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GUIDELINES ON WATER EFFICIENT MEASURES FOR RESIDENTIAL TOWNSHIPS

New Design and Retrofit | Operation and Maintenance | User Behavioural Changes

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Message

The Mahindra-TERI Centre of Excellence (MTCoE) is a joint research initiative of Mahindra Lifespace Developers Limited (MLDL) and The Energy and Resources Institute (TERI). MTCoE has been established to develop science-based solutions for India's future built environment with emphasis on enhanced occupant comfort, resource efficiency and sustainable construction. The CoE aims to create a repository of innovative materials and technologies and provide an array of strategies for achieving sustainable habitats. Under the Ist phase of the five-year research scope, the CoE has created guidelines, toolkits, and handbooks to mainstream principles of energy-efficiency, thermal & visual comfort, and sustainable water use in habitats.

Issues such as inadequate water supply, depleting groundwater table, and increased water demand and water misuse in townships has been a growing area of concern over the years and has posed a challenge to building professionals, architects, and local municipal authorities. Global change impact on the use of water resources is the reality and recognizing that expansion of residential townships will exert a greater impact on human activity compared to climate change, at least up until 2050, requires urgent action. Hence, it is crucial to spread awareness and for residences to adopt sustainable practices to replenish and conserve water.

The Mahindra-TERI CoE is pleased to present "Guidelines for Water Efficient Measures for Residential Townships' as a step towards achieving water use optimization and efficiency in existing and upcoming residential townships in India. These guidelines have been prepared to help building professionals, real estate developers, policy makers, administrative agencies, architects, engineers, and end users to generate awareness on the aspects of water conservation and sustainable management and provide potential solutions to overcome the water related challenges faced in the townships. It talks about various sustainable design options, technologies, operation and maintenance measures that can be adopted for water related systems and infrastructure in the township and incorporate best practices by the user for attaining water efficiency.

I hope these guidelines will help townships to move on the path of sustainability and become water efficient. I gratefully acknowledge the support of all those associated with the development of this guideline and look forward to their continued guidance for its enhancement.

Sanjay Seth
Senior Director
Sustainable Habitat Programme, The Energy and Resources Institute (TERI)

Table of contents

List of Figures

Disclaimer

Guidelines for Water-efficient Measures for Residential Townships is an attempt towards developing a generic ready-reference guide that provides a quick overview of an array of simple, innovative, and implementable measures for residential townships across India to achieve water efficiency and sustainable water management in their facilities. However, it is worth mentioning, various strategies suggested in this guidebook have been developed on the basis of TERI's knowledge and water audits of townships conducted. Their sole aim is to provide recommendations and therefore their utilization should be interpreted according to the prevalence of the site conditions. Their application highly depends on the requirements of the sites. It is strongly suggested here that technical support of relevant field experts should be sought before proposing or implementing the strategies specified in the publication.

Introduction

In the context of extreme neglect, unsustainable consumption, and poor management of the water resources throughout the world, it can be established that water from 'ubiquitous resource' today has become a 'precious' one. Water is a unique resource and has no substitutes or alternatives. Over the years, the overutilization of water resources, pollution of river systems, and lack of water-treatment facilities have aggravated the already existing water crisis in India. This coupled with climate change is going to make the water shortage more severe in coming years due to alteration in rainfall patterns across the country, thus unbalancing water demand and supply.

The annual per capita water availability is expected to reduce to 1140 cubic metres (cu. m) by 2050, close to the official water scarcity threshold of 1000 cu. m. India has already become 'water stressed' with annual per capita water availability dropping to 1544 cu. m in 2011, below the global standard of 1700 cu. m.[1]

The future estimates show an alarming scenario with water demand in various sectors (energy, industry, drinking, irrigation, etc.) across India, increasing on account of rapid economic and demographic change, particularly in the urban centres. It is expected to reach 1180 billion cubic metres BCM in 2050, surpassing the average annual water availability of 1122 BCM.[2] Also, the water demand is anticipated to exceed supply two folds by 2030.[3] The Central Pollution Control Board (CPCB) estimates that sewage generation will increase to over 1,20,000 million litres per day MLD by 2051.[4]

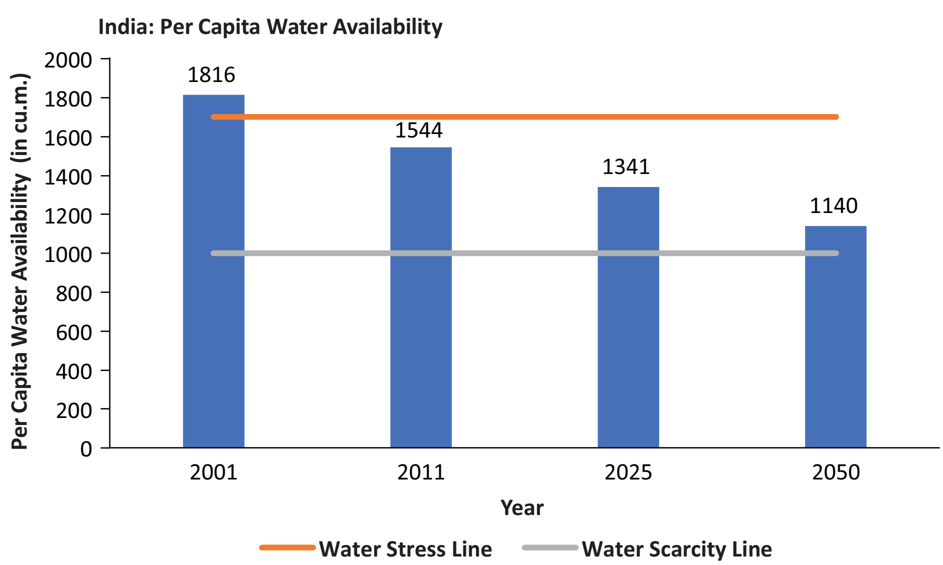


FIGURE 1 India's per capita water availability in 2001 and 2011 and estimated values for 2025 and 2050

1 Press Information Bureau. 2017. Ministry of Water Resources. Shortage of Water. Details available at <http://pib.nic.in/newsite/PrintRelease.aspx?relid=168727>
2 Press Information Bureau. 2013. National Commission on Integrated Water Resources Development (NCIWRD)
3 Niti Aayog. 2019. Composite Water Management Index
4 Details available at <https://www.orfonline.org/research/arresting-indias-water-crisis-the-economic-case-for-wastewater-use/>

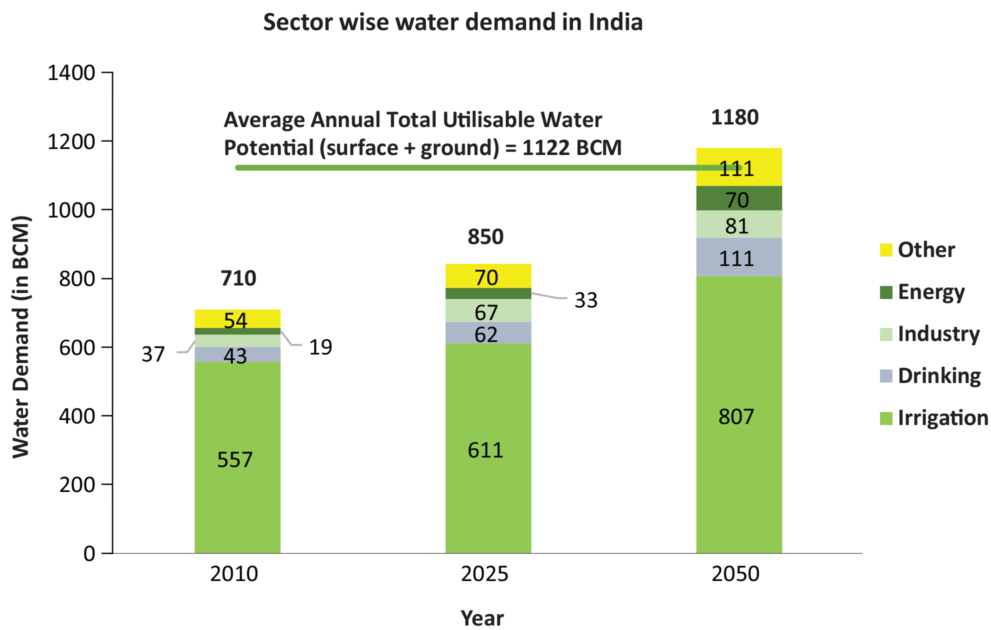


FIGURE 2 Water demand in various sectors in India in 2010 and estimated value for 2025 and 2050

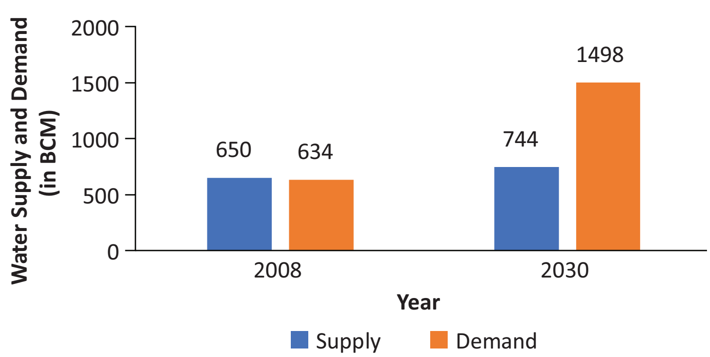


FIGURE 3 Water demand and supply in India in 2008 and estimated value for 2030

Traditionally, governments in India have had dealt with water scarcity and pollution in cities using a two-pronged approach–infrastructure for access, distribution, treatment and the use of regulatory and fiscal instruments. However, this approach is old and has lost its practicality. In the present context, it is focusing more on developing policies and regulations for driving sustainable development that mandates improved water efficiency in the built environment. What is also new is the engagement of all socio-economic segments such as consumers, financiers, managers, developers, and corporates in which this concern of water scarcity and pollution is being felt increasingly. These stakeholders can play a crucial role in achieving water efficiency across various sectors of infrastructure development.

As population continues to boom along with rapid urbanization and concentrates in the metropolitan cities such as Bengaluru, Chennai, Gurugram, Mumbai, Pune, etc., a growing need for accommodation has given rise to a new type of residential development called townships, mushrooming at a rapid pace in and around the cities. Global change impact on the use of water resources is the reality and recognizing that urbanization such as expansion of residential townships will exert a greater impact on human activity compared to climate change, at least up until 2050, requires urgent action. Therefore, it has become important for residences to use and manage water sustainably.

Various spaces in a residential township which utilise water to fulfil their daily requirement include the residential flats, community hall, swimming pool, café, sports/gym, parking (for cleaning cars), park and playground.

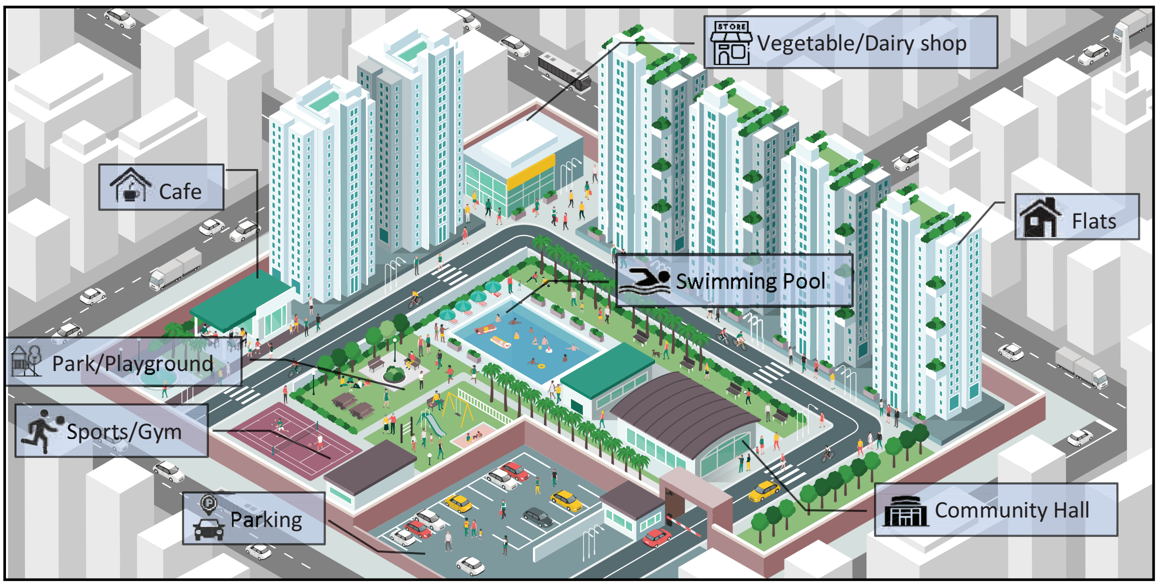


FIGURE 4 Types of spaces in a residential township[5]

Since the concept was developed in the early 1990s, developers across the country have continuously re-defined the township model as per the market demand. With the emerging environmental, social, and governance (ESG) mandate in corporate governance in India, this has made many corporates to embark on the road to sustainability. Companies have started gradually incorporating Sustainable Development Goals (SDGs) into their responsible business actions such as achieving water self-sufficiency being one of the key action themes. Developers are re-discovering the township model with growing focus on water conservation and zero-wastewater discharge in their projects. They are now expected to contribute to achieve sustainable water use and management through advanced technology and innovation. With growing environmental concerns, buyers too today are increasingly interested in homes equipped with water-saving technologies.

In fact, in recent turn of events due to the Covid 19 pandemic, people are now getting used to the 'new normal', many businesses are moving towards work from home and employees are spending a greater share of their time at homes now. This has resulted in significant increase in the residential water demand. And therefore, it becomes more crucial today to inculcate water-efficient measures in the residential building design for sustainable water utilization.

5 Details available at <https://www.shutterstock.com/image-vector/isometric-aerial-view-contemporary-efficient-cooperative-1597083832>

This document lays down a set of guidelines on ways to overcome the challenges related to water conservation and achieving water efficiency in a residential township. It is a help guide which can help townships to move on the path of becoming net water positive i.e. reducing the dependency of fresh water supplies. The measures listed in the document are innovative, practical, and easy to implement as they have been developed after conducting thorough research and water audits of several townships across India to understand the issues and design solutions accordingly.

The Three-point Approach

Simple and innovative measures focusing on reducing water usage, harnessing alternative sources of water such as reuse of treated wastewater and rainwater and designing green infrastructure can easily be included in new buildings, and retrofitted to old ones, for establishing water-efficient residential townships.

