alternative to a new or expanded physical water supply.

Xeriscaping and water-efficient landscaping

Xeriscaping is an innovative, comprehensive approach to landscaping for water conservation and pollution prevention. Xeriscape landscaping combines planning and designing of landscapes that minimises the use of water by selection of suitable plants, practical turf areas, efficient irrigation practices that conserve water.[11]

Some of key points for xeriscaping/water-efficient landscaping are:

- Growing native plants that are adapted to the local climate and rainfall
- Use of mulch around plants and trees to retain moisture; minimizing turf
- Use of drip and other low-flow irrigation devices
- Use of water-efficient systems and fixtures for watering, e.g. drip-irrigation system

Possible reuse options at various scales:

Individual scale	Water-efficient practices for maintenance of personal backyard/frontyard lawns
Neighbourhood scale	Water-efficient practices for maintenance of common spaces such as parks; xeriscape landscaping or use of native species for landscaping
City/zonal scale	Water-efficient irrigation practices for maintenance of public open spaces such as botanical gardens, use of native trees and shrubs for plantations along the roads and open areas etc.

Water-efficient systems, plumbing and fixtures

Water-efficient fixtures can assist in reducing average water use and hence demand on water resources and infrastructure. Installing water-efficient fixtures not only saves water, but can also provide ongoing savings with water bills. Traditionally, water-using plumbing fixtures in a building would include toilets (cisterns and commodes), faucets, shower heads, urinals etc.[12]

- Replace existing single-flush toilets with dual flush toilets.
- Modern taps often have aerators at the tip to help save water and reduce splashes. Without an aerator, water usually flows out of the tap in one big stream. An aerator spreads the water flow into many small droplets.

- Low water-use urinals: In some standard systems, water falls automatically through a continual drip-feeding system or by automated flushing at a set frequency, 24x7, regardless of whether or not the urinal has been used.

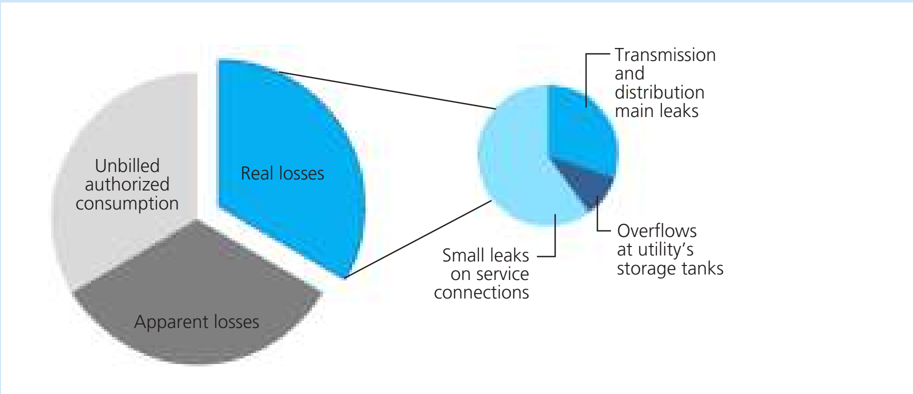
Possible reuse options at various scales:

Individual scale	Install efficient shower heads, faucet aerators in sinks and dual flush toilets
Neighbourhood scale	Water-efficient irrigation system for community parks, use of water-efficient fixtures in community centres and community toilets
City/zonal scale	Use of water-efficient fixtures in public toilets, toilets of public buildings like library, court, etc.

Reducing NRW

The term NRW is used by local bodies to indicate water losses in the distribution network that cause loss of revenue. NRW comprises not only real losses from leakages but also apparent losses (faulty or non-existent billing) and unbilled losses (unauthorized consumption, public purposes like firefighting etc.).

Components of non-revenue water



Source: http://www.wachsws.com/newsroom/4-components-of-a-water-loss-control-programme

Preventing NRW losses and protecting water resources has become increasingly important. It is of great significance for city/zonal scales as the benefits seen are maximum as compared to smaller scales. NRW management facilitates efficient distribution of water by reducing losses and allowing utilities to expand and improve service, enhancing financial performance.

To reduce NRW, the cause and the effect of each non-revenue water component should be examined. These include:

- Unbilled authorized consumption
- Apparent losses
- Real losses

Strategy for dealing with water losses: NRW reduction is a long term continuous process that requires integrated planning, sustained institutional building and deligent process transformation.[13] The two most important components of NRW are real losses and apparent losses. Controlling water losses from these two components requires significant resources in terms of logistics, staffing and finance. The third component, unbilled authorized consumption, can be controlled fairly well without much resource. It is therefore important to develop the appropriate strategies for controlling water losses especially through real and apparent losses. Management of NRW involves:[14]

- Improving estimation/measurement techniques using metering, followed by a regular calibration policy and meter checks.

- Installing bulk metering at the district/city level and metering of all consumers is required to be done.
- Quantifying leakage and apparent losses: This can be done through network audit, which includes leakage studies (reservoirs, transmission mains, distribution network) at the operational as well as at the customer's end.
- Upgrading the network by designing a strategy and action plan.
- These may be later upgraded by introducing 24x7 leakage monitoring through various softwares, sensors etc.
- Regular O&M of the water supply network.

Measures for behavioural change:

- Educate on water-conservation and efficiency measures, such as turning off water while washing hands and dishes.
- Install signs that encourage WEC in public toilets or work areas where water is used.
- Involve stakeholders—seek suggestions of WEC ideas.
- Monitor and meter the water system to determine the largest water consumption areas. Monitoring also can help detect leaks in water systems.

Designing a plan includes WEC criteria, knowledge of various technical solutions, and generic methods for information, evaluation and presentation. All planning is situation-driven and must be carried out in local context. Table 11: *Analysis of challenges and opportunities for WEC planning* gives an example of the comprehensive approach for WEC planning.

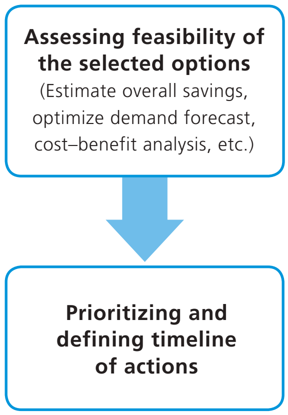
Table 11: Analysis of challenges and opportunities for WEC planning

Challenges	Opportunities
Drivers to initiate WEC • Is water scarcity a recurring problem in the area? • Are there revenue losses by municipality/ increase in tariff for water supply? • Is water shortage affecting water pricing in the area?	Shift from supply-side solutions for water security to demand-side solutions.
Policies and regulation • Are there supporting policies and regulations for developing WEC plan? • Are there any incentives for implementation of WEC?	Cities where regulations and policies concerning WEC have been adopted could be targeted as suitable to undertake such interventions.
Access to technology and finance • Is there enough land available to develop infrastructure, if required? • Are there suitable funders for the initiative? If there are, how can finances be raised for the projects? • Are there suitable technology providers in the area? • Is the project feasible? Does it have social acceptability?	Resource requirement would vary with the choice of WEC measure, which depends on the demand and expected benefits. Therefore, in a city where there is dedicated funding and a plan to implement WEC projects, there is a strong case for a practitioner or utility to take up implementation.
Scale of intervention • What would make a more beneficial case: Operating in a small area or across the entire city? • Is there a possibility of similar small-scale interventions across the city? • Will working at a decentralized level, for instance with resident welfare associations (RWAs) or ward councillors, lessen financial and technical challenges?	Smaller-scale WEC planning and interventions are easy to implement and may showcase direct benefits, including economic benefits in terms of improving system's efficiency, saving water demand, less energy requirements for pumping etc.
Management strategy and institutional framework • Who could be the main stakeholders to support such initiative? • What is the potential to involve private stakeholders on PPP model basis?	City/sites with active community help-groups, RWAs and a responsive private sector offers the scope of realization of goals in a time-bound manner.
Consumer/public perception • How do people in the area relate to the proposed WEC intervention? • Has there been any such intervention in or around the area in the past? How was it perceived? Was it successful?	Scaling-up potential is high in places where some WEC interventions are already implemented and has showcased benefits.

Source: CSE, 2017.

Stage 4: Strategy development
Strategic planning is an integrated, comprehensive approach that emphasizes not only on the technical and economic aspects but also the challenges of institutional capacity and public participation in WEC.[15] A strategic plan identifies and selects an appropriate programme or project for WEC after detailed feasibility analysis wherein it assesses if the proposed measure is technically, financially, socially, legally, environmentally and institutionally feasible by examining different options (see *Figure 13: Steps for strategy development*).

Figure 13: Steps for strategy development



Source: CSE, 2017.

Assessing feasibility of selected options
To assess the feasibility of a proposed measure, the following techniques may be adopted:
- Estimating cost for implementation and probable sources from the existing schemes such as AMRUT, Smart city and SBM.

Technical Box 5: Cost–benefit analysis

Cost–benefit analysis (CBA), or benefit–cost analysis (BCA), is a systematic approach to estimate the strengths and weaknesses of alternatives. It is used to determine options that provide the best approach to achieve benefits while preserving savings.[16] CBA is also defined as a systematic process for calculating and comparing benefits and costs of proposed alternatives. It is done for two reasons:
1. To determine if the project is viable and if it is a good investment
2. To compare one project investment with other competing projects to determine which is more feasible.

Cost estimation of water-efficiency measures at the district/city level:
Example: *Cost calculations for city 'ABC' involve a two-step process with respect to supply of water for the whole district/city:*
- First, the cost of water delivery for the city is calculated. This is the cost to the city of the 'last unit' of water delivered, and is the most expensive unit of water delivered, i.e. through maximum distance.
- Second, the cost to the city of each water conservation measure is found by the reduction in units of water demand. Comparing the avoided costs value with conservation measures' costs per unit of demand reduction allows the assessment of cost-efficiency. For example, if city 'ABC' has a reduced cost value of Rs 10,000 per unit of reduction, any conservation measure

that costs less than Rs 10,000 per unit of water savings is considered cost-efficient. The district will recoup the cost of the measure with its savings from lowered water delivery.

TOTAL COST/TOTAL WATER DELIVERED = AVERAGE COST

For the purposes of this study, the output is a unit of water in the case of a new supply and a unit of water savings in the case of an efficiency measure.

Total cost comprises the cost of all components of the system to be analysed. It includes:

- Capital costs: Capital costs are fixed, one-time expenses needed to bring the project into operation. It includes structures, land, equipment, labour and allowances for unexpected costs or contingencies. They are annualized over the life of a project and divided by the water production capacity.
- Operation and maintenance (O&M): O&M costs are incurred during operation of the device or facility and typically vary with output levels. For projects that are currently in operation, use average annual O&M costs whenever possible. Otherwise, use values available from the most recent year. O&M costs are annualized over the life of the project and divided by the annual water yield.

Annualized capital and variable costs are added together to get an estimate of the cost of water.

Cost estimation of water-efficiency measures at small scale

1. Depending on the selected WEC measure, examine the system for cost estimation.
2. Calculate the cost of conserved water (quantity of water estimated to be saved) after implementation of efficiency measures. Calculate on the incremental cost of purchasing. This cost is annualized over the life of the device and divided by the average annual volume of water conserved, resulting in an estimate of the cost of conserved water.

