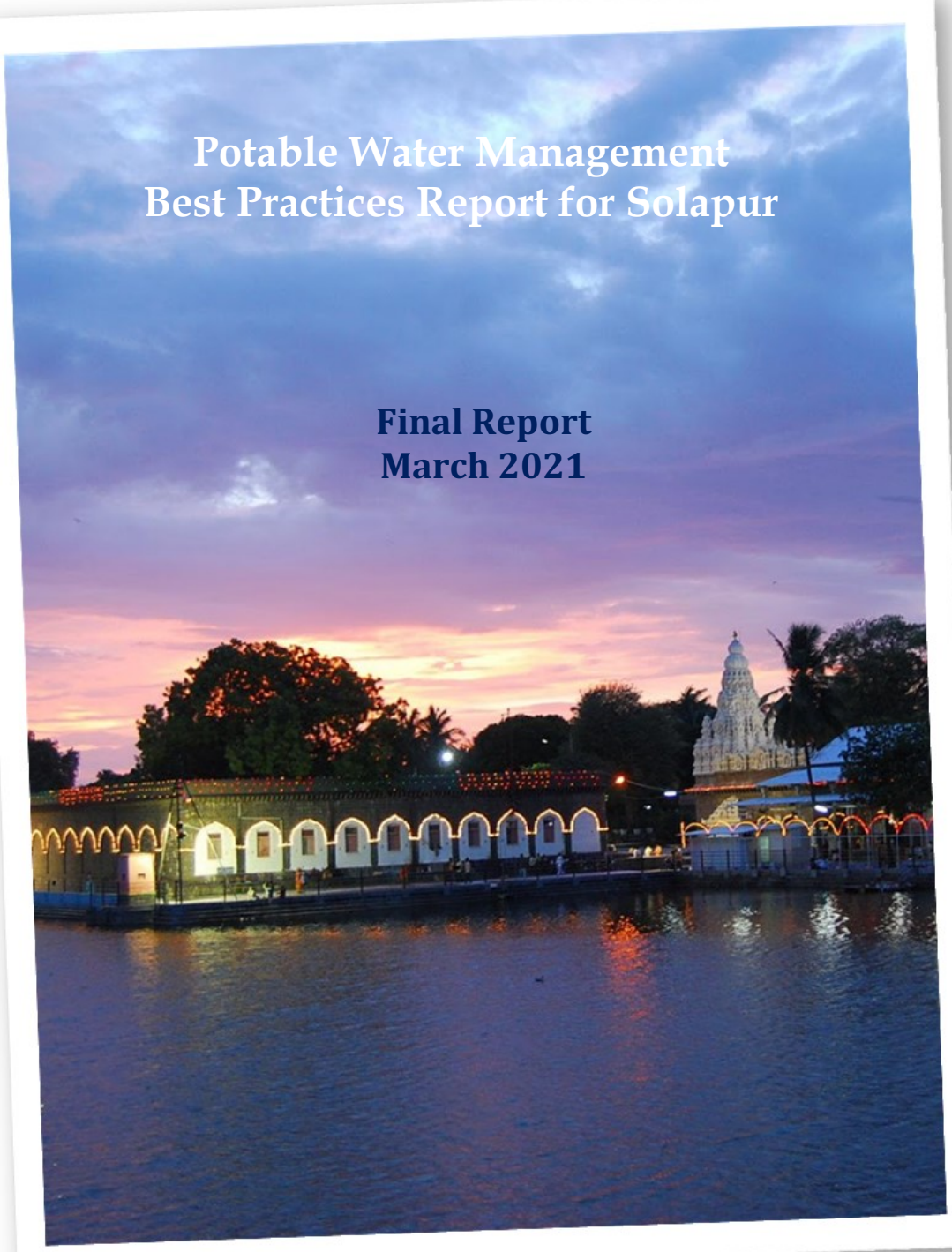
INTERNATIONAL URBAN COOPERATION
European Union

Solapur Municipal Corporation

Potable Water Management Best Practices Report for Solapur

Final Report
March 2021



Funded by the European Union

This report was produced with the financial support of the European Union. Its contents are the sole responsibility of IUC-India and do not necessarily reflect the views of the European Union.