- Reducing water usage: To the extent possible, facilities should first try to decrease their need for water by increasing efficiency and reduce total water volume used within the project. Using water-efficient fixtures and appliances, irrigation equipment, sustainable landscape design solutions, enhanced operation and maintenance of water systems can help in reducing the water usage drastically.
- Harnessing alternative water sources: Once efficiency has been optimised, facilities should maximise the use of water that is collected, used, purified, and reused on-site/building. Some of the major alternatives are harvested rainwater and treated wastewater. The 'collect and treat' strategy minimises the treatment and transport losses, in addition reducing the overall energy expended in processing and conveyance. It also contributes in decreasing the dependence on freshwater supply, thus reducing the stress on water resources.
- Integrating green infrastructure: The third domain in this three-point approach focuses on reducing the storm water runoff which forms one of the major reasons for the occurrence of water loss from a facility. As we continue to replace forests and green fields with buildings and pavements, the rainwater which runs off from these surfaces such as roofs and pavements, picks up trash, bacteria, fertilizer, oil, pesticides, dirt, and other pollutants and makes its way towards the storm water drains, and this untreated runoff is further diverted into to the bodies of water such as streams, rivers, lakes, and oceans. This storm water runoff is one of the major causes of water pollution and flooding in the cities. To counter the negative impact, integrating customised green infrastructure solutions on the site such as rain gardens, permeable pavements, green roofs, infiltration planters, rainwater harvesting systems, etc. can help storm water to infiltrate to the original water source. This not only substantially reduces flooding but also prevents polluted runoff from reaching sewer systems or to surface waters (streams, rivers, lakes, and oceans) to a great extent.

This three-point approach framework can be utilised for enhancing the sustainable water management of a project. These three domains cover all the actions required in various levels of project designing to develop a multifunctional and resilient water system.

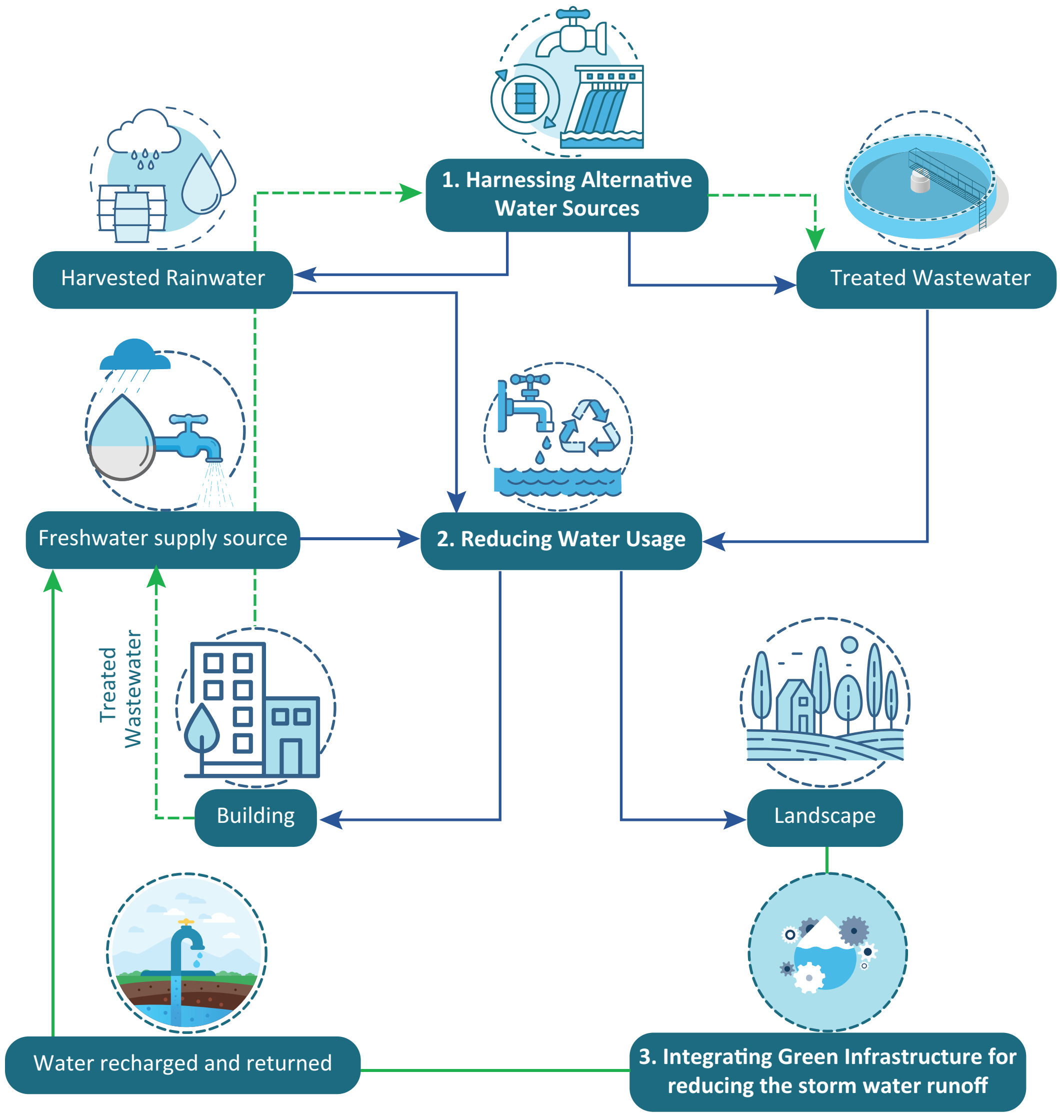


FIGURE 5 The three-point approach for achieving water efficiency in a residential township

This guideline provides a number of measures for achieving water efficiency in residential townships using the three-point approach which could be categorized as follows:

» Sustainable design and technological integration at various stages of a project–in new design and retrofits to the existing design. Design intervention helps in realising cost-effectiveness, further the reduced cost can be invested in technological enhancements of the project.

» Operation and maintenance

» User behavioural changes

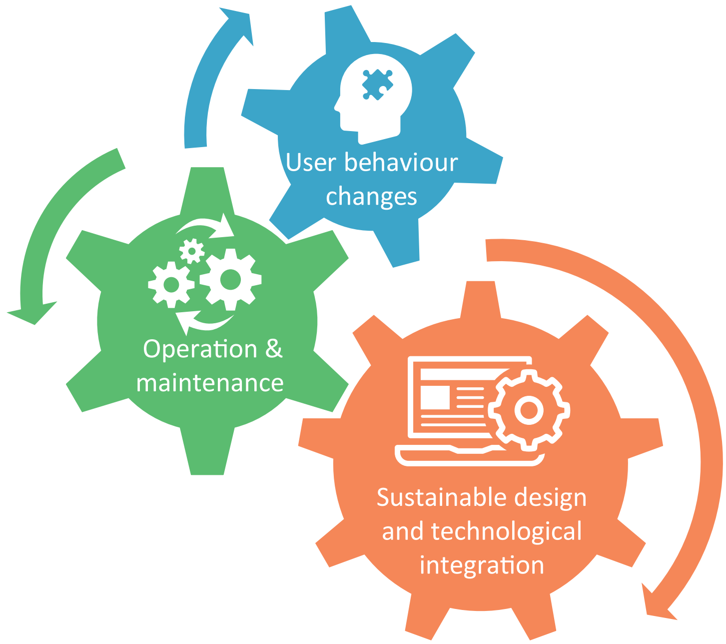


FIGURE 6 Categorization of measures for achieving water efficiency in residential townships

Reduction in Project's Water Usage

Residential townships are places where significant amount of water is consumed in daily activities, at the same time, these townships have the maximum potential to carry out water saving. Water use in residential settings mostly occurs in bathrooms (showers, water faucets, and bath tub), kitchens, toilets, dishwasher, laundry, cleaning, car wash, and landscaping. Reducing water usage at homes and for irrigation can be one of the easiest ways for cost and energy savings and reducing the household's impact on the environment.

Buildings—new design and retrofit measures

» Pressure-assisted flushing systems in toilets: Toilets with pressure-assisted flushing systems are relatively new and use a combination of water and pressurised air for flushing out the waste. These systems require less water for flushing as compared to gravity-fed flushing systems. This is because they utilize additional

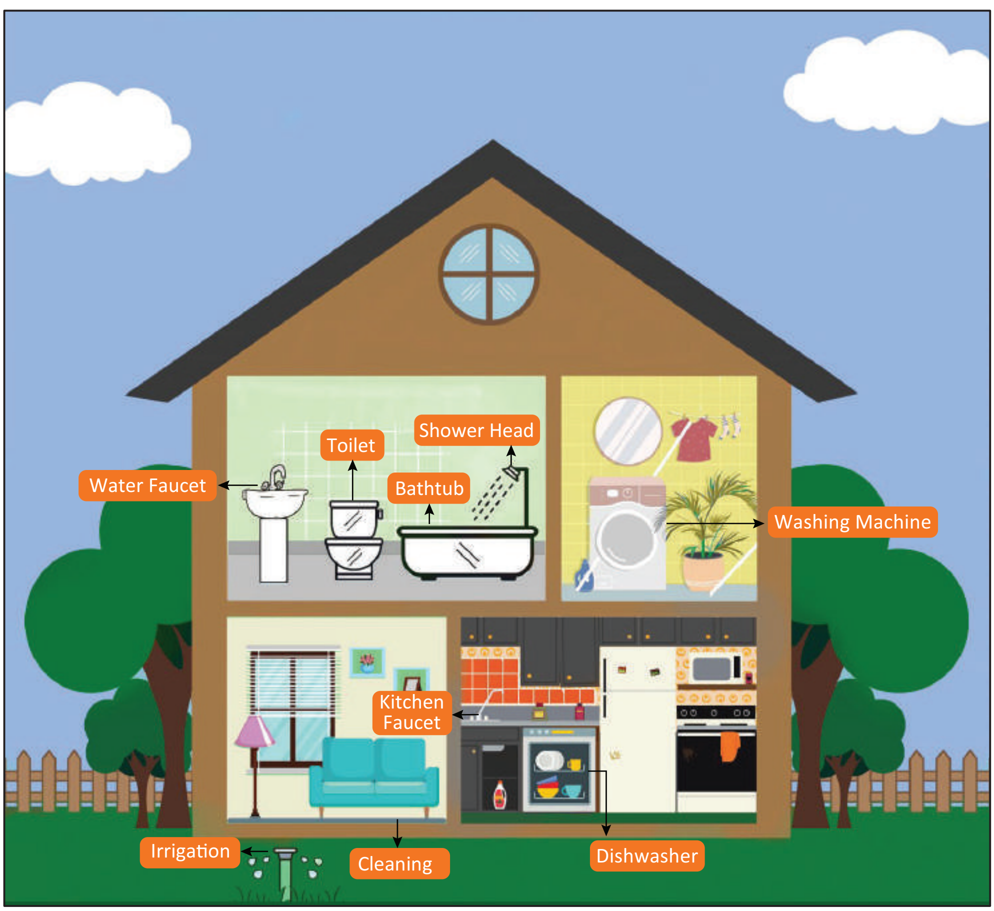


FIGURE 7 Typical water use in a residential setting

pressure from air and thus don't require as much water as gravity-assist toilets do to achieve the same flushing efficiency. If expressed in numbers, a pressure-assisted toilet consumes nearly 20% less water than its gravity-fed counterpart.

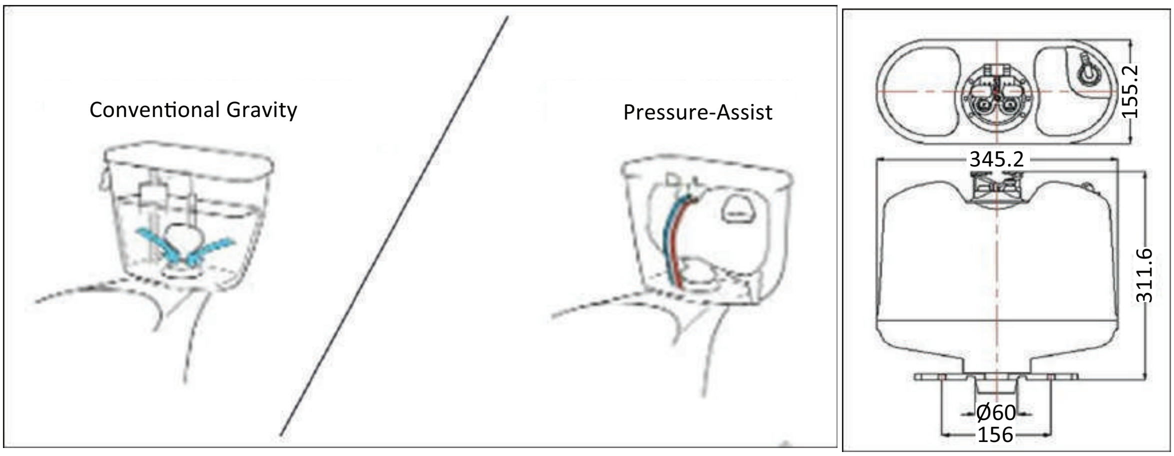


FIGURE 8 Pressure-assisted versus conventional gravity-fed flushing system with plan details of pressure-assist tank

- Low-flow water faucets and fixtures according to the usage type: Using low-flow water fixtures is advantageous only for activities where number of uses is constant such as using shower for bathing, flushing, using wash basins, etc. These low-flow fixtures are not appropriate for activities such as filling a container from kitchen tap for cooking/drinking, filling a bucket for bathing, washing or cleaning, etc. where nearly fixed volume of water is required. Therefore, fixtures with low-flow rates are ideal for showers, flushing and wash basins, and not suitable for bathroom and kitchen taps. Using these low-flow water faucets and fixtures can help reduce water consumption by 30%–40%.
- Water-saving aerators should be installed in all the faucets: Water-saving aerators for faucets maintain a constant rate of water flow with minimal variation in the flow due to pressure fluctuations. These are equipped with mesh screens that divide the flow of water into multiple small streams by adding air in between. The volume of water flowing from the tap gets reduced as the water stream is diluted with air. This results in water savings on faucets. As utilising aerators does not significantly reduce the water pressure, so there is negligible difference in the amount of water coming out of the faucet. Residents can benefit from the usable water flow while maintaining water efficiency, at the same time.

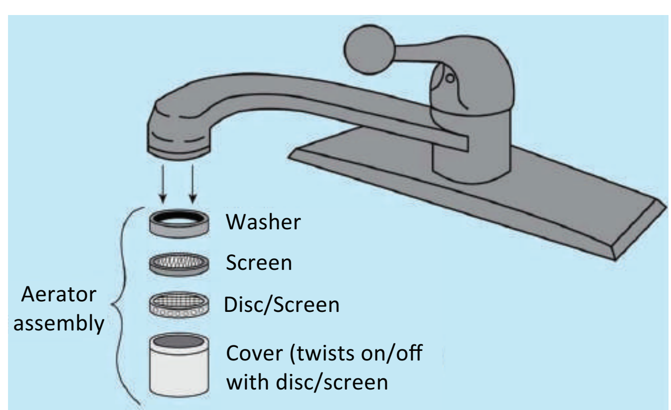


FIGURE 9 A typical assembly of an aerator for sink water faucet

Conventional faucets dispense between 8 litres per minute (lpm) and 15 lpm of water. An aerator can help cut the water flow by less than half or even more. Various flow pattern models are available in water-saving aerators such as shower flow (2-4 lpm), laminar flow, mist flow (1.2 lpm), foam low (4-8 lpm), etc. Mist flow works best for hand washing, shower flow pattern works best for utensils washing and foam flow works reasonably well with both hand and utensil washing purposes.