For example, to estimate water savings and incremental cost under fixture replacement, develop two scenarios:

- Baseline
- Efficient scenario

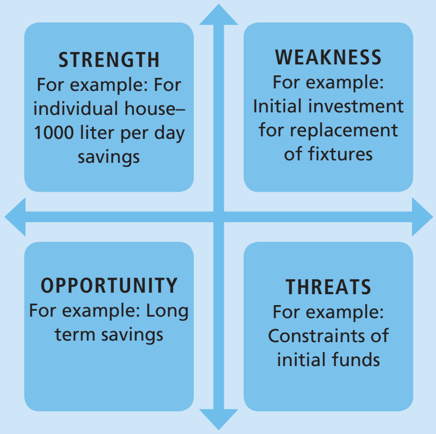
For the baseline scenario, assume the old device is replaced by a new device that uses the same amount of water. For the efficient scenario, assume that the old device is replaced with a new, efficient model. Annual water savings are calculated as the difference in water use between the two models, multiplied by the estimated average frequency of use. The incremental cost is the cost difference between a new efficient and a new inefficient device and is based on price surveys of available mode.

Some efficiency measures have a 'negative' cost. This is because for these measures, the non-water benefits that accrue over the lifetime of the device exceed the cost of the water-efficiency investment. This is especially true for efficiency measures that save energy, but other 'co-benefits' may include savings in labour, fertilizer or pesticide use, and reductions in wastewater treatment costs etc. For example, a high-efficiency clothes washer costs more than a less-efficient model; however, it uses less energy and produces less wastewater than a less-efficient model, thereby reducing household energy and wastewater treatment requirements. Over the estimated 14-year life of the device, the reductions in energy and wastewater bills are more than sufficient to offset the cost of the more efficient model, resulting in a negative cost of conserved water.[17]

Source: CSE, 2017.

- Estimating overall savings gives clarity and helps in prioritization.
- Defining plan of action in terms of short-term, intermediate and long-term goals or use of time lines.

SWOT analysis: Technique for assessing selected WEC measures



SWOT analysis, developed in the 1960s, is a widely used analytical tool to support the preparation of strategic planning. It is mainly used to establish a framework showing the key internal and external factors that should be confronted during the strategic planning process. This framework is the base used by policy decision-makers in the making of a strategy that ensures a good fit between internal and external factors. The most common way to present all the listed factors identified in the SWOT analysis is through the so-called SWOT matrix, forming a milestone of this analytic framework.[18]

SWOT is a cost- and time-efficient means for highlighting key issues relating to the context of a WEC measure or initiative which if not identified and addressed could critically affect the chances of success. It also offers the benefit of framing these issues in a way that is easy for stakeholders to understand and discuss.

SWOT has often been done in the order implied by the name: first examining strengths, then weaknesses, opportunities and finally threats. However, it is recommended instead to first examine opportunities and threats and then proceed to the other ones. This helps keep a stronger focus on results and helps identify which threats are 'critical threats' (i.e. those that are compounded by corresponding weaknesses) and which opportunities are 'promising opportunities' (i.e. those that are matched by corresponding strengths).[19] Prior to the development of a WEC strategic plan, a feasibility analysis and prioritizing different WEC measures is required. From the results obtained during data search, a SWOT matrix is established in order to identify strengths, weaknesses, opportunities and threats in relation to WEC measures. The SWOT matrix is a kind of radiograph of the situation of water resources, its current status and future possibilities. It can draw some conclusions that will point to responses with different strategies. From the SWOT analysis and the results taken from the data analysis about various WEC measures will develop a strategic plan that attempts both to maintain the strengths identified and give response to problems identified, taking into account both the opportunities and current threats that face the management of water resources.

Any WEC measure that is to be assessed using SWOT must have clearly defined objectives that are well understood. Clear objectives are a kind of lens through which the various external and internal factors relevant to the WEC plan can be identified as strengths or weaknesses, opportunities or threats. If the objectives seem to be unclear, they should be clarified and agreed upon before a SWOT is embarked on.[20]

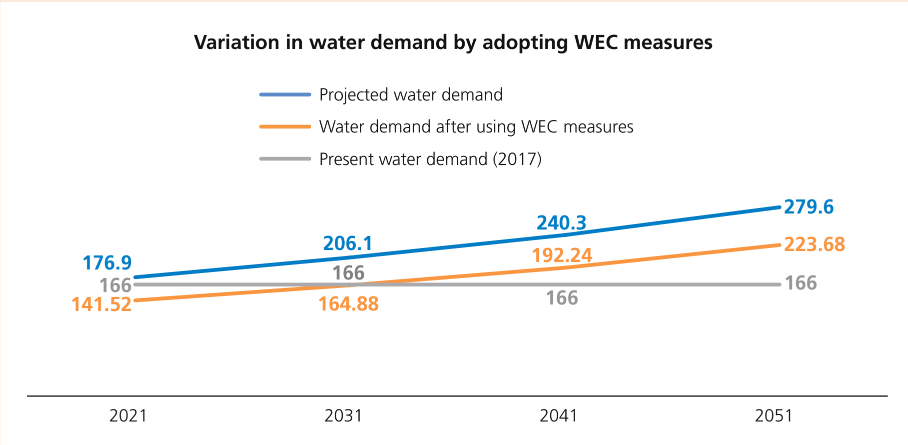
While the plan of action is being finalized, it is best to optimize the demand forecast; this could be supported by a cost–benefit analysis for the stakeholders and decision makers to visualize the impact of the proposal. This is more relevant at a city scale.

Technical Box 6: Optimizing demand forecasting

Estimation for the reduction in the water demand after proposed WEC measures are implemented:
The demand forecast for next five decades is taken as the starting point. Reduction in the water demand can be estimated on the basis of proposed measures cumulatively.

Assumption: Water demand can be reduced by 20 per cent by adopting the proposed WEC measures in city 'ABC'

The trend for the reduction is shown in the graph below:



It is evident that if WEC measures proposed for city 'ABC' are adopted and implemented, water demand up to 2031 can bemet without any change in the present infrastructure. This shows the effectiveness of the proposed WEC measures for the city.

Source: CSE, 2017.

3.2 WEC planning at various scales

WEC plan at the city scale ideally should be implemented under the jurisdiction of the municipality/ULB. The municipality/ULB is capable of offering the most suitable, indigenous tailor-made measures that vary from one city/zone to another in accordance with the enabling environment such as local conditions, budget, political will, stakeholder involvement etc. At the neighbourhood scale for residential areas this will be under the jurisdiction of RWAs/CBOs while for institutions its administration is responsible. At the individual scale, the success of the plan depends on ownership and behaviour of residents (see *Table 12: Application of WEC measures at various scales*).

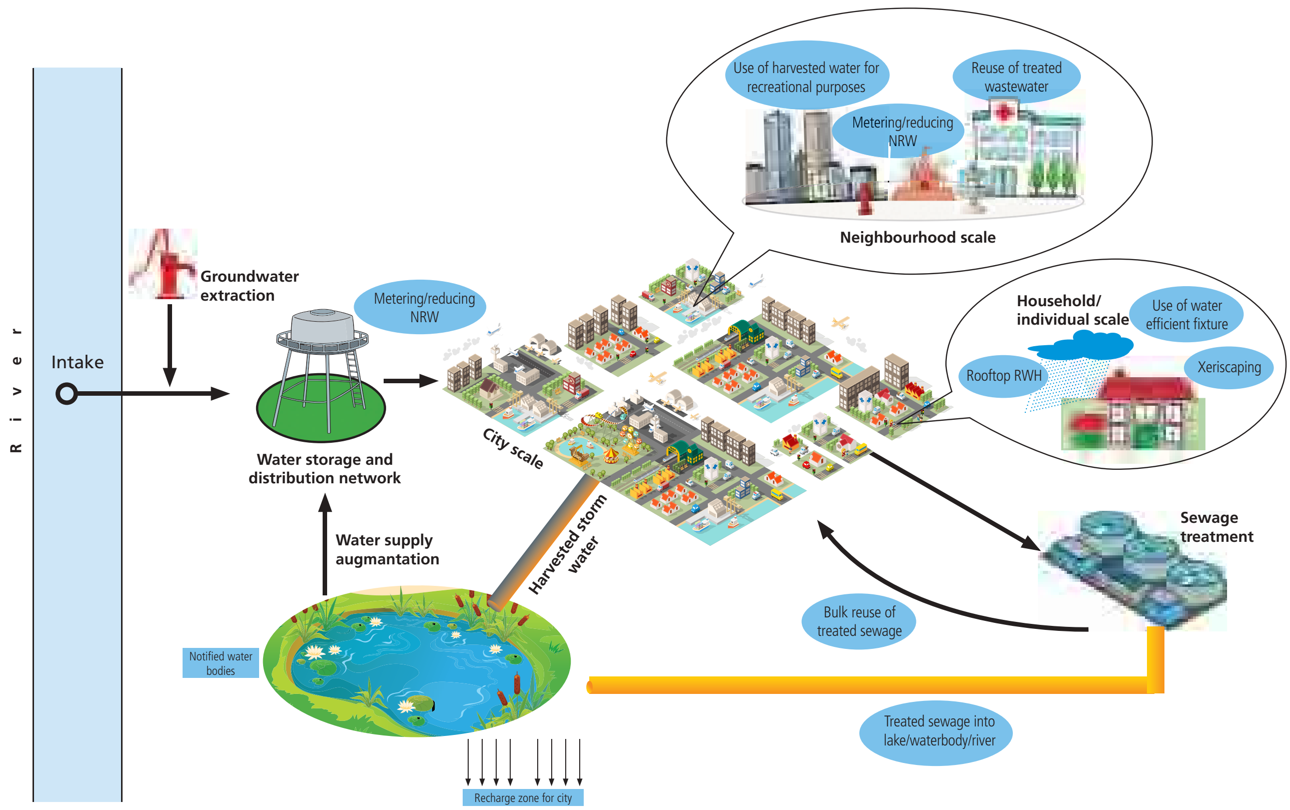
Table 12: Application of WEC measures at various scales

WEC measures	Area / Intervention	Single household	Commercial and industrial development	Neighbourhood and residential development	Recreational areas and open spaces	Public and semi-public utilities
In situ water augmentation	Wastewater reuse	✓	✓	✓	✓	✓
	Conservation of waterbodies			✓		
	Rainwater harvesting	✓	✓	✓	✓	✓
Water efficiency	Water fixtures	✓				✓
	Reducing losses	✓	✓	✓		✓
	Xeriscaping	✓		✓	✓	✓
Behavioural change	Awareness	✓	✓	✓	✓	✓
	Water pricing	✓	✓			
	Social acceptability	✓	✓	✓	✓	✓

Source: CSE, 2017.

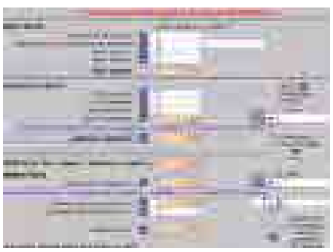
Indicative WEC interventions are illustrated in the *Figure 14: WEC approach at different scales*. *Table 13: Open-source tools for WEC* lists mobile applications and calculators that are available and relevant in Indian context to be used while planning and designing for WEC.

Figure 14: WEC approach at different scales



Source: CSE, 2017.

Table 13: Open-source tools for WEC

Tool	Where to find it	Use	Description
Jal Sanchayan mobile application 	Smartphone-based application—download from Google Play Store as Jal Sanchayan	Tool on water conservation through RWH	A user-friendly android mobile application comprising all components of RWH on a single platform
Captain Plop's Water-Saving Mission 	Smartphone-based application—download from Google Play Store as Captain Plop's Water-Saving Mission	Educational tool—improves awareness	An android-based app by the South Australian Water Corps on the benefits and needs for water conservation to bring about consumer awareness
Water footprint calculator 	Download the tool on the android platform through Google Play Store. Can also be accessed online on web platform by simply searching it on any search engine like google.com, bing.com etc.	To track water consumption	Water footprint calculator allows the user to quantify the amount of water used and thus can be compared with the average water footprint of the country
AWWA (American Water Works Association) water audit software 	• Go to awwa.org • AWWA requires to login/register to obtain this free information. • Search for 'water loss control' • Click on the water audit software link to download the file	Water audit tool	A spreadsheet-based water audit tool

Source: Compiled by CSE.