Table of Contents

Executive Summary 8
1. Introduction and Study Objectives 16
1.1 Introduction 16
1.2 Brief on IUC- India partnership and Solapur and Murcia city pairing 16
1.3 Study objectives 16
2. Background – Solapur City 18
2.1 City profile 18
2.2 History, macroeconomic and topography 18
2.3 Climate 20
2.4 Solapur Municipal Corporation (SMC) 20
2.5 Demographics 21
2.6 Land use pattern 23
3. Major challenges in Solapur water supply system 24
3.1 Solapur water supply system 24
3.2 Ongoing initiatives 29
3.3 Impacts of water shortages 31
4. Policy Framework 33
4.1 National Water Policy 33
4.2 Maharashtra State water policy 34
5. Stakeholder analysis 36
5.1 Irrigation Department 36
5.2 Maharashtra Water Resources Regulatory Authority (MWRRA) 36
5.3 Groundwater Surveys & Development Agency (GSDA) 36
5.4 District Collectorate 37
5.5 Solapur Municipal Corporation 37
5.6 Solapur City Development Corporation Limited (SCDCL) 37
6. Global best practices in potable water management – Murcia (Spain) 39
6.1 Murcia city profile 39
6.2 Best practices in water management in Murcia 41
7. Indian best practices in potable water management – Surat and Bangalore 45
7.1 Indian case study 1: Formation of NRW cell & water audit in Surat city 45
7.2 Indian case study 2: Bulk water metering system in Bangalore city 50
8. Recommendations 53

8.1 Supply side measures 54
8.2 Demand management 61
8.3 Other water conservation measures 63
8.4 Behavioural change activities 64
8.5 Monitoring and evaluation related measures 65
9. Conclusion and way forward 68
Annexures 70
Annexure 1 References 70

Abbreviations

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AdoptIUWM	Adopting Integrated Urban Water Management in Indian cities
ABC Waters	Active, Beautiful, Clean Waters
BWSSB	Bangalore Water Supply and Sewerage Board
CAGR	Compounded Annual Growth Rate
CAPEX	Capital expenditure
CBUD	Capacity Building for Urban Development
CBD	Central Business District
CAP	Climate Action Plan
CDP	City Development Plan
CMP	Comprehensive Mobility Plan
CCC	Command and Control Center
CSR	Corporate Social Responsibility
DBMOT	Design, Build, Maintain, Operate and Transfer
DPR	Detailed Project Report
DMAs	District Metered Areas
ECS	Equivalent Car Space
EPC	Engineering Procurement Construction
ESR	Elevated Storage Reservoir
EESL	Energy Efficiency Services Limited
EU	European Union
FY	Financial Year
GCoM	Global Covenant of Mayors for Climate and Energy
GHG	Green House Gases
GoI	Government of India
GoM	Government of Maharashtra
GSDA	Groundwater Surveys & Development Agency
GSR	Ground Storage Reservoir
GIS	Geographic information system
GSM	Global System for Mobile Communications
GUI	Graphical User Interfaces
HH	Household
IoT	Internet of Things
IRR	Internal Rate of Return
IUC	International Urban Cooperation
IOW	Intelligent Operation of Water
IUWM	Integrated Urban Water Management
IWWA	Indian Water Works Association
ISWP	Integrated State Water Plan
ICT	Information Communication and Technology
ICCC	Integrated Command and Control Center
ITMS	Intelligent Transit Management System
IOW	Intelligent Operation of Water
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
LAP	Local Action Plan
LEDS	Low Emission Development Strategies
LPWAN	Low-power WAN
MWRRA	Maharashtra Water Resources Regulatory Authority
MLD	Million Liters per day
MoUD	Ministry of Urban Development
NB-IOT	Narrow Band IoT
NTPC	National Thermal Power Corporation
NPV	Net Present Value
NIUA	National Institute of Urban Affairs
NRW	Non-Revenue Water

OPEX	Operating expenditure
O&M	Operation and Maintenance
PPP	Public Private Partnership
PAS	Performance Assessment System
PID	Proportional-Integral-Derivative
PLC	Programmable Logic Controllers
RD & WCD	Rural Development & Water Conservation Department
RWH	Rainwater Harvesting
SCM	Smart City Mission
SCP	Smart City Proposal
SMAC	Smart City Center
SCDCL	Solapur City Development Corporation Limited (SCDCL)
SPV	Special Purpose Vehicle
SLBs	Service Level Benchmarks
SCADA	Supervisory Control and Data Acquisition
SUDS	Sustainable Urban Drainage Systems
SMC	Solapur Municipal Corporation
SMnC	Surat Municipal Corporation
UCLAP	Urban Cooperation Local Action Plan
UIDSSMT	Urban Infrastructure Development Scheme for Small and Medium Sized Towns
UCAP	Urban Cooperation Local Action Plan
UN	United Nations
UTs	Union Territories
WRD	Water Resources Department
WTP	Water Treatment Plant