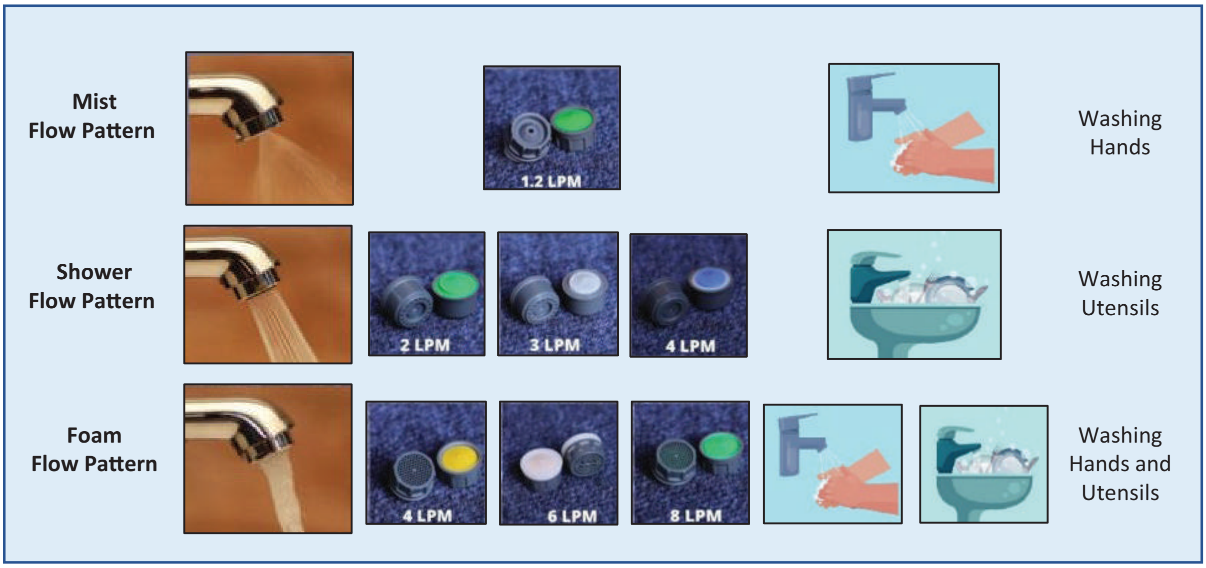


FIGURE 10 Design types of water-saving aerators, their flow rates, and uses

» Water metering: Metering and measuring facility's water use helps to analyse saving opportunities. In order to effectively monitor and reduce the water wastage and implement water-saving measures, water meters should be installed on site to record the real-time data on water consumption. Water meter installed on the site, at the water inlet from the source level, is used to record the overall water consumption of the site.

FIGURE 11 Advantages of installing water meters on site

In addition to this, water sub-metering and smart water meters are recommended for apartments and townships with multi-family residential buildings. This involves installation of separate water meters, allowing fair billing of water consumption of each household. Homeowners or tenants will be aware of their consumption and therefore find ways on how they can cut down their utility expenses while saving water at the same time. Apart from this, the suggestive locations for installing the water meters in the facility can be for recording the use of freshwater, treated water from sewage treatment plant STP, stored rainwater, etc. for various applications such as domestic, flushing, irrigation, backwash, cooling purpose, etc. This can help in tracking water consumption from various sources and prevent water wastage, resulting from leaks in the facility.

An example from Seosan city, South Korea is worth mentioning here where existing water management was combined with the smart water management tools. It resulted in significant improvement in water efficiency.[1] It enabled a sustainable water supply to the city by reducing water leakages, effectively saving water and energy.

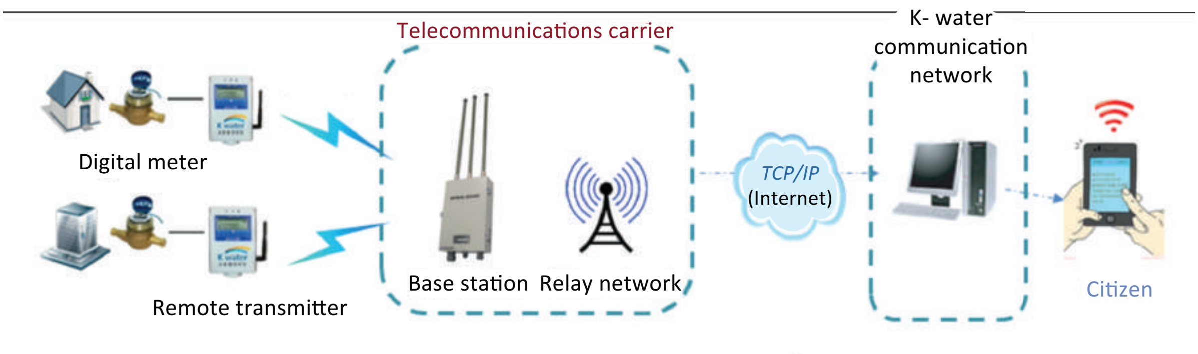


FIGURE 12 Outline of smart metering system in Seosan city[2]

Increase in adoption of smart water metering system in Indian metropolitan cities has also gained momentum in last few years. In 2019, in order to reduce their water footprint, over 420 houses in Sobha Daffodils apartment in Bengaluru adopted smart water flow meters that could monitor water usage in real-time. As a result, the average water intake dropped by about 15%–20%. Many other apartments in Bengaluru, for instance, Mahaveer Seasons and Sundale Apartments, reduced their water consumption by 30%–35% and 30%–50% respectively, after installing internal metering.3 Power consumption for pumping water also reduced substantially. This is to be highlighted here that since internal metering had not been considered in the design of most Bengaluru apartments, retrofitting (separate piping is required to be installed for individual houses, which is necessary to measure consumption by each flat) had posed challenges at times. Therefore, internal sub-water metering should become an integral part of the apartment design in initial stages.

HM Tambourine Apartments in Bengaluru also successfully implemented water meters in their G+10 complex with replumbing to connect all inlets of a house to one. This helped in overall reduction of water consumption by 35%.

- It was found that 10% of the flats had major water closet WC flush tank problem. Twelve kilolitres (kl) per day per house was going in drain due to flush tank's faulty float. Residents immediately started rectifying flush tanks and water-leaking taps.
- Installing water conservation filters was the foremost step taken.
- Monkeys opening taps in utilities of closed houses were identified and closed. This was a major issue earlier.

1 Details available at <https://www.iwra.org/swmreport/>
2 Details available at <https://www.iwra.org/wp-content/uploads/2018/11/SWM-report-final.pdf>
3 Details available at <https://bengaluru.citizenmatters.in/bwssb-water-meter-policy-apartments-penalty-64426>

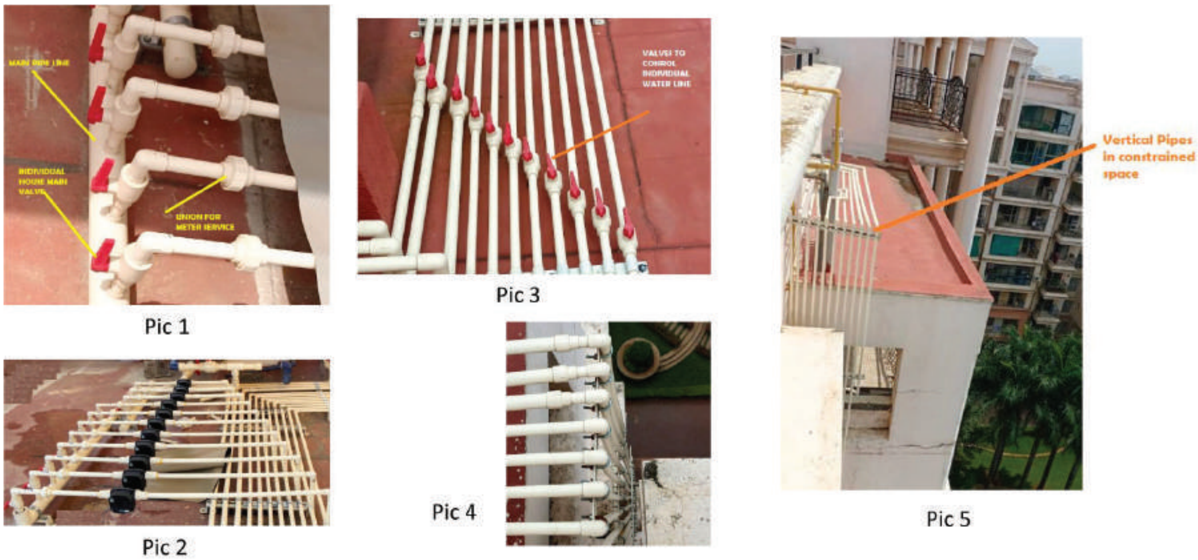
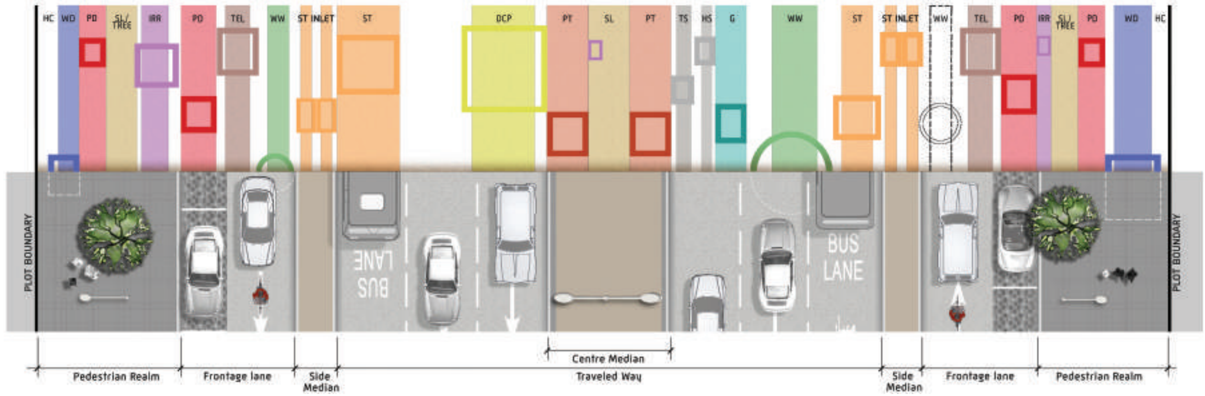


FIGURE 13 Water pipeline distribution, measurement and control in HM Tambourine Apartment in Bengaluru[4]

» Design utility corridors for services lines: Currently all the required utility lines to a site such as municipal water supply, fire water line, irrigation mains, grey and black water supply and the storm water line are laid down separately. If there is a need of any repair/upgrades in any of the lines, it requires digging up the site thus disrupting traffic and other surface activities. All the water supply lines running along the site have a hierarchy, depending on their quality; these can be clubbed together for easy maintenance. Therefore, utility corridors should be developed that allow the grouping of utility lines in a single, accessible space which eliminates the conflict between these lines, minimize trenching and reduce or eliminate the need of manholes. The water supply line in the utility corridor can be divided into domestic use (freshwater) and flushing and irrigation use (treated water from STP). Fire water line is pressurised as it is required on 24×7 basis, it should not be laid underground but should run around the boundary wall, hidden by shrubs. The storm drains can be made in channels and all the water-utility lines can be integrated into it except drinking and black water lines. Filling of storm water lines will only occur during the monsoon season, therefore they can be easily cleaned and maintained.

Ideally it is suggested that on one side of the road there should be a water-utility corridor and on the other side there should be an electric corridor. In the water-utility corridor, proper segregation of various water pipelines should be taken care of. The worst quality water should be made to run at the bottom so that in case there are any leakages it remains down. The hierarchy of installing lines should be: Drinking water supply line on the top, followed by domestic line, then storm water line, grey water line for flushing, and black water line for sewage at the bottom.

4 Details available at <https://baf.org.in/admin/article_resources/a1d0c6e83f027327d8461063f4ac58a616352353581011/1635235558592691249baf%20water%20meter%20presenetation%20%20v4.pdf?download_this>



WD WATER DISTRIBUTION | WW WASTEWATER | IRR IRRIGATION | ST STORMWATER | DCP DISTRICT COOLING

PT POWER TRANSMISSION | PD POWER DISTRIBUTION | SL STREET LIGHTING | TEL TELECOMMUNICATION

TS TRAFFIC SURVEILLANCE | HS HIGH SECURITY | G GAS | HC HOUSE CONNECTION

FIGURE 14 Typical utility corridor layout according to Utility Corridors Design Manual (UCDM)[5]

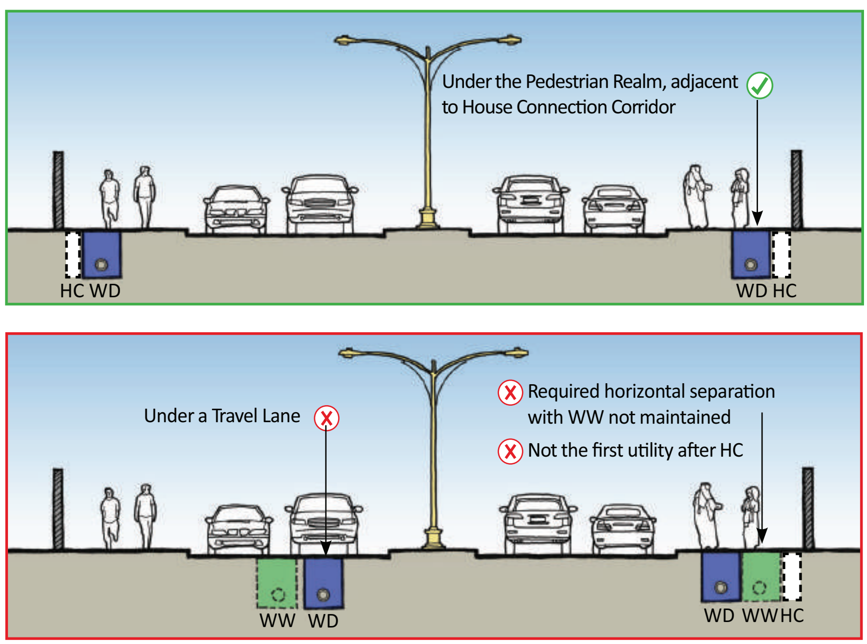


FIGURE 15 Typical potable water corridors' locations

For example, utility corridors form an integral part of urban planning of Abu Dhabi city. Abu Dhabi Utility Corridors Design Manual is a guide that provides standards and guidelines for planning and allocation of utility corridors for new urban streets and the retrofitting of existing urban streets in the Emirate of Abu Dhabi. The Manual ensures utility corridors are designed and arranged to maximise the efficient use of space within a given right-of-way (RoW) width.

5 Details available at <https://data.abudhabi/dataset/abu-dhabi-utility-corridors-design-manual/resource/500cf07d-c344-43f1-9325-eb7e39a5a7aa>

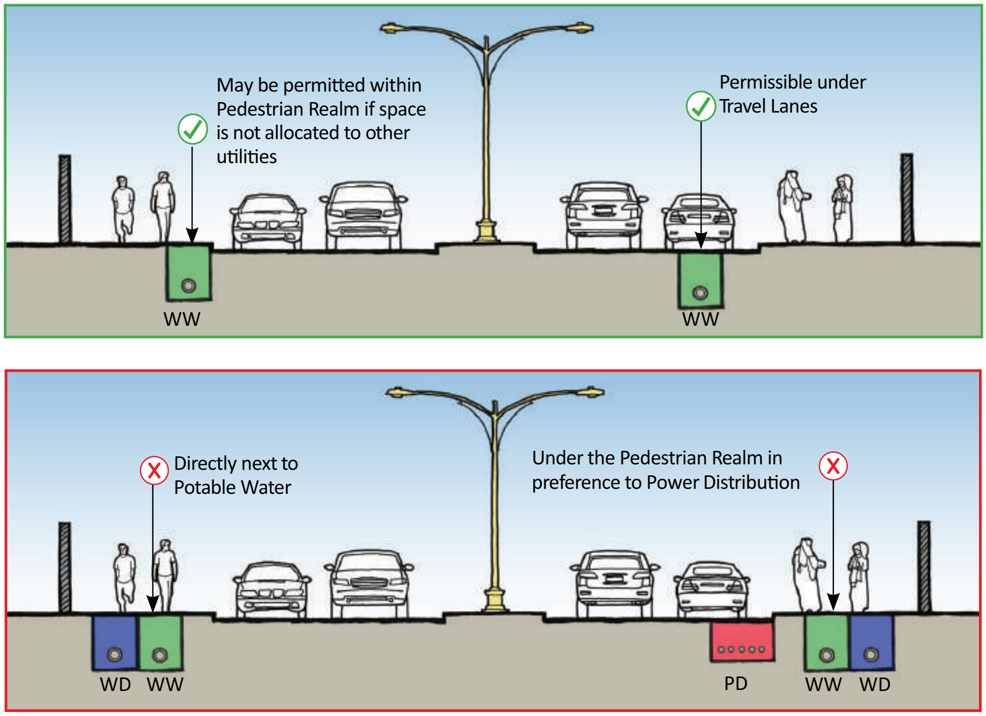


FIGURE 16 Typical wastewater collection corridors' location

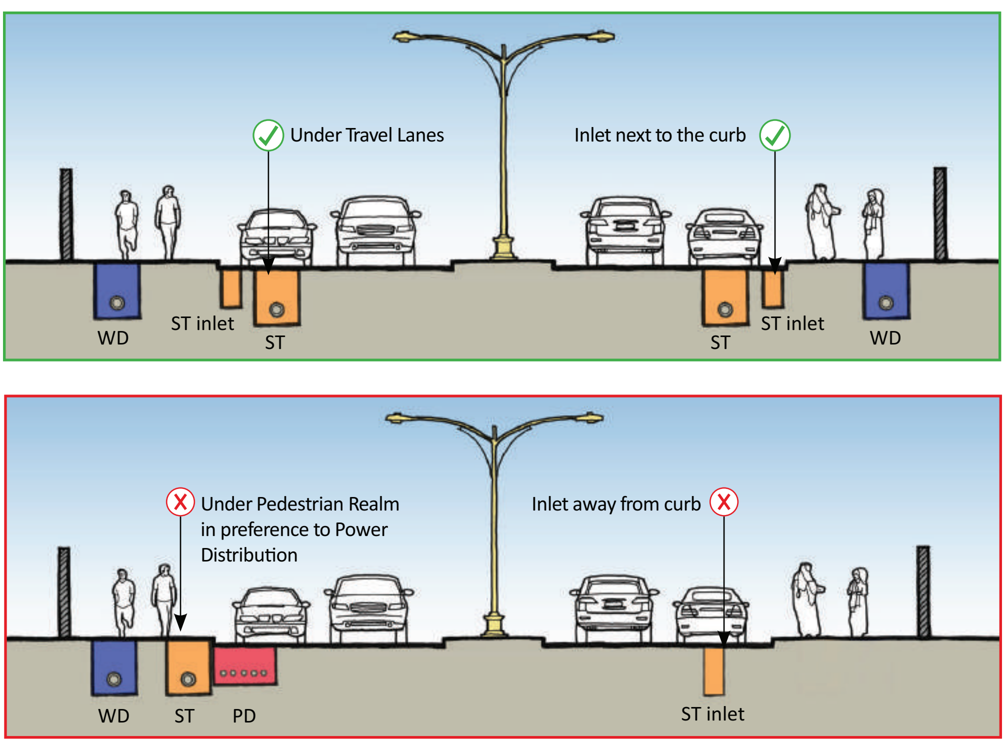


FIGURE 17 Typical storm water collection corridors' locations

Street Family	Side 1		Side 2	
	Pipe Corridor Width (m)	Chamber Corridor Width (m)	Pipe Corridor Width (m)	Chamber Corridor Width (m)
Access lane	1.0	1.5	1.0	1.5
Street	1.0	1.5	1.0	1.5
Avenue	1.0	1.5	1.3 (1.0)	2.2 (1.5)
Boulevard	1.0	1.5	1.8 (1.3)	2.7 (2.2)

(x) Indicates the absolute minimum pipe and chamber corridor width

FIGURE 18 Water supply utility corridor allocation in Abu Dhabi[6]

TYPICAL RESIDENTIAL/EMIRATI NEIGHBOURHOOD AVENUE WITH PARKING and CYCLE TRACK ON BOTH SIDES

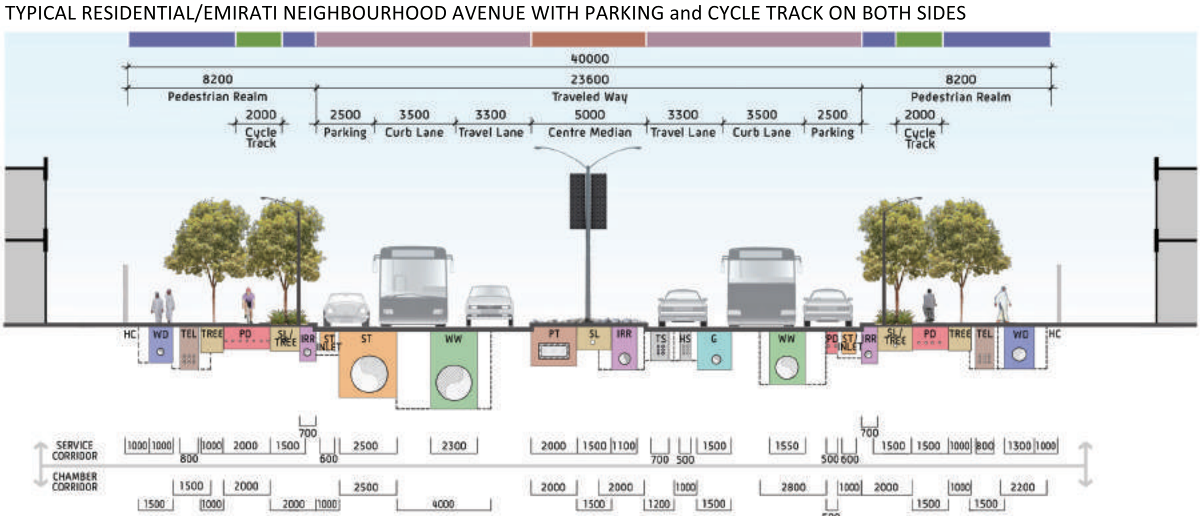


FIGURE 19 Typical residential neighbourhood avenue in Abu Dhabi[7]

Adoption of utility corridors is still in nascent stage in India. Gujarat International Finance Tec-City or GIFT City is one such early project which is being developed as a state-of-the-art financial hub which shall require huge infrastructure with excellent planning, designing, and engineering with latest technologies. In respect to vast infrastructure systems, GIFT City developed the vision of 'Digging-free City' by placing all the utilities in a tunnel across the City so that there is no need to excavate the roads in future for repair/maintenance.[8]

6 Details available at <https://data.abudhabi/dataset/abu-dhabi-utility-corridors-design-manual/resource/500cf07d-c344-43f1-9325-eb7e39a5a7aa>

7 Details available at <https://data.abudhabi/dataset/abu-dhabi-utility-corridors-design-manual/resource/500cf07d-c344-43f1-9325-eb7e39a5a7aa>

8 Nilesh Puery. Presentation: Gujarat International Finance Tec-City made at ITU Training Event Leveraging ICTs for Smart Sustainable Cities for Asia-Pacific Region, Delhi, March 24-26 2015. Details available a

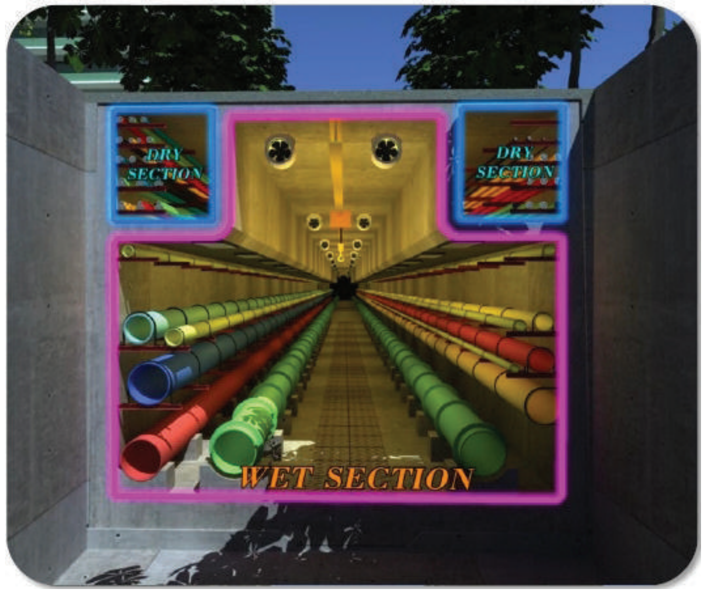


FIGURE 20 Utility tunnel, showing wet and dry sections[9]

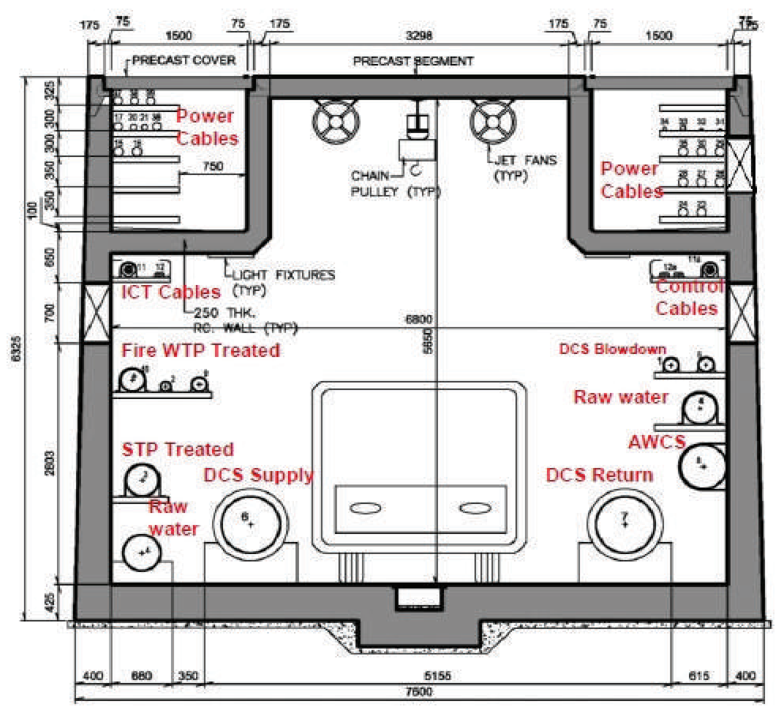


FIGURE 21 Utility tunnel, showing dimensions

9 <http://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Pages/Events/2015/March%20SSC%202015/ITUTRAISSC2015.aspx

FIGURE 22 Utility tunnel, showing support brackets

FIGURE 23 Utility tunnel, showing waste and water pipes

Buildings—operation and maintenance

» Water flows in various fixtures should be set at a pressure level where it can flow smoothly to the top floors of the apartment buildings, thus avoiding the unnecessary water wastage which happens when the supply is set at an excessive pressure level.

» Proper maintenance of water faucets and fixtures can ensure their operation at peak efficiency and reduce leakage risks.

» Dirt and debris can get trapped in a faucet aerator over time. Cleaning of aerators should be done every 2–3 weeks in order to improve the water pressure.

» There are a number of ways for removing the dirt and debris from the faucet aerators. One such way is using normal water sponge filtration which can be easily removed and cleaned as required. One of the major reasons for debris to accumulate in the water tank is through inlet line when water is pumped. Sponge filters can be placed at two locations, either at the source from where municipal water is being supplied to the apartment or at the inlet of the receiving water tank. The water which enters the tank is filtered as it passes through the sponge filters with thick coarse filter first, followed by thinner filters. If the water is filtered in the tank itself, the dirt/debris will not reach the fixtures, thus reducing the cost of cleaning and changing the aerators. These filters can be placed either vertically or horizontally. Vertical installation of sponge filters is preferred as it works faster due to gravity as compared to horizontal installation. In fact, if the first sponge filter in the horizontal installation is choked, the water shall backflow.

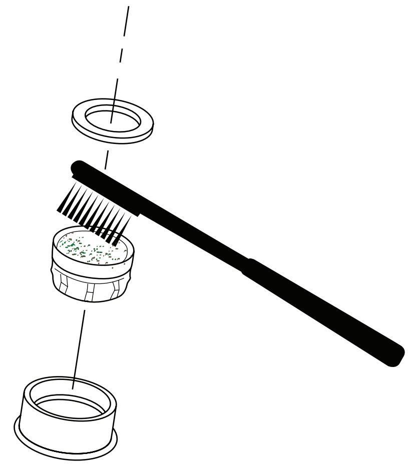


FIGURE 24 Cleaning of a water faucet aerator using a brush

» Training of the onsite maintenance team.

Landscape—new design and retrofits measures

» The landscape water demand can be reduced by doing appropriate plant selection, planning, and design. The landscape design should take into account both local climate and soil conditions. Focus should be on preserving as many existing trees and shrubs as possible because established plants usually require less water and maintenance. In order to preserve existing trees during construction, a retaining wall or a dry well or a tree guard can be built around them.

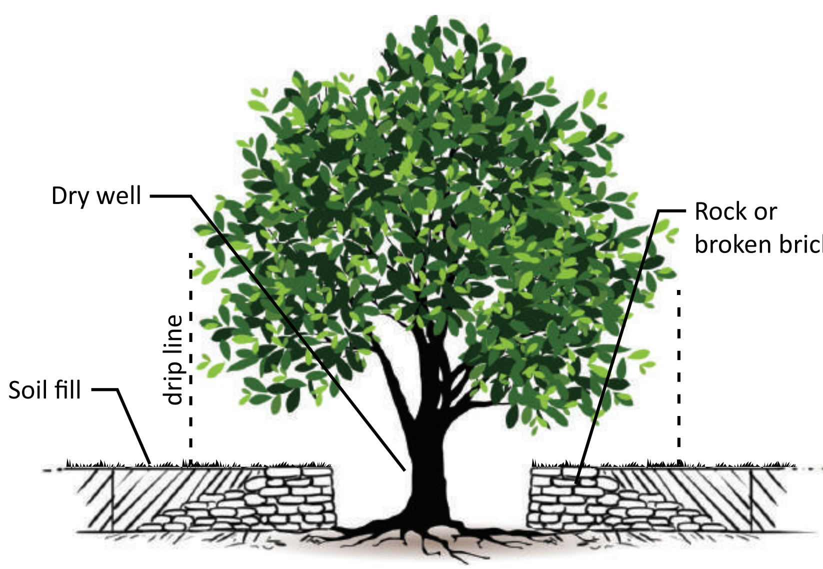


FIGURE 25 Section of a dry well constructed to protect existing tree on site

» A Handbook of Landscape, Central Public Works Department, 2013 recommends to plant native trees on site for all major planting schemes.10 Native, drought-tolerant, and low-water-use plants in the region should be used, as once established they require very little to no additional water beyond normal rainfall. The use of exotic species should be curbed. As native species, they are part of the ecological balance that involves feeding the pollinators in return for pollen dispersal, and providing food and habitat for different kinds of local wildlife. Native trees are also easily adaptive to local climate and provide shade and cooling as well. Apart from being aesthetically significant, the trees contribute to urban greening.

The 'Simplified Landscape Irrigation Demand Estimation' which is used to estimate the water demand of established landscapes takes into account the plant factors (fixed plant constants) which are empirical snapshots of species-specific plant architecture (aerodynamic interaction with wind) and highly dynamic biological (stomatal pore opening and closing) control of transpiration.11 Plant factors of native species such as trees, shrubs, and adapted deserted plants are low, resultantly their water requirements are drastically low as compared to exotic species.

» Residential townships having the podium design on site should do more landscaping on the ground than on the podium in order to reduce the water use.

» Turf areas (grass/lawn) both on podium and on the ground should be minimised as they require more water for maintenance. If turf area has to be designed, water-efficient varieties such as native Indian grass should be used.

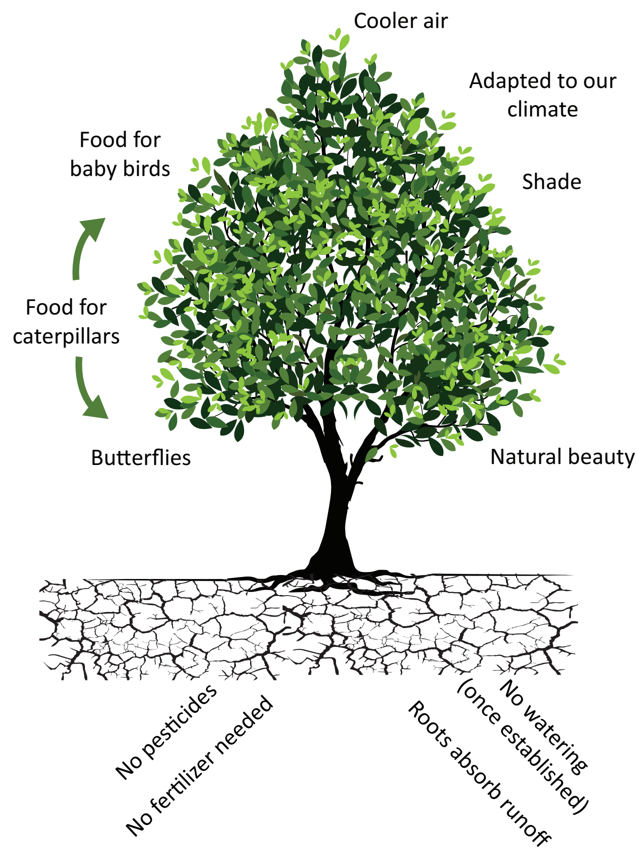


FIGURE 26 Benefits of planting native trees

» Plants should be grouped into 'hydro zones', clustering together plants with similar water requirements tend to conserve more water.

» On both podium and ground, it is preferred to use shrubs instead of grass as shrubs require less maintenance, help in the moisture retention, and are flowering.

» If trees are to be planted on podium, point load trees such as Bauhinia (mandarani), Creteva (mavalingam), shrubby cassias, ixora (vetchi) trees, muraya paniculate, henna, dwarf mango varieties, gooseberry trees, lemon trees, pomegranate trees, native medicinal trees such as adathoda, nochi, etc. which have shallow root system and extend straight down the soil, should rather be used than the ones having long lateral roots which could damage the structure.

10 Details available at <https://cpwd.gov.in/Publication/LandscapeBook.pdf>

11 Details available at <https://ucanr.edu/sites/UrbanHort/files/248814.pdf>

FIGURE 27 Replacing turf area with native plant species in a backyard of a facility

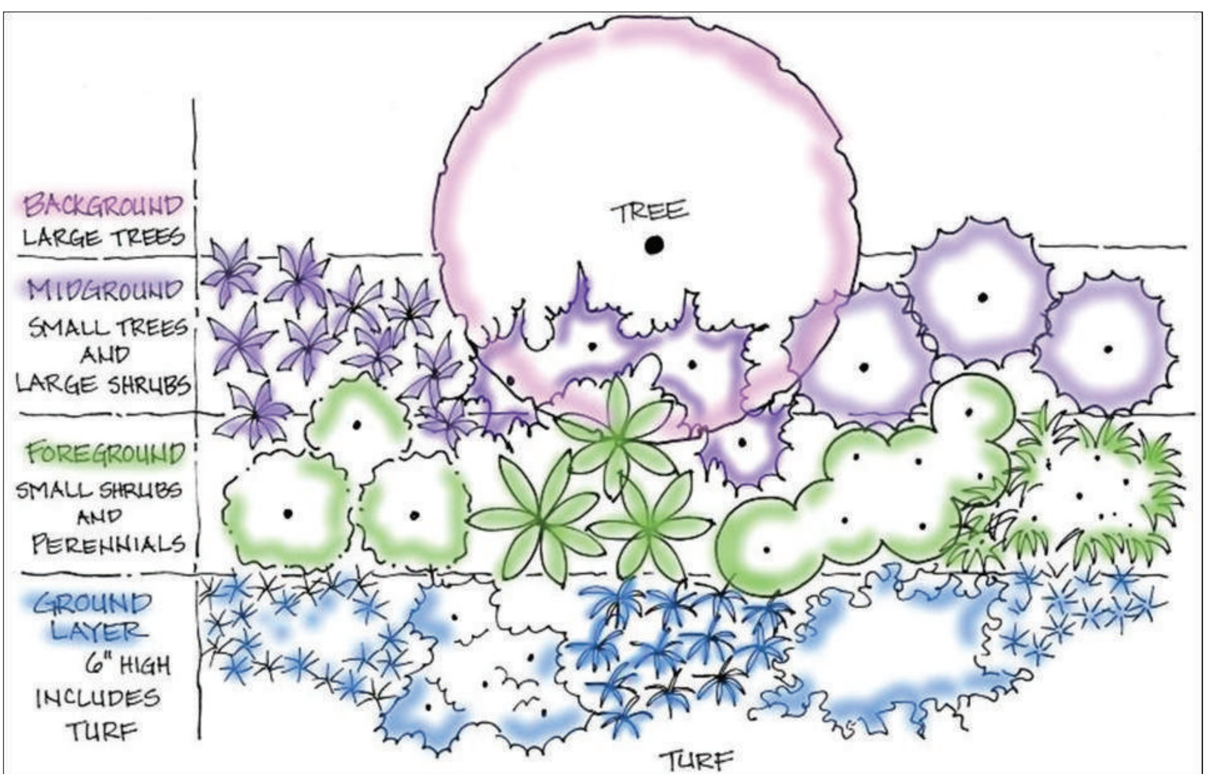


FIGURE 28 Plan view showing similar water requirements plants arranged together in layers, from front to back

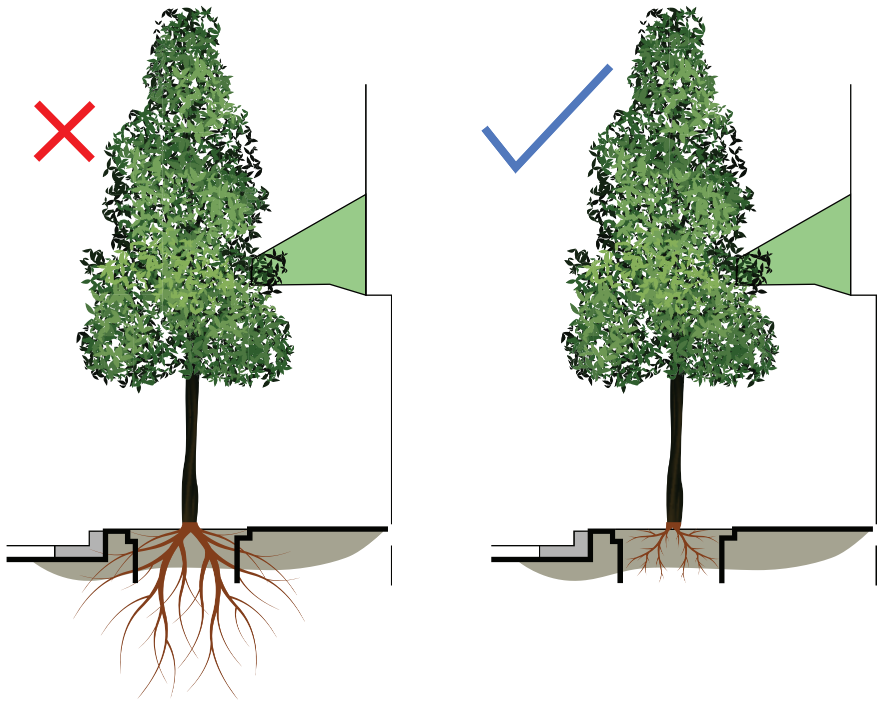


FIGURE 29 Trees with shallow root system should be planted on the podium

- Incorporate trees to your landscape that provide shading. Plant small shrubs near large trees that provide shading as shaded areas typically require less supplemental water than areas exposed to direct sun.

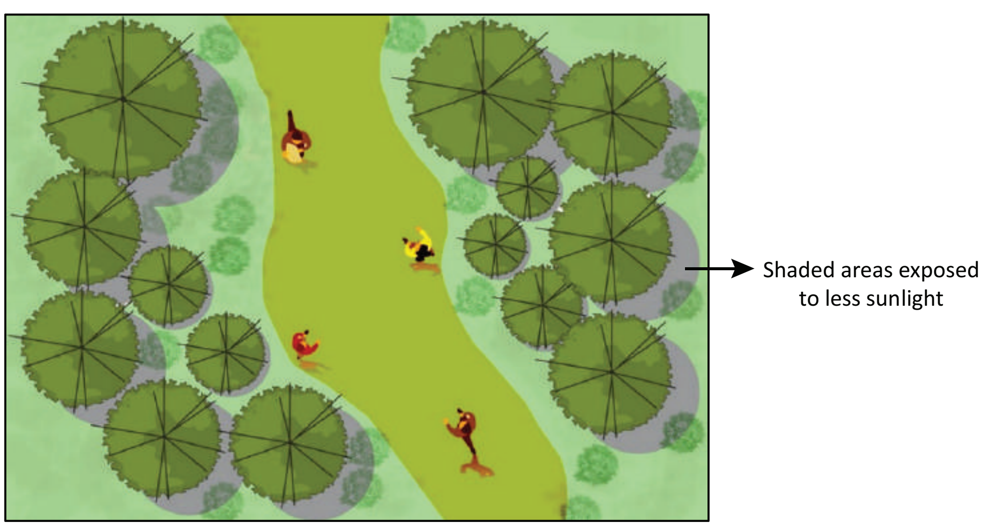


FIGURE 30 Plan of a typical landscape with trees providing shade

- Drip irrigation system for watering trees and shrubs should be considered as it delivers water directly to plant roots at a low flow rate, avoiding water loss due to runoff.

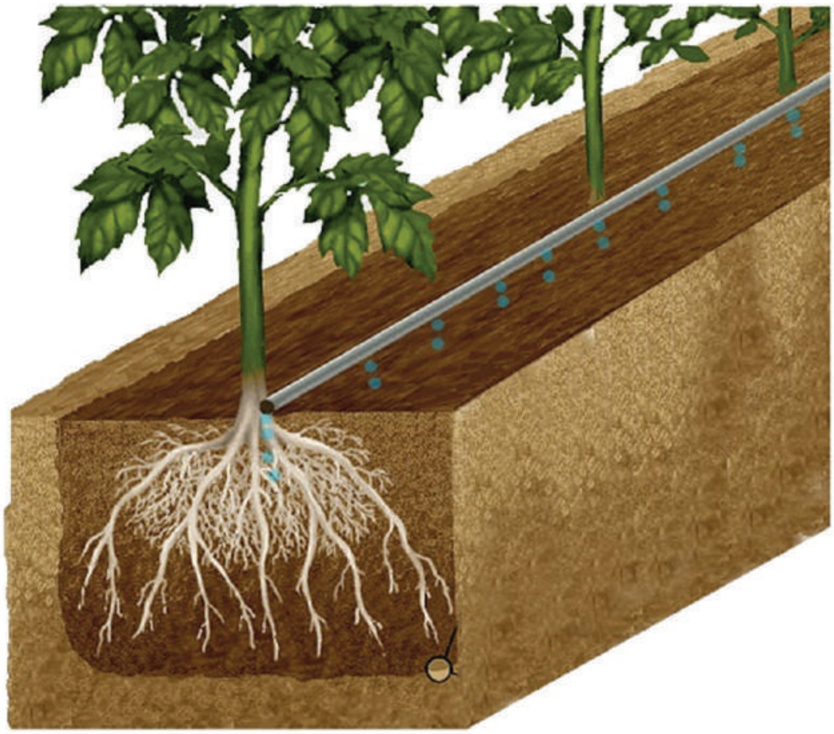


FIGURE 31 A typical drip irrigation system being used for watering the plants

» Generally, trees are planted on the site's boundary, this provides shading to the adjacent plot. Contrary to this, trees should be planted on site in such a way that their shade is utilised. Therefore, shrubs should be planted on the boundary and trees should be planted on the other side of the road (between road and the pedestrian pathway/cycling track) so that it shade could cover both the road and the pavement inside the facility.

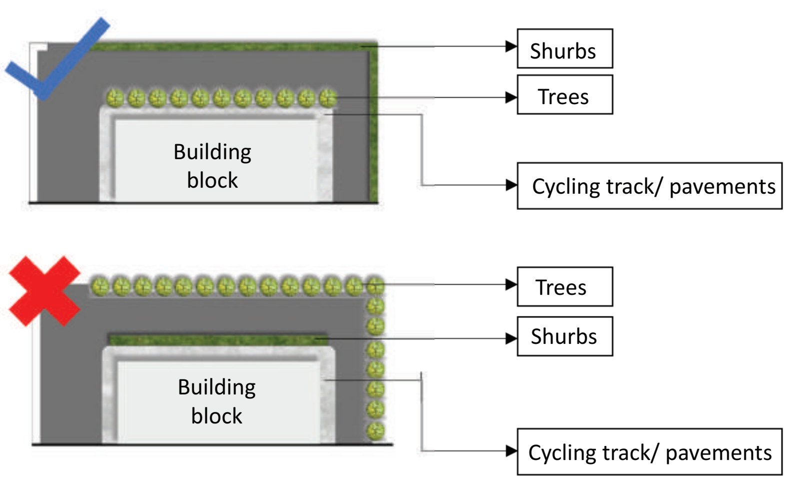


FIGURE 32 Efficient utilization of trees by planting them inside the facility provides shading to both the road and the pavement

Landscape—operation and maintenance

Landscaped area should contain lot of good topsoil as it helps capture precipitation when it falls and directs water back to the plants over time, thus reducing the water requirements. Topsoil refers to the uppermost layer of soil, usually 2–8 inches in depth, and contains most of the ground's nutrients and fertility which help in promoting plant growth. A good topsoil is the one which has mixture of sand (40%–65%), silt (20%–60%), and clay (5%–20%). This combination of elements in soil is sometimes referred to as loam, and is the ideal combination for the most topsoil.[12]

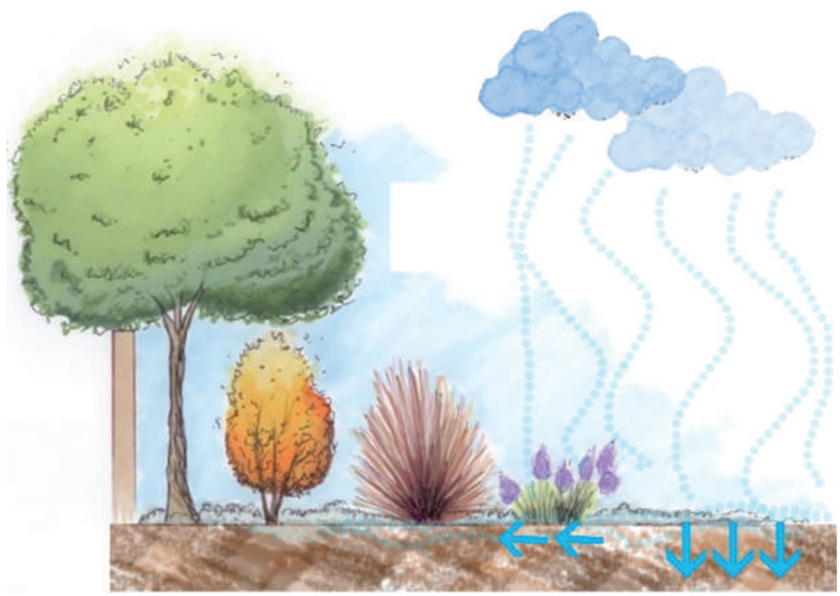


FIGURE 33 Good topsoil captures rainwater and thus reduces water requirements

» Watering of plants should be done either in early morning or evening as the temperatures are down during these periods, this prevents loss of water from evaporation.

» It should be ensured that the system pressure of water sprinklers operate according to the specifications laid down by the manufacturer for a uniform coverage, in order to make it work at its peak efficiency.

» Sprinklers should be adjusted to avoid wastage of water and ensure uniform distribution during irrigation.

» During retrofitting of irrigation equipment such as sprinkler nozzle, it should be replaced with the same manufacturer, also ensuring that it is compatible with the current equipment, for the system to work more efficiently.

» Full audit of irrigation system (both equipment and landscape design) should be done periodically, preferably in every 2 years by a professional team to check its performance, identify any shortcomings, and accordingly design solutions to improve it.

» Dedicated water meters should be installed, in order to measure and manage the amount of water used in landscaping.

12 Details available at <http://njaes.rutgers.edu/pubs/plantandpestadvisory/1996/ln0328.pdf>

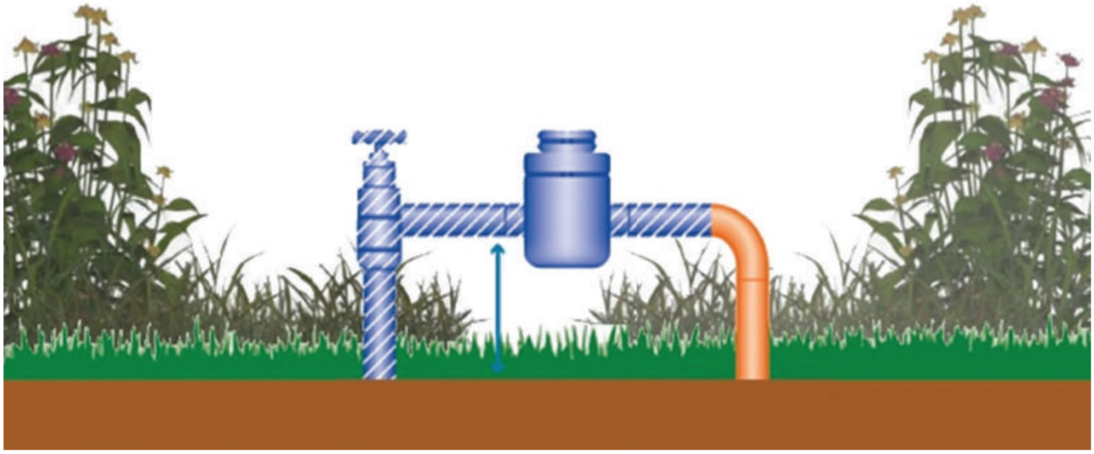


FIGURE 34 Water meter installed to measure the amount of water being used for irrigating the plants

- Training of staff for ensuring regular maintenance of irrigation systems and attending courses should be executed to learn more techniques on water efficiency.
- Drip irrigation system should always be on a pressurised line, duly equipped with a filtration system to avoid blockage.

Harnessing Alternative Water Sources

From an environmental perspective, using alternative sources of water which are not derived from fresh surface or groundwater sources can reduce demand for freshwater resources, diversify, enhance reliability of access to the resource and reduce volume of wastewater discharged into the environment. It can also contribute in reducing the energy required to transport water from the point of production to the point of use; and reduce greenhouse gas emissions (due to energy savings). Sustainable alternatives of water sources include the following:

» Harvested rainwater, storm water

» Treated wastewater

» Air-cooling condensate

» Rejected water from water purification systems

» Water derived from other water reuse strategies

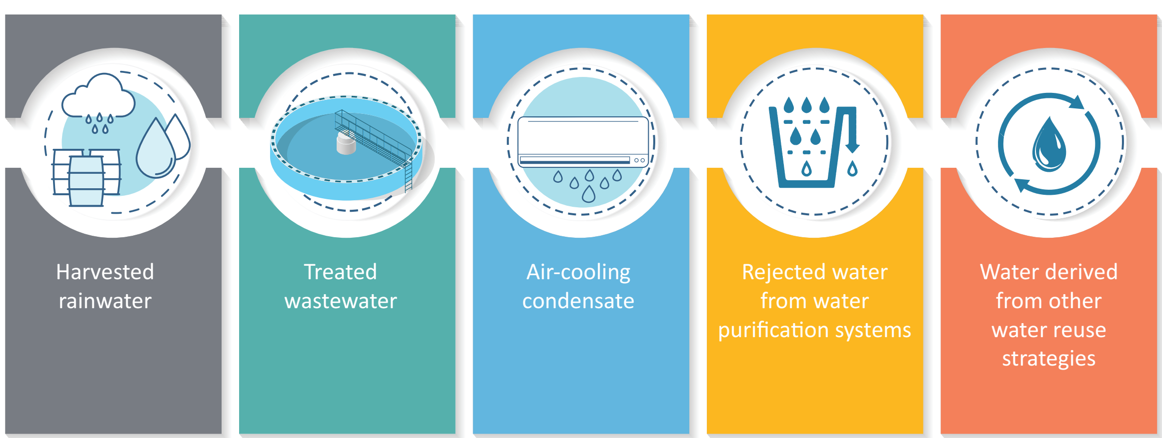


FIGURE 35 Sustainable alternatives of water sources

New Design and Retrofits

» Rainwater collected from rooftops can be easily channelized and stored directly in the raw water tank used for storing municipal or groundwater and used for domestic purpose. Another viable method for utilizing rainwater is to store it in the tank containing treated water from STP, however, such water should only be used for flushing or irrigation purpose. This evades the need for designing a separate rainwater tank, thus saving money and space.

The best option is to store and reuse the rainwater collected from rooftops as it is cleaner than rainwater collected from site.

One of the examples of efficient harvesting of rainwater in residential township can be cited from Tengah Sustainable Township in Singapore where rainwater is collected from rooftops and stored to wash common areas and water plants[1] The new system reduces the usage of potable water for block washing at void decks, refuse chutes, and corridors. The facility makes use of a smart irrigation system which is equipped with moisture sensors that switch off the scheduled watering once enough water has been sprinkled. This allows easy maintenance of the greenery and landscape while saving tonnes of water.

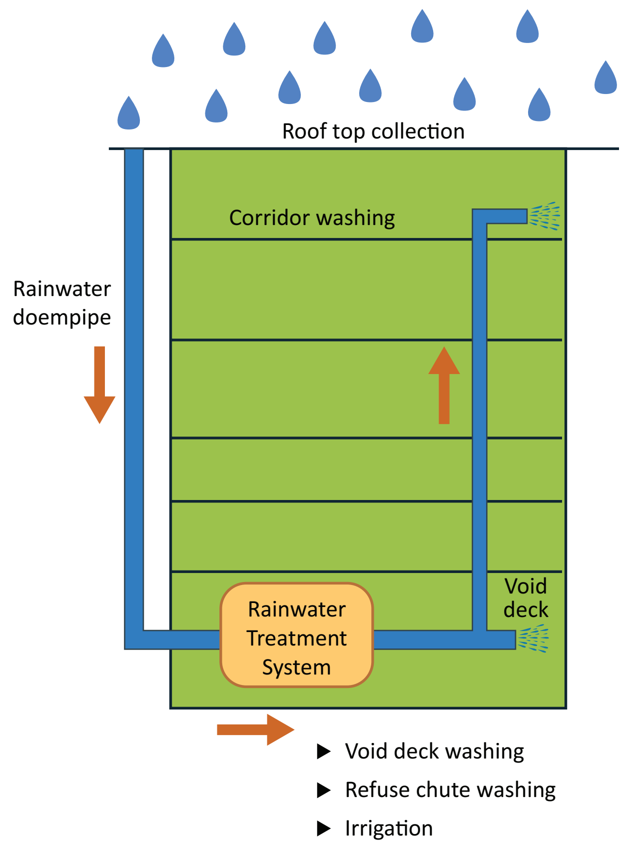


FIGURE 36 Rooftop rainwater harvesting in towers of Tengah residential township in Singapore

In another example, in Potzdamer Platz, Berlin, a historic square built in 1998, as part of DaimlerChrysler Potzdamer Platz, the Urban Waterscape, showcases rainwater harvesting at the urban redevelopment scale.[2] Rainwater is harvested from the rooftops of 19 buildings with a total catchment area of 50,000 sq. m. A little more than half of the 23,000 cu. m (approx. 6 million gallons) of rainwater harvested annually is used for landscape irrigation and for the pools and canals at the development site. Remaining water is used in the buildings to flush toilets and urinals, and as supply for fire-suppression systems. On an average, 80% requirement of the annual water usage for the toilet and urinal fixtures is met through rainwater.

» Selection of the type of sewage treatment technology depends on the building typology and type of wastewater generated by it. However, currently it has been observed that generally same technology is used to treat different types of wastewater, thus, reducing efficiency of the treatment. In case of residential township, black water is generated more and accordingly the STP should be selected for installation on site.

» Segregation of black3 and grey[4] water for increasing the water-treatment efficiency: The major challenge that hampers the reuse of treated water is common plumbing system which lets off all types of wastewater into common municipal drains/ septic tanks/soak pits instead of collecting black and grey water separately and treating it. The implications of this type of common disposal are overloading of the municipal sewerage system, wastage of reusable grey water and additionally leading to hazardous environmental and public health impacts.

1 Details available at <https://www.mytengah.sg/tengah-breaking-frontiers-in-smart-and-sustainable-townships-in-singapore/amp/>
2 Details available at <https://land8.com/potsdamer-platz-in-berlin-becomes-a-sustainable-ecofriendly-urban-square/>
3 Black water is any waste from toilets or urinals.
4 Grey water is wastewater that has been used for washing, laundering, bathing or showering.

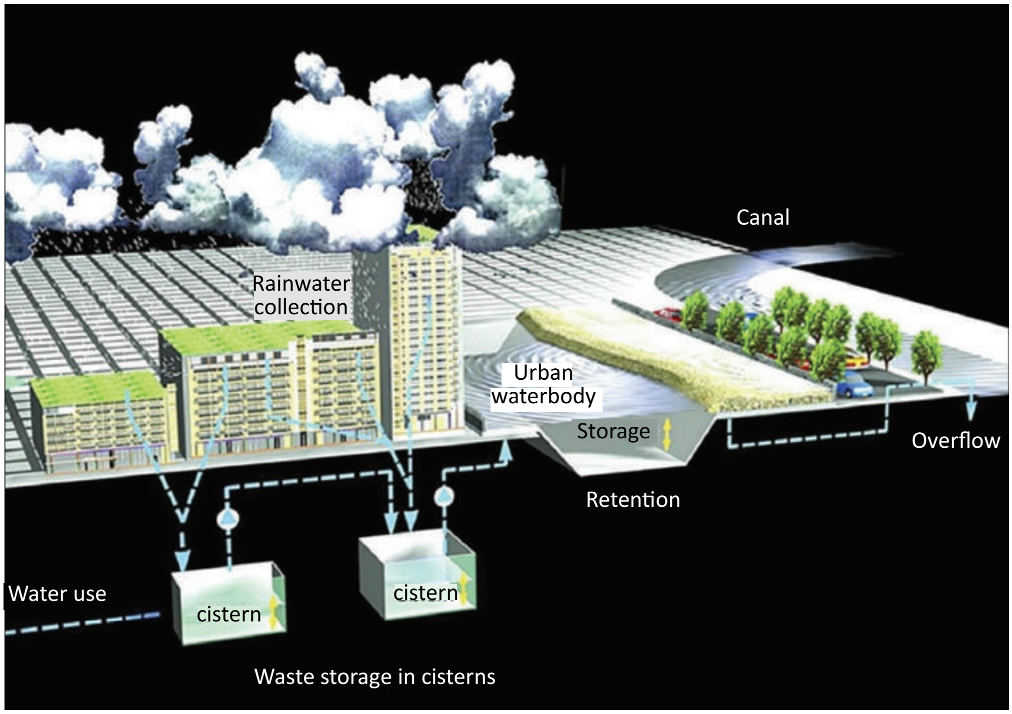


FIGURE 37 Storm water management of Potsdamer Platz, Berlin[5]

As grey water is less contaminated than black water and responsible for around 62% of the total building water demand hence less filtration systems or minimum efficiency of filters can treat the available grey water on site and provide the required parameters of treated water as defined by Central Pollution of Control Board (CPCB). Grey water, being a potential substitute for freshwater for a variety of uses, can be utilized for both domestic and industrial applications. On the other hand, black water is more polluted and represents only 26% of the total building water demand. Hence, project should install high-efficiency filters, only for 26% of the black water and not for the 100% wastewater generated on site which directly impacts the installation cost of wastewater treatment system.

On the basis of the discussion, it can be established that townships should install sewage treatment plant for treating grey and black water separately.