4. WEC implementation and practices

4.1 Stakeholder analysis

Involving all relevant stakeholders throughout the planning and implementation process is key for a successful WEC plan. Their knowledge of technological, social, economic, political and environmental aspects provides the basis against which proposed solutions must be measured. Also, the goals, problems and remediation strategies generated by stakeholders define what's desirable and achievable.[1]

Relevant stakeholders should be identified early in the planning phase. Early contacts contribute to identification of specific and relevant issues and priorities in the area. Stakeholder involvement is particularly important in WEC planning as interest groups are expected to play an active role in the implementation process and in operation and maintenance.

Involvement of stakeholder serves the dual function of providing a feedback mechanism between water managers and users while also serving as a means to educate users on the value of WEC. Stakeholder processes can also be used as a vehicle to generate public support for plans and ensure that the plans are representative of community values.[2]

Importance of stakeholder participation

- Creates ownership and improves sense of responsibility among actors involved
- Clarity and ownership of responsibility for decisions or actions
- Creates solutions that are most likely to be adopted
- Leads to better, more cost-effective solutions
- Forges stronger working relationships
- Enhances communication and coordination of resources

Stakeholder involvement and determining feasibility
Ideally all beneficiaries and stakeholders in the water sector are involved at this stage, including household residents. Organizations that own, implement, operate, finance, issue permits or control the water services, as well as housing companies are also stakeholders.[3] Participation of the beneficiaries/users in the planning process is crucial as it brings water services closer to the people involved (see *Figure 15: Participation of stakeholders at different levels*).

In the Indian context, Central government endeavours to supplement efforts of states by providing financial and policy support to encourage efficient management of water resources through various schemes and programmes. The Government of India formulates policies, sets standards and provides technical as well as substantial financial assistance to states. Central government funding constitutes about 40 per cent of the total investment in the sector.

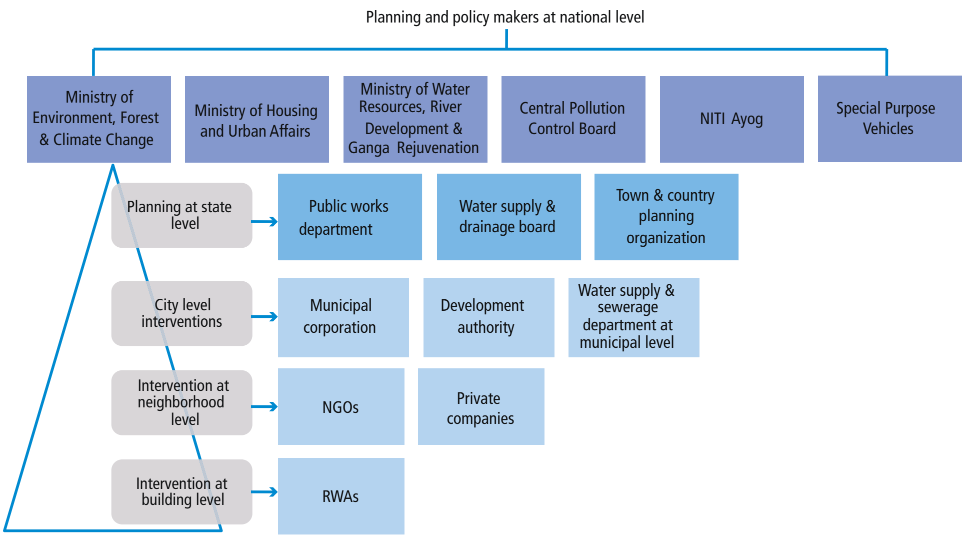
Some key functions of the Central government are to:
- Emphasize reuse of treated wastewater and reduction in groundwater usage in the National Water Policy. This is especially relevant for sectors like agriculture that consume 70–80 of freshwater supplies.
- Expand funding for water source development under schemes such as JNNURM, AMRUT and Smart cities.

- Increase technical assistance grants for capacity building of ULBs to manage public–private partnership projects

State government bodies formulate various policies and plans for implementation of strategies and measures at the state level. It also works under the guidance of the Central government to address the priorities for water efficiency and conservation by providing assistance to ULBs. The role of the state government in the WEC sector is to:

- Create regulatory institutions to oversee management of water resources and pricing of bulk water
- Support ULBs in developing robust water supply and wastewater treatment project structures to attract private investment
- Increase technical assistance grants to ULBs for reducing losses and recycling and groundwater recharge projects.

Figure 15: Participation of stakeholders at different levels



Source: CSE, 2017.

After an internal assessment of the driving forces and issues is completed, it might be determined that convening a stakeholder group is not the best approach to achieve goals. It may make more sense to form a small technical workgroup and proceed with implementation, especially if the project is for smaller scales and involves only a few outside groups.

However, it may be required at the city/zonal scale to have a properly handled stakeholder participation that contributes to consensus and acceptance of proposals. Involvement of organized, representative stakeholder groups facilitates communication, participation and implementation of projects.

After the driving forces have been assessed and internal goals and objectives for the project identified, the following should be reflected on:

1. Is the stakeholder involvement needed?
2. What would be the level of involvement?

This is the time to start outlining a structure for the stakeholder group, possible roles and responsibilities, and decision-making methods.

This is a preliminary framework. Stakeholder participation requires commitment, transparency in process, acknowledgment of alternative views, ideas, time and human resources. When developing a stakeholder involvement framework, the following questions should be answered: [4]

- How will the group be structured, i.e. will it be a fully empowered management entity, an advisory body, a subset of the management committee or an ad hoc group?
- How will decisions be made, i.e. by majority vote, consensus or input received but decisions made by responsible party?
- What is the membership of the group—one representative from each locality or interest group, a cross section of the watershed residents, etc.?
- What are the roles and responsibilities of the stakeholders—outreach, selection of management options, representation of larger constituencies or preparation of reports etc.?

Each stakeholder group is unique. A one-size-fits-all approach will not work. The formation and operation of each stakeholder group will depend on several factors—the driving forces of the effort, goals, geographic scale, time frame needed for decision making, available budget and political climate, all of which must be considered to determine the best way to proceed.

The community is the primary stakeholder group, but other stakeholders with specialized capacities and responsibilities are essential. Including members of the public community during implementing and monitoring can increase the overall success of the plan. Ongoing involvement can help maintain and build support for achieving water-efficiency goals. Additionally, public participation in monitoring provides valuable information on challenges during implementation and factors contributing to success factors.

Some communities may be better organized and resourced than others and can exert influence, which must be balanced by public-sector representatives. The community in an area may not be homogeneous, comprising numerous groups and stakeholders with different perspectives, aspirations and interests. Some problems and solutions may be agreed on, but there may be opposing views and interests as well. There is always a need to select the best possible measure. The municipality, guided by sound development principles and policies and advised by a steering committee representing all key stakeholders, is responsible for final decisions and plans.[5]

Diverse actors with different roles and responsibilities could be involved in the planning and implementation phases of the community and stakeholder participation process:

- *Decision makers*—The decision makers are involved throughout the process, from approving the plan to deciding implementation contracts.
- *Plan preparation and coordinating teams*—Plan preparation is the responsibility of the lead municipal department. The planning team works and coordinates with the task team.
- *The community*—Beneficiaries can contribute to planning and implementing to the extent of their involvement in the communication programme, enabled by effective communication and participatory methods. Local organizations and individuals may also be beneficiaries, if involved in construction, maintenance and service projects that receive funding or contracts and pay for local work.
- *Implementing agencies (including contractors)*

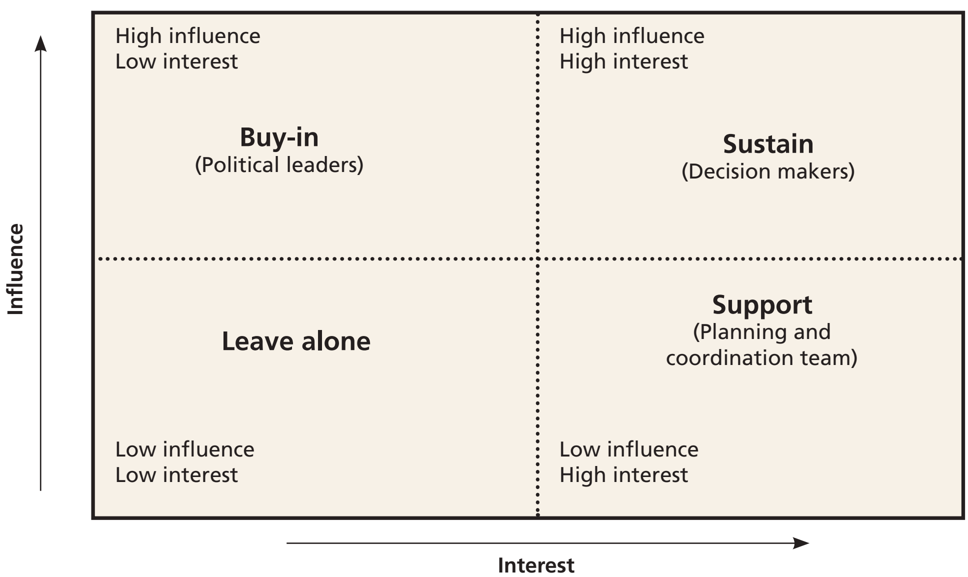
- *Supporting agencies*—A sustainable community unit may include a number of wards, and all ward councillors must participate in the planning process.
- Ward councillors should:[6]
  - Share information with organizations in their wards;
  - Represent the needs of stakeholders;
  - Liaise with other ward councillors and municipal officials regarding development needs and project priorities; and
  - Keep the community informed on development issues, the planning process and outcomes.

Activities to promote community participation as stakeholders[7]

- Conduct regular meetings with the community to keep them informed of the municipality's progress in meeting the water-efficiency goals.
- Provide a forum (e.g. survey, workshops and blog) for participants to supply input on the level of satisfaction or dissatisfaction with the municipality's water-efficiency activities.
- Recruit volunteers (e.g. students and retirees) to assist with monitoring water-efficiency efforts such as conducting public surveys on certain water-efficiency activities. This can be a cost saving for the provider who will not have to invest in staff time for such services.
- Develop programmes and provide materials and training to teachers on the importance of water efficiency and measures that can be taken at the individual level.
- Use social networking (e.g. Facebook) to get community members engaged.
- Recruit volunteers to solicit signatures in support of water efficiency. This would provide volunteers the opportunity to inform the public about water provider's water efficiency activities

Once identified, stakeholders should to be analysed based on the interest and influence chart as shown in *Figure 16: Stakeholder engagement strategy*. Stakeholder analysis includes understanding their profile, interests, position (for or against), and ability to influence a WEC plan. Stakeholders are then engaged through different strategies.[8]

Figure 16: Stakeholder engagement strategy



Source: Suresh Kumar Rohilla, Bhitush Luthra, Amrita Bhatnagar, Mahreen Matto and Uday Bhonde 2017, *Septage Management: A Practitioner's Guide*, Centre for Science and Environment, New Delhi.