List of Exhibits

Exhibit E 1 Location - Solapur 8
Exhibit E 2 Impacts of water shortages 9
Exhibit E 3 Murcia water supply - SPV 11
Exhibit E 4 BWSSB - Water operations Dashboard 13
Exhibit E 5 Key recommendations 14
Exhibit E 6 Illustration of smart meter – Murcia and Parivartan app- Solapur 15
Exhibit E 7 Overexploitation of ground water in Indian cities 25
Exhibit E 8 Impacts of water shortages 31

Exhibit 2-1: Location - Solapur 18
Exhibit 2-2 Solapur - landmarks 19
Exhibit 2-3: Chronology of events in extension of Solapur municipal limits 21
Exhibit 2-4 Historical population and growth rate of Solapur city 21
Exhibit 2-5 Projected Population (2041) - SMC 22
Exhibit 2-6: Trend in sex ratio of Solapur 22
Exhibit 2-7: Land Use map of Solapur City 23
Exhibit 3-1: Solapur - water supply demand projections 24
Exhibit 3-3: Water supply connections in Solapur (2019-20) 26
Exhibit 3-4: Water supply revenue – demand, collection and balance (2019-20) 27
Exhibit 3-6 Cost of coping with intermittent water supply in India 32
Exhibit 6-1 Location – Murcia 39
Exhibit 6-2 Aguas de Murcia - SPV structure 42
Exhibit 6-3Micro sectors and their NRW levels 43
Exhibit 6-4 evolution of NRW and the technical performance (THP) of the network since 198944
Exhibit 7-1: GRID water supply network system 46
Exhibit 7-2: Leakage Mapping Mechanism 47
Exhibit 7-3: Reduction of leakages per km length during 2006-11 48
Exhibit 7-4: BWSSB Service Level Benchmark 50
Exhibit 7-5: Water operations Dashboard 52
Exhibit 8-1: ICT based Smart Metering helps in reduction of NRW 53
Exhibit 8-6: Strategies for NRW reduction in Solapur – as per NRW study under CBUD 57
Exhibit 8-2 SCADA system – components 59
Exhibit 8-3 Use of ICT for improving water supply management 59
Exhibit 8-4 Pune - Dashboard for grievance management system 60
Exhibit 8-5 Illustration of smart meter – Murcia and Parivartan app- Solapur 61

Exhibit 8-7 SLB performance parameters as per MoHUA, GoI 65
Exhibit 8-8 Suggested frequency and jurisdiction of reporting 66
Exhibit 8-9 Illustrative performance report card 67
Exhibit 8-1: ICT based Smart Metering helps in reduction of NRW 68

Executive Summary

1. Background

The European Union's International Urban Cooperation (IUC-India) project is supporting the Solapur – Murcia city pairing in relation to the development of an Urban Cooperation Action Plan (UCAP) on Best Practices for Potable Water Management.

2. Solapur city

Solapur, one of the growing cities in Maharashtra State in India, is situated within the basin of river Bhima. The population of Solapur city was 9,51,000 as per Census 2011, which is expected to increase to 12,27,327 (1.2 million) in 2021 (projected pop[1]). Solapur city is administered by the Solapur Municipal Corporation (SMC).

The city falls under the category of dry (arid and semiarid) climate, the monsoon lasts from June to the end of September, with irregular, erratic scanty rainfall, with annual average of around 500 mm to 700 mm (20 - 30 inch).