For example, in Masdar city of Dubai all the building are designed with a unique water management system. Potable water enters the building for personal consumption and bathing.[6] Treated wastewater also enters the building for toilet flushing use. Grey and black water are passed out of the building for treatment and reuse. The water treatment and wastewater treatment plants are centrally located due to the large central demand for each of these treatment streams.

In India, a residential apartment in Saidapet, Chennai has set a great example of wastewater segregation and recycling. It has been recycling grey water for 16 years now by developing the necessary infrastructure at the

5 Details available at <http://www.dreiseitl.com/en/portfolio?region=all&typology=all#potsdamer-plaza>

6 Meghan Hartman, CH2M HILL; Mark Bone Knell, MASDAR; Jay Witherspoon, CH2M HILL CH2M HILL PO BOX 35248 Abu Dhabi, United Arab Emirates

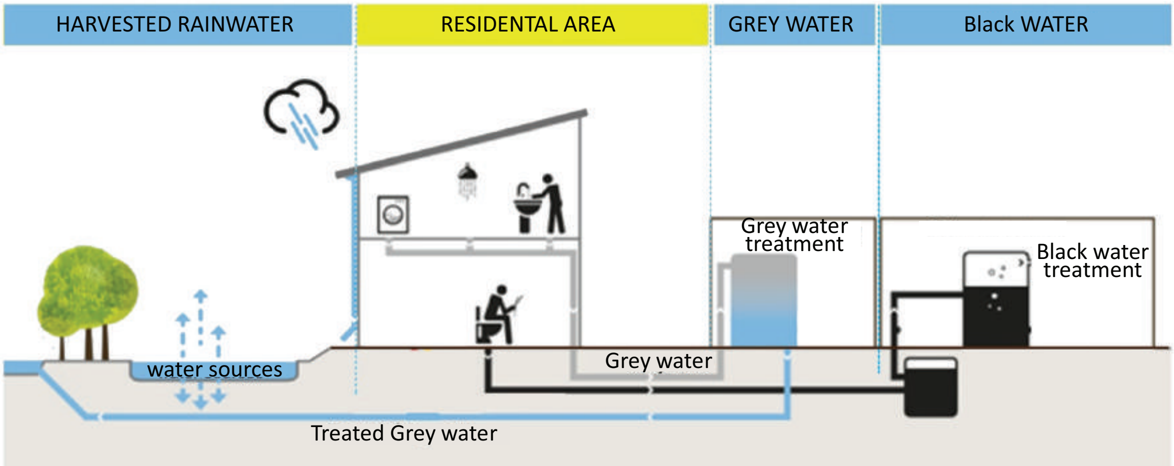


FIGURE 38 Separate waste treatment plants installed at the facility to treat grey and black water separately

construction stage itself. Through separate pipelines, grey water is diverted to a bed of water-loving plants. Owing to this, the apartment has been able to reduce reliance on private water tankers, the groundwater dries only during the peak summer season (around May), unlike in other apartments who are forced to buy water from February month itself.

FIGURE 39 Indukanth S Ragade, a grey water recycling expert initiated the procedure at an apartment in Saidapet[7]

» It is suggested to use multiple small modules of STP instead of a single big unit in a residential township. This is because the occupancy in a township varies from time to time and wastewater treatment plant efficiently works only when amount of wastewater generated and going into STP is more than 80% of the capacity, which is not the case always. When the wastewater generation is low, many a times people add freshwater to it to increase its capacity to 80% so that the STP works efficiently, but this is accompanied by

7 Details available at <https://chennai.citizenmatters.in/world-water-day-saidapet-apartment-chennai-grey-water-recycling-3860>

a lot of freshwater wastage. Else they use the STP for long intervals which reduces the system's efficiency. Therefore, it is suggested to install multiple small modules of STP. This basically means to have multiple filtration system but the same one storage tank. When the wastewater generation is less than 80%, depending on its quantity, number of modules can be used accordingly. In this way, the system's efficiency is increased and energy is saved. The number of modules of STP for a site can be decided according to the site's variation in occupancy.

» A standard process for disinfection of an STP includes chlorination, ozonation, ultraviolet, and activated carbon absorption. It is suggested to not include chlorination process as it is required only for treating clean quality of water such as drinking water and not for contaminated water such as treated water from STP. If done, this can become hazardous. If the chlorination is mandatorily required for treating the wastewater from STP, it should be done at the end after ozonation, ultraviolet, and activated carbon absorption.

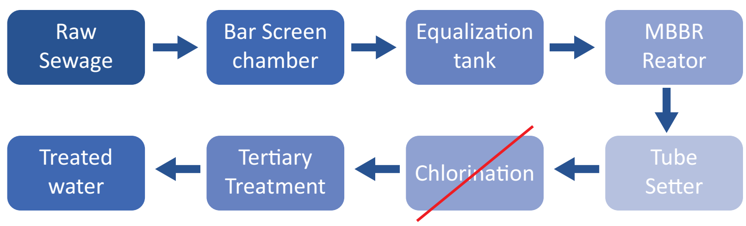


FIGURE 40 Standard STP process excluding chlorination from contaminated water treatment

» For wastewater treatment in buildings, a new type of technology known as ECO STP is becoming quite popular in India. Most STPs in use in India today work with aerobic bacteria. This requires continuous use of air and hence regular power is required to operate the STP. An ECO STP, on the other hand, works with anaerobic bacteria, which cleans water in a natural and chemical-free manner. This technology treats sewage in a decentralised, self-sustainable way in underground chambers without involving power, chemicals, or human intervention and makes use of gravity and other natural gifts unlike pumps/blowers used in conventional treatment plants. The ECO STP utilises functional principles and strategies of microorganisms and ecosystem found in a cow's stomach. It uses a combination of microorganisms, plants, and gravel to clean sewage water and return clean water back, completing the sustainable life cycle. As a result, unlike conventional plants, this system is cost effective, has low operational and maintenance expenses and can be designed to suit existing land-use planning. The space above the ECO STP can be used for parking lots, playgrounds, landscaping, etc. The treated water adheres to all pollution control board PCB norms.

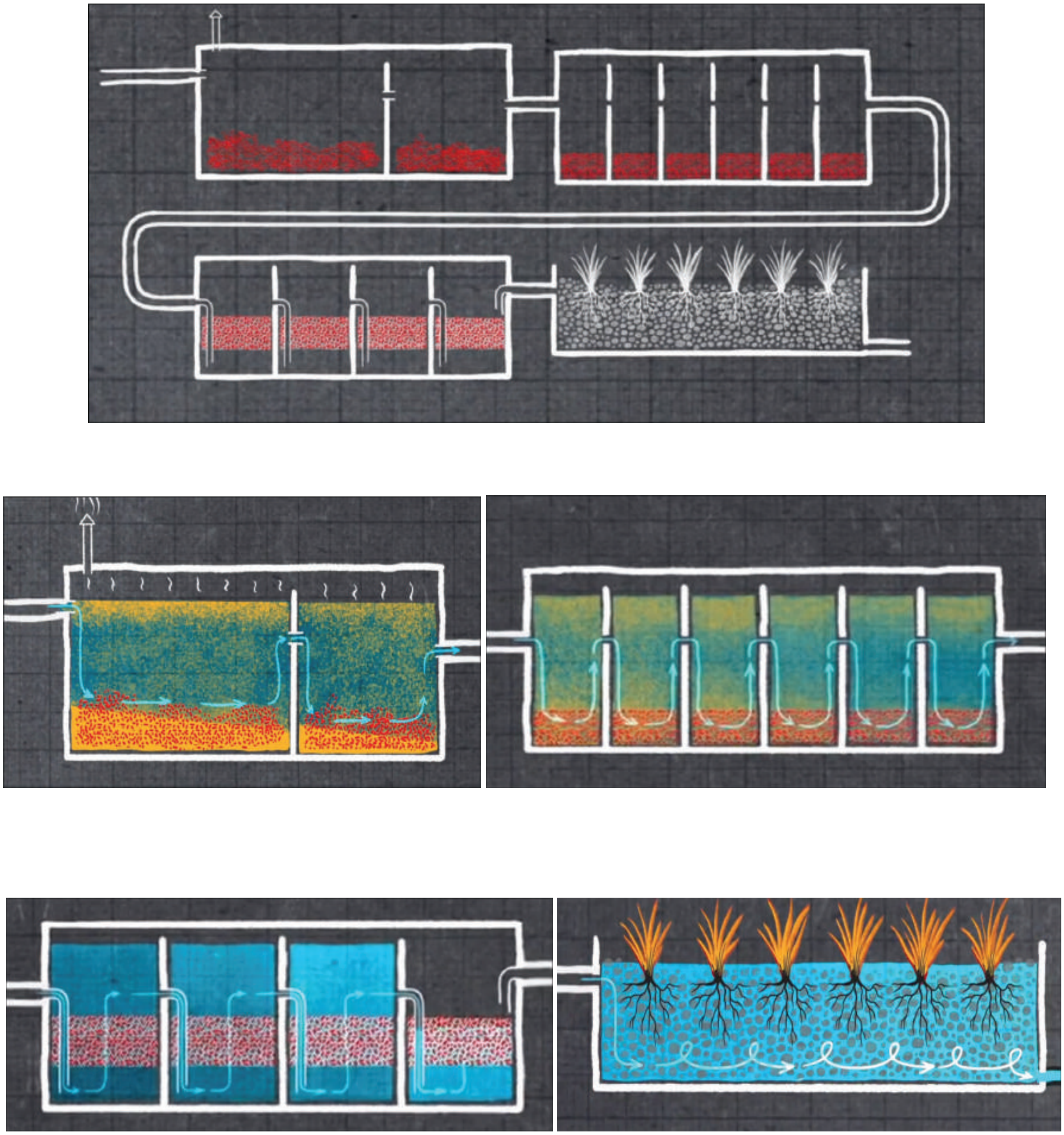


FIGURE 41 A typical gravity-fed ECO STP design, developed by Mr Tharun Kumar, Founder, ECOSTP Technologies Private Limited[8]

Steps involved in the sewage treatment using ECO STP method use bacteria from cow dung, with no blower motors and power, and uses gravity to move the sewage. As solid waste sinks to the bottom and the rest is converted into gas and clear water after passing through tanks and plant bio-filters, this clean water can be used for irrigation and flushing purposes.

8 Details available at <http://www.ecostp.com/about-us/>

For example, in Aishwarya Amaze Apartments, Bengaluru, the DTS ECOSTP developed by Ecoparadigm is being used for the last six years. The Apartment uses a complete natural process to treat the on-site generated waste. The treated water is run through a plant bed consisting of Canna and Colocasia plants. The final water is used for toilet flushing and involves minimum maintenance.

FIGURE 42 Plant bed in Aishvarya Amaze Apartments uses treated water from an ECOSTP

Operation and Maintenance

» The first flush diverters should be used for diverting the first initial downpour to storm water drains instead of an in-storage tank as it is contaminated and filled with sediments that washes into the pipes from the roof. Once the roof gets cleaned after the first initial millimetres of rain, the rainwater from rooftop can be diverted to the storage tank. Basic filtration should be done before diverting the rainwater to fire water tank, then raw water tank, and finally into the water treatment plant.

Integrating Green Infrastructure

Green infrastructure is based on the principle that protecting and enhancing nature and natural processes should consciously be integrated into spatial planning and site development. It is an approach to water management that protects, restores, or mimics the natural water cycle. Green infrastructure solutions can be applied on different scales, from the house or building level, to the broader landscape level.

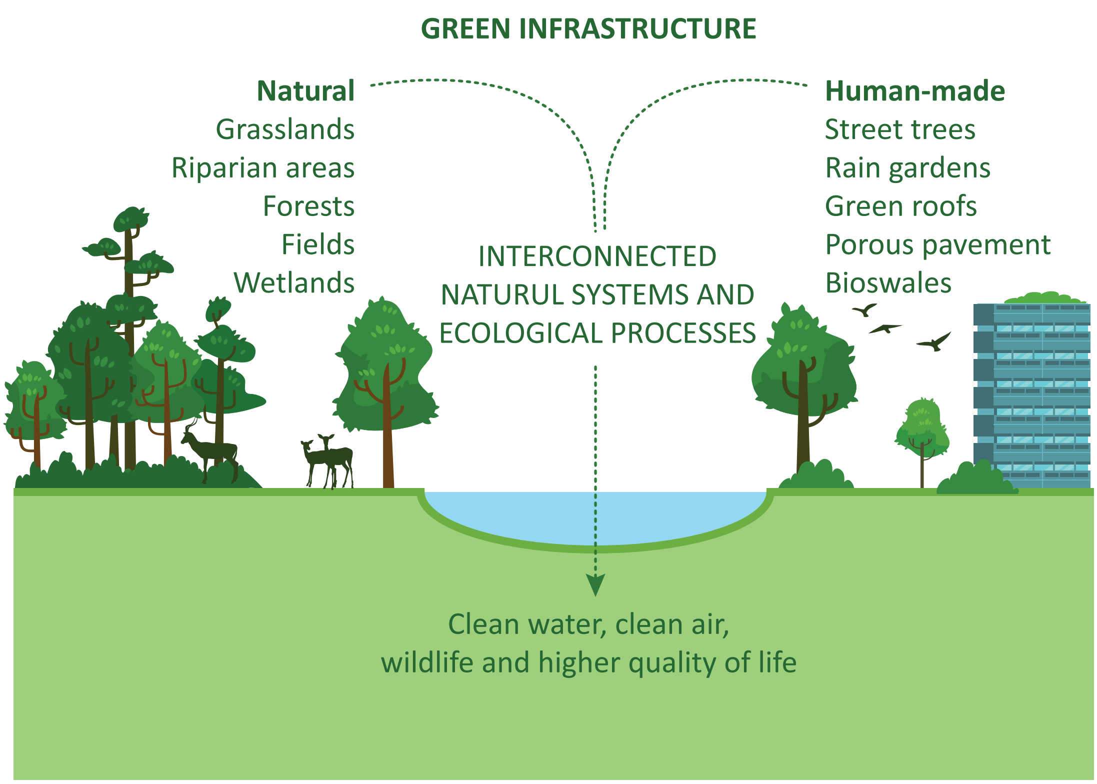


FIGURE 43 Components of green infrastructure[1]

It is a strategy for mitigating the harmful impacts of urban storm water runoff. It offers a variety of cost-effective solutions to many of the water challenges such as flooding, storm water pollution and excessive runoff faced in residential townships. It incorporates natural infrastructure, enhanced solutions and engineered systems to provide clean water, conserve ecosystem values and functions, and provide a wide array of benefits to people and wildlife.

1 Details available at <http://www.metrovancouver.org/services/regional-planning/PlanningPublications/ConnectintheDots.pdf>

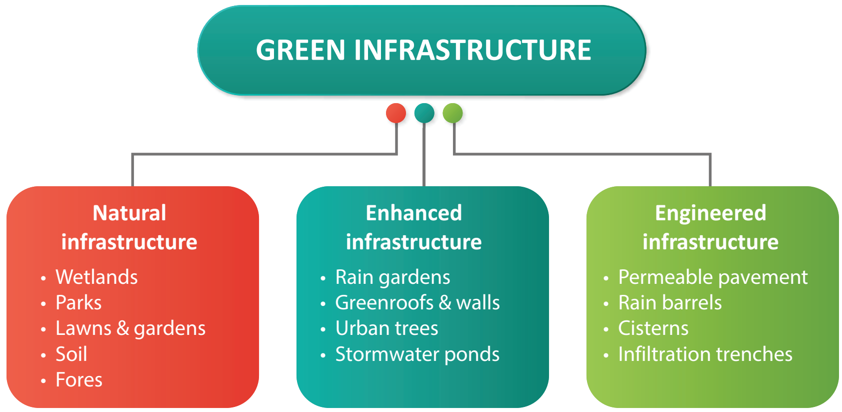


FIGURE 44 Types of green infrastructure and their examples

These systems have the capacity to capture, infiltrate, treat, and convey urban runoff safely into the natural environment to avoid pollution, flooding, and many other unintended consequences. These systems have been found to eliminate over 90% of pollutants that were commonly found in roadway runoff by infiltrating through soils and plant tissues. In addition to natural infrastructure, enhanced and engineered systems such as green roofs, bioretention cells, and permeable pavements are capable of retaining 50%-70% of annual storm water runoff when maintained properly.

On the local/building level, green infrastructure practices include rain gardens, permeable pavements, green roofs, infiltration planters, trees and tree boxes, vegetated rooftops, rainwater harvesting systems and other measures that capture, filter and reduce storm water, and turning rainfall into a resource instead of waste. It also increases the quality and quantity of local water supplies and provides a number of other environmental, economic, and health benefits—often in nature-starved urban areas.

FIGURE 45 Components of green infrastructure link together to form a functional network[2]

2 Details available at <http://www.metrovancouver.org/services/regional-planning/PlanningPublications/ConnectintheDots.pdf>

New Design and Retrofits

Basement construction for parking and other miscellaneous purposes has become an integral part of almost all the residential townships. Owing to its central location, groundwater recharge pits are therefore generally constructed along the periphery of the plots. This causes flooding due to concentration of pits in one area. Once the pits reach their recharge capacity, overflowing occurs, resulting in flooding. The solution to this problem is to design and construct a recharge pit in a 16-column grid in the basement with centre space being used as a shear column which is hollow from inside and filled with aggregate. This shear column acts as a load-bearing structure and can also be used as a localised recharge pit by diverting rainwater for recharging groundwater. This ensures even distribution of recharge pits across the site, thus reducing chances of flooding. The size and number of recharge pits in the basement shall depend on the structural design of the building and the site's storm water management requirements.

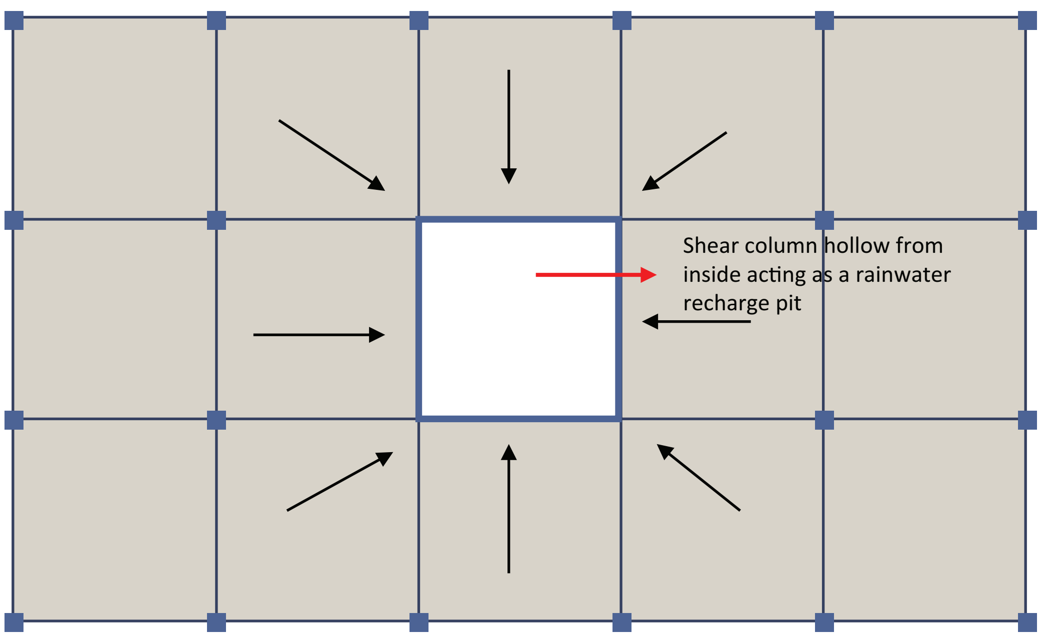


FIGURE 46 Shear columns in basement acting as groundwater recharge structure

» Provide baffle walls at a few points within the storm water drains. They intercept the storm water flow and direct it into a recharge pit via desilting chamber. They act as a part of the rainwater collection system through storm water drains which trap the trash/debris and remove sediments before the water is channelized into the recharge pits or storage tank.

For example, to improve the quality of storm water runoff in New Brighton, Minnesota, one such placement at the intersection of Rice Creek Road and Long Lake Road was installed. 3 It receives storm water runoff from a 4.2-acre site, residential watershed that is approximately 55% vegetated and 45% impervious. Storm

3 Gulliver, J.S., A.J. Erickson, and P.T. Weiss (editors). 2010. Stormwater Treatment: assessment and maintenance. University of Minnesota, St. Anthony Falls Laboratory. Minneapolis, MN. Details available at <http://stormwaterbook.safl.umn.edu/>

water influent is introduced tangentially to the swirl chamber, inducing a swirling motion inside the manhole. Relatively heavier particulates contained in the storm water (sands, trash, etc.) settle out of suspension in the swirling chamber. Storm water escapes the swirling chamber by overflowing standpipe in the middle of the manhole, where the water is conveyed to a floatable trap. Buoyant material (hydrocarbons, cigarette butts, some organic matter, etc.) that pass through the swirling chamber via the overflow standpipe are retained in the floatable trap since water must travel beneath the baffle wall to escape the system. Downstream of the device, the effluent from the discharges into a reinforced concrete pipe, which eventually empties into Long Lake. The distance between pipe inverts and manhole inverts is approximately 4.5 feet in each treatment manhole. One access point is provided to the swirl chamber, and one access point on each side of the baffle wall in the floatable trap.

» For an efficient management of storm water runoff and to enhance the groundwater recharge, desilting chamber and grease removal traps should be integrated on the site as per the requirement. Desilting chambers act as an important part of the rainwater harvesting system which helps in the removal of 90% of the suspended particles from the water before being discharged into the storm water drain or to a recharge structure. On the other hand, grease removal traps ensure that the grease from open parking and diesel generator DG set areas doesn't flow out and mixes with the storm water.

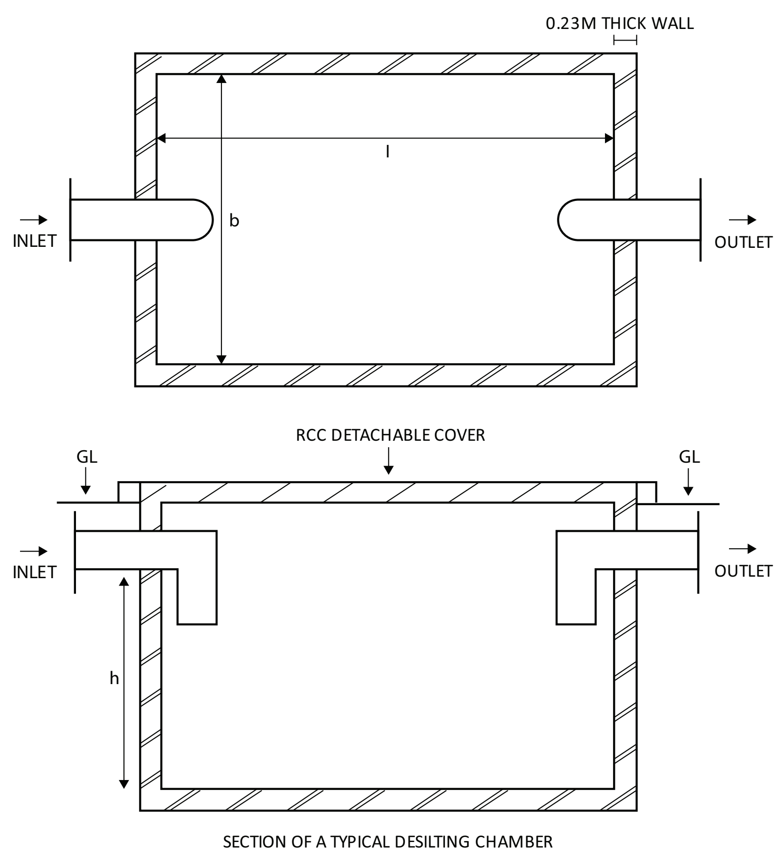


FIGURE 48 Plan and section of a typical desilting chamber

It is suggested that instead of channelizing storm water runoff out of the site into the drains, it should be trapped on site with increasing the localised groundwater recharge using methods such as vegetative swales, rain garden, permeable sewer, etc. This shall help in reduction of contamination of storm water runoff in addition to increasing groundwater levels.

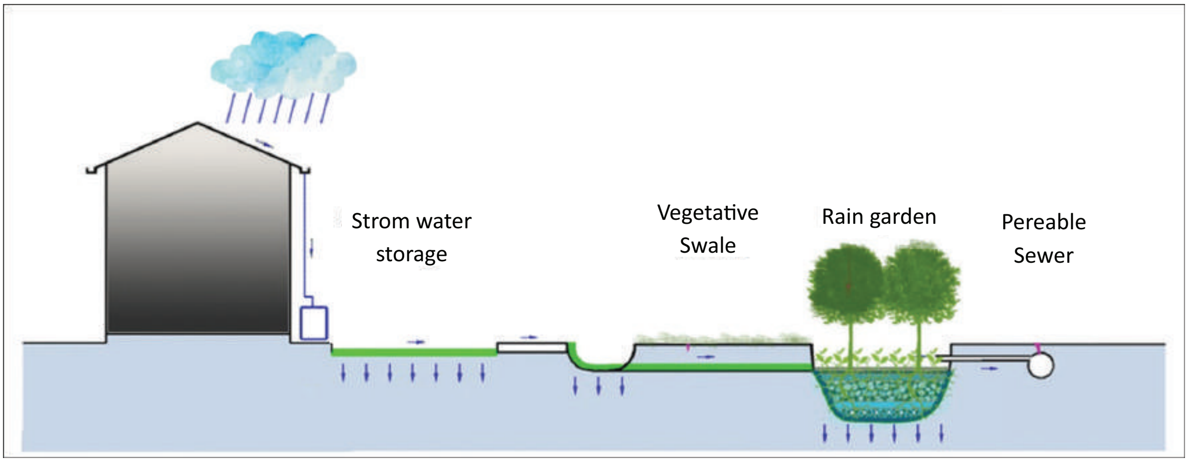


FIGURE 49 Various methods for channelizing storm water on site

For example, in residential development in Montgomery Township, New Jersey, specifically, a mix of 218 single-family and duplex units were designed and developed over a 138-acre parcel, preserving over 30% of it and incorporating green infrastructure measures, including preservation of wooded areas, bioretention basins, water quality swales, rooftop disconnections, porous asphalt, and forested retention, throughout.4

4 Details available at <https://www1.villanova.edu/content/dam/villanova/engineering/VUSP/2019Sympresentations/3c/1%20Andrew%20Smith%20-%20Green%20Infrastructure_rev.pdf>

FIGURE 50 Green infrastructure measures implemented in Montgomery Township, New Jersey

Operation and Maintenance

» General maintenance of the desilting chambers, filter media, etc. should be carried out before monsoons to ensure that clogging doesn't happen.

» A 5-yearly impact assessment can be done for the water recharging system which has been proposed on site to check whether these systems are performing properly and recharging the groundwater tables as required.

» For designing the filter media of recharge structures, instead of sand only gravel and other aggregate could be used as chances of saturation of sand is higher due to which it hinders the movement of water penetrating downwards.

User Behavioural Changes

Water plays a key role in sustaining life and building the social structures. As the water resources are becoming scarce, conservation of water has assumed high priority around the globe. There are two main categories of water-saving measures to reduce water use:

(1) Technical measures include a network improvement, repair of leaks, and developing water-efficient appliances.

(2) Non-technical measures cover information, education, and awareness which can change the consumer habits.

Water-saving practices if adopted by residents can significantly reduce water consumption thus conserving natural resources and supporting environmental stability. Given below are some of the viable ways, if introduced as behavioural changes in users could help in realizing water saving:

» Turn off the faucet when you are brushing your teeth or shaving. Turn off your faucet after you wet your toothbrush or razor, and leave it off until it's time for your rinse.

» Turn off the faucet while you are washing your hands. Use a squirt of soap, lather, and turn on the faucet to rinse. Use water only after you are done with your lather and ready for your rinse.

» Use low-flow dual-flush toilets, low-volume showerheads and water faucets.

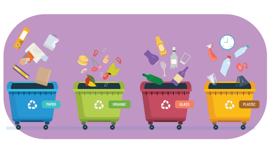
» Use water-efficient appliances. Automatic washing machines and dishwasher should be used on full loads only.

» Leaking faucets and toilets must be repaired and all faucets should be closed when not in use.

» Reduce the time for shower, instead use filled bucket as it uses less water than shortest showers.

» Water the plants in the morning when the temperature is cooler, as less water will evaporate.

» Wash fruits and vegetables in a pan or pot of water instead of letting the water run from the faucet.



» Segregate household garbage according to the type of waste generated such as organic waste, paper waste, glass waste, plastic waste, etc. Avoid using plastic items. These measures will reduce pollution of rivers and lakes.

» Strengthen outreach by organising awareness workshops for the residents of the townships, educating them on the importance of adopting sustainable practices to replenish and conserve water.

» Encourage your family to keep looking for new ways to conserve water in and around your home. Form a group of water-conscious people and encourage your friends and neighbours to be part of this mission. Promote water conservation need and methods in community newsletters and on bulletin boards.

The Mahindra–TERI Centre of Excellence (MTCoE) is a joint research initiative of Mahindra Lifespaces (MLDL) and The Energy and Resources Institute (TERI). It focuses on developing science-based solutions for India's future built environment, with a view to reduce the energy footprint of the real estate industry.

The overall scope of the project includes standardization and measurement of building material, thermal and visual comfort study, development of performance standard matrices, guidelines and numerical toolkits and water-related activities for realising sustainable water use in habitats.

The Centre's exercise on sustainable water use in habitats is envisioned to look at a holistic way of managing water (water efficiency, conservation, and management) within a premise for sustained availability for all its consumers. The water sustainability city-level assessment, building-level water audits, and web-based tool is likely to generate awareness among relevant stakeholders including citizens, mitigate potential risks, and ensure efficient water-management at micro and macro levels. Furthermore, the outcomes of the study will help in development of policies and designing measures towards protecting the regions ecosystems, propagation and adoption of water-conservation practices, and strengthening water governance structure and administration.

The MTCoE is located at TERI Gram, Gurgaon–Faridabad Road,
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