Guiding principles for stakeholder engagement[9]

- Build confidence—While interacting with stakeholders, planners must ensure respectful collaboration. Individual partner inputs must be taken seriously and how their contributions are reflected in the outcomes must be made visible. This helps build confidence among stakeholders in the ULB and the project activities.
- Ensure to reach the community—The project must look attractive. The value additions made by the project for the community must be visible. The needs and the intended societal benefits form a strong force in the acceptability of the project.
- Involve stakeholders actively in identifying the problem and developing the solution—This helps bring different perspectives on a challenge and identified the most appropriate solution. It raises stakeholders' understanding of the issue, builds their capacities and makes communication of subsequent action to the public easier.
- Include stakeholders in implementation and success stories—Stakeholder involvement in success stories and follow-up activities after implementation is essential to building trust and ownership of the community over the project.
- Public information, education and communication—Offering maximum awareness and outreach opportunities ensures effective communication and capacity building of the stakeholders.

4.2 Economic and social aspects of WEC

A key challenge in getting consumers, ULBs and practitioners to invest in WEC practices and technologies is the misconception that water efficiency doesn't produce economic benefits since the low cost of water (subsidized) delivered to the tap doesn't translate volume savings into money savings.

If WEC measures are widely accepted and implemented at smaller scales, it would reduce demands and hence associated revenue. This could cause ULBs to raise rates/tariff since traditional rate-making involves three discrete, logical steps[10] (see *Figure 17: Conventional rate-making by water service utilities*).

Step 1: Identify costs and the ULB's revenue requirements

To provide water service to its customers, the ULB must receive sufficient revenue to recover its costs, including operation and maintenance costs, capacity costs (represented either by depreciation allowances or by debt-related costs), customer costs and administrative costs.[11] ULB must get enough revenue to sustain in the long run. Adequate cost recovery is necessary to maintain a financially viable service providers.

Step 2: Allocate costs to types of water usage

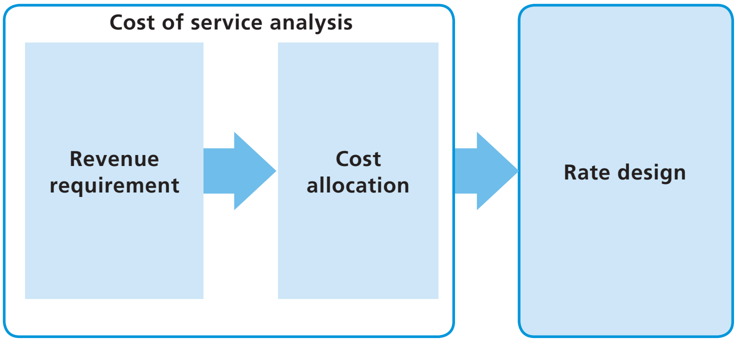
After revenue requirements have been established, costs are allocated among different types of water users and rates are designed to reflect the cost of providing water service. The cost of service rate-making can be stated to cover the rate so that users pay-in water rates for the costs they impose on the utility for its production and delivery. To avoid undue discrimination, rate analysts strive to achieve two forms of equity:

- Horizontal equity: Users with similar costs of service face similar rates.
- Vertical equity: Users with dissimilar costs of service face dissimilar rates.

Step 3: Design rates for each type of water usage to recover costs from customers

- Define goals and objectives of the rate structure
- Evaluate available alternatives in meeting objectives
- Understand and communicate potential effects on customers

Figure 17: Conventional rate-making by water service utilities



Source: AWE 2008, Fundamentals of Water Rate Making.

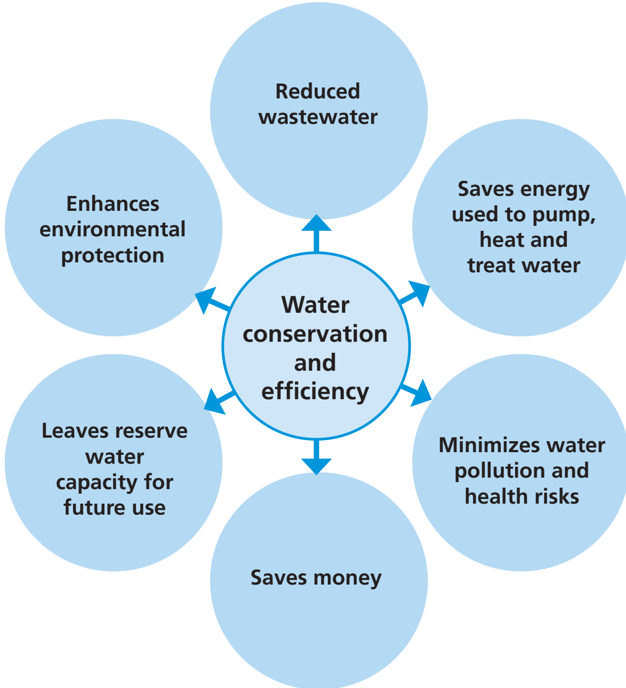
WEC should be seen as a long-term investment and there are several potential economic benefits to invest in WEC if planned accordingly. A study was published in December 2008 that quantitatively examined economic growth impacts of water and energy-efficiency investments, realized benefits specifically in terms of job creation, income, GDP, national output, water savings and other benefits.

Implementation of WEC measures can reduce water and sewer costs by up to 30 per cent. Significant savings in energy, chemical and maintenance expenses are also possible (see *Figure 18: Benefits of WEC*). The typical payback period is three to seven years. Some general benefits of water conservation include:[12]

- **Energy savings:** Less energy is used for pumping and treating water.
- **Financial savings:** Less water will be used as consumers will avoid wasting water. Billing will enable local bodies to generate maximum revenue, particularly if proper metering is operational.
- **Less wastewater:** Reduced water usage will cut sewer service costs. In some areas, wastewater utilities offer financial incentives for reduced wastewater output.
- **Various environmental benefits** include increased water available to local streams and wetlands and their natural inhabitants. Less wastewater leads to less degradation of water reservoirs and less pollution.

Broadly, collecting existing data concerning site conditions, design, implementation and O&M activities comprises the measure heads for costing WEC project implementation. The budget is divided into three major heads on the previous successful projects implemented by CSE (see *Table 14: Budget allocation for implementation of WEC measures*).

Figure 18: Benefits of WEC



Source: CSE, 2017.

Table 14: Budget allocation for implementation of WEC measures

Activity	Activity component	Allocation of budget
Collection of data and design (survey and analysis)	**Site-specific data collection** • Metered data • Meteorological parameters, water profiling and audit • Drainage pattern (natural/artificial): Catchment mapping (for big projects) • Survey: Site plan and catchment area, location, geology/soil, slopes, drainage line and sewage discharge arrangements • Water demand assessment and storage potential planning • Design of the structures	5 per cent
Implementation (civil work/ hardware)	• Type of structure (ready-made, constructed), interconnecting pipes, gutter • Scale of implementation	80 per cent
O&M	• Repairing leaking pipes and tanks/cracks at catchment and tanks • Conducting water quality tests (total dissolved solids, total suspended solids, minerals, pathogens) • Paying salary to operators • Cleaning/removing algae/ water hyacinth/ silt from waterbodies	15 per cent

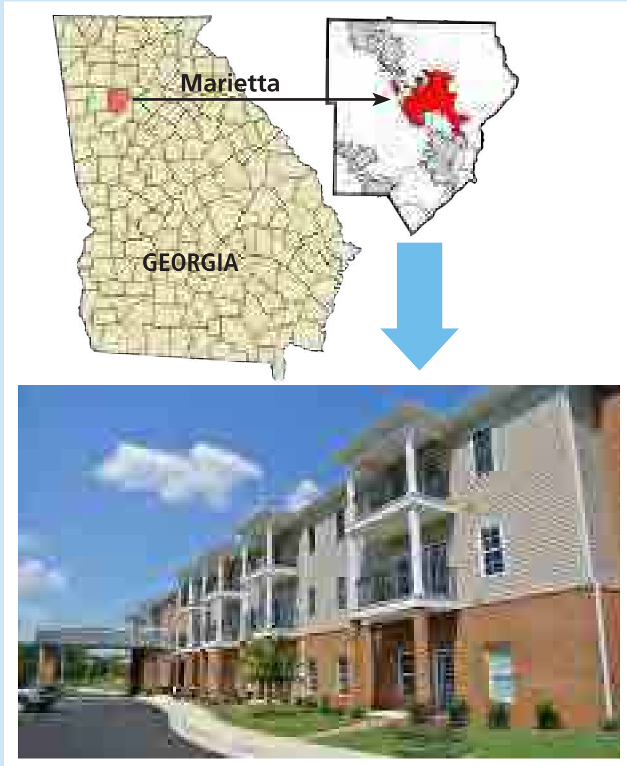
Source: CSE, 2017.

4.3 Case studies

With increasing need to improve water-use efficiency and initiate conserving practices, cities, neighbourhoods and individuals are implementing innovative and affordable practices that focus on an integrated WEC approach. A review of select case studies was undertaken to demonstrate the applicability and feasibility of such best management practices on different scales and local-climatic conditions.

The case studies show how implementation of coordinated WEC measures can be planned or integrated at various scales to bring about water savings. The following section illustrates the WEC approach for integrated water management to achieve environmental, economic and social balance.

CASE STUDY 3: Reducing water consumption by using water-efficient fixtures in a residential neighbourhood in Georgia, United States



Implemented in 2014

Background

Edinborough Apartments, a residential neighbourhood with 128 houses, is situated in Central Cobb County, Marietta, Georgia, USA. Georgia is one of the driest states in USA. Much of its land has been classified as under 'exceptional drought' in recent years. Cobb County is still considered to be at risk for water shortage. As a result, the community in the area are seeking ways to reduce water consumption and lowering overhead expenses associated with their water and sewerage usage.

The Green City Cobb Program was launched in 2014 in an effort to address the water stress and positively impact the area's water consumption. Cobb County Water System, a municipality in Georgia, partnered with Niagara Conservation, a manufacturer of high-efficiency water and energy-conservation products to deliver the Green City Cobb Program. To reduce water use, programme implemented use of water-efficient fixtures in multi-family buildings among owners and residents .

In September 2014, 130 water-saving UHET (ultra-high efficiency toilets) kits from Niagara Conservation were installed (retrofitted) throughout the residential neighbourhood. The three-part kit included a ultra-high-efficiency Stealth toilet, a 1.5-gallon-per-minute (GPM) shower head and a 1.5-GPM aerator for the kitchen and bathroom faucets.

The EPA-certified Stealth uses just 0.8 gallons of water for a powerful, quiet flush. Using 37 per cent less water per flush in comparison to a standard 1.28-gallon high-efficiency toilet, the Stealth forces air down a transfer tube into the trap way that allows for a powerful suction that ensures waste in the toilet bowl is cleared out and enters into the sewer system with every flush.

The high-efficiency, high-powered shower head uses up to 40 per cent less water than other 'low-flow' shower heads. Since faucets can account for nearly 16 per cent of an average household's daily water consumption, the faucets were also retrofitted in kitchens and bathrooms.

Results

Within one month of the programme being in effect, Edinborough Apartments owners reported that the neighbourhood was able to save 192,000 gallons and $1,860 of their water bill in September 2014 as compared to September 2013.

The savings continued for the remainder of the year and beyond. Over the next four months, the savings on the water bills in Edinborough Apartments was $574.67–952.58. Year-over-year comparisons from October 2014 to January 2015 showed a cost reduction of 18–26 per cent with an average monthly savings of $977. Utility bills were dramatically lowered and property value rose.

Units installed	128
Time frame	1 month
Money saved	$1,860
Gallons saved	192 K

Source: A Study of Individual Household Water Consumption, Edinborough Apartments, 2014.

CASE STUDY 4: Reducing water demand by xeriscaping and using efficient water-fixtures at an institutional campus in San Francisco

Implemented in 2001

Background

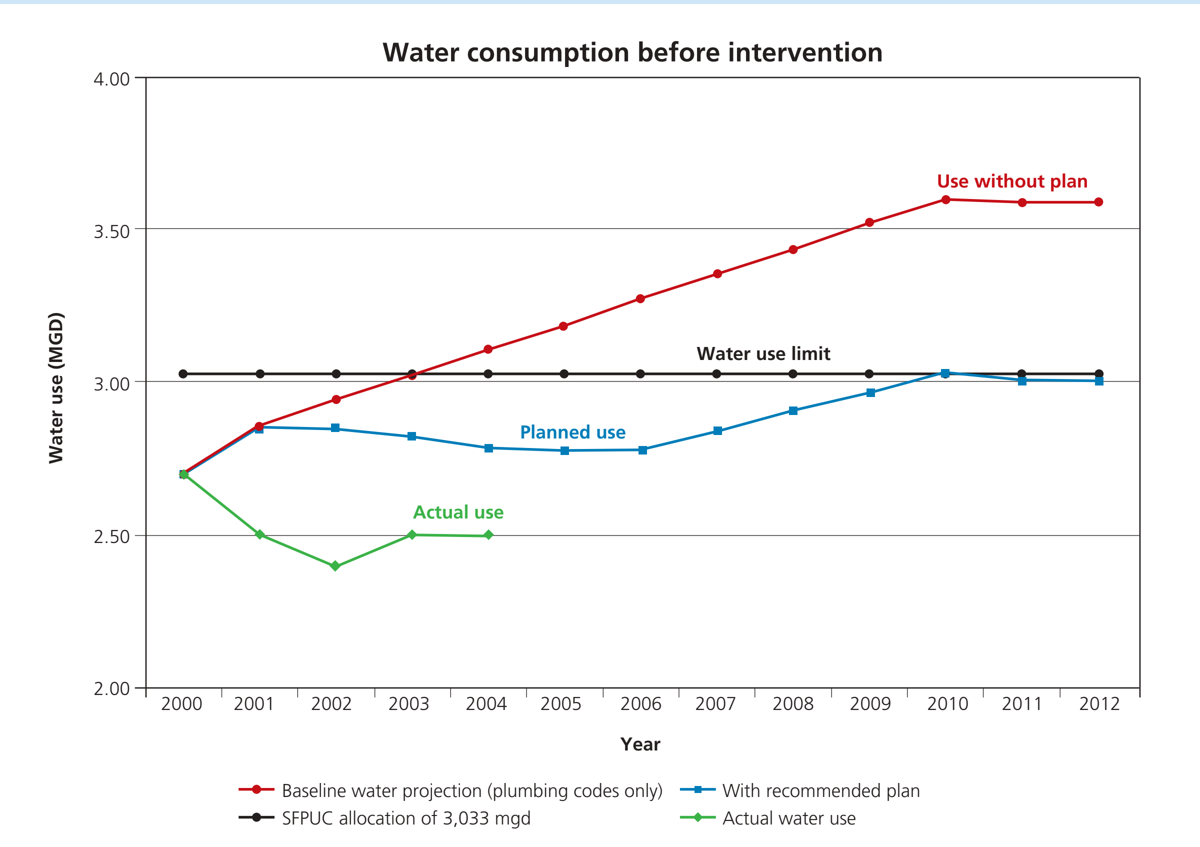
Stanford University's campus, in the San Francisco Bay Area, includes twelve classroom buildings, two dormitories—one for women and one for men—and engineering laboratories. The Facilities Operations Water Shop maintains the domestic water system that provides potable water to the Stanford campus. The Water Shop also operates a non-potable (lake) water system on the campus. The lake water supply is used for irrigation and backup fire protection. The approval of the general use permit (GUP) and the EIR for expansion of 20 per cent had specific requirements, one of which was the completion of a water conservation, reuse, and recycling master plan.

Stanford University developed the water conservation, reuse and recycling master plan in 2001 to identify ways to keep water demand below the San Francisco Public Utilities Commission (SFPUC) allocation of 3.033 million gallons per day (MGD).

Planning

Baseline information was collected for a year in 2000–01, assuming a steady development rate until 2010 on the basis of the collected information. A projection of average daily demand from 2000 (2.7 MGD) to 2010 (3.6 mgd) in 2010 was anticipated and plotted. It was estimated that it would increase from 2.7 MGD in 2000 to 3.6 MGD in 2010.

The following graph shows projected baseline water use from the master plan with and without conservation through 2010 and actual use through 2004:



It was evident that the major consumption was for toilet flushing and landscape irrigation, which accounted for over 30 per cent of the total domestic water used on campus. Therefore, in addition to an evaluation of other end uses, flushing and landscape irrigation were therefore specifically targeted by conservation measures.

Water consumption before intervention

Flushing toilets	280,000 gallons per day (10 per cent of total domestic water use)
Irrigation	22 per cent (largely around faculty and students housing)

On the basis of baseline information and analysis, 14 new conservation measures were recommended. These measures were then evaluated by means of a model to assess the cost effectiveness and potential water savings of each measure. WEC measures were proposed after review.

Planning and implementation of conservation measures and additional water-conservation opportunities were also evaluated. Based on discussions between Stanford staff and Maddaus Water Management, 14 measures were agreed upon for further analysis. The measures, most of which were added in the next four years, are listed in the table below along with additional measures and estimated cumulative water savings.

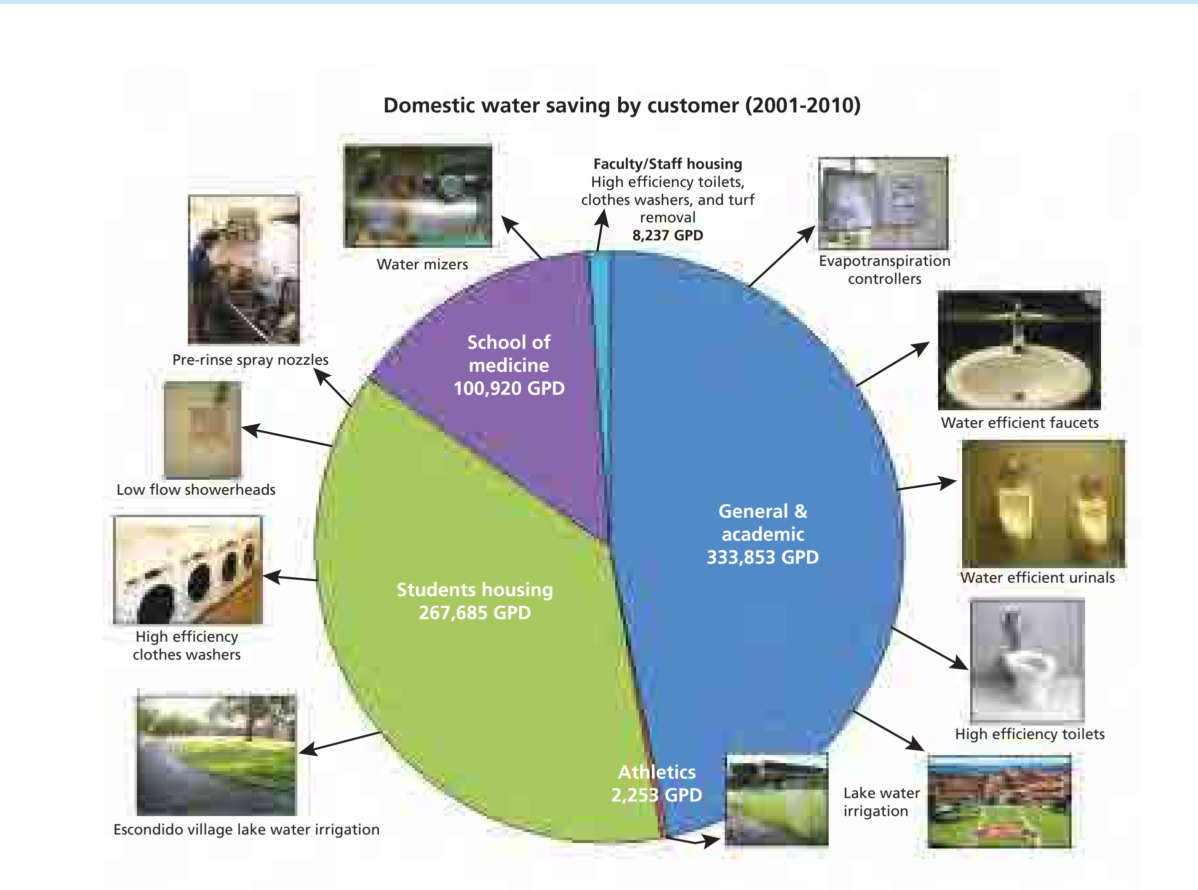
Measure	**Brief description**
Ultra low flush toilet replacement	Replace 90 per cent of in efficient toilets with 1.6 gallon/flush models in all campus facilities.
Shower-head retrofit	Replace 90 per cent of in efficient shower head with low-flow models in all campus facilities.
Urinal replacement	Continue with current urinal replacement plans but hold off on the remaining until 0.5-gallon flush units or valves are on the market and use these to attain a 90 per cent replacement rate.
High-efficiency washer replacement	Replace existing washing machines in student housing with efficient (such as front loading) models. Retain pay-per-use machine types.
Public outreach programmes	Implement a multi-faceted public education programme directed at departments, students, and employees and emphasizing on the need to conserve water, highlight programmes and rebates available.
CEF blow-down reuse	Prepare preliminary engineering and pilot testing of cooling tower and boiler blow water for irrigation, determine best way to integrate this source with the lake system and use it to irrigate new and existing areas.
Faculty/staff housing water audits	Offer indoor/outdoor water audits to not less than 30 per cent of the faculty-staff housing on a repeating five-year cycle. Focus on reduction of irrigation, toilet and washer use.
Landscape water management	Provide water budgets and tracking of performance on a monthly basis for large irrigated sites, conduct large turf audits periodically.
Selective landscape retrofit	Retrofit of turf areas known or shown to be inefficient with low water-use plant landscapes where feasible and cost-effective.
New water-efficient landscape	Amend and require use of Stanford's Landscape Design Guidelines to ensure predominant use of water-efficient plant types, develop and adhere to water budgets, conduct water efficiency reviews of plans.
New landscape on lake water	Put all new landscapes on the lake water system.
ET controllers for new faculty staff housing	Instal evapo-transpiration (ET) controllers on all irrigated landscaped areas associated with new faculty/staff housing units.
Selected academic areas on lake water	Switch irrigation of five specifically identified landscapes from the domestic to lake system.
Football practice field on lake water	Extend the lake system to irrigate the football practice field.

Measure	Brief Description
Once-through cooling retrofits	Retrofit existing once-through domestic water cooling for research and building equipment with recirculating chilled water cooling systems. Require all equipment and building systems use recirculating chilled water for cooling. Track water use before and after retrofits.
Spray rinse nozzles for kitchens	Retrofit kitchen sink spray nozzles with water efficient models. Project sponsored by Santa Clara Valley water district. Track water use before and after retrofits.
Water mizers for autoclaves	Retrofit existing constant domestic cold water quench for autoclave hot water discharges with water mizers that only turn on cold water when solenoid valve detects heat. Track water use before and after retrofits.
Scrubber water reuse	Reuse neutralization system water for scrubbers in and academic building. Track water use before and after retrofits.
Decorative fountains	Investigate water use by fountains, survey all fountains for water use, leaks maintenance type, and recommend retrofits. Retrofits will include meters, periodic leak detection, and where appropriate, chlorinators and wind gauges.

Results

The success of Stanford's Water Conservation and Efficiency Program is demonstrated by decreased domestic water use from 2.7 mgd in 2001 to 2.1 mgd in June 2014, despite more than 2.5 million square feet of new campus added.

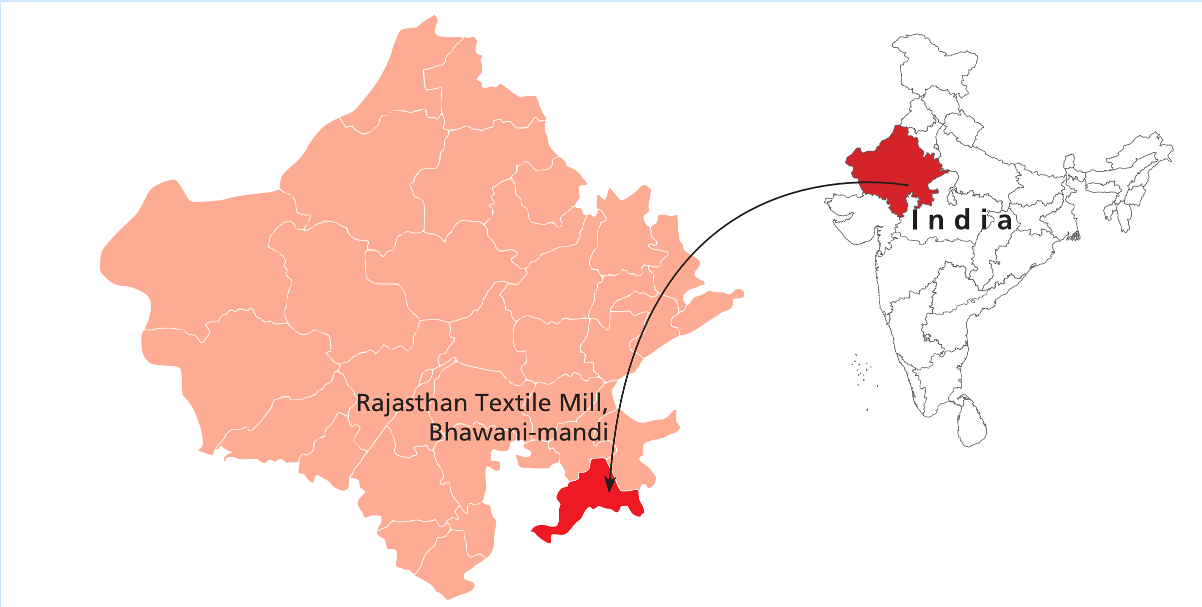
If the current cost of conservation savings is amortized over 15 years at 3 per cent discount rate, the equivalent annual cost is $126,200 per year. The programme's estimated savings is 0.26 mgd or 95 million gallons (MG) per year. This results in a unit cost of water saved of $1,329/MG.



Source: Stanford University water efficiency program fact sheet, 2014 [can be accessed from-http://lbre.stanford.edu/sem/Environmental_WaterEfficiency]

CASE STUDY 5: Water-efficient landscape design for Rajasthan Textile Mill, Bhawani-mandi, Rajasthan, India

Implemented in 2016



Background

Rajasthan Textile Mill in Bhawani-mandi is a landscape project where the role of landscape is greater than just aesthetics. The warm and temperate climate posed the challenge to design an aesthetic and functional green for the factory that would also be easy to maintain. The area to be designed was approx. 0.80 hectare of front area of the site.

Water-efficient landscape design at the site serves aesthetic needs as well as creates a salubrious micro climate. Green mounds were designed over the base of grit bound by a pathway. One irrigation point in centre of the point watered the mound; the size of the mound was decided accordingly. The area with grit was planted with large *Mimosopselengi* and *Plumeria* trees. The landscape is maintained by the treated water from STP generated from the factory.

For the peripheral areas, trees like *Alstoni* and *Bombax* were planted along with ficus and bougainvilleas. These plants are hardy (they can survive in low temperatures) and low maintenance. Drip irrigation system was used along the boundary plantation.

Result

Site view during construction

Hardy plants along the periphery

Site view of the landscape post construction

The total area of the site to be landscaped was approximately 1.7 ha, which included the peripheral green as well as the front green of approximately 1 hectare.

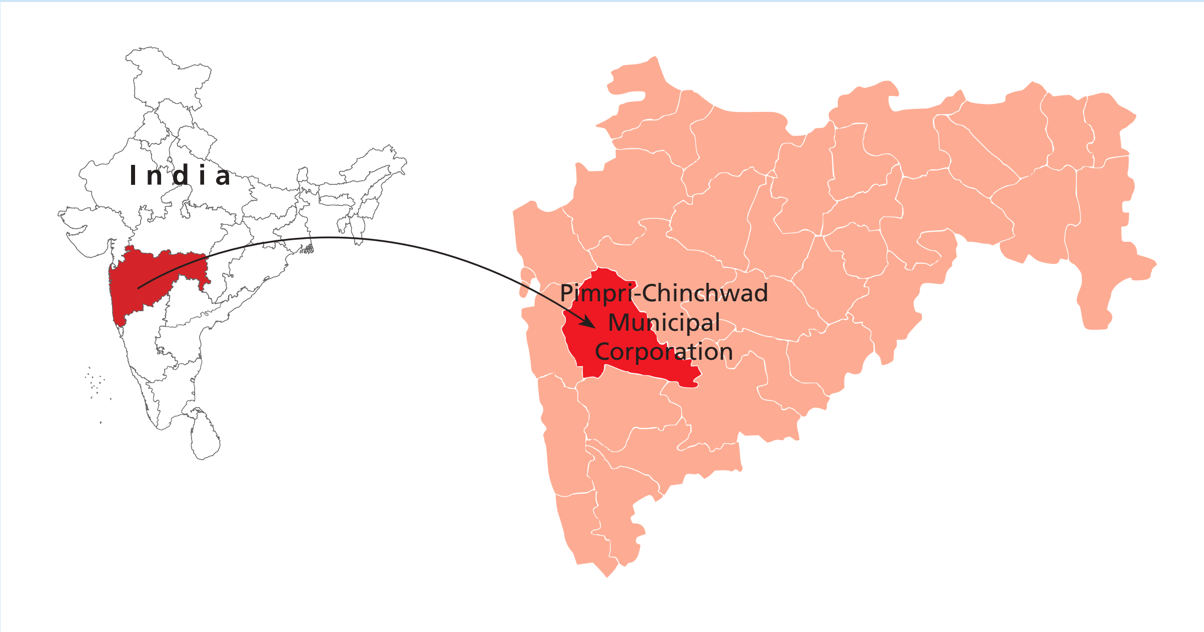
Going by the rule of the thumb, around 1.89 lakh litres of water per day for irrigation in summers. To make the design water-efficient, grit was introduced and hardy trees and shrubs planted. The grit area planned was around 1.4 ha, which saved approximately 0.54 lakh litres of water per day during peak season. The hardscape area of 0.1 ha saved another 0.12 lakh litres of water per day.

The shrub area of another 1.4 ha used half of the water required by grass.

Source: Compiled by CSE 2017

CASE STUDY 6: Reducing NRW for 24x7 water supply at Pimpri-Chinchwad City, Maharashtra, India

Implemented in 2015



Background

Pimpri-Chinchwad, a city in the Pune metropolitan region of the state of Maharashtra, covers an area of 177 sq. km and has a population of approximately 1.6 million. The existing water supply to the city is managed by Pimpri-Chinchwad Municipal Corporation (PCMC). Pawana Dam, 35 km from the city, is the main source of the city water supply system. PCMC plans to convert the existing intermittent water supply to continuous pressurized 24x7 water supply for the whole city.

The service-level benchmark for NRW is only 20 per cent but the NRW in Indian cities is more and there is considerable scope for its reduction in almost all the cities of the country.

The water supplied to Pimpri-Chinchwad is 370 MLD at rate of 170 lpcd. The total number of water connections is 117,936. The water supply infrastructure was strengthened following the conceptualization of 24x7 water supply project in two phases as follows:

Phase I: PCMC proposed to convert the intermittent water supply to continuous (24x7) water supply for the 40 per cent area covering 8 lakh people.

Phase II: A project under water supply for 100 per cent coverage and reduction of NRW under Central Government's AMRUT Mission.

Components included in the 24x7 water supply project (40 per cent area) for achieving NRW reduction:

- **Water balance:** Components of water balance, such as authorized billed meter consumption, authorized billed unmetered consumption, unauthorized consumption due to thefts, metering inaccuracies, leakage in transmission mains, distribution house service connection, were computed and a water audit carried out.
- **Water loss:** Leakage areas were identified by conducting step tests and data gathered from the data loggers. The exact location of leak spots was fixed using leakage identification instruments such as injection of helium gas, sounding rods and noise correlator.
- **NRW reduction:** Measures are to be taken up to bring NRW within the accepted limit. The exact location of leakage will be detected and then fixed by using leakage identification instruments such as injection of helium gas, sounding rods and noise correlator.

The following shows the process followed to reduce NRW in Pimpri-Chinchwad:

Strengthening the water supply infrastructure	• Construction of water treatment plant phase IV • Strengthening the water supply distribution network • Construction of elevated service reservoirs (ESRs)
Technical interventions	• Metering of all connection • Detailed GIS mapping of water zones • Implementation of supervisory control and data acquisition (SCADA) system, centralized monitoring and control system to save on operation and maintenance of water works and network and to optimize for energy saving
Administrative reforms	• Restructuring the water wards/zones • 24x7 dedicated water supply helpline
Public awareness	• Public awareness on water supply through effective communication strategy

Results

- Operational zones are demarcated with respect to ESR capacity and serviceability. District metering areas (DMAs) are set up for each zone. Analysis of water flow and pressure in these areas has enabled leakage specialists to identify leakages and calculate the level of leaks in a particular DMA.
- The entire transmission and distribution network can be mapped by using a GIS mapping tool which will facilitate replacement of a few kilometres of pipeline out of total area selected. NRW will consequently be brought down after pipelines are replaced, reducing the leakage losses.

Source: Urban Water Supply and Sanitation in Indian cities, Pearl, 2014

CASE STUDY 7: Water efficiency and conservation for sustainable water management at Rainbow Drive, Bengaluru, India

Year of implementation: 2012

Background

Rainbow Drive, in southeast Bengaluru, has 430 plots covering 14.5 hectares. The sloped land posed a challenge for the residents because of excessive flooding during the monsoon. Also, lack of connectivity to the municipal water supply meant that the residents depended on groundwater from bore wells for their daily consumption.

As a result of the scarcity and flooding, residents opted to conserve, reuse and recycle water through RWH, recharge wells and a phytorid sewage treatment plant. This was done by creating a layout association that worked collaboratively.

RWH: The storm water is diverted to 360 recharge wells created all over the residential campus. The pits of the recharge wells are circular, with a diameter of 3 feet and a depth of 20 feet.

Land area	14.56 ha
RWH potential	154KL ~56ML per annum
Design for RWH	360 recharge wells, 20-feet deep and 3 feet in diameter on average

Phytorid-based sewage treatment plant: The sewage generated inside the residential campus from 430 plots is treated through a natural system based on phytorid technology. The phytorid system is a subsurface flow type in which wastewater is applied to the cell/system filled with porous media such as crushed bricks, gravel and stones.

The hydraulics is maintained in such a manner that wastewater does not rise to the surface retaining a free board at the top of the filled media.

The system comprises three zones:

(i) Inlet zone composed of crushed bricks and stones of different sizes

(ii) Treatment zone consists of same media as the inlet zone with plant species

(iii) Outlet zone where treated water is collected

Other measures taken:

- Blocking the digging of private bore wells
- Data collection to discover consumption and supply patterns
- Banning groundwater use for construction
- Implementing RWH at household and community levels
- Water supply through community bore wells only
- New water pricing scheme
- Use of treated sewage for horticulture purposes

Results:

- The residential area doesn't have the frequent flooding issues it did and implementing the WEC approach successfully showcased sustainable storm-water management and creation of alternative water resource for lower-quality usage.
- Reduction on treated effluent for total suspended solids (TSS) was 70–80 per cent, BOD 78–84 per cent, nitrogen 70–75 per cent, phosphorus 52–64 per cent and fecal coliform 90–97 per cent.
- The treated effluent is useful for horticulture.

Source: Rainbow Drive Layout's Efforts towards Water Sustainability – Citizens at the Centre of Integrated Urban Water Management by Biome Environmental Solutions Private Limited, 2012.

CASE STUDY 8: Water audit for water efficiency and conservation at the Centre for Science and Environment, New Delhi, India

Implemented in 2005

Background

Centre for Science and Environment (CSE), covering an area of 1000 sq. m, is a public interest research and advocacy organization in Tughalakabad Institutional Area in southeast Delhi. The only source of water supply is groundwater, most of which is extracted through a private bore well outside the building; the rest is provided by the Delhi Jal Board supply line fed by another bore well a few metres from the building. There is no municipal water supply in the entire institutional area that includes institutional complexes, an unauthorized colony and some defence installations. Groundwater is the only primary source for the entire area. Consequently, it is highly exploited, leading to a rapidly falling groundwater table. There is thus a need to take up water conservation and efficiency measures at the building scale. This case study focuses on the water efficiency potential and conservation techniques in the CSE building.

A total of 6,608 litres water is required per day at CSE, of which 470 litres is consumed for potable uses (drinking and cooking) while 6,138 litres is used for non-potable purposes (cleaning, flushing, gardening, cooling etc.). As all the water requirements are met through groundwater extraction, some measures have been taken for recharging groundwater and potentials have been identified which, if adopted, could prove to be effective in WEC at the building scale.

The following WEC measures are taken at the site:

In situ water augmentation

- Water conservation through RWH: The site receives 755 mm of annual rainfall (average annual rainfall recorded for Delhi). The RWH potential for the site is about 377,500 litres per annum and all the harvested water is recharged into the ground. The system recharges groundwater through 45-m deep abandoned bore wells, 9.1-m deep soak ways, raised storm-water drainage and recharge troughs.
- Recycling wastewater: A wastewater treatment system treats 8,000 litres of wastewater per day. Its components are a settler, baffled reactor, planted filter and vortex. All the treated water is used for horticulture and recharge at the Anil Agarwal Green College (AAGC) building.

Potential for water-efficient measures

- Water use can be reduced by around 30–40 per cent and 870 litres can be saved per day by replacing single-flush cisterns with dual-flush cisterns in both the men's and women's toilets: Dual-flush WCs operate on a split button with the option of using either one. Usually the smaller button operates the shorter flush of 3 litres, which is adequate for flushing liquid waste, while the larger button is for 6 litres flush for substantial waste.
- The urinals in the men's toilets, using about 5 litres of water per flush, can be replaced with water-efficient urinals that use 2.8 litres per flush.

- Flow fixtures can be installed on taps on the terraces, which are used to water plants with on all floors (except the fifth) to slower the flow rate by about 30–50 per cent. Other technology is aerators which can be installed to cut water usage of faucets by as much as 40 per cent from 15 litres per minute to 9.4 litres per minute.
- A water meter on the bore well and the motor drawing water from the DJB line can be installed to measure daily withdrawal which would ensure records of the supply balance from the bore well or DJB pipe to the storage tank and overhead tanks thereafter.

Results

- Groundwater is the main water source. Water is pumped out of deep wells and distributed to the various points of water utilization.
- A significant amount of water use can be reduced by adopting water-efficient strategies.
- Groundwater needs to be recharged where it is the only source of supply. For this, harvested rainwater and treated water can be efficiently used in recharging groundwater.

Source: CSE, 2017.

CASE STUDY 9: Water efficiency and conservation potential at San Francisco Public Utilities Commission Headquarters, United States

Implemented in 2012

San Francisco Public Utilities Commission Headquarters

Background

The San Francisco Public Utilities Commission (SFPUC) completed construction of its new, 277,500 square-foot headquarters at 525 Golden Gate Avenue in San Francisco's Civic Center District with the LEED Platinum certification. The building houses approximately 950 employees, contains two non-potable water systems—a sewage treatment system (ecological—mimics nature and uses plants) and a rainwater harvesting system.

From the beginning of the planning stage for the building, SFPUC's goal was to have a headquarters that demonstrated the agency's ambitious sustainability goals and served as an example for building smart, efficient, and sustainable buildings. As a water, wastewater, and power utility, the SFPUC recognized an opportunity to demonstrate its commitment to sustainable and innovative practices in water treatment and reuse by installing low-energy, high-profile non-potable water systems at its headquarters.

The sewage treatment system, treats all of the building's wastewater, up to 5,000 gallons per day, and then distributes the treated water for toilet flushing. The system utilizes a series of diverse ecologically engineered wetlands, located in the sidewalks surrounding the headquarters and in the building lobby, to treat the wastewater. This unique treatment process blends function and aesthetics – the wastewater is treated to San Francisco Department of Public Health (SFDPH) reuse standards while providing a high-profile pilot project for on-site water reuse.

The building also has a 25,000-gallon cistern to capture rainwater from the building's roof and children daycare centre's play area. The water is treated and distributed to nine irrigation zones around the building where it is used for subsurface irrigation for non-living machine plantings and street trees. Because of water-efficient landscaping, the rainwater cistern provides more than enough non-potable water to meet all of the building's annual irrigation demands.

Results

The RWH system allows the SFPUC headquarters to fulfil the requirements for potable water by providing an annual potable offset of approximately 8,000 gallons.

The sewage treatment system reduces the building's potable water consumption by approximately 65 per cent and provides an annual potable offset of approximately 1,500,000 gallons.

Source: http://sfpublicworks.org/sites/default/files/525%20Golden%20Gate%20Fact%20Sheet.pdf, last accessed on 11 August, 2017

CASE STUDY 10: Rainwater harvesting in Goa University, Taleigao, Goa, India

Implemented in 2007 and 2008

Background

The campus of Goa University, on the outskirts of Panaji (the capital city of Goa), covers nearly 173 ha on the Taleigao Plateau overlooking the Zuari River that joins the Arabian Sea. The region receives very high rainfall—around 250 cm per annum in the coastal belt and 400 cm per annum in the vegetated regions. The average rainfall of Goa is approximately 320 cm per annum. The university caters to water supply for 1,500 both resident and non-resident staff as well as students. The estimated demand for water supply is 0.45 million litres per day to meet water requirements of the administrative blocks, teaching blocks, hostels, residential quarters and landscaping. Keeping in view the vast potential of harvesting rainwater on the campus, the university has installed an RWH system on campus. The existing rainwater system has two main structures—one main structure for harvesting surface runoff constructed in 2007 with a catchment of 1.5 ha, mainly unpaved area and, two, a rooftop harvesting system constructed in 2008 for harvesting the runoff mainly from the built-up area on campus.

Parameters	Details of RWH system
Total catchment area	173 ha
RWH structures (two)	Recharge trench in natural depression/pond Recharge bore well for rooftop water harvesting

Site 1: Surface runoff harvesting
The total catchment area contributing to runoff for the surface runoff RWH structure is 1.5 hectare to the natural depression—a pond (see picture below of surface runoff catchment of RWH structure).

Surface runoff catchment area of the RWH structure

Plan showing the roof water harvesting catchment and structure

Site 2: Roof-water harvesting
The roof areas of about 400 m^2 form the catchment for the RWH structure at this site. The rooftop runoff storage tank has capacity of 1,00,000 litres. The rooftop runoff passes through a sand and coal filter. After filtration the water is taken to the nearby recharge bore well feeding aquifer at 100 mbgl depth.

Results

- The site received a record recharge in the year 2010 due to heavy rainfall of 3.7 m.
- The total groundwater recharge from both the structures is up to 39 million litres. About 38 million litres is from at site 1 and the rest is from rooftops.
- Water bills were subsequently reduced by conserving rainwater. The capital cost incurred for RWH system involving surface water and rooftop harvesting has been recovered within five years and six years from implementation respectively through reduction in the bills.
- Various stakeholders (NGOs, government officers, schoolchildren and citizens), industry representatives and researchers regularly visit the site, leading to awareness, information dissemination and knowledge of groundwater conservation methods.

Source: Suresh Kumar Rohilla, Nidhi Pasi, Mahreen Matto and Shivali Jainer, 2014, *Urban Rainwater Harvesting–Case studies from Different Agro-climatic Regions*, CSE, New Delhi.

5. The way forward

This practitioner's guide is intended to provide an opportunity for ULB officials to perceive water-use efficiency and conservation in an integrated manner so as to reap multiple benefits from sustainable urban-water management. Well-defined WEC strategies such as in situ water augmentation, improving water-use efficiency and behavioural changes backed up by a well-defined planning approach will bring multiple benefits such as reduced water pollution and health risk, recreational opportunities, amenities and biodiversity.

The approach of the guide is to create an environment where water-use efficiency and conservation are an integral part of the urban water-cycle. The aim is to help cities transition from water-meagre to water-secure cities.

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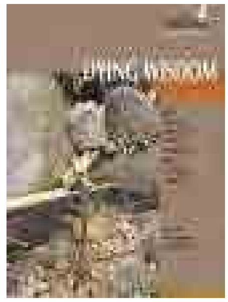
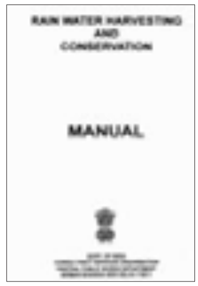
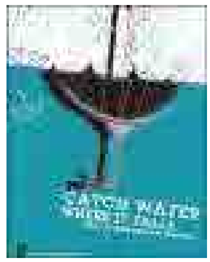
Annexures

Annexure 1: National reference documents for implementation of various WEC measures

WEC measure	Title of publication	Year of publication	Highlights	Photo
In situ water augmentation	*Dying Wisdom – The Rise, Fall and Potential of India's Traditional Water Harvesting Systems, CSE*	1997	A comprehensive overview of India's millennia-old tradition of water harvesting. The book documents the extraordinary wealth and ingenuity of its people living across different ecological systems to manage water. The systems range from ways of harvesting glacier water in the cold deserts to delivering water with precision over long distances through bamboo drip irrigation systems in the northeastern hills of India.	
In situ water augmentation	*Rainwater Harvesting and Conservation Manual by CPWD*	2002	A compilation of important guidelines of RWH that facilitates optimum utilization of rainwater.	
In situ water augmentation	*CPHEEO manual on operations maintenance of water supply systems, MoHUA*	2005	Guidance for operation and maintenance of water supply systems to managers and key personnel, including grass-root level operators and technicians. The manual consists of sections on water audits and checks on water loss.	
In situ water augmentation	*Manual on Artificial Recharge of Ground Water, CGWB*	2007	Talks about various aspects of artificial recharge schemes, artificial recharge techniques and design of structures, monitoring augmented water levels and water quality, and economic evaluation of recharge projects and issues related to operations and maintenance. Rooftop RWH techniques that are particularly suited for urban areas have also been included.	
In situ water augmentation	*Waternama – Traditional water conservation structures of Karnataka – Traditional BMPs on RWH conservation*	2007	A compilation of traditional water conservation structures with case examples. This publication is an effort to improve and spread traditional knowledge of the engineers and water managers	

In situ water augmentation	*Do-it-yourself: Recycle and reuse wastewater*	2008	A documentation of case studies on decentralized wastewater treatment options that were tried and tested, cost-effective and eco-friendly. This also included step-by-step guide to plan, design and implement decentralized wastewater management	
Water efficiency	*Rating system for water efficient fixtures A Way to sustainable water management in India, CSE*	2010	The document present status and need for introducing water efficiency rating system for water using fixtures has been highlighted	
Water efficiency	*Water efficient products India, International Association of Plumbing and Mechanical Officials, IAPMO India*	2013	It is a rating system for sustainable plumbing in India. Prior to this, no rating system existed in India for water efficient products. The increasing need for defining water efficient products in India prompted IPA to develop such a document in collaboration with IAPMO-India	
In situ water augmentation	*Catch Water Where it Falls: Toolkit on Urban Rainwater Harvesting, CSE*	2013	This is a hands-on book based on exhaustive case studies on how RWH is being implemented, across India – in residential, institutional, and industrial/ commercial segments. It is supported by case studies to get a know how about the details required to implement RWH in a premises	
In situ water augmentation	*Reinvent, Recycle, Reuse: A Toolkit on Decentralized Wastewater Management, CSE – Talks about reuse of treated wastewater with case studies*	2013	In today's world sewage treatment is a challenge for all practitioners. The call of the hour is to reuse and recycle used water. The toolkit is a collection of thoroughly researched case studies to update our understanding and address the issue efficiently	
In situ water augmentation	*CPHEEO Manual on Sewerage and Sewage Treatment Systems, Part A Engineering*	2013	Provides guidance, information, techniques for planning, designing, implementation of sewerage and sewage treatment systems including reuse of treated wastewater. A chapter on reuse and decentralized wastewater treatment comprises case studies and recommends norms of treated water quality, suggests decentralized natural treatment technologies	

In situ water augmentation	*Advisory on Conservation and Restoration of Water Bodies in Urban Areas, CPHEEO*	2013	Provides guidance for conservation and restoration of waterbodies in urban areas. The initiative gains importance in the sense that urban lakes/waterbodies are the first victims of urbanization and their conservation/restoration is a sign of healthy and sustainable urban development	
Water efficiency	*Water use efficiency in Urban India, USAID and Confederation of Indian Industry (CII)*	2013	Suggests strategies to improve water-use efficiency for industries and domestic purposes through case studies.	
Water efficiency	*Guidelines for improving water use efficiency in irrigation, domestic and industrial sectors, CWC, MoWR*	2014	Includes guidelines for improving water-use efficiency in various sectors such as irrigation, domestic and industrial sectors.	
Water efficiency and In situ water augmentation	*Green Infrastructure: A Practitioner's Guide, CSE*	2017	Provides introduction and guidance to strategies related to sustainable water management within the existing urban fabric of a city or region. Demonstrates green infrastructure as one of the solutions to overcome the emerging water management issues of water supply and quality regulation and moderation of extreme flood events.	
Water efficiency and In situ water augmentation	*Water-Sensitive Urban Design and Planning: A Practitioner's Guide, CSE*	2017	Assists practitioners involved in sectors related to water management as well as urban designing and planning. It guides to explore possible innovations spanning areas of alternative approach of water management and shows how it can be applied at various scales keeping the existing challenges and opportunities into consideration.	

Annexure 2: Checklists for data collection

A. Checklist for data collection at city/zonal scale

The following is a suggestive checklist for data collection. The data may be collected from primary or secondary sources. Details and accuracy of data collection will make plan realistic and more relevant for the area of interest.

Background	• Location—map • Municipal area (sq. m) • Population, details of floating population, annual migration rate • Number of slum areas included in the municipal area, area (sq. m)
Water supply	• Existing source(s) of supply, e.g. reservoirs, lakes, rivers, aquifers, intakes, wells, pumps • Water supply coverage • Number of water supply connections, water connections in process • Water requirement data—demand • Identify social/cultural factors affecting water demand, e.g. community relies on the water source for cultural activities? • Identify recreational and/or other social attributes that may impact supply
Waterbodies	• Number of waterbodies in the area • State of the quality of water—quality analysis • Responsible body/organization for pond/lake management • Map indicating the water body with its catchment area
Water system infrastructure	• Description of each component, the length and/or capacity, the age, cost (capital and annual O&M) and existing condition: 1. Water treatment process used 2. Distribution system, including balancing storage reservoirs 3. Connections 4. Sewer collection system (if applicable) 5. Sewage treatment used (if applicable) 6. Include effluent receiving environment 7. Rainwater/storm water 8. Is rainwater/storm water intentionally or unintentionally combined with sewage? • Proposed water augmentation plan—details, capacity, status • Ongoing projects of water augmentation—details, capacity
Storm-water management	• Existing storm-water management system • Details of storm-water pumping stations (if any) • Maps with storm-water drains
Wastewater	• Number of STPs • Location of STPs • Treated water discharge (per day) • Quantity of treated water that is reused, if any (per day) • Maps with sewerage drains
Expenses	Total expenditure by the municipality on water supply • Cost for raw water treatment • Cost for distribution • Cost for maintenance and monitoring • Staff cost
Revenue	Water tariff Total water supplied Total revenue collected
Funding source	Schemes/incentives for water efficiency and conservation

Additional information that will be helpful for planning interventions

- Geomorphologic data: Terrain, Soil type
- Climatic data: Rainfall data, Average temperature
- Groundwater data: Groundwater level, Groundwater quality

B. Checklist for data collection at neighbourhood/institutional scale

The following is a suggestive checklist for data collection. The data may be collected from primary or secondary sources. Details and accuracy of data collection will make plan realistic and more relevant for the area of interest.

Background	• Location—Map • Type of land use • Number of users • Area (sq. m)
Demand	• Has a water audit been conducted earlier? • Consumption data • Water metering and tariff • Major water systems and equipments
Water supply	• Municipal supply—Quantity/number of household connection, type of connection (domestic or commercial) • Groundwater pumping—Quantity/number of hours of pumping and capacity of the pump 1. Source 2. Number of hours of water supply 3. Flow (velocity m/s) 4. Diameter of the pipes • Identify social/cultural factors affecting water demand, e.g. mass community functions/gatherings
Data for in situ water augmentation	• Existing green spaces, paved area, area available (sq. m) • Quantity of wastewater discharged/reused • Existing systems o RWH o Reuse of treated wastewater (decentralized wastewater treatment for local reuse) o Local waterbody management (if any)
Data for water efficiency	• Does the RWA/facility manager have standard-leak repair equipment and parts? • Number of non-metered households/users with municipal water supply • Number of non-metered households/users that pump water from the ground • Total metered households/ users • Types of plants growing/ type of landscaping
Expenses	• Water tariff • Water bills to municipality (Rs/annum)
Revenue	• For neighbourhoods/community-based organizations/ RWAs—service fees
Funding source	• What are the existing funds available? • What are the additional sources of funding that could be explored?

Additional information that will be helpful for planning interventions

- Geomorphologic data: Terrain, Soil type
- Climatic data: Rainfall data, Average temperature
- Groundwater data: Groundwater level, Groundwater quality

C. Checklist for data collection at individual/building scale

The following is a suggestive checklist for data collection. The data may be collected from primary or secondary sources. Details and accuracy of data collection will make plan realistic and more relevant for the area of interest.

Background	• Building description (purpose—residential/commercial/ institution) • Number of users
Demand	• Major water systems and equipments • Water tariffs • Water metering • Consumption history
Water supply	Municipal/groundwater—quantity (per day)

Data for in situ water augmentation	• Rooftop type • Rooftop area (sq. m) • Quantity of wastewater generated (generally 80 per cent of water consumption)
Data for water efficiency	• Details of existing water fixtures • Number of toilets—Number of fixtures with details • Number of kitchen/canteens—Number of fixtures with details • Green area (sq. m) • Type of plantations/ landscaping
Expenses	Water bill (Rs per annum)

Annexure 3: Checklists for self-assessment

A. Checklist for self-assessment at city/zonal scale

What efforts have already been made for water efficiency and conservation by the local body/ municipality? Several questions are listed below to help gauge present performance.

Commitment and resources

- Are water-efficiency responsibilities delegated?
- Are quantitative goals established and tracked?
- How are water-efficiency goals communicated to users?
- What are the incentives and feedback loops for participation, suggestions and increased awareness?
- Has the local body taken advantage of available schemes from state or Central government for funds and resources?

Water-efficiency survey

- What is the breakdown of your water use: domestic, industrial and commercial supply?
- What is the breakdown of the total expenditure by your ULB on water supply: energy, staff, unauthorized connections, billed and non-paid connections etc.?
- Are there regular leak inspections and metering?

Identifying opportunities for WEC—target areas

In situ water augmentation	• What is the provision for storm-water management? Is the storm-water harvested? • Is there any waterbody? Who is responsible for its management? Is it managed properly?
Landscaping	• Has xeriscaping been thought of?
Reuse of treated wastewater	• Is there bulk reuse of treated wastewater? • Has the possibility of using treated wastewater for maintaining public parks, gardens, fire-fighting or construction been thought of?
Reducing water loss	• Has there been any effort to reduce NRW and water losses through the water supply and distribution system?

Water efficiency and conservation action plan

- Have you performed a cost analysis on water-efficiency opportunities?
- Do you have a prioritized implementation schedule?
- Are water users informed of the changes and communication channels open for feedback?

Tracking and communicating results

- Is there a mechanism to announce monthly water losses and usage to users?
- Are there provisions of tariff rebates/incentives for users with water conservation and efficiency achievements? Are these recognized in case study articles, media coverage, business environmental exchange programmes or in award programmes?

Source: Adapted from Water Efficiency Manual, 2009, North Carolina

B. Checklist for self-assessment at neighbourhood/institutional scale

What efforts have already been made for water efficiency and conservation? Several questions are listed below to help gauge present performance.

Commitment and resources

- Are water-efficiency responsibilities delegated?
- Are quantitative goals established and tracked?
- How are water-efficiency goals communicated to users?
- What incentives and feedback loops exist for participation, suggestions and increased awareness?
- Have your RWA/institute taken advantage of available help and resources from your utilities, assistance programmes, vendors or consultants?

Water-efficiency survey

- Do you know the actual breakdown of your water use: domestic use, cleaning activities, kitchen, laundry, landscaping, water treatment regeneration, evaporation, cooling, leaks or others?
- Do you know your lifecycle water costs for supply water, wastewater treatment, sewer/ discharge and heat and mechanical energy losses?
- Are you doing simple things such as leak inspections, eliminating unnecessary uses and using timers? Are these practices institutionalized?

Identifying opportunities for WEC—target areas

In situ water augmentation	• Are there any water-efficient fixtures being used? • Is there any existing rooftop RWH system? • What is the provision for storm-water management? Is the storm water harvested? • Is there any waterbody? Who is responsible for its management? Is it being managed properly?
Landscaping	• Has xeriscaping been ever thought of?
Reuse of treated wastewater	• Has reuse of treated wastewater been examined for flushing, horticulture, street washing, fire-fighting, construction etc.?
Reducing water losses	• Is the water usage metered?

Water efficiency and conservation action plan

- Have you performed a cost analysis on water-efficiency opportunities?
- Do you have a prioritized implementation schedule?
- Are water users informed of the changes and communication channels open for feedback?

Tracking and communicating results

- Do you post monthly water usage rates to employees and management?
- Are your water-efficiency achievements recognized in case study articles, media coverage, mentoring to other businesses, business environmental exchange programmes or award programmes?

Source: Adapted from Water Efficiency Manual, 2009, North Carolina

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