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Delivering a Sustainable and Climate Resilient Water Future for Bengaluru

A Master Plan for Water, Used Water and Asset Management

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ABSTRACT

Bangalore Water Supply and Sewerage Board (BWSSB) is the water utility for Bengaluru – India's information technology (IT) capital and a megacity with a population of more than 10.5 million – and is responsible for managing the city's water services. As Bengaluru's population continues to grow, BWSSB is facing multiple challenges in the form of increasing water demand, lack of a diverse water portfolio with severe over dependence on a distant, depleting, monsoon-fed, and sole surface water source – River Cauvery. In addition, overexploited groundwater, polluted urban waterscape caused by ingress of untreated used water into the city's drains and lakes from unconnected areas, ageing water assets, a retiring workforce, and increasing costs leading to non-sustainable water services delivery. Climate change projections for Cauvery River basin predict spatial and temporal variability in rainfall leading to erratic runoff pattern, and up to four times increase in drought frequency. Lack of sufficient storage dams in Cauvery Basin will further exacerbate the impact of climate change. In order for BWSSB to continue providing resilient, sustainable and affordable water services through the future, Jacobs developed a Strategic Water, Used Water and Asset Management Master Plan, and Vision – 2050 Document. Strategies were developed to ensure long term water security and water quality, proper used water and biosolids management, optimised operation and maintenance, continual public engagement, capitalising on digital innovation and big data prowess, and implementing fiscal ingenuity to achieve long term financial sustainability for BWSSB. This Master Plan is a first step for BWSSB to prepare itself towards transformation as a Water Utility of The Future (UoTF).

Keywords: Climate change and resilience; sustainable; master plan; cyclical water management.

INTRODUCTION

Bengaluru is the state capital of Karnataka, the third most populous city in India and a globally-significant information technology and biotechnology centre. Between 2019 and 2035, it is predicted that Bengaluru will have the third fastest economic growth of any city in the world (Oxford Economics 2018).

Bengaluru's water supply and used water management infrastructure has been developed progressively, in line with demand growth. The city's first formal water supply system dates to 1896, when a scheme sourcing water from the proximal Arkavathi River (at a location 18 km north of the town) was constructed. In 1933, a second dam on the Arkavathi was constructed (TG Halli) with a water treatment plant (WTP) at its foot.

In the period shortly prior to and post Indian independence in 1947, the population of Bengaluru started to grow, mainly because of the opportunities that Bengaluru has to offer. To support the water needs of this growing population, an alternative water source was required, and in 1964, the scheme to harness water from Cauvery River (approximately 90 km to the southwest of the city, and around 350 m below the city's elevation) was sanctioned by the Government of Karnataka (GoK). BWSSB was established in 1964 as one of the first water boards in India to deliver this project and provide water management services to the city of Bengaluru. When India opened its market for global investments in the early 1990s, Bengaluru picked the race by attracting IT based industry. The pleasant climate, friendly people and good infrastructure provided additional impetus for the people to migrate to Bengaluru (**Figure 1**).

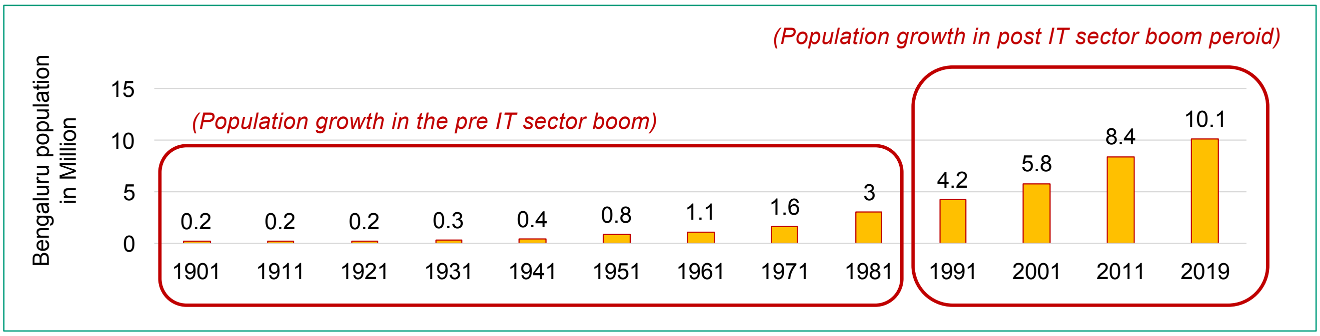


Figure 1: Population growth of Bengaluru over years

Today, BWSSB is one of the largest water utilities in India, serving an area of approximately 800 km^2 and more than 9.5 million customers. BWSSB now employs around 4,000 staff to manage, operate and maintain a diverse range of assets, of value of more than USD 1 billion. **Figure 2** provides an overview of BWSSB's assets.

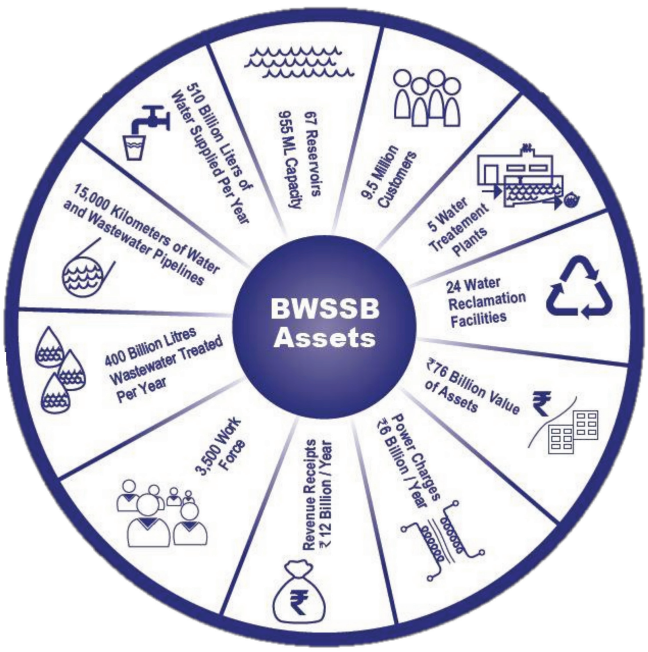


Figure 2: BWSSB assets at a glance (as on April, 2018. Source: BWSSB)

Figure 3: BWSSB challenges

Bengaluru, being one of the fastest growing cities in the world, naturally faces several challenges for effective and efficient water and wastewater management (**Figure 3**). These challenges were comprehensively evaluated and addressed in the master plan, ensuring BWSSB is better prepared for the future. The challenges include:

- **A growing population:** By 2050, the population of Bengaluru City is projected to be more than 20 million from the current 10.5 million, increasing the water demand up to 3,900 MLD from the existing 1,800 MLD;
- **Climate change impacts:** By 2050, the Cauvery Basin is expected to have more erratic rainfall with high intensity and reduced frequency. Temperature is likely to increase up to 1.2ºC, with a four (4) times increase in drought frequency (from the current 1 in 20 years to 1 in 5 years);
- **Non-diverse water portfolio:** With a distant, expensive and monsoon-fed River Cauvery[1] and exploited groundwater, Bengaluru critically requires a diverse water portfolio to sustain its economic and societal growth;

[1]Cauvery River has a 50% dependable annual yield of close to 57,000 MLD (from its catchment which has portions of four neighboring Southern Indian States). The yield from Cauvery River has consistently reduced in the past two decades due to changing climate and rapid changes in Cauvery Watershed. In a dry year, this quantity has been as low as 30,000 MLD. In a normal monsoon year, 21,000 MLD of water is allocated for the entire Karnataka State, and with reducing flows in Cauvery over years, the proportionate share of Karnataka has also come down. This is worrisome for the farmers in Karnataka's portion of Cauvery Watershed, who are totally dependent on Cauvery River for their irrigation needs.

- **Used water and biosolids management:** Around 40% of BWSSB's used water treatment infrastructure needs treatment process upgrade to meet revised environmental discharge standards. The current biosolids management strategy of land application is environmentally unsustainable and requires BWSSB to move towards beneficial use such as energy and nutrient recovery. With growing population, both used water and biosolids management must be holistically addressed to accomplish environmental sustainability;
- **Polluting urban waterscape:** Currently, only up to 70% of used water is treated in Bengaluru, and the remaining 30% finds its way into local lakes and rivers. Rivers and lakes are all interdependent components of the integral waterscape of Bengaluru, and if not protected, Bengaluru runs the risk of losing local water sources that can be developed to diversify the city's water portfolio;
- **Water quality concerns:** River Cauvery watershed comprises of agriculture activities coupled with progressively increasing urbanisation. Going forward, there is a need to monitor the water quality in order to mitigate the water quality risks pertaining to contaminants of emerging concern;
- **Rising costs:** With rising costs, managing water services of Bengaluru is becoming very expensive. The monthly power required to pump 1,460 MLD of water to Bengaluru alone itself costs around USD 6 million. To meet increased service demand and consequent infrastructure expansion requirements, BWSSB must identify alternate project funding, debt restructuring and tariff rationalising strategies to accomplish financial sustainability in the long term. Maintaining a proactive approach towards O&M would be critical for long term cost savings;
- **Ageing infrastructure:** Some of BWSSB's assets, such as storage reservoirs, the distribution system, and treatment plants (water and used water), are more than 50 years old, and such assets need rehabilitation. Going forward, BWSSB will need to focus on efficiently rehabilitating its ageing infrastructure, while creating new infrastructure in peripheral areas of the city;
- **Evolving consumer expectations:** With increased awareness of environmental issues and widespread access to various media, BWSSB's customers are placing the organisation under continuous scrutiny and expect it to be much more than a utility. It requires BWSSB to re-strategise its public education and engagement approach to continue to retain its customers' trust;
- **Utility data management:** Utilising the collected data for knowledge creation is critical. Although a lot of utility-wide data is collected, it is disintegrated because it is either siloed at different offices/locations or its availability is in various forms (hard copy drawings, CADD/GIS files, operators notebook, filed engineer's memory). Utilities are now moving towards utilisation of advanced technologies (such as Building Information Modelling or BIM) for designing and tendering purposes, and unless the data that is collected by utilities is not unified and recorded on a common platform and is analysed using advanced data analytics, BWSSB runs the risk of losing the valuable knowledge that the data provides.

Climate change impacts

In order to have a secure and sustained water future for Bengaluru, it is imperative that the potential impacts of climate change are considered in water resources planning and management. This means creating a system-wide resiliency for extreme events such as droughts and flooding.

Cauvery basin covers an area of approximately 64,679 square kilometres[2]. **Figure 4** shows the entire basin of Cauvery River; three sub basins highlighted reflect the part of Cauvery Watershed that contributes to KRS Reservoir[3], Kabini Reservoir[4] and to the point of water extraction from Cauvery to Bengaluru. Collectively, this watershed represents the northwest quadrant of Cauvery watershed, and is approximately one quarter of the total Cauvery watershed area.

[2](Gosain et al 2006)
[3] On Cauvery River
[4] On Kabini River

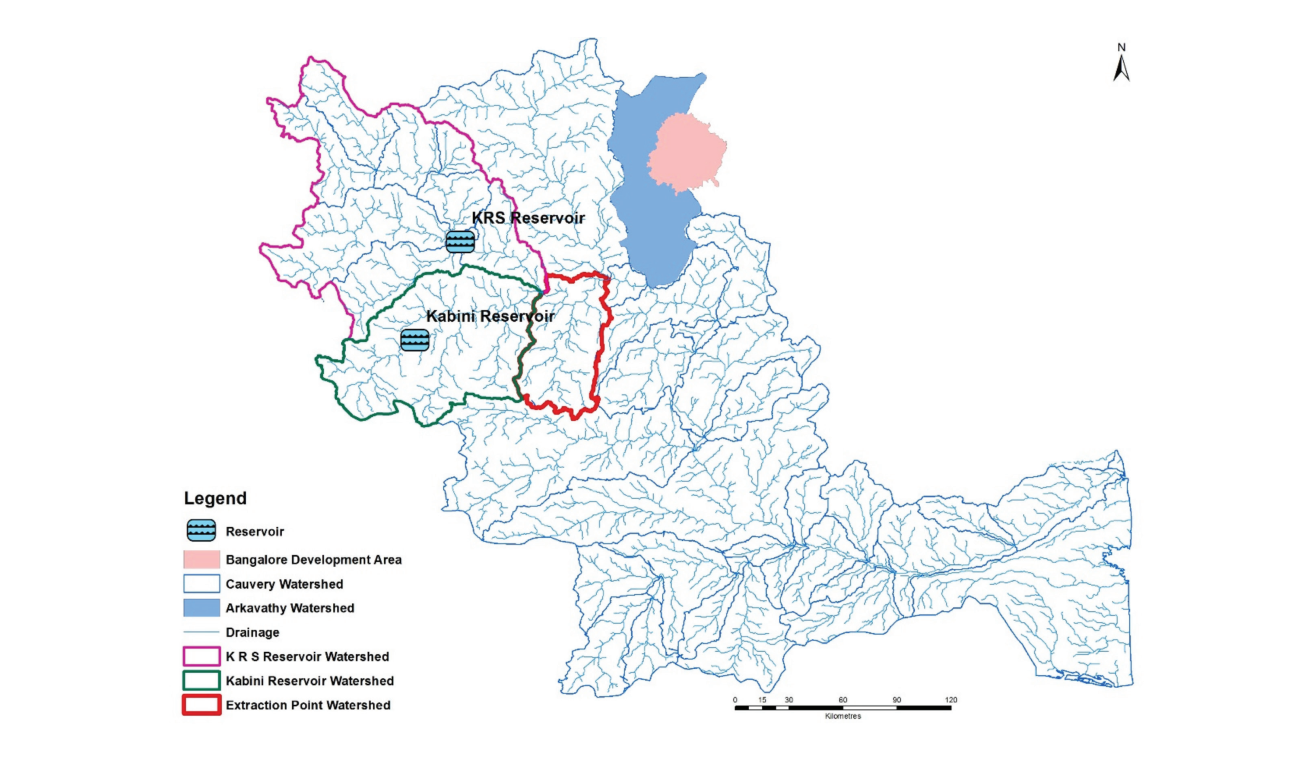


Figure 4: Cauvery watershed

A detailed climate change analysis was carried out including climate modelling to predict future meteorological parameters. The first step was to understand how rainfall, temperature and drought frequency in the Cauvery River basin (and other potential water sources) may change in future. The Intergovernmental Panel on Climate Change (IPCC) recommends that the most recent 30-year climate 'normal' period should be adopted as the climatological baseline period when conducting climate change impact and adaptation assessments. This Master Plan adopted 1995 as the baseline year, in accordance with IPCC guidelines, and evaluated potential future climate changes in terms of temperature, precipitation and drought frequency based on:

- An ensemble for 40 CMIP5 (Coupled Model Intercomparison Project Phase 5) general circulation model (GCM) pattern;
- The worst-case representative concentration pathway (RCP) for radiative forcing, on the basis of providing a conservative analysis, but one that is also aligned with the current trend in greenhouse gas emissions; and
- Median sensitivity, representative of medium feedback mechanisms in the global climate system.

Annual baseline precipitation for the Cauvery basin was noted for its seasonality and also its spatial variability. Large areas of the basin receive less than 600 mm annually, with only the far northwest highlands receiving substantial falls, but even these are highly seasonal. These high rainfall areas do however fall largely within the sub-basins that feed the Cauvery weir, and hence the Bengaluru water supply. **Figure 5** shows the spatial variation in precipitation in Cauvery Watershed for a baseline scenario.

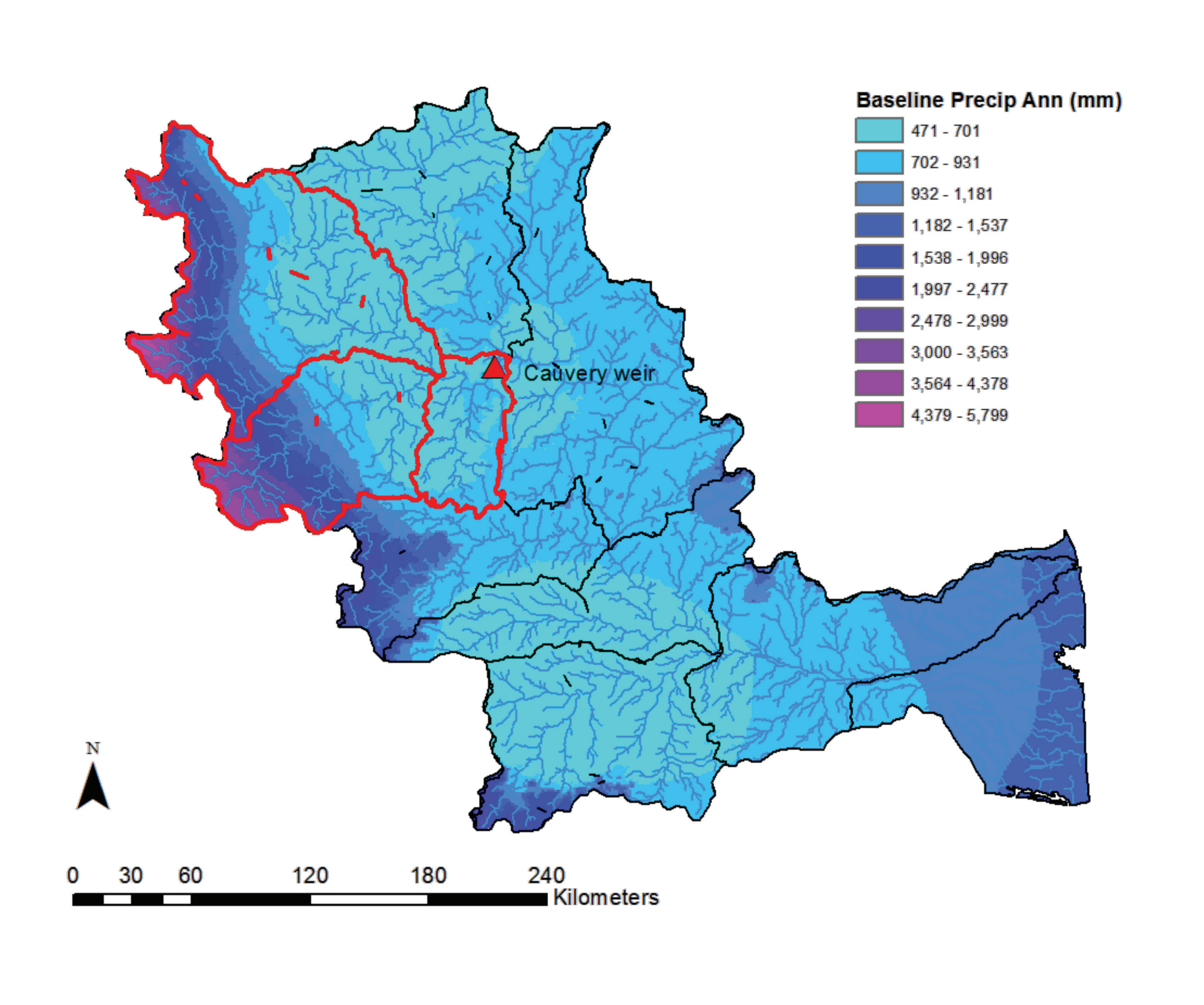


Figure 5: Annual Precipitation in Cauvery Watershed - Baseline Scenario

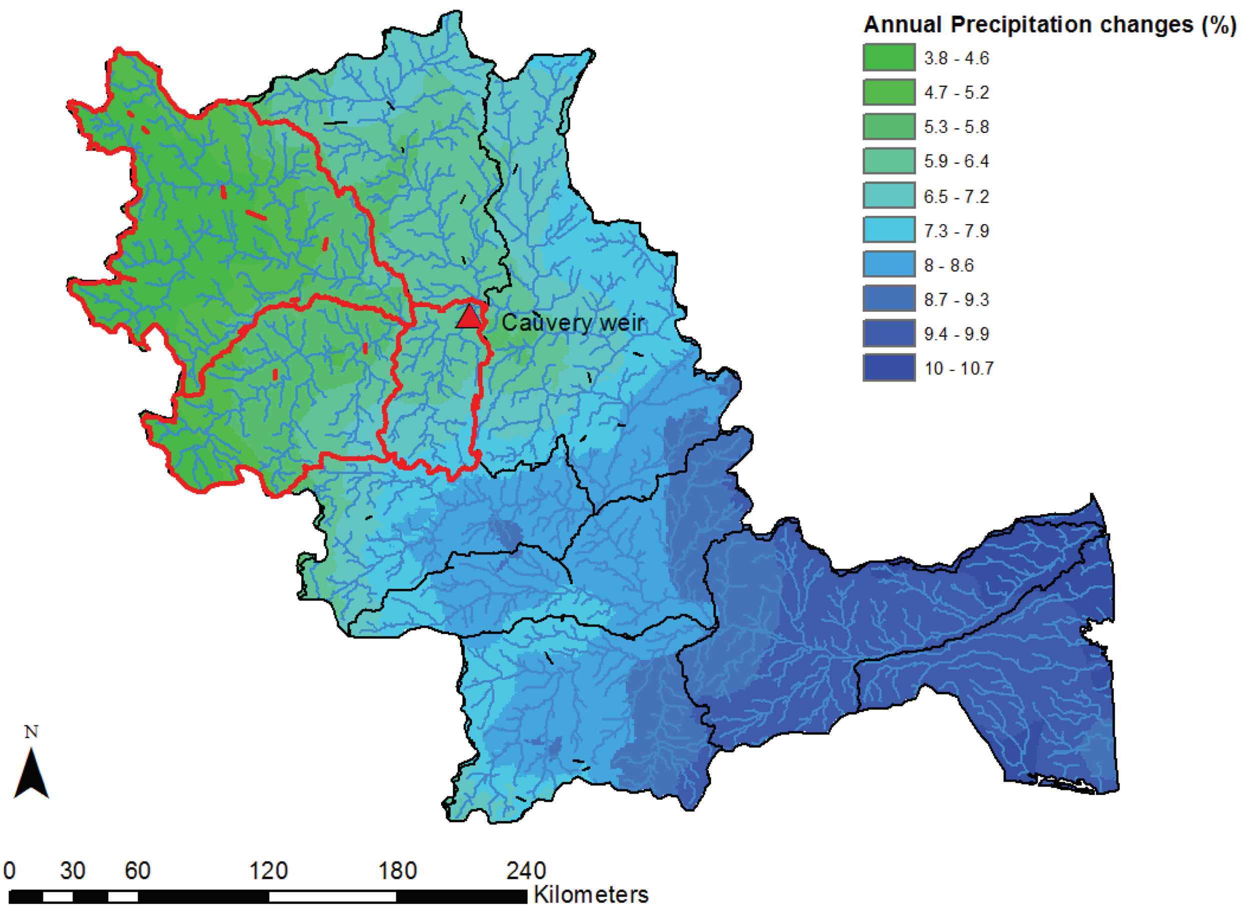


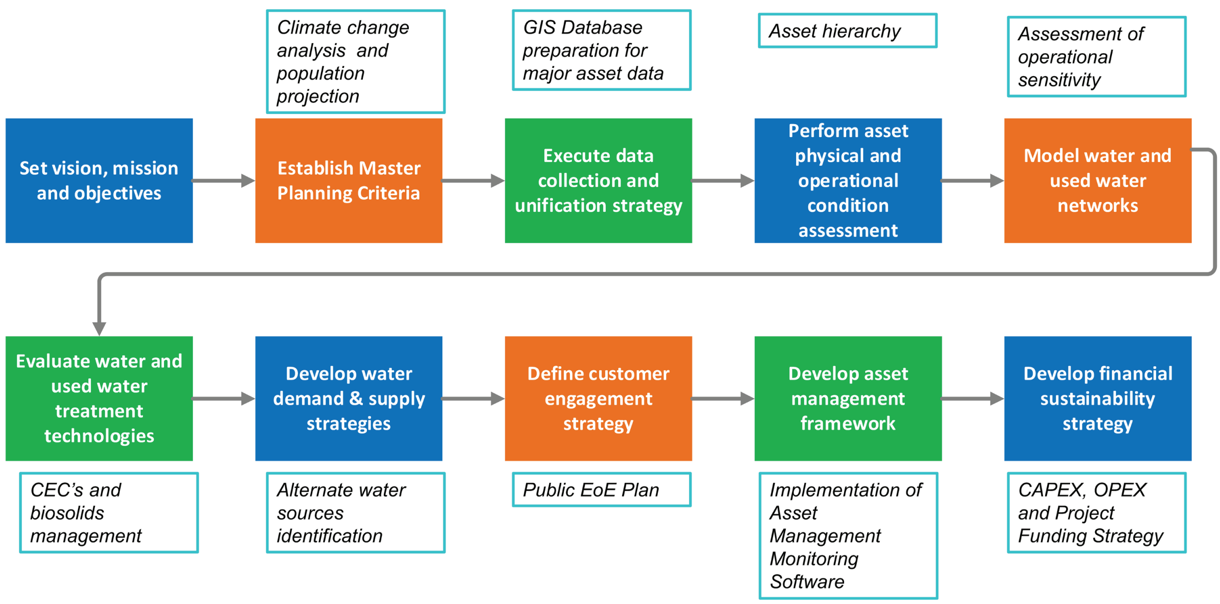
Figure 6: Year 2050 Annual Precipitation Variation

The year 2050 spatial variation in estimated annual precipitation changes for the three basins is shown in **Figure 6**.

Measures such as: creating enough water storage in Cauvery Basin to cater during droughts; identifying a diverse water portfolio that includes local water resources such as recycled water and harnessed rainwater; creating a network of sensors at strategic points in Cauvery Watershed for early preparedness in the event of a flood; identifying a suite of used water treatment technologies that would be more feasible to operate and produce the desired effluent at relatively higher temperatures, etc., are detailed in the subsequent section of this paper.

APPROACH

Our approach (**Figure 7**) focussed on identifying existing and potential future challenges for BWSSB (**Figure 3**), and establishing Key Performance Indicators (as indicated in light blue boxes in **Figure 7**) that were aligned to project initiatives (**Figure 8**). These will enable BWSSB to achieve the attributes of high performing water utilities up to 2050.



CEC: Contaminants of Emerging Concern; EoE: Education, Outreach and Engagement; CAPEX: Capital Expenditure; OPEX: Operational Expenditure

Figure 7: Project approach

Long Term Water Security	•Water resource diversification through due diligence of identified potential new water sources, examine water source resiliency, with emphasis on water demand management for an overall water portfolio sustainability.
Total Water Management	• Operationalise "One Water" thinking while considering development of sector-wide focus on technological application, Wastewater Recycle and Reuse, Strategies for non-rainfall dependent sources.
Asset Management	• Identification and development of sustainable asset management practice that will optimise the capital and operational expenditure of BWSSB.
Financial Sustainability and Tariff Restructuring	• Established Guidelines/Framework for economic analysis, Implement appropriate tariffs and structure, Improved service levels, Identify and seek reliable source of funding
Capacity Building for a Learning Organisation	• Performance Driven and Motivated Organizations, Forward looking Human Resource System, Training Programmes and Plans, Implementation of Best Practices, Meaningful Partnerships
Water and Wastewater Services to All	• Development of strategy for phase wise development of water and wastewater conveyance as well as treatment infrastructure, for providing access to water and wastewater services to all citizens of Bengaluru.
Optimal, Sustainable O&M Framework	• Improvements in O&M performance, asset management, Greater accountability and control of key assets, Effective use of funding resources for critical assets , Greater in-house O&M capacity.
Data Management	• Efficient data collection and management to provide access to information and knowledge in data analysis for BWSSB
Effective NRW Management	• Reduction in Non-Revenue Water Levels, Improved Service Levels, capacity building for equipping BWSSB with a knowledgeable Team for NRW Management.
Climate Change Resilience	• Study of climate change impact for developing attrbutes for climate change resilient utility, and understainding the reliability of existing and potential water due to change in climate.
Community Engagement	• Forged partnerships and communication channels with the community, Public education program , Improved public relations and service levels, Heightened public profile of the water sector.
Water Sector Development	• Strengthened water assets, Growth of local R&D and technologist talents , Participation of local water industry, Export of water industry services.

Governance | Infrastructure | Community

Figure 8: Alignment of project initiatives with Governance, Infrastructure and Community

There were three key drivers for the master plan – population growth, water demand, and climate change. The subsequent development of planning criteria for water and used water management through the master planning horizon involved identifying and selecting water resources for a diverse portfolio; expanding the water transmission and distribution network as well as used water collection and conveyance system to cater for future demand; upgrading, expanding and creating new water and used water treatment plants; creation of recycled water infrastructure; application of digital innovation and big data prowess for creation of knowledge through data collection, storage, retrieval and analysis; creating financial sustainability; optimising operation and maintenance, asset management and stakeholder engagement.

The key tasks included performing and recording utility-wide physical and operational condition assessment of water and used water assets including treatment process performance (via staff consultation and physical inspection) and creation of asset condition grading as well as asset hierarchy; migrating water and used water network data in various formats onto the GIS platform; developing Multiple Objective Decision Analysis Criteria for evaluating alternate water resources, water supply strategies and treatment technology evaluation; water and used water network modelling to develop strategies for network rehab, upgrade or new construction to cater for future flows, as well as identifying interconnections in the water network to enhance resiliency; phase wise upgrade, expansion and creation of new water and used water treatment infrastructure; and subsequently developing a capital infrastructure implementation plan with timelines and financial outlay up to 2050.

RESULTS

Given the interdependence of water and used water management measures, the project initiatives were further refined into strategic initiatives (**Figure 9**) to coherently structure the projects that are specific to water, used water, asset management and common across all three, and yield a series of overarching outcomes (**Figure 10**) which support BWSSB's vision.

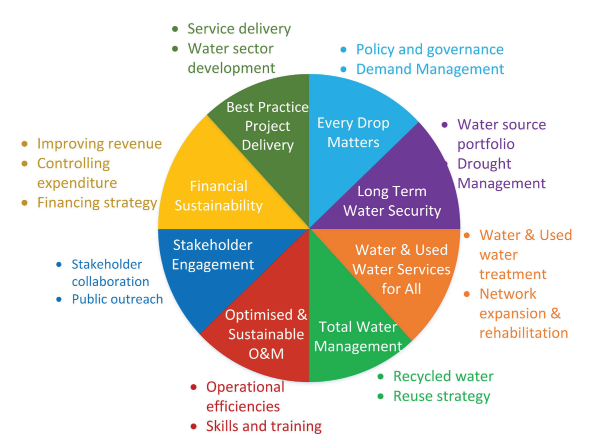


Figure 9: Strategic Initiatives

Figure 10: Outcomes

SUMMARY OF STRATEGIC INITIATIVES AND THEIR IMPLEMENTATION PLAN

Every drop matters – strategic initiative

This strategic initiative outlines the policies and measures that BWSSB are adopting to encourage the wise use of water, ensuring that everyone recognises the value of this precious resource. Two components were identified under this strategic initiative:

Organisation and governance

- Renaming "Bangalore Water Supply and Sewerage Board" as "Bangalore Water Board", and therefore removing the negative connoting word "Sewerage"; this will also enforce that all the water is "One Water" in different forms such as used water, rainwater, surface water or recycled water, and can be treated to make it fit for purpose;
- Organisational restructuring in short, mid and long term, aligned to execute the projects identified under the Master Plan at different time periods; projects such as implementing long distance surface water conveyance, indirect potable reuse of recycled water, harnessing rainwater on catchment scale for potable/non-potable purposes, use of advanced data analytics for knowledge creation and decision making, etc., requires appropriate organisational alignment and competency for successful project execution;
- Developing framework policies for water metering, recycling and reuse, groundwater utilisation, staff's training and capacity building, etc., which will support an efficient water services management.

Water demand management

- Running water conservation campaigns in association with academic institutions and Non-Governmental Organisations, external government stakeholders who have a bearing on the city's water resource management such as municipalities and city development authority;
- Promoting the use of water efficient fixtures and fittings;
- Time-based water tariff restructuring;
- Continuous and concerted efforts for Non-Revenue Water (NRW) reduction;
- Reducing per capita demand over master planning horizon;
- Implementing property level rainwater harnessing.

Long term water security – strategic initiative

This strategic initiative aims to ensure long-term water security for Bengaluru by identifying a reliable and resilient water portfolio, comprised of existing and future water (re)sources, including a timeframe for their development and deployment. This strategic initiative forms the core of BWSSB's approach to develop a sustainable and climate change resilient water portfolio. At present, Bengaluru receives its water supply through the Cauvery Water Supply Scheme (CWSS), which was developed in four stages (namely Stage I, II, III and IV of respective design capacities of 135 MLD, 135 MLD, 300 MLD, 300 MLD and 540 MLD). At present, Cauvery Stage V Water Supply Scheme is under execution, which will provide an additional 750 MLD of water to the unconnected peripheral areas of Bengaluru. The scheme is likely to be commissioned in 2023.

Development of a long-term and sustainable water portfolio for Bengaluru was guided by the following factors:

- Climate change impacts on the availability of water in Cauvery River basin;
- Bengaluru's water demand in the short, mid and long-term;
- The impact of mid to long term population, and land use change on water catchment;
- The impact on existing dependent water use(s)/user(s) of harnessing/partaking water;
- Social, environmental, technical, and financial considerations for developing the identified water resources.

In 2050, the projected water demand for Bengaluru is estimated at 3,860 MLD. To select the portfolio of water supply options (out of all identified water sources for Bengaluru) that best support the sustainable growth of this city, the relative performance of each water source option was assessed against a series of criteria, grouped into economic, technical, social, environmental and implementation categories (MODA - Multi-Objective Decision Analysis). Each short-listed option was assigned a score from 1 (very bad) to 5 (very good) against each of the criteria (**Figure 11**).

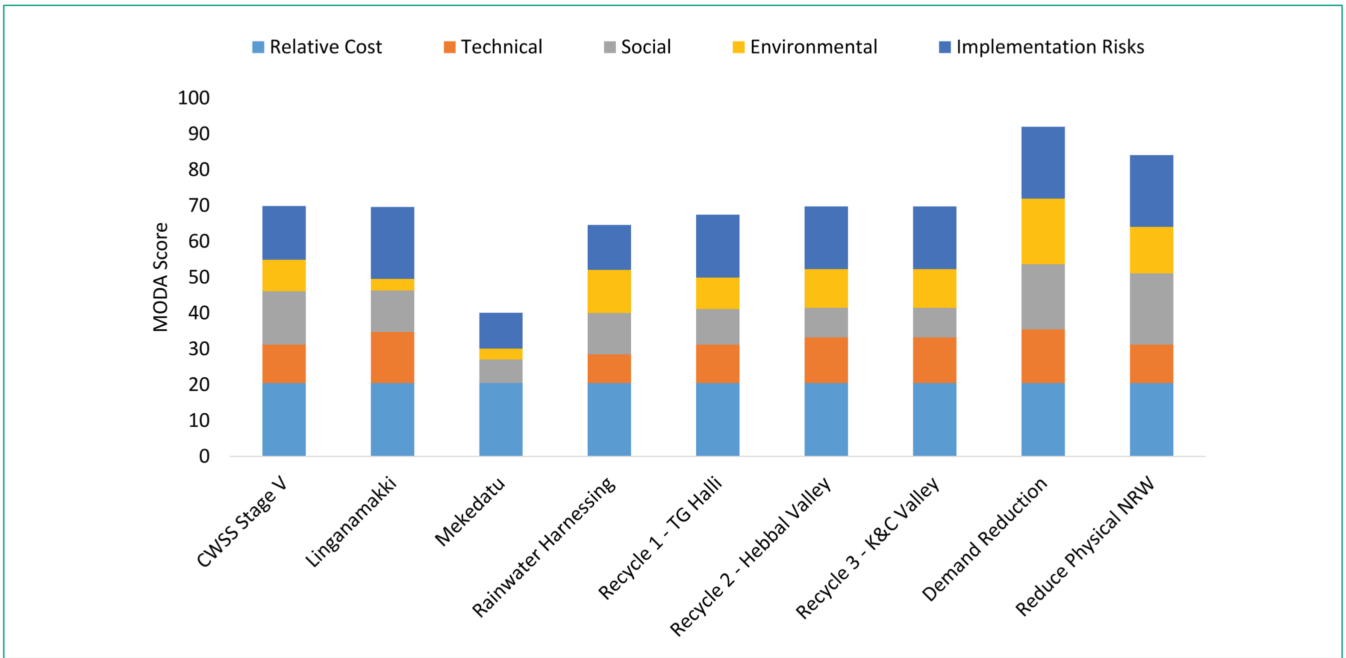


Figure 11: Water Source Multi-Objective Decision Analysis

The water sources (**Figure 12**) considered included:

- Concerted and ongoing NRW Reduction and Water Demand Management Measures;
- Recycle and reuse;
- Catchment scale rainwater harnessing;
- Integrated rainwater harnessing and recycle/reuse;
- Creating storage across Cauvery River to harness monsoon flows;
- Harnessing a new surface water source (Linganamakki).

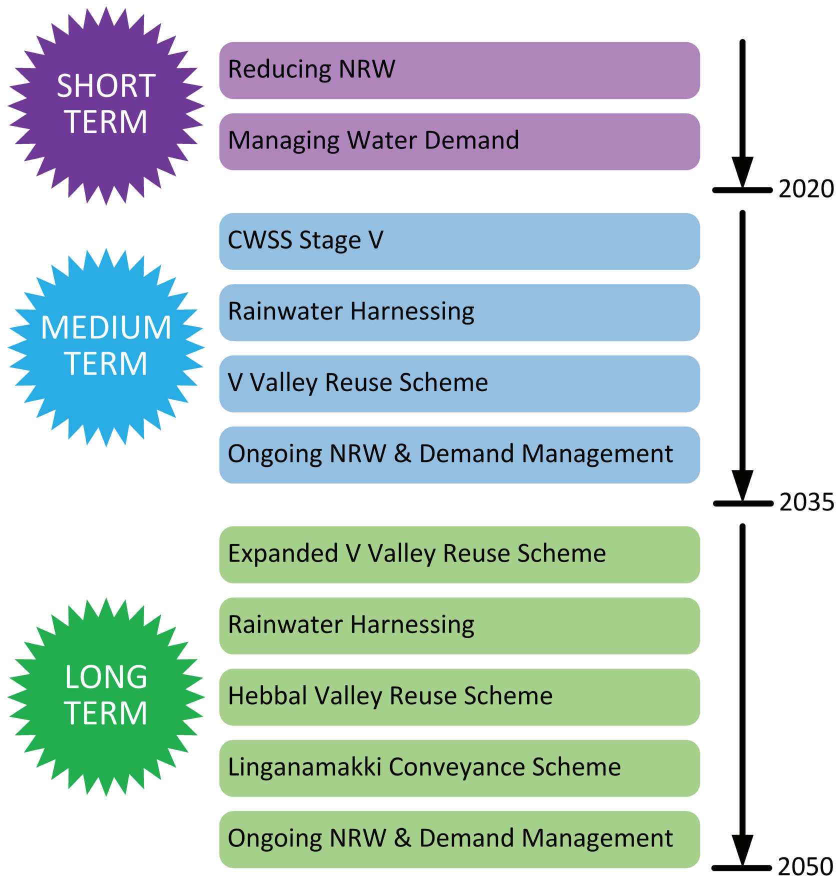


Figure 12: Bangalore's water portfolio

Figure 13 presents the preferred water portfolio, which indicates the potential estimated yield along with implementation timeframes for respective water resources.

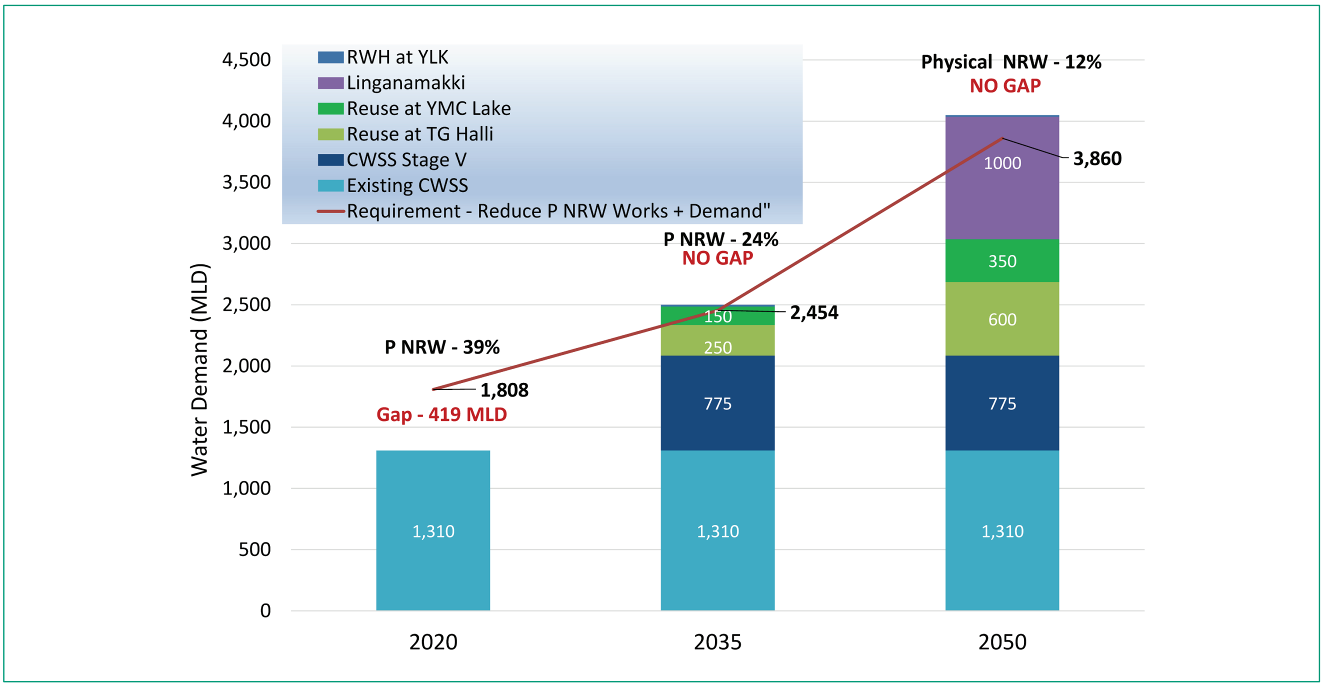


Figure 13: Meeting the Deman-Supply Gap

Short term to 2020

In the short period to 2020, the focus will commence with the following water source initiatives:

- Initiate rainwater harnessing scheme for non-drinking water supply at Yelahanka Lake (potential availability up to 15 MLD),
- Commence feasibility study for:
  - Reuse of treated used water from V Valley via TG Halli Reservoir, including rehabilitation of the catchment, construction of a new WTP downstream of the dam and construction of new conveyance infrastructure to Bengaluru (250 MLD, expandable to 600 MLD);
  - Reuse at Yele Mallappa Chetty Lake (150 MLD, expandable to 350 MLD); and
  - Conveying water from Linganamakki Reservoir to TG Halli Reservoir (potential yield of 1,000 MLD).

In addition, demand management measures should be implemented through a progressive programme that extends across the lifetime of the master plan. A strategy for reducing physical NRW was defined and front loaded to achieve feasible quick wins.

Medium term - 2021 to 2035

- Implement CWSS Stage V – 775 MLD;
- Implement integrated rainwater harnessing and reuse scheme at Yele Malappa Chetty Lake (150 MLD).

Long term - 2036 to 2050

- Expand integrated rainwater harnessing and reuse scheme at Yele Mallappa Chetty to produce additional 200 MLD (total 350 MLD) of drinking water;
- Expand V Valley Indirect Potable Reuse Scheme (total 600 MLD).

In the scenario that the extent of the benefits achieved through NRW and demand management measures are not as expected, and the flows of used water and harnessed rainwater that ultimately supply the proposed reuse scheme does not fill the demand supply gap, the backup water source initiative, i.e. Linganamakki Scheme, will be implemented (1,000 MLD capacity) to meet 2050 demand.

Total water management – strategic initiative

This strategic initiative focuses on the cyclical use of water in Bengaluru's urban waterscape. It envisages implementation of advanced treatment technologies to reliably treat and to produce high-quality recycled water that exceeds drinking water standards.

Under this initiative, BWSSB will implement a comprehensive stakeholder and public outreach program, and continually engage to build support and confidence for recycled water utilisation. In continuation, BWSSB will create opportunities to utilise recycled water for indirect potable and industrial purposes, through construction and operation of advanced recycled water treatment plants.

Short to midterm – to 2035

In the short to medium term, the activities of this strategic initiative include:

- Constructing a 15 MLD water treatment plant for harnessed rainwater and recycled water at Yelahanka;
- Implementing stage 1 of Indirect Potable Reuse in V Valley through highly treated recycled water (a key climate change adaptation strategy), and storing it at TG Halli Reservoir prior to treating and supplying for drinking purposes (250 MLD);
- Restoring TG Halli Reservoir and rehabilitating its water treatment plant.

Long term – 2036 to 2050

- Expand stage 2 of V Valley Reuse Scheme to produce an additional 350 MLD (total 600 MLD) of highly treated water.

Climate change adaptation for water infrastructure – strategic initiative

This strategic initiative aims to ensure that the BWSSB's used water infrastructure is resilient to potential future climate change and that it continues to deliver a high standard of service.

The primary components of the used water system which can be impacted by climate change induced weather events are the used water pipe networks and water reclamation plants (WRPs). Potential interaction of flow between the used water pipe system and stormwater drains during floods is also of potential concern. Under this initiative, an assessment of potential climate change impacts on the existing treatment technologies in BWSSB's UWTPs/WRPs and conveyance infrastructure – pipe material has been made.

Under this initiative, BWSSB will identify suitable adaptation action plans and integrate these commitments into their existing capital investment and maintenance programs. Adaptation options can be "soft", including management, operational and policy changes, or "hard", such as physical modifications to existing infrastructure or new assets.

A time-phased implementation plan for the recommended climate change adaptation initiatives has been developed.

Short term – now to 2020

- Comprehensive network of monitoring of used water qualities and flows – comprising continuous monitoring at strategic locations and regular manual sampling for verification;
- Formalised data and information sharing relationship with Karnataka State Natural Disaster Monitoring Centre (KSNDMC) and Indian Meteorological Department (IMD);
- Working with KSNMDC, IMD and academic institutes to develop early warning systems linked to specific operational responses set down in SOPs. Engage other city authorities (BBMP, Bengaluru Development Authority - BDA, emergency services) in this process;
- Working with the above partners to develop future system scenarios and use network models to test alternative operating approaches.

Medium term – 2020 to 2035

- Reduce inflow and infiltration and improve used water connectivity to households to reduce the likelihood of extreme rainfall resulting in increased flows to WRPs;
- Work with BBMP and BDA to encourage SUD (Sustainable Urban Design) initiatives in urban catchments;
- Improve segregation of stormwater and used water conveyance systems/pipelines;
- As advised by short-term network modelling, increase used water treatment capacities where required and optimise capacities elsewhere;
- Use results of scenario testing to implement infrastructure updates on the basis of risk and criticality.

Long term – 2035 to 2050

- Continued refinement of disaster management strategy and operational protocols based on ongoing data collection that describes performance of plan implementation.

Stakeholder engagement – strategic initiative

This strategic initiative aims to ensure that all stakeholders with an interest in sustainable water resource management for Bengaluru, endorse and work together to achieve the vision of this Water, Used Water and Asset Management Master Plan, and that such engagement is continuous throughout the Master Plan horizon. Key activities under this initiative include (**Figure 14**):

- BWSSB's Public Relations Department initiates and progressively intensifies the outreach for the master plan projects that are most dependent on public support such as water conservation, water demand reduction, and used water recycling; introduce new logos, branding, social media profiles, style guides, videos, website and distribution materials focused on the three fundamental themes of the Master Plan: water conservation and demand management, recycle and reuse, and rainwater harnessing;
- BWSSB establishes working partnership with education institutes of international repute such as Indian Institute of Sciences (IISc) and other non-government organisations, and leverages these to further strengthen its social standing and enhance its trust among customers;
- Expand existing Rainwater Harnessing Theme Park as a new Visitor Centre by introducing audio-visual based exhibits showcasing key master plan projects and themes;
- Establish a regional Water Working Group (called the "Water Future Hub") to facilitate industry collaboration, share data and promote innovation.

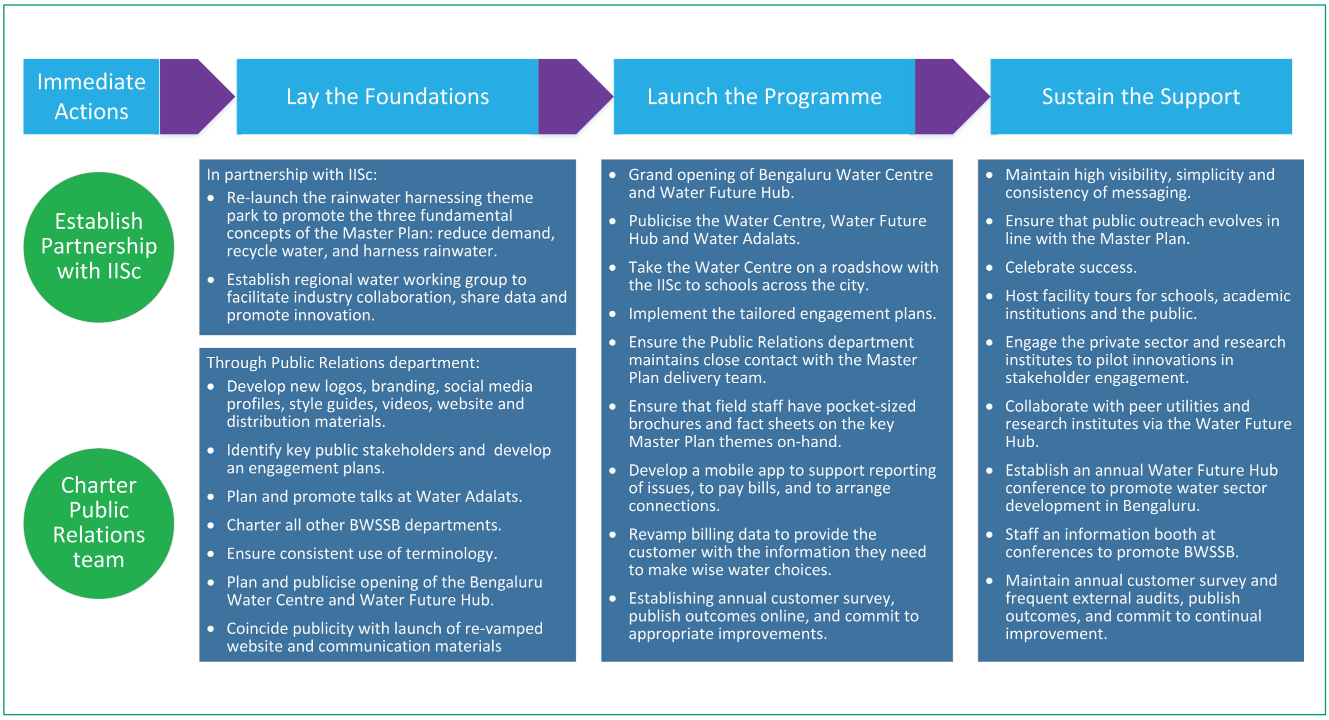


Figure 14: BWSSB stakeholder engagement program

CONCLUSION

One of the critical aspects of the study was to establish a set of processes and indicators that will measure the performance of strategic initiatives. The first step was to identify the Target Service Level Benchmarks (SLB) as shown in **Table 1** below.

Table 1: Target Service Level Benchmarks for BWSSB

Focus Area	Performance Indicator	2018	2025	2035	2050
Water Supply Sources	Supply of water per person per day – Fresh water (lpcd)	110	100	100	100
	Supply of recycled water per person per day (lpcd)	~12	20	25	35
Water Treatment	Water samples meeting or exceeding specified water quality guidelines	100%	100%	100%	100%
Water Transmission & Distribution	Households with direct water supply connection	75%	100%	100%	100%
	Non-revenue water (technical and commercial losses)	37%	30%	25%	15%
Wastewater Collection System	Households with direct connection to the wastewater collection network	80%	100%	100%	100%
Wastewater Treatment	Wastewater treated to secondary level	80%	100%	100%	100%
Recycled Water	Wastewater received at water reclamation plant that is recycled or reused	10%	15%	20%	25%
Financial sustainability	Ratio of annual operating revenue to operating costs	>0.95	>1	>1	>1

Further, to accomplish the identified Service Level Benchmarks (SLB) by the respective horizon years, the following activities were put into action:

- Creation of an internal committee at BWSSB which will oversee the implementation of master planning projects pertaining to water and used water infrastructure development; it will also be cognisant of future uncertainties and recommend any variation in proposed solutions by updating the master plan at every 3 to 5 years duration;
- Population projection for immediate, interim and target horizon years to determine the water demand and used water generation, which will guide the development of water and used water infrastructure as well as the commissioning of new water sources (recycled water, harnessed rainwater at catchment scale, Linganamakki Reservoir surface water scheme) that will be implemented to bring additional water to Bangalore;
- Implementation of Asset Management Monitoring System (AMMS) for the entire asset classes of BWSSB, with a target to get ISO 55000 certification by 2023; this activity is ensuring that all BWSSB assets are steadily being incorporated in AMMS, and asset management process is getting documented. With this activity, BWSSB is now trending towards having a complete asset data set recorded for proactive asset management;
- Creation and standardisation of a comprehensive and unified GIS based data bank for water and used water infrastructure data, which not only includes converted asset information, but also includes standardised templates to be utilised by all BWSSB offices for storing different types of data; it also includes a road map to upgrade the software, hardware and organisational skills with required manpower as BWSSB continues through the future;
- Creation of an operational water network hydraulic model of BWSSB's Transmission and Feeder Network, which is currently being further developed for its utilisation in day-to-day water network operations; this initiative is supported by another undergoing master plan project which envisages installation of flow, velocity, and pressure sensors to collect and transmit the real time data that can be utilised for network operations with a targeted timeline of 2025;
- The Statutory Pollution Control Authority in India has directed water utilities to comply with revised and stringent treated used water quality standards[5] by 2020, and include recycled water to meet up to 20% of total water demand by 2025;
- Road map for used water infrastructure development and treatment technology upgrade to address planning for existing, under construction and future proposed treatment plants, along with technological interventions for treating contaminants of emerging concern and recovering energy and nutrients from beneficial biosolids management;
- Identification of time based NRW reduction targets (35%, 30%, 25% and 15% by 2020, 2025, 2035 and 2050 respectively) with application of tools and technologies such as cluster and cohort analysis to have risk-based analysis for supporting network rehabilitation measures;
- Installation of flow and quality monitors at strategic locations along Cauvery River in the upstream of headworks to determine the long-term flow and water quality variations, and accordingly plan for treatment technology as well as treatment capacity upgrades;
- Development of strategies for proactive network rehabilitation, upgrade or new construction to meet the future growth and demand, while developing the network resiliency through interconnections network sensitivity analyses via network hydraulic modelling;
- Aligning vision to international initiatives and best practices such as ISO-55000 and the Utility of The Future (UOTF) initiatives to focus strategy, and implementing projects to establish technical ingenuity, and social, environmental, financial prudence.

Figure 15 presents the implementation timeline for the Master Plan.

[5]BOD ≤ 10 mg/L, Suspended Solids ≤ 10 mg/L, Total Nitrogen ≤ 10 mg/L, Dissolved Phosphorus ≤ 2mg/ L

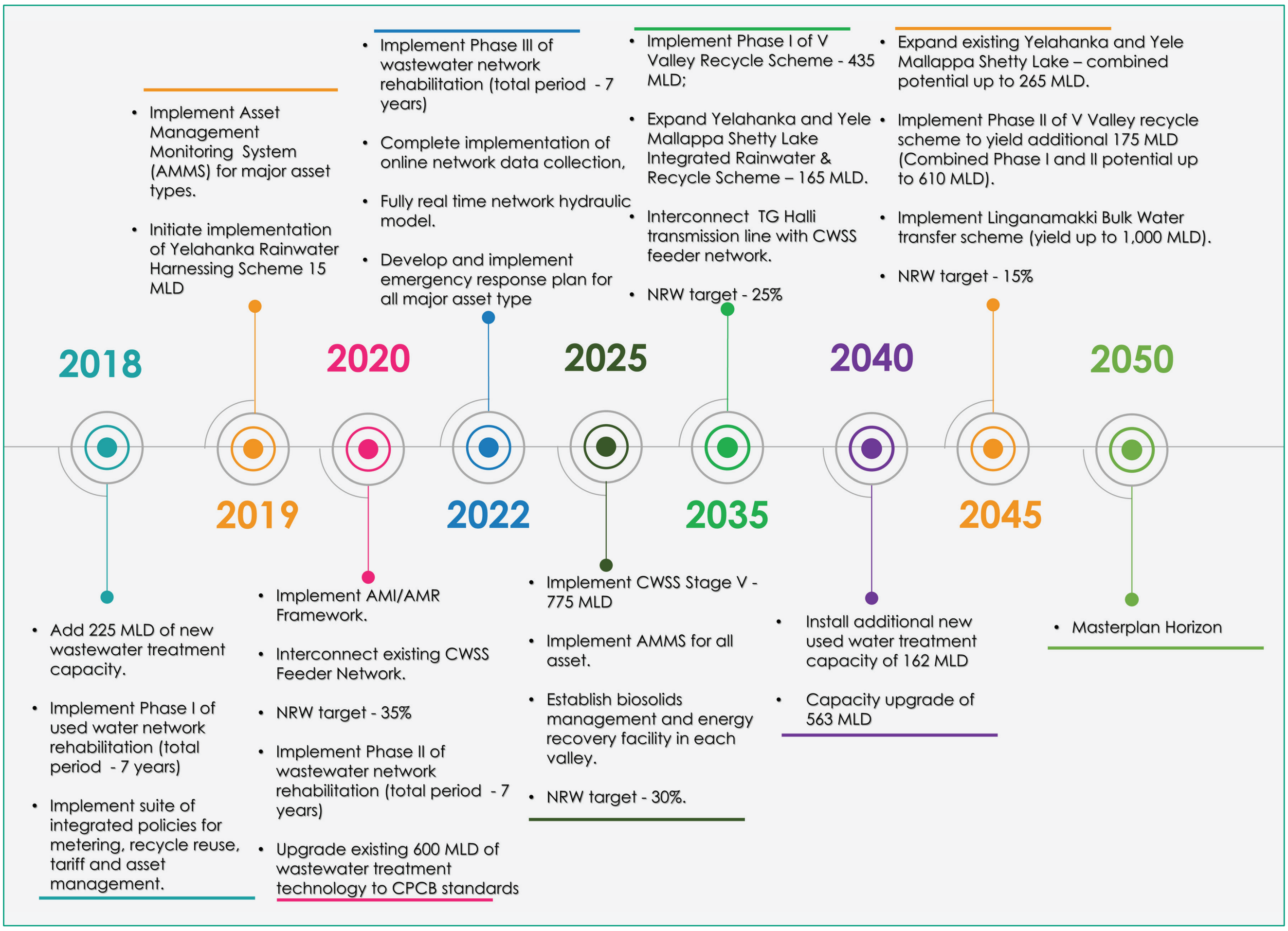


Figure 15: Master Plan project implementation timeline

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