Exhibit E 1 Location - Solapur

Source: Wikipedia & Maharashtra Remote Sensing Applications Centre

3. Water supply system in Solapur city – status and key challenges

Solapur receives water from three sources, Ekrukh Tank, Bhima River, and Ujani dam reservoir. Key challenges in water supply system are as follows -

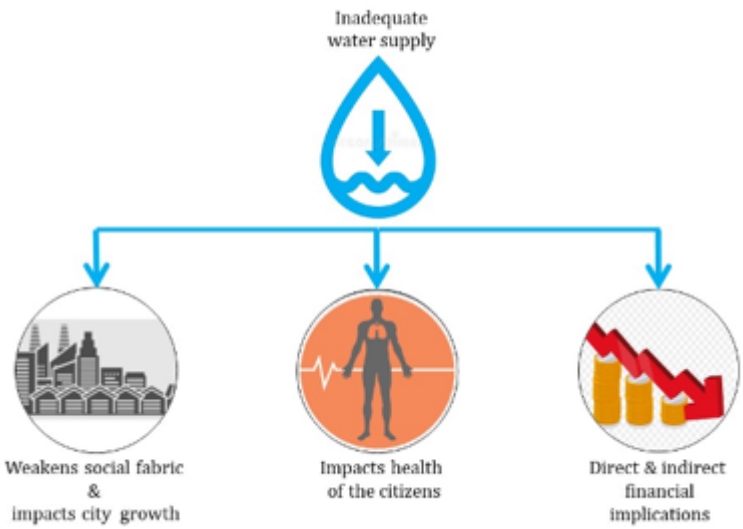
- **Inadequate water allocation:** Raw water allocation from dams is inadequate due to which water is supplied once in four days in the city and coverage needs to be further increased.
- **Water supply gap:** Total estimated water demand of the city was 200 MLD in 2020, 253 MLD in 2031 and 327 MLD in 2041. The gap in supply is around 76 MLD in 2021. This gap will be reduced to 31 MLD in 2031 as the ongoing source augmentation scheme of 110 MLD capacity will be operational by then.
- **Non-Revenue Water (NRW):** Higher percentage of NRW and low revenue collection is a big challenge. SMC has tried to ascertain NRW levels through various studies. Some old

[1] Source: Revised City Development Plan for Solapur, 2041.

studies provide baseline information on NRW. For example, the water audit in 2006 showed 44% of physical losses, whereas 2015 NRW study, indicated that the physical losses were at 29.2% and the overall NRW was 57%. As per SMC records, the physical losses in the system are 25% and the NRW was 29% in the year 2019-20. There is a need for a periodic assessment of NRW levels and actions to address it in comprehensive manner.

- **Water supply Operation & Maintenance (O&M) cost recovery:** As per the Performance Assessment System (PAS)[2] reporting for 2019-20, annual O&M cost of water supply system is INR 625.4 million while the total revenue demand (water supply) is INR 452.5 million, thus the O&M cost recovery is 72.4%. Major component of the O&M cost is electricity charges and fuel cost (48%), followed by staff cost (24%).
- **Connections and lack of metering:** Currently there are only 9,271 metered connections, which is 8.3% of total water connections. Out of these metered connections, only 478 connections (5.1% of total) have functional meters.
- **Groundwater - inadequacy and overexploitation:** Due to intermittent water supply many housing societies resort to groundwater resulting in overexploitation of this valuable source. At the same time there are very few efforts towards water conservation and rainwater harvesting, thus making the situation more challenging.
- **Lack of wastewater recycling and reuse:** There is a need for recycling of wastewater and reuse for non-potable purposes as an alternative to fresh water supply to these non-potable usages. SMC has already planned one such initiative to supply secondary treated wastewater to thermal power plant near Solapur city.

Exhibit E 2 Impacts of water shortages



[2] The performance measurement framework draws on the Government of India's ongoing initiative of standardised Service Level Benchmarks (SLB) for urban water supply and sanitation sectors developed by the Ministry of Urban Development (MoUD). This activity now covers 6 states and 900+ cities in India and has become a major repository of urban water and sanitation database in India.

4. Impacts of water shortages

The intermittent and inadequate water supply along with the losses in the system majorly affect the overall social fabric of the city, impact health of citizens and has substantial economic and financial implications for both citizens and the government.

5. National and state policy framework for water management

The Government of India (GoI) has formulated the National Water Policy in 1987, which was subsequently reviewed and revised in the year 2002 and 2012. The National Water Policy has been shared with all States/ Union Territories (UTs) for appropriate action. As per available information, 16 States/UT have formulated and adopted their State Water Policies.

Based on the findings and learnings from the existing situation, the National Water Policy has proposed a framework for creation of a system of laws and institutions and for a plan of action with a unified national perspective.

State of Maharashtra had framed its Water Policy in 2003 which was subsequently revised/reviewed in 2011 & 2019. Water being the state subject, the Government of Maharashtra (GoM) is aware of the importance of policy framing and its immediate need/action in the cities. Despite the challenges and concerns, since adaptation of this policy, significant positive changes have occurred in the water scenario of the State.

6. Stakeholder analysis

Key agencies / stakeholders involved in water management in Solapur city is given in the Exhibit E 3.

Exhibit E 3 Stakeholders involved and their roles

Agency	Role
Water Resources Department	Since 2004 Irrigation department of Maharashtra State is known as the Water Resources Department. It is responsible for the allocation of water from rivers and reservoirs to different user categories such as Urban Local Bodies (ULBs), rural local bodies, agriculture, industries, and other bulk users.
Maharashtra Water Resources Regulatory Authority (MWRRA)	The MWRRA establishes a regulatory mechanism for overseeing the relationship between the service provider and water user entities, and within a water user entity, in terms of determination, enforcement and dispute resolution of entitlements and fixation of water charges.
District Collectorate	The District Collectorate oversees the law and order in the district. The Tahsildar of the Taluka is responsible for the law and order situation in their respective Talukas. The district collectorate plays an important role in managing the water bodies-rivers and lakes.
Solapur Municipal Corporation (SMC)	Solapur city is administered by the Solapur Municipal Corporation (SMC), which is governed under Maharashtra Municipalities Act, 1965. SMC oversees the engineering works, health, sanitation, water supply, administration, and taxation in the city, and deals with activities like developing new layouts and roads, town-planning, and land acquisition. It is responsible for water supply and sewerage services to the citizens of Solapur city.

Agency	Role
Solapur City Development Corporation Limited (SCDCL)	SCDCL is an SPV formed under the Smart City Mission of Government of India. The SCDCL is responsible for implementation of various projects identified under the Smart City Proposal (SCP) as per the Area Based Development and Pan City initiatives.
Groundwater Water Survey Development Agency (GSDA)	GSDA is one of the leading institutions concerned with groundwater surveys, exploration, assessment, monitoring, development, management, and regulation of groundwater resources for irrigation, drinking and industrial needs.

7. International best practices concerning potable water management - Murcia's experience

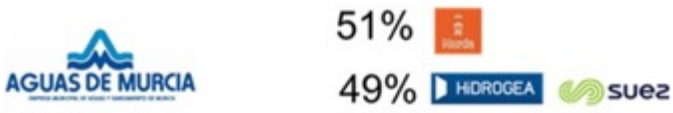
Murcia - background

Murcia city is in south- eastern Spain, with a population of 4,47,182 inhabitants (2018). The city lies on the Segura River. Due to Mediterranean climate, the temperature in Murcia reaches an annual average of 18 degrees, with hot summers and mild winters, and with scant and irregular rain. The 881.86 sq. km. (340.49 square miles) territory of Murcia's municipality is made up of 54 pedanías (suburban districts) and 28 barrios (city neighbourhood districts).

Murcia – water supply system

The daily water demand of Murcia city is 67 Million Liters per Day (MLD) and the population served is the same as a total population of the city i.e. 4,53,258 inhabitants (2019 data).

Exhibit E 4 Murcia water supply - SPV



The water management company was created as municipal service in 1982. Aguas de Murcia is Murcia's municipal water and sewer system company, which manages the complete water cycle for the whole town. It was founded in 1989, with a 51% shareholding owned by Murcia City Council and the remaining 49% owned by Hidrogea in the Suez Group on Public Private Partnership (PPP) basis for 50 years.

Key challenges in potable water supply in Murcia

Main limitations in the performance of the company's activity are related to: (i) Population dispersion (~881km^2), (ii) Uniqueness of its orography (part of the municipality encased by mountains), (iii) Water shortage (driest basin in Europe, 365mm annual rainfall) and NRW levels, (iv) High agricultural activity (> 2.6 million tons/year of fruits and vegetables produced in the region).

Key strategies in NRW reduction

Efficient management of NRW brings economic, environmental, socio-sanitary, and technological benefits. In relation to means aimed to optimize use and consumption of the resource, different corrective actions have been defined depending on the deficiency/ problem detected, which are as follows -

1. Reduce and control consumptions not invoiced
2. Set up mechanism to reduce measurement errors and reading errors
3. Take up billing analysis, automