Building Block for

Urban Water Management

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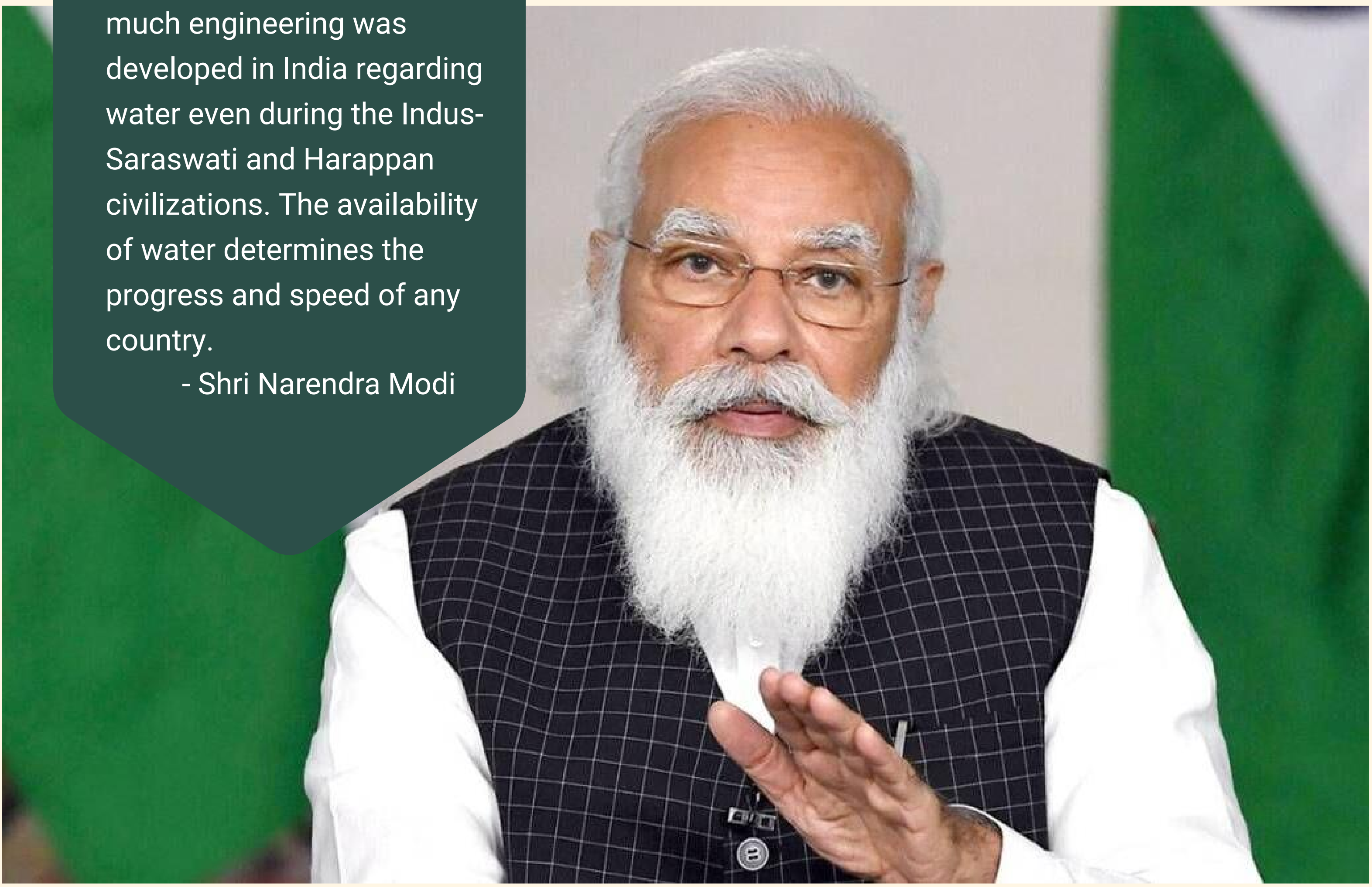
> “In Valmiki Ramayana, special emphasis has been laid on water conservation, on connecting water sources. Similarly, students of history would know, how much engineering was developed in India regarding water even during the Indus-Saraswati and Harappan civilizations. The availability of water determines the progress and speed of any country.
>
> - Shri Narendra Modi



Handbook for Urban Local Bodies Officers

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FOREWORD

The 74th Constitutional Amendment marks a landmark moment in India's realm of urban local self governance, creating urban local bodies (ULBs) constitutional entities with the authority to provide better governance and more effective delivery of civic services to communities. It is therefore important for the states to devolve greater responsibility, power, and resources to the ULBs through the devolution of finances and officials envisioned in the Twelfth Schedule to the Constitution.

Amidst unparalleled economic growth and a rapidly increasing population, India is faced with a series of difficult decisions regarding its future. With a 7.4 percent average annual growth rate during the previous decade, the country will become the world's fourth largest economy in approximately two decades. Indian Institute of Public Administration, New Delhi holds the cause of Namami Gange programme in high priority. We have developed a complete training programme under the project "Blended Capacity Building Programme for Stakeholders of River Ganga" The modules have been developed in a clear and easy-to-understand manner for the Urban Local Bodies. Though mostly based on missions of Namami Gange and state governing municipal administration, it lends itself to customization to meet the special needs of other states and river bodies.

This programme has been envisioned in a strategic step towards increasing the capacity of Urban Local Bodies. I am happy to note that the progress made in this direction will inspire masses to re-imagine the current scenario of the country and put together an integrated vision and process of Urban Planning. IIPA looks forward in working with other stakeholders of River Ganga too.

S.N. Tripathi IAS(R)
Director General IIPA

PREFACE

It is undeniable that Indian cities are experiencing a water shortage. Water shortages, flooding, groundwater depletion, and polluted water bodies have become frighteningly more common and intense in the last decade or two. A rising corpus of policy research shows that averting a larger disaster will necessitate a national focus on water security, backed up by effective institutions and management tools. The country has shown its desire for the former by undertaking a number of important water security measures. The National Mission for Clean Ganga, The Atal Mission for Rejuvenation and Urban Transformation (AMRUT), the Smart Cities Mission, the Jal Jeevan Mission, and the Jal Shakti Abhiyaan are just a few of them. As a result, at the highest level, a very favourable enabling environment has already been formed.

It is now critical to leverage on this to create an impact on the ground. Adopting a sound strategy for managing the water sector in cities is the first step toward making things right. One such idea that is widely acknowledged around the world, particularly in India, is Integrated Urban Water Management (IUWM). Despite its widespread appeal, however, the use of IUWM in Indian cities has been restricted. One of the causes of this anomaly is a lack of awareness and information about the finer points of IUWM among various stakeholders.

In the hope to qualitatively advance the Urban Water Management in India, the module is prepared for Urban Local Bodies by IIPA under the NMCG sponsored project "Blended Capacity Building Programme for Stakeholders of River Ganga." The module discusses the challenges faced by ULBs as well as the overall management of urban water with a focus on the Ganga basin states. It examines India's situation by laying out measures taken and implemented by local governments, as well as drawing on examples of best practices from around the world to establish long-term solutions. It is our sincere hope that this will benefit ULBs and local stakeholders, motivating them to work towards the common goal of River Rejuvenation.

Prof. Vinod K. Sharma **Dr. Shyamli Singh**

Faculty IIPA

Target Groups

District Collectors

Urban Local Bodies

Panchayati Raj Institutions

Academia

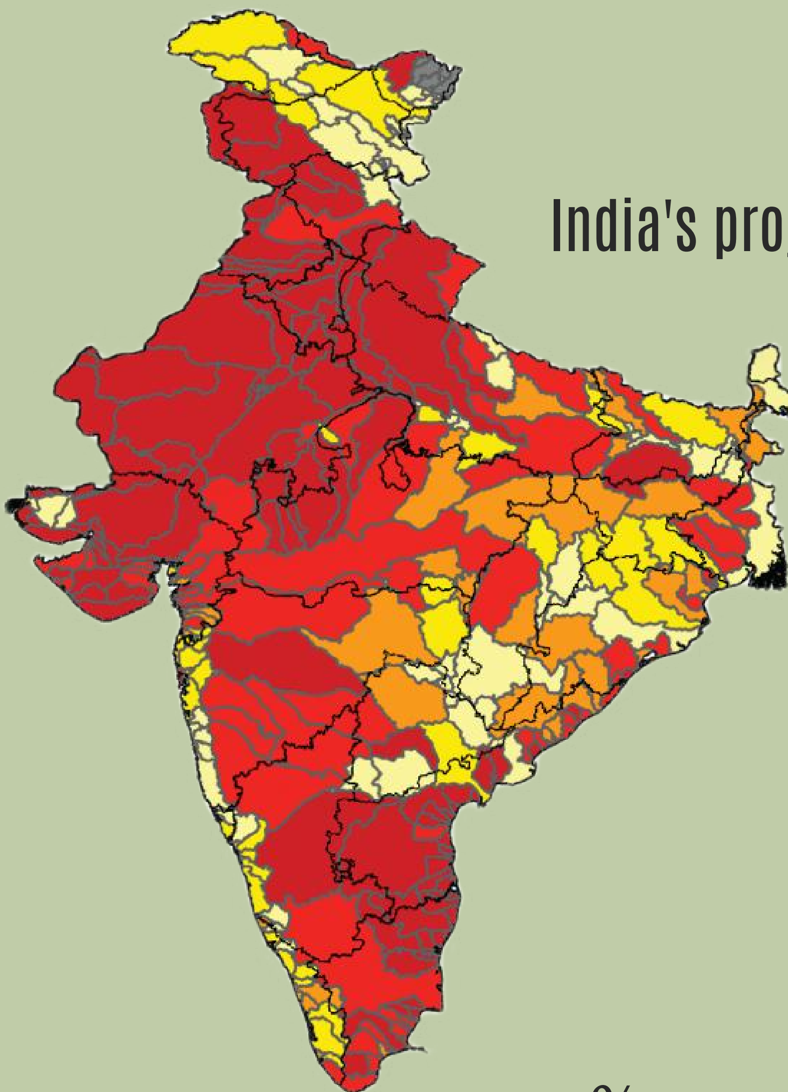
Introduction

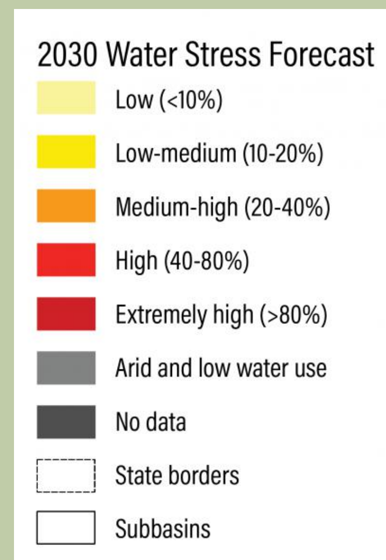
Water stress is a severe condition faced by urban spaces in India, mainly owing to rapid urbanization and population growth. This situation gets aggravated with archaic water infrastructure and governance issues. Many urban residents in India face water shortages while a great number die each year from contaminated water supplies. Many cities rely on groundwater as the net raw water resource for which they abstract heavy amount of groundwater. This has a direct impact on the health, safety and sanitation needs of the citizens.

Adding to this, Indian cities witness limited or no segregation of grey and black water discharges. Most sewage treatment plants function inefficiently and, consequently, most of the treated outflow does not meet the desired reusable water quality. A large part of wastewater is discharged into unlined stormwater channels, which leads to contamination of the stormwater drainages and the groundwater aquifers. As a result, the cities face water pollution concerns, such as high total dissolved solids, high electrical conductivity, variable amounts of toxic metal content, low dissolved oxygen, high biological oxygen demand, high chemical oxygen demand, and presence of E-coli in piped water and groundwater due to sewage mixing with leaky pipelines or infiltrating the groundwater systems from unlined conduits.

The problem gets complicated further for the basin managers as huge pressure is thrown at them to manage risks and conflicts in balancing economic development while also maintaining healthy water resources. There is a need to find smarter ways to develop and manage water resources and find responses appropriate to the circumstances in river basins. As a consequence of biological and chemical pollution, rivers become over-rich in nutrients and aquatic weeds proliferate. The alteration of river and lake flows and diminution of groundwater tables, has dire consequences on the health, safety of the people.

India's projected Water Stress, 2030





54% of India faces High to Extremely High **Water Stress**

16% Country is drought prone

75% of annual rainfall is concentrated in 100-120 days of South-west monsoon

50% people exposed to drought

35% area received rains between 750-1,125 mm and is drought prone

33% India received less than 750 mm of rain and is chronically drought prone

More than **100 million** people live in areas with poor water quality

Source: WRI Aqueduct Water Risk Atlas

GANGA'S WOES

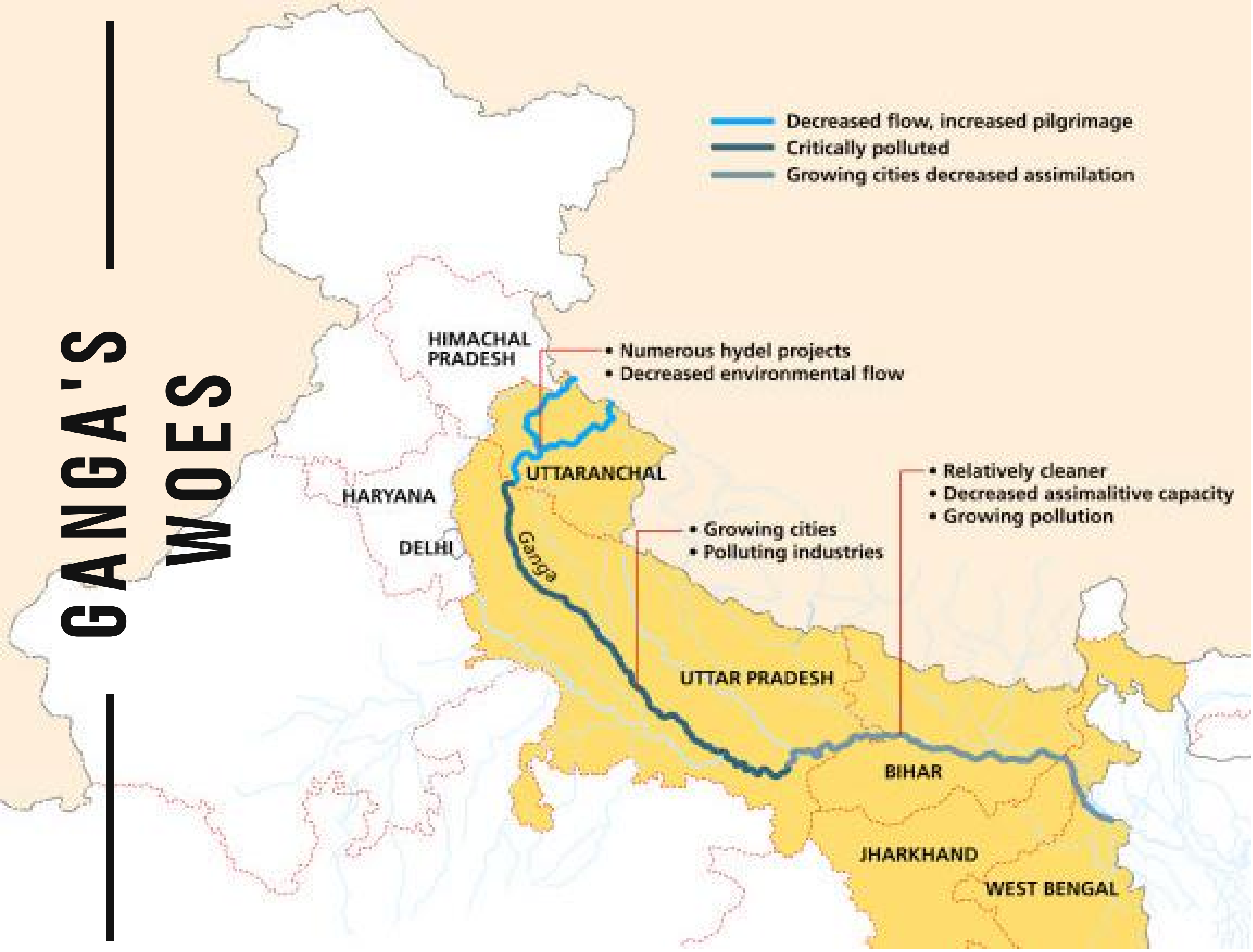


Image source: Centre for Science and Environment (2008)

Upper Ganga Region (Gomukh to Haridwar)

294 km

1. Disruption of natural flow due to several dams
2. Retreating glaciers
3. High Inflow of tourists

Middle Ganga Region (Haridwar to Varanasi)

1082 km

1. Huge quantities of water abstraction & diversion
2. Pollution load from domestic, & agricultural activities
3. Cluster of Tanneries in Kanpur

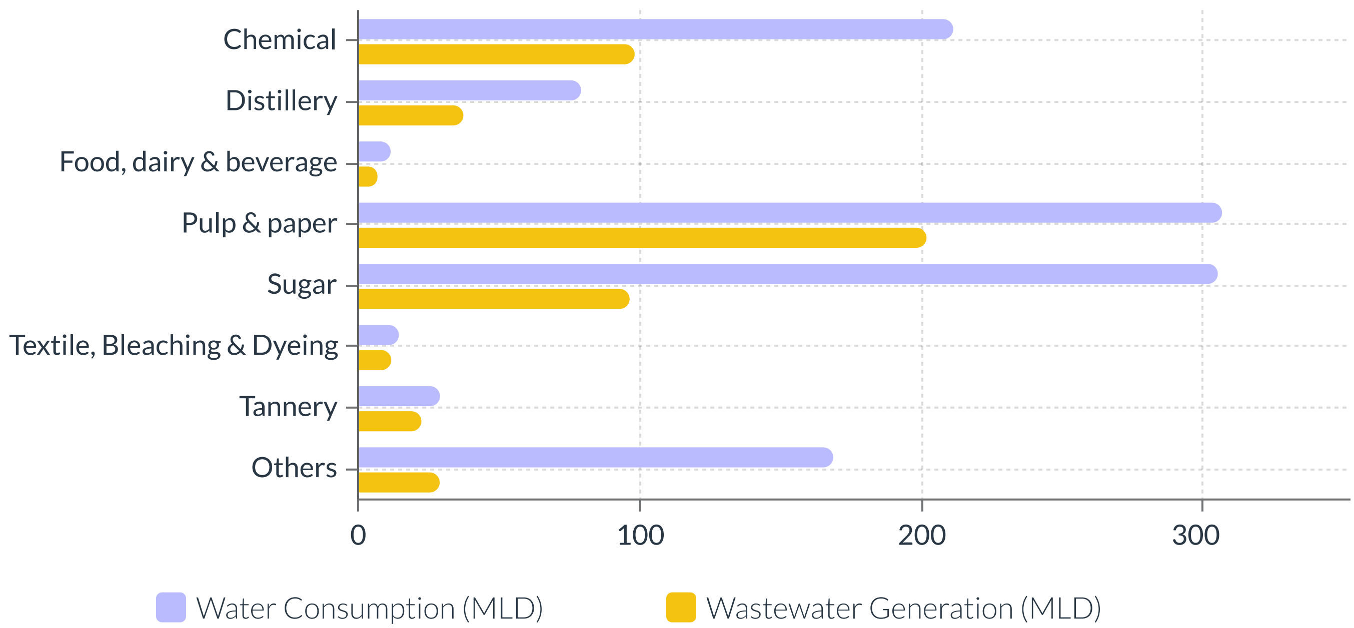
Lower Ganga Region (Varanasi to Kolkata)

1134 km

1. Large point and non-point pollution load
2. Frequent oods & droughts
3. Encroachment of river bed, sand mining, etc.

Sector speci c Industrial Water Consumption and Wastewater Generation

Status of major five states where Ganga flows



89 million litres of sewage is dumped into the Ganga daily

Industrial toxins emitted by tanneries cause cancer, convulsions & death

Over 100 ML of fecal coliform exist

70% of those that use water for drinking & bathing are expected to contract a waterborne illness

110 million litres of sewage is dumped into the Ganga daily

Nearly 90% of municipal drinking water is contaminated with faecal matter

Issues faced by ULBs

1 Physical Interdependencies

Autonomy of ULBs remain low ,Excessive control by state govt.

2 Lopsided Expenditure

Large amount of funds spent on capital works, routine maintenance is ignored

3 Institutional Weaknesses

No separate regulatory institution, operational and regulatory functions bundled with the state govt,. lack capacity, staf ng issues

4 Lack of competition

Constrained by tradition

5 Poor cost recovery

Only a part of O&M expenditure is recovered through water tax and water charge in most cases

6 Weak finances

Primitive accounting practices, poor nancial management

Regulatory framework

Many laws, legislation, and regulations exist at the national level for urban water management. Because water is a state concern, it is necessary to analyse state policies. The actions taken by local governments would be initiated due to the influence of these policies.

- **1974** The Water (Prevention and Control of Pollution) Act was enacted
- **1986** The Environment (Protection) Act
- **1987** Indian National Water Policy
- **2021** Coastal Regulatory Zone Notification
- **2002** Revised National Water Policy
- **2012** Revised National Water Policy
- **2016** The Model Bill for Regulation of Groundwater

The National Water Policy decries the fact that only a small portion of water is currently used for economic development, and even proposes 'non-conventional' water-use methods such as inter-basin water transfers and seawater desalination as large-scale, high-tech solutions to increase overall water availability.

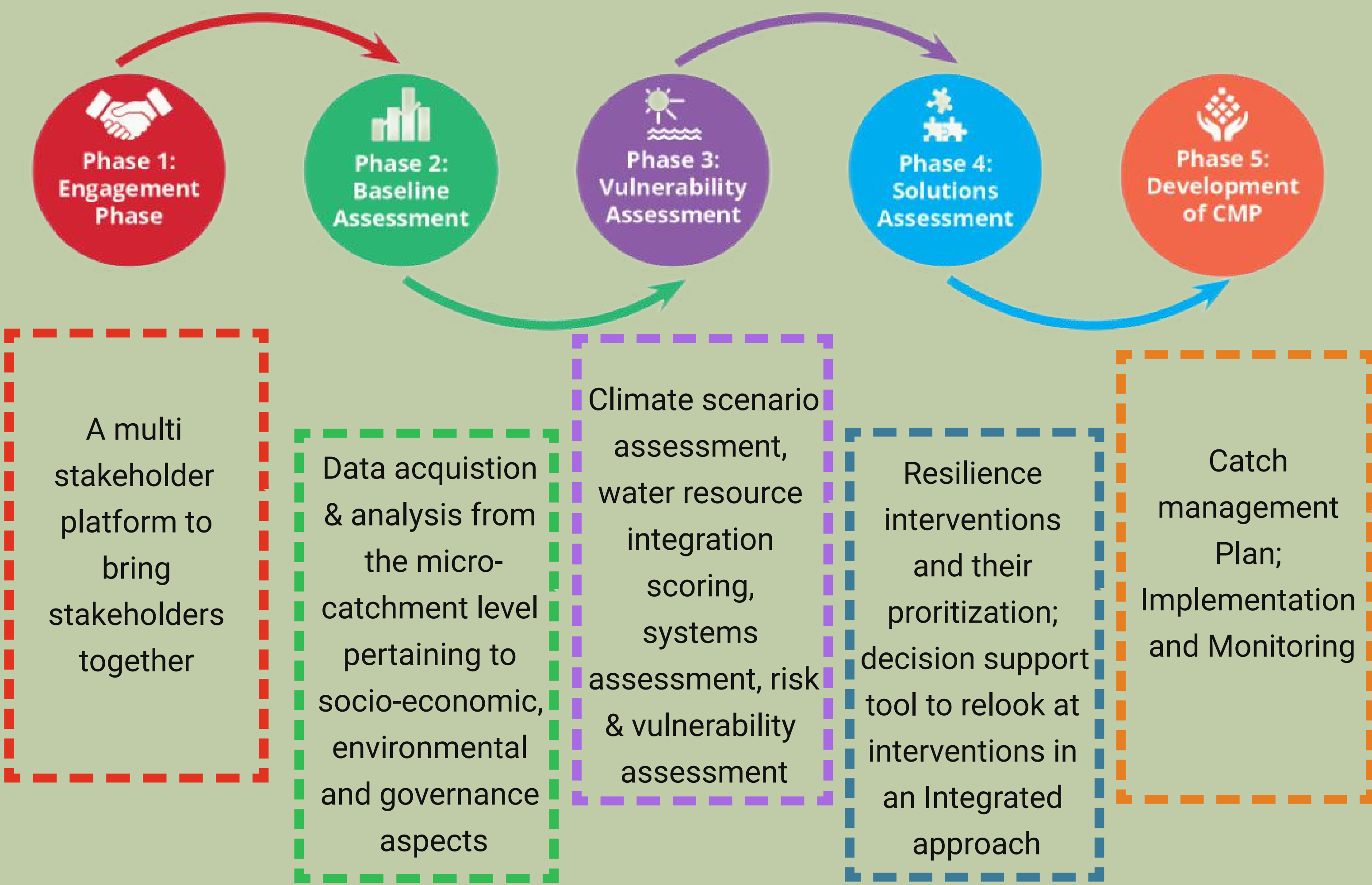
Water allocations for drinking, irrigation, hydropower, environment, industry, navigation, and other purposes are prioritised in the revised National Water Policy of 2002.

Water for drinking and residential requirements, irrigation, and "minimum ecological needs" are all given equal and "high priority" in the revised national water policy of 2012, which introduces the idea of "minimum ecological needs" and their necessity for "high priority" allocation.

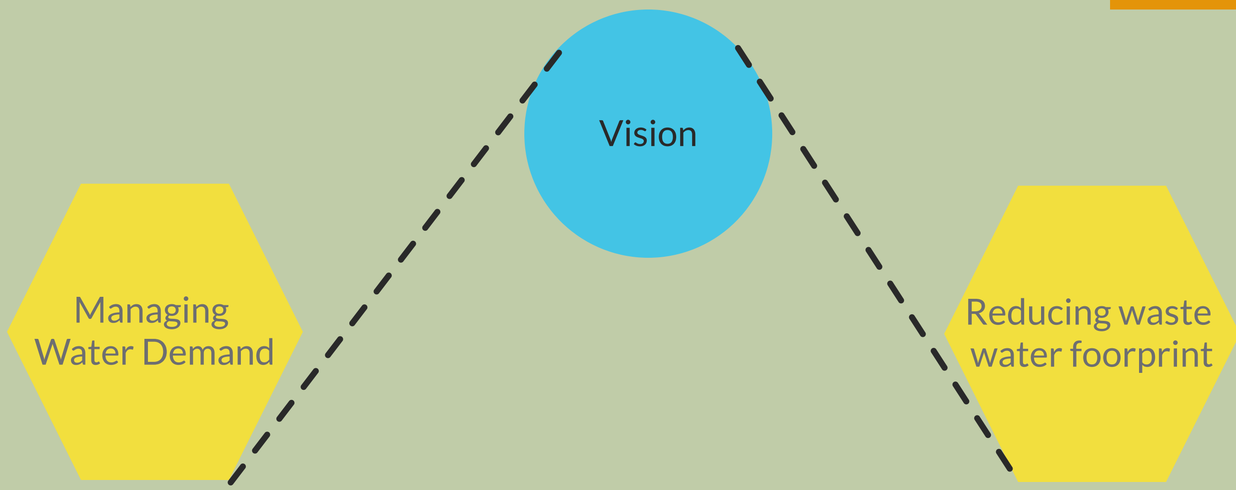
To grasp the intensity of the situation, local rules and regulations must be assessed after examining national and state policies and laws. Many cities have established legislation for urban water management. These rules may be included in their GDCR (General Development Control Regulations) or policy resolutions. In the master plan, urban local bodies can take particular measures to improve water supplies, such as designating a sensitive or ecology zone, among other things.

Approach

To ensure an integrated approach to water resource development, with rational and fair resource allocation and priority for the poor and unserved, a complete policy framework is required. Effective policy frameworks consider water as a finite and fragile resource over the long run and address the entire water cycle. They also keep track of important behavioural functions at all levels. Establishing standards and targets, as well as a method to monitor and use them as indicators for planning and management, should all be part of an effective policy framework. The government's aims and means for achieving them should be stated in a national water sector strategy. It will comprise investment and project development standards, with the goal of ensuring that water supply development takes into account water resource management and environmental factors, such as equitable distribution of water resources and pollution avoidance.



Source: IAdapt-Publications (urbanwatermanagementindia.org)



Policy commitments

01 Plan for integrated Water and Waste Water Management

02 Reduce Non Revenue Water (NRW)

03 Ensuring Universal Access to affordable, safe and adequate water supply

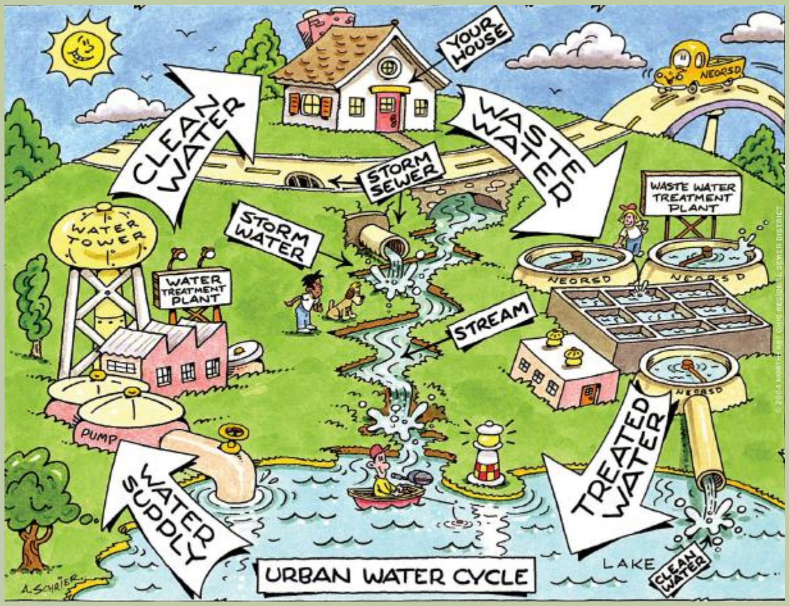
04 Prioritise operations and management of water and sanitation infrastructure

05 Ensuring Manual Cleaning of septic tanks and sewers

06 Prioritise non networked and decentralised sanitation systems

Integrated Urban Water Management

Integrated Urban Water Management (IUWM) is a holistic approach to strategic urban planning that takes a landscape perspective to maintain water sources, prevent contamination, while recognising the demands of both upstream and downstream users. It is essential for cities to move away from large-scale, centralised infrastructure towards a more decentralised system that integrates water, built and natural surroundings, and communities.



Urban Water Cycle; Image Source: www.neorsd.org

a. Key Principles of Integrated Urban Water Management

1. Integration across the Water Cycle

- Wastewater and stormwater: a resource
- Water cycle as one stem
- Matching water quality with intended use

2. Integration of urban and water systems

- Pursuing economic efficiency, social equity, and environmental sustainability
- Integrating water resources, land-use planning and key urban services (e.g. solid waste, housing, transport, etc.)

3. Integrated Planning and Implementation

- Stakeholder involvement instead of top-down
- Multidisciplinary planning teams

b.Benefits of Integrated Urban Water Management

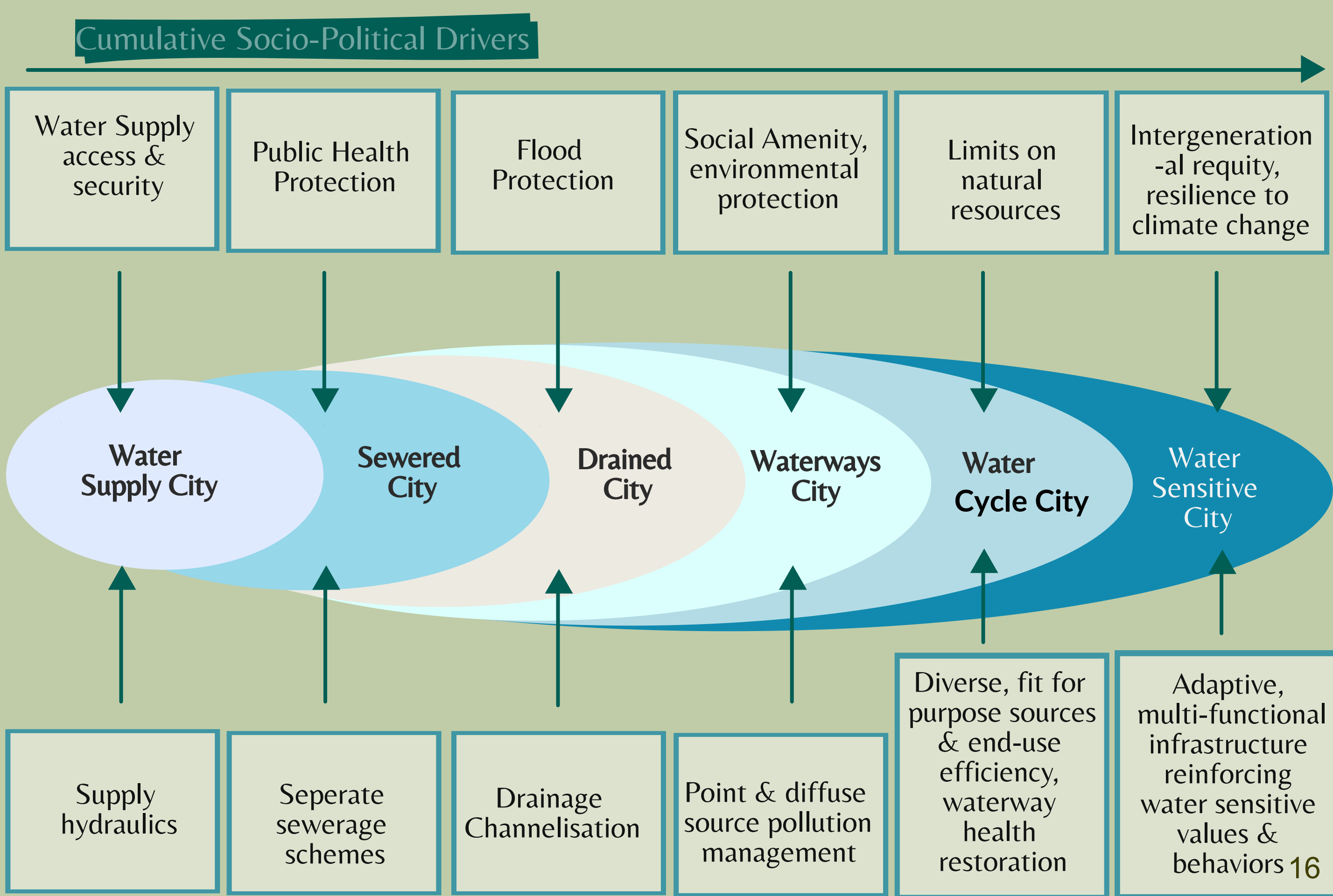
Cost savings through coordination and synergies and by promoting alternative technologies and approaches

Leveraging complementary finances different sectors; different levels of government, bringing in alternative financing (private sector, payment for environmental services)

Improved living conditions, quality of life, economic stimulation, etc., through urban transformation, including green and cultural aspects

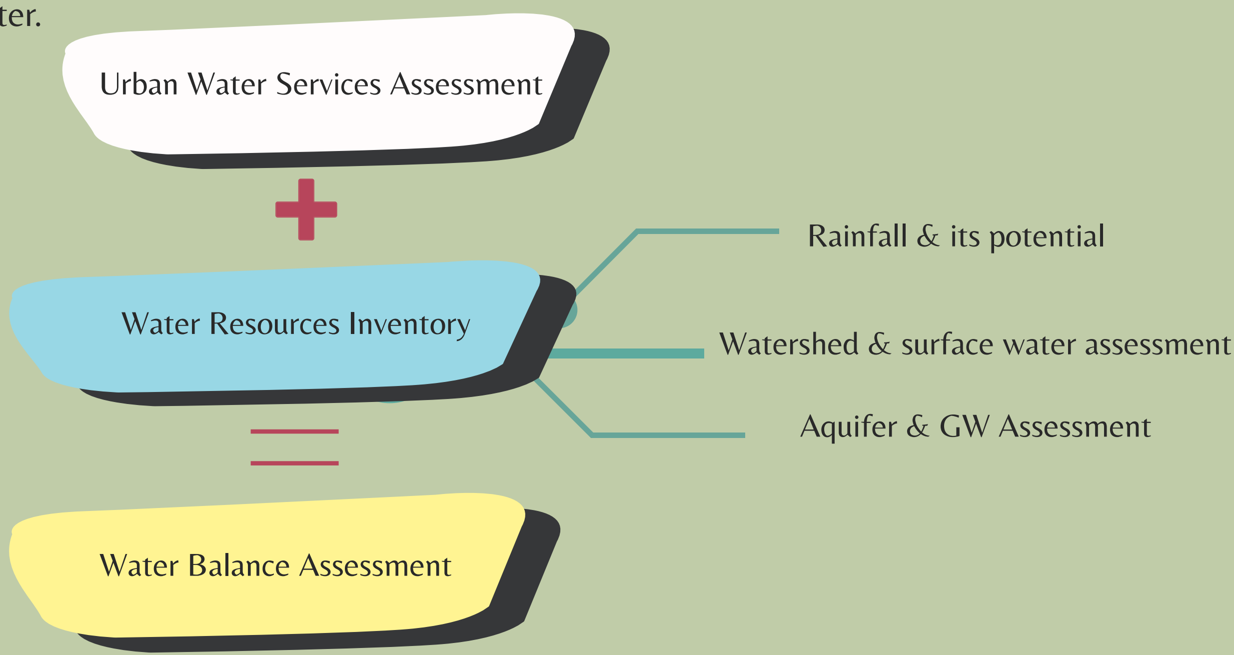
Establishing the awareness, motivation, and capacity among stakeholders to drive their water sensitive city transformation requires developing a shared view of water today in connection to future water sensitive goals. Cooperative Research Centre for Water Sensitive Cities Ltd. established a framework to help cities navigate their water sensitive city Journey.

Urban Water Transitions Framework



Resources perspective

Water resources are sources of water that have the potential to optimize. In our context, the majority of our resources are divided into two categories: surface water and ground water. The hydrological cycle explains the movement of water above, on, and beneath the earth's surface, as well as between various water sources. We use the water we get from these sources for agricultural, industrial, residential, and recreational purposes. However, in order to conduct a water balance evaluation that takes into account both urban water services and the natural water cycle, Urban Local Bodies must must also examine the environmental uses of water.



A **water balance** is a term used in hydrology to describe the flow of water into and out of a basin. It is a comparison of precipitation and other inflows with outflows, as well as accumulation/storage changes over time, of the various flow components of a specific region's hydrological cycle.

The calculation of a city's water balance aids in determining the present state and trends in the availability of water resources in a certain area. It also shows whether there is enough excess to plan for future water demand.

Equation of hydrology: Inflow = Outflow + Change in Storage

Surface Water Assessment

Surface water supplies provide for a substantial portion of urban water supply. Groundwater and surface sources have important geological links. As a result, assessing surface water sources is critical for a city's integrated water security plan. Following are the steps:

1

Map Water Resources

Identify and map existing rivers, streams, lakes, canals, irrigation dams, check dams,tanks etc.

Present condition of water bodies (structural damage, silting, vegetation, encroachment, urban encroachment, dry, solid waste dumping)

2

Quality Testing

Physical Test : turbidity, pH, TDS, taste, colour, odour and temperature

Chemical Test : total hardness (as CacO3, ppm), chlorides (as Cl) , sulphates (as SO4), uorides(as F), nitrate (as NO3), calcium(as Ca), magnesium (as Mg), alkalinity and acidity(pH)

Bacteriological Test : total coliform and faecal coliform e.g.: e-coli

3

Mapping Urban Watersheds and land use

Features that must be included in the mapping process include:

Natural drainage, existing streams, lakes, and the sea

Physiography, contours, slopes, and the boundaries of watersheds

Storm water drainage network, percent road coverage by length, water logging incidences

Other boundaries – protected forest, etc.

Groundwater and Aquifer Assessment

Groundwater and the aquifer must be assessed as part of any water resource planning and management activity.

Step 01

Aquifer Identification and Delineation

1. Geological Mapping for surface
2. Tectonic – Lineament mapping for identification of aquifer boundaries, localized specific characteristic influencing groundwater levels and quality
3. Well inventory and litho-log mapping for sub-surface
4. Reduced water level maps for groundwater flow direction and to identify discharge area

Step 02

Aquifer Characterization

1. Pumping test for discharge measurement: A Pumping Test is a field experiment in which a well is pumped at a controlled rate and water-level response (drawdown) is measured in one or more surrounding observation wells; response data from pumping tests are used to estimate the hydraulic properties of aquifers, evaluate well performance and identify aquifer boundaries.
2. Groundwater replenishment / withdrawal estimation
3. To understand transmissibility – Permeability
4. Porosity test to estimate storage potential - Rock sample saturation method

Step

03

Groundwater Monitoring

1. Establish a monitoring network based on aquifer and zones of influence
2. Regular monthly/seasonal monitoring of water levels in monitoring wells to record fluctuations. Recordings should especially be taken before and after monsoon season
3. Water level measurement should be accompanied by Quality tests for Drinking Water as well as Irrigation Water
4. Produce seasonal water level and quality contour maps
5. Trend assessment - Reduced water levels and TDS or any quality influence parameters
6. Identification of reasons for aberrations in levels, quality parameters and trends
7. Estimate yearly changes in storage - Compute changes in quantity in the form of increase or decrease levels and quality in different in areas of watershed
8. Identify vulnerable zones

Groundwater is a dynamic resource and its levels change from season to season and vary in different localities. Knowing the levels and quality of groundwater is important for understanding the health and potential of aquifer. It also helps in determining how the groundwater interacts with local surface water sources, and understanding how surface development has impacted the aquifer.

Strategies

The majority of current water management plans focus solely on creating new sources to meet the ever-increasing demand for water. In reality, water management in urban areas should be aided by both steps to improve the efficiency of current water systems and water conservation practises. This necessitates a paradigm shift, with the practicality of various solutions being assessed by Urban Local Bodies in the context of local realities in order to achieve the greater aim of Urban Water Security.

The approach in the urban context mainly constitutes of augmenting a city's water supply by bringing water from afar.

Alternative Urban Water Sources

Rainwater Harvesting

Revival of Local Water Sources

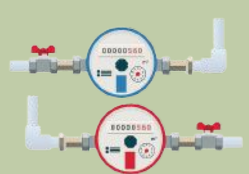
Groundwater Recharge

Wastewater Reuse

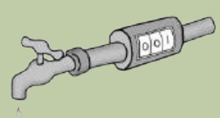
Moreover, there are many steps that Urban Local Bodies can take to increase efficiency without having to upgrade entire facilities and piping system. Implementing a few initiatives can save utilities significantly. The Urban Local Bodies of the area can implement efficiencies that will increase revenue and decrease water loss, all with the least capital expenditure possible.

To improve efficiency of existing Water Systems

Reducing Non Revenue Water (NRW)



Metering of Water Supply

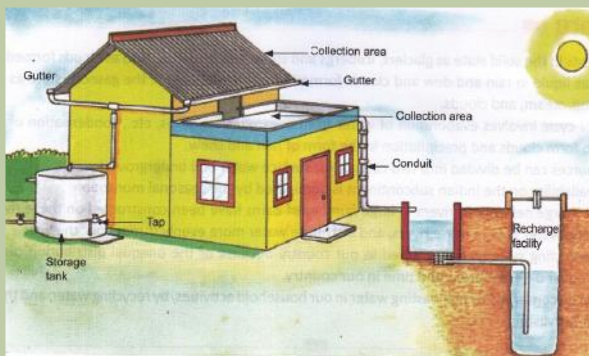


Pricing as a tool for water demand management

Improve quality of water supply

Alternative Urban Water Sources

1. Rain Water Harvesting

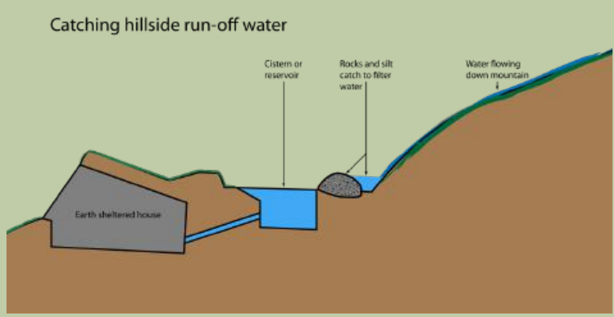


a) Rooftop Rainwater Harvesting (RRWH)

In rooftop harvesting, the roof becomes the catchments, and the rainwater is collected from the roof of the house/building.
Catchment Area (m²) X **Amount of Rainfall** (mm) = **Volume of water received** (litres)

b) Surface run-off Rainwater Harvesting

Surface run-off rainwater harvesting, also known as stormwater harvesting, collects rainwater from highways, parks, gardens, parking lots, and other locations to recharge aquifers. Micro-watershed management techniques are used in parks and open places to allow rainwater infiltration and percolation into the earth. Percolation pits and dispersion trenches must be provided in sufficient numbers to reduce runoff. Rainwater runoff from open space and paved areas can be collected by sand-bed filters and directed down channels to be stored in subterranean sumps. Rainwater collection from highways is also a realistic solution to consider. For this, an infiltration trench might be dug alongside the drain, wherever practical, all the way down the road. Water percolates into the ground as precipitation from the road flows into the infiltration trench.



Source: Wikipedia

The factors affecting RWH system design are Rainfall quantity (mm/year), Rainfall pattern, Collection surface area (m2), Runoff coefficient of collection, Storage capacity (m3, Daily consumption rate (litres/capita /day), Number of users, Cost, Alternative water source

2. Groundwater Recharge

a) Feasibility Analysis & Site Identification

Areas suitable for ground water recharge are:

- Areas where ground water levels are declining on regular basis.
- Areas where substantial amount of aquifer has already been desaturated.
- Areas where availability of ground water is inadequate in lean months.
- Areas where salinity ingress is taking place

Assessment of sub-surface potential for Ground Water Recharge

Based on the hydrogeological and geophysical surveys, the thickness of potential unsaturated zone for recharge should be worked out to assess the potential for artificial recharge in term of volume of water which can be accommodated in this zone vis-à-vis source water availability. The studies should bring out the potential of unsaturated zone in terms of total volume which can be recharged.

b) Identification of Required Recharge Structure and Technique

Direct surface techniques	Direct sub surface techniques	Combination Techniques	Indirect Techniques
Flooding	Injection wells or recharge wells	Basin or percolation tanks with pit shaft or wells	Induced recharge from surface water source.
Basins or percolation tanks	Recharge pits and shafts		Aquifer modification
Stream augmentation	Dug well recharge		
Ditch and furrow system	Bore hole flooding		
Over irrigation	Natural openings, cavity fillings.		

c) Enumerating required recharge structures

After the selection of the area where artificial recharge is feasible and selecting the type of artificial recharge structure, next step is to calculate the numbers of recharge structure required. This step helps to calculate the number of recharge structures required in the selected area. Based on the numbers of recharge structures, the cost estimation can also be obtained which would in turn help in deciding the phasing of this project.

3. Reviving Local Water Sources

An important aspect before planning any new projects to cater to future water demand is to assess the potential of its local water resources.

a) Mapping of catchments & lakes and other water bodies

For reviving the local water sources, the first step is to map and identify the catchment areas.

b) Identifying and bringing together all stakeholders

Based on the mapping process, the second step is to identify the relevant stakeholders. Various state government agencies, city level officials and other civil society groups and citizens can be identified and grouped together for working on the revival of ones own water sources.

c) Identifying the missing links and issues affecting local water sources

The third step is to identify the issues which are deteriorating the condition of local water sources. These damages could be mainly by anthropogenic activities which needs to be relooked on.

Based on the mapping and stakeholder involvement, issues catchment area can be identified as (examples):

- Water Stagnations
- Wastewater Inflow
- Damaged Diversions
- Paralyzed flow
- Encroachment
- Debris Dumping

d) Decisions regarding revival of local water sources

On the basis of the first three steps, decisions must be taken to revive the local sources. Along with the support of various stakeholders, decisions must be taken to make the catchment functional again and revive its local water sources.

De-silting Lakes, canals, streams, etc.

Repairing and widening canals

Cleaning of wells and removing debris

Streaming the natural flow if interrupted

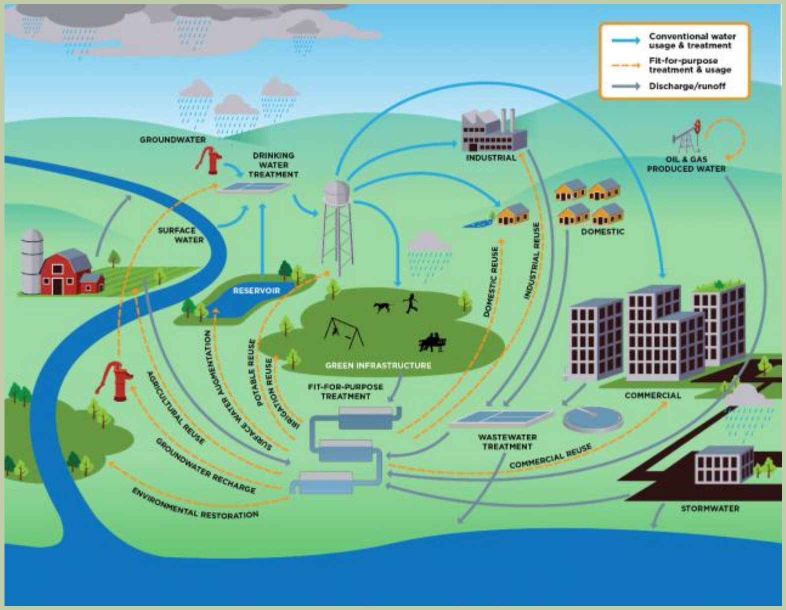
Removing encroachment

Water supply system will depend on how city manages its water resource today and future perspective of its own resource. A city can become self-sufficient in water if it tries to sustain, recharge and develop its local water resources

4. Wastewater Treatment and Resue

An important aspect before planning any new projects to cater to future water demand is to assess the potential of its local water resources.

Conventional approach for wastewater can be viewed as a linear process where input is one part and output is the discharge of treated wastewater in the downstream. An alternative approach to it would be by managing the wastewater correctly and using it as a resource. Need is for looking at the appropriate wastewater treatment alternatives and applying more integrated approach for diverse ecosystems. Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use.



Wastewater Chain and Reuse Options

Source: EPA

Reuse Strategy

- Providing Reliable Treatment To Meet Water Quality Requirements
- Protection Of Public Health And The Environment
- Gaining Public Acceptance
- Economic Viability

5. Reducing Non revenue water (NRW)

Water that has been produced but is "lost" before reaching the consumer is referred to as non-revenue water (NRW). Real losses (such as those caused by leaks, which are often known as physical losses) and seeming losses (such as those caused by theft) are both possible. (For instance, through theft or metering errors).
Reducing non-revenue water can aid a city's ability to improve services and operate more effectively. It enables the city to systematically reduce water losses, resulting in lower capital expenditures on new water sources. Reducing physical losses will not only help utilities delay capital investments in new water sources, but it will also help them save money on their electrical bills. Water loss reduction can also assist water utilities maintain financial sustainability and avoid a downward spiral: Reducing the apparent loss component of NRW to the economic level reduces the volume of unpaid water provided to customers, maximising revenues, while reducing the real loss component of NRW to the economic level reduces overall operating expenses.

a) Measurement of NRW

<table>
<tr><td rowspan="9">System input volume</td><td rowspan="4">Authorised consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Water Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Customer Meter Inaccuracies</td></tr>
<tr><td rowspan="3">Real losses</td><td>Leakage on Transmission and distribution Mains</td></tr>
<tr><td>Leakage & overflows at reservoirs</td></tr>
<tr><td>Leakage on service connections up to metering point</td></tr>
</table>

b) Identification of Issues and Prioritization

After performing water audit and measuring NRW in a city, identification of all the issues and its prioritization is important. Based on the investment required and time required to resolve the issues, these could be prioritized.

Cost and Time requirements of NRW Reduction Measures		
Short term- Low Cost	Medium term- Medium Cost	Long term- High Cost
Reduction in free supply	Reduce customer meter inaccuracy	Replacement of Pipelines
Regularization of illegal connection		Replacement of service connection
Repair valves and storage tank		Pressure Management

c) Priority Wise actions

To reduce NRW, both apparent and real losses must be tapped and folliowing improvement measures are recommended to the ULBs.

LOSSES	IMPROVEMENT MEASURES
Unbilled authorized consumption	Start charging free supply
Illegal consumption	Identify and then regularize illegal connection
Meter inaccuracy or no metering	Install meters or Prepare meter replacement plan
Leakage in transmission and distribution main	Repair leaking valves, Repair or replace leaking pipelines
Leakage and overflow at storage tank	Create awareness in staff, Repair or rehabilitate storage tank
Leakage at service connection	Replace service connection, pressure management

d) Pricing as a tool for water demand management

Water is currently provided at a heavily subsidised rate. Instead of being considered as a precious resource, water is treated as a free product. Water pricing as a demand control strategy is projected to have the dual benefits of reducing demand while also enhancing the financial sustainability of delivery systems. A city can choose from a variety of tariff systems that are appropriate for it. Tariffs would also be determined by people's ability to pay and willingness to pay. As a result, a city's water tariffs must be adjusted proportionately.

6. Improving Quality of Water Supply

For the treatment of water, consideration must be provided towards its source. Also the impurities present in the water must be tested and accordingly the treatment water must be selected. Poor water quality imposes indirect coping cost on households in terms of money spent on RO treatment or purchasing of RO bottle water.

1. Identify Sources
2. Test the Water
3. Plan for treatment
4. Regular & Reliable Testing

Source	Treatment Required
Ground water and spring water fairly free from contamination.	No treatment or cholrination
Ground water with chemicals, minerals and gases	Aeration, coagulation (if necessary), filtration and disinfection
Surface water reservoirs with less amount of pollution	Disinfection
Other surface waters such as rivers, canals and impounded reservoirs with a considerable amount of pollution.	Complete Treatment

Key issues and strategies

Inflow		Natural Processes		Supply for Human Use		Waste water generation	
Rainfall on built up area	Roof RWH	Evaporation	Protect Water resevoirs	Public water supply system	Demand management, moving away from centralised systems, manage increased demand from covering unserved areas	Waste water generation	Opportunities for reuse
Rainfall on unpaved areas	Groundwater Recharge	Keep in consideration ecological water requirements		Leakage from water supply	Minimize losses and ensure maximum efficiency metering	Stream flow to downstream catchments	Ensure safe Wastewater disposal in rivers
Stream flow from upstream carchments	Surface water source-check pollutions	Groundwater storage	Monitor levels and quality regularly	Private GW extraction	Should be regulated to a sustainable amount	Wastewater disposal on land	Potential GW pollutant, opportunities for reuse
Water import	Minimize Inter-basin transfer, undertake special recharge activities if importing from aquifer fallling outside city boundaries	Run-off	Harness to increase GW recharge and surface storage	Return flow from irrigation	Potential GW pollutant due to use of pesticides	Leakage from sewer systems	Potential GW pollutant

Service level benchmarks

The quality of the water provided is just as significant as other service delivery measures. Poor water quality can be dangerous to people's health. In Indian cities, especially among the urban poor, water-borne infections are fairly widespread. Although the source of water that causes such diseases/epidemics is usually not the municipal piped water supply, it is critical to keep an eye on it. As a result, this performance indicator, which has a benchmark value of 100 percent, must be reviewed on a frequent basis.

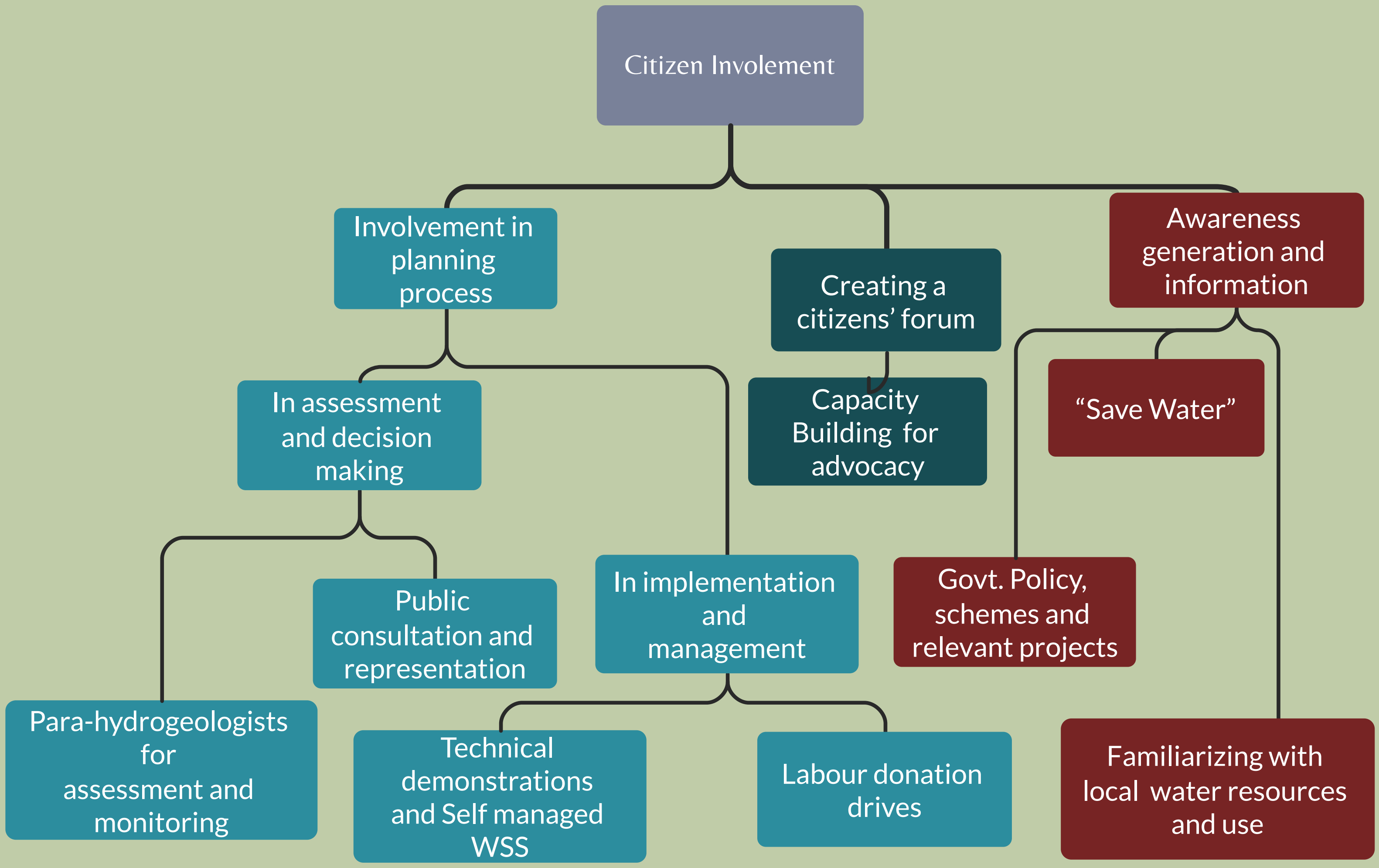
Performance Indicator		
Indicator	Unit	Definition
Quality of Water Supplied	%	The percentage of water samples that meet or surpass the Central Public Health and Environmental Engineering Organisation's set drinkable water requirements (CPHEEO). The sample procedure should adhere to the established criteria and regulations.
Data Requirements		
Data required for calculating the indicator	Unit	Remarks
a) Total number of water supply related complaints received per month	Number per month	The total number of water samples collected for testing over the course of a month. Samples should be taken at both the treatment plant outlet and the consumer end. The sampling procedure should adhere to established standards and regulations.
b. Number of samples that meet the specified potable water standards in the month	Number per month	The percentage of samples that met or surpassed the stipulated potable water requirements out of the total number of samples drawn in the month. All of the quality standards' requirements should be met. Even if one of the standards isn't satisfied, the sample can't be presumed to have met all of them.
Quality of Water Supply	%	Quality of water supply = [(b/a)*100)

This performance indicator provides an overall indication of the adequacy of the water supply to meet the needs of the citizens in the city. Monitoring this on a monthly basis will reveal seasonal variations. The benchmark value for this indicator is 135 lpcd. However, the additional information in respect of the areas where water is supplied at the rate of 70 lpcd should also be indicated. The key limitation of this indicator is that it provides information on a city-wide basis, and does not reveal intra-city variations

Performance Indicator		
Indicator	Unit	Definition
Per capita quantum of water supplied	litres per capita per day (lpcd)	Total water supplied to consumers expressed by population served per day
Data Requirements		
Data required for calculating the indicator	Unit	Remarks
a. Water supplied to the distribution system	litres per month	Metering should be used to measure daily quantities, and records should be kept. The monthly total supply should be based on the sum of daily quantum. Only treated water should be tested as it enters the distribution system. If water is delivered from numerous sources, the total quantity should be taken into account. Water audit tests should be used to determine the quantity, which should not include bulk water transmission and distribution losses. This quantity should include any water acquired directly from other sources and distributed through the distribution system, if applicable. Water may have been purchased from nearby ULBs, Cantonment Boards, and other sources. Water delivered in bulk to large water-intensive companies or industrial estates should be prohibited.
b. Population served	Number	While the number of residents is usually taken into account, if the city has a large floating population of tourists who visit the city on a temporary basis, that population should also be taken into account. On the basis of hotel bed capacity and occupancy rates, tourist population estimates can be reasonably calculated.
c. Number of days in the month	Number	The number of days in the specific month.
d. Additional information on areas where water is supplied at a rate less than 70 lpcd	litres per capita per day (lpcd)	The number of persons served by the utility in these service zones. Water supply to these places is measured using bulk metres or scientific calculations based on flow velocity and head.
Water supplied	lpcd	Per capita water supplied = [(a/c) /b]

Citizen Involvement

Ways for citizen involvement in water resources management may vary depending on the degree of involvement. The first and easiest is awareness generation and Information. This may include general campaigns for water conservation, information about local water resources and education about government policy, schemes and relevant projects. The second is method is supporting the creation of a Citizens' forum for water related advocacy amongst other citizens and decision makers. Finally, citizen involvement in the planning process and range from assisting in assessments and monitoring, to decision making through a public consultation. Self managed water supply systems and labor donation drives can also be a form of involvement in implementation.



Aviral Ganga

Ecology & flow

The roadmap to Aviral Ganga

- Increase in Water use efficiency in agriculture sector (biggest consumer of freshwater resource), industrial sector and domestic water usages to reduce freshwater extraction.
- Promotion of reuse of treated wastewater for non-potable purposes
- Protection and conservation of flood plains, ponds, and other water bodies.

Initiatives under Namami Ganga

Wetland Conservation

Comprehensive conservation of wetlands within buffer of 5 k.m. (101 wetlands) and 10 k.m. (125 wetlands) each side in 27 riverbank districts in U.P.

Waterbodies Rejuvenation

Work was carried out under MGNREGA for rejuvenation of water bodies in 52 districts in the States of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal.

Treated wastewater reuse

MoU signed for reuse of treated effluent from Bingwan STP (120 MLD) Kanpur in Panki Thermal Power Plant, Kanpur; An agreement was signed between NMCG and Indian Oil Corporation Limited For the reuse of 20 MLD of treated sewage water by IOCL's refinery in Mathura

Nirmal Ganga

De-polluting River Ganga

Initiatives under Namami Gange

Municipal Sewerage Management

Sewage Treatment

A total of 157 projects have been sanctioned to create a total STP Capacity of 4,916.05 MLD 1035.59 MLD (Rehabilitation)) and 5213.76 Km of Sewerage Network in Ganga Basin States

Decentralized STP

NMCG has sanctioned Decentralized Sewage Treatment Plants and onsite treatment in the towns of Nandprayag, Karanprayag, Devprayag, Kirtinagar, Chamoli-Gopeshwar and Bithoor

Septage Management

NMCG has sanctioned one project for Faecal Sludge Management at Chunar and two projects for Co-treatment of sewage and septage at Bhagalpur & Howrah.

Industrial Pollution Abatement

Status of action taken by SPCBs for GPIs (river Ganga Basin including river Yamuna till 31-03-2021)

S. No.	State	Inspection Report Submitted	Action Completed	Complied	Temporary Close	Permanent Close	Show Cause Notice (Non-Complied)	Closure Direction (Non-Complied)
1	Bihar	53	37	30	1	0	6	0
2	Uttar Pradesh	900	649	393	118	36	92	10
3	Uttarakhand	51	44	37	4	1	2	0
4	West Bengal	53	46	29	7	0	10	0
5	Jharkhand	5	4	0	0	0	4	0
6	Haryana	748	603	267	81	142	113	0
7	Delhi	228	183	78	19	38	48	0
	Total	**2038**	**1566**	**834**	**230**	**217**	**275**	**10**

Jakkur Lake Rejuvenation: Bengaluru

Source: India times Deccan Herald

Jakkur Lake is about 160 acres in size and is located near Yelahanka in Bengaluru's northern outskirts. It gets storm water from Yelahanka, Agrahara, and Shivanahalli through three input drains. Because of urbanisation and population growth, the amount of storm water reaching the lake has dropped dramatically over time, causing the drains to get clogged. Instead, the lake began getting sewage from the 12,500 houses that surround it. The government carried out the initial restoration between 2009 and 2011, while Jal Poshan carried out the subsequent restoration from 2015 onwards.

The objective of the project was to use natural and self-sustainable methods of treating domestic wastewater to rejuvenate Jakkur lake.

Key Highlights

1.Improvement in the biodiversity in the surrounding area
of the lake, increasing the aesthetic value of the locality
2. Increase in employment opportunities and livelihood
opportunities to the fishermen
3. Increase in the usage of the lake by the local residents
for recreational purposes

Approach

The restoration work in the Jakkur model has combined traditional grey and green infrastructure.

The following step-by-step procedure was used:

• The original 10 MLD secondary STP was upgraded to a 15 MLD tertiary treatment STP after encroachments were removed and the lake was de-silted.
• Islands were created and trees were planted along the sides of the lake to create bird habitation and to maintain natural flora and fauna, and the local governing body maintained the legal standards for the STP as the water was fed into the constructed wetland for treatment and later into the lake.
• Wetland species such as vetiver, water hyacinth, typhaceae, and alligator weed were used to build the 7-acre manmade wetland. They contributed to the phytoremediation of lake water.
•During religious/cultural festivals, a separate tank (kalyani) was erected for idol immersion, preventing polluting of the lake water.
• Jal Poshan has been bringing in several groups to restore the lake ecology since 2015, using a collaborative and multi-stakeholder engagement methodology.
• Sustainable landscaping (permaculture, community gardens, etc.)
• Creating a permanent place for the fishing community were just a few of the main efforts.
• Improvements to the current sedimentation tank

Benefits & Co-Benefits

• The rehabilitation of Jakkur Lake has provided fishermen with a source of income.
• 100,000 litres of water per day is collected from a step well near the lake for agricultural uses
• Improved biodiversity in the surrounding area with increased presence of local and migratory species
• Increased land value of nearby properties

Future prospects

This is an example of a collaborative approach to lake restoration that has worked well. Institutional processes should be put in place to make communication between the numerous administrative bodies responsible for keeping the lake clean and healthy easier.

Rain water Harvesting, Jodhpur

Inlet for Road side drainage
Source: CSE India

Series of storage tanks
Source: CSE India

The Umaid Heritage residential complex, located southeast of Umaid Bhawan in Rajasthan, is a private township. The site lies in the city of Jodhpur, where industrialization and urbanisation are rapidly destroying the indigenous water management system. The site's water table is still fairly low, ranging between 20 and 40 metres below ground level (mbgl).

Henceforth, the "Birkha Bawari" is designed as a monumental RWH structure at Umaid Heritage, which is based on the concept of "Kunds" and "Baoli", which were the traditional practices of RWH in Rajasthan and Gujarat. The Bawari structure acts as a recreational space for inhabitants as well as storage structure of rainwater

Key Highlights

The RWH system collects approximately 21.1 million litres of rainfall, reducing reliance on municipal water and groundwater extraction.

2. 15 acres green area irrigated

2. Simple historical concept integration to better utilise and protect in-situ resources

TECHNOLOGY & DESIGN

Catchment area

The entire site serves as a catchment region for the water collection system. Rainwater is collected from open areas via natural slopes, as well as from roof tops of dwellings, which are connected to the natural slope of the site by drainage conduits. The catchment area is rocky and has a high runoff coefficient. To prevent trash and dust particles from entering Bawari, rainwater is prohibited from entering the intake wall for the first two flushes of rainfall.

Conveyance system

The housing complex is divided into two phases: phase II, which includes apartments, and phase I, which includes planned homes. Storm water drains, open channels, and slots gather rainfall from rooftops and road channels. The runoff from Phase II is gathered in storm drains and connected to phase-I drains sloping towards the RWH structure – Birkha Bawari, which is located in Phase I of the complex.

Sedimentation and storage tanks

The Birkha Bawari is made up of open rainwater storage facilities that run lengthwise. The system is made up of a succession of manufactured tanks that form a 135-meter long linear structure. The water enters from both sides of the subterranean longitudinal storage structure (Bawari), which contains 17.5 million litres of captured rainwater annually and serves as a rich source of water for green area landscaping water requirements in an otherwise water poor location. Rainwater enters the buried settlement tank from each side of the construction (Bawari) and then flows to a succession of tanks with the deepest depth of 18 metres below ground level.

PEROFRMANCE

The RWH system collects approximately 21.1 million litres of rainwater, minimising the need for municipal water or groundwater extraction. In Jodhpur, the average cost of a water tanker (10,000 litres per tanker) is Rs. 800–10,000/-, so using rainwater as an alternative source of water saves roughly Rs. 2.36 million per year. The township's rainwater harvesting system catches 30% of the available rainwater on the site to meet the complex's horticultural water requirements while also maintaining the green space. Furthermore, the Bawari structure serves as a recreational spot for locals as well as a rainwater storage facility.

Orange City Water Project, Nagpur

Nagpur's Water Management Project, source: Hinudstan Times Rrport

Nagpur's smart water management serves as a model for other Indian cities. Nagpur, Maharashtra, is the first to grab the lead. It is the first city of its size in the country to outsource water supply to a private operator under the PPP model for 25 years, and it is now included in the smart cities list. It has a population of over 2.5 million people and is the first city of its size in the country to outsource water supply to a private operator under the PPP model for 25 years. The scheme's major goal was to offer 100% clean drinking water to the whole population, including slum dwellers, 24 hours a day, five days a week. In ten years, the second goal was to reduce non-revenue water (50 percent of water delivered to communities that is untraceable, unrecorded, and unpaid for) to around 25 percent.

Takeaways

- PPPs hep ULBs in governance by separating monitoring and regulation from service provision and bringing in technical and managerial know-how along with proper implementation.
- PPPs need to be backed with contract monitoring and administration capacity building, and wide stakeholder engagement.
- Maximum liability, full accountability and wholesome planning ensures greater availability of water, minimal losses and consumer satisfaction.

INTERVENTION

The aim of the project Nagpur 24x7 was to address problems of water that was being wasted and not getting billed. The city was supplying 575 million litres per day (mld) of treated water of which only 175 mld was getting billed and paid for. Most meters were either non-existent or non functional. Also, the city was receiving water supply for eight to 10 hours or on alternate days. The tanker mafia added to the problem. On the sewage side, the city was generating 550 mld of sewage and had the capacity to treat only 100 mld.

The remaining untreated sewage was polluting water bodies that supplied water to the city. For this project, the private company invested 30% of the estimated project cost, 70% grants came from the JNNURM scheme, shared by both the state and the Central government. The project was initiated by the Nagpur Municipal Corporation. This project has showcased as the model case study for other cities at the launch of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Smart City initiative. The company also undertook a waste water reuse project for Nagpur city under which National Thermal Power Corporation (NTPC) will be reusing 200 mld of treated water from the STP for its Mauda plant. By doing so, the city will get an additional 200 million litres per day of water, which is enough for 200 lakh people.

ACHIEVEMENTS

- OCWPL has taken over water supply and replaced 85000 out of 321,000 connections along 450 km of the pipeline coverage.
- Close to 100,000 unauthorised connections have been identified during rehabilitation phase and commercial losses have reduced
- improvement in NMC revenues
- Service delivery issues being tackled through infrastructure augmentation and increase in capacity of Elevated Service Reservoirs.
- 24x7 water supply has ensured better standards of living for Nagpur residents.
- Consumer grievances being addressed through round the clock call centre
- Bill payments managed through zone level kiosks set up by OCWPL.

References

INTRODUCTION

[1] Creating Urban Water Resilience in India: A Water Balance Study of Chennai, Bengaluru, Coimbatore and Delhi | ORF (orfonline.org)

INDIA'S PROJECTED WATER STRESS

[2] Water Crisis in India: Causes, Effects & Solutions | UPSC Essay - IAS EXPRESS

GANGA'S WOES

[3] Ganga Action: Threats to Lifeline. Gangaaction.org publication

[4] NMCG Pollution Assessment Report

ISSUES FACED

[5] Uttar Pradesh Development Report-Vol. 2, Pg. 267-282

POLICY FRAMEWORK

[6] NiUA. Urban Water Supply and Waste Water | Policy Framework

[7] Central Water Commission, New Delhi, National Water Policy

APPROACH

[8] IAdapt-Publications (urbanwatermanagementindia.org)

VISION AND POLICY COMMITMENTS

[9] NiUA. Urban Water Supply and Waste Water | Policy Framework

INTEGRATED URBAN WATER MANAGEMENT

[10] Hilary Hart. Integrated Urban Water Management – An Overview

[11] Water Sensitive Cities Index - CRC for Water Sensitive Cities

RESOURCE PERSPECTIVE

[12] CEPT University, Urban Water Security Planning Toolkit, Dec 2017

GROUNDWATER AND AQUIFER ASSESSMENT

[13] CGWB. (2000). Guide on artificial recharge to groundwater. India: Central Groundwater Board.

[14] CGWB. (2007). Manual on Artificial Recharge of Groundwater. India: Central Groundwater Board.

References

SERVICE LEVEL BENCHMARKS

[15] MoUD. Handbook of Service Level Benchmarking

NAMAMI GANGE PROJECT STATUS

[16] NMCG Annual Report 2020-21.

CASE STUDY 1

[17] Jakkur Lake- Urban Lake Management (cseindia.org)

CASE STUDY 2

[19] Pasi, Nidhi. (2014). Urban Rain Water Harvesting - Case studies from different agroclimatic regions

[20] Rainwater Harvesting System at Umaid Heritage Housing Complex (cseindia.org)

CASE STUDY 3

[20] Nagpur 24x7 - Orange City Water Project (OCW) | by vishvaraj infra | Medium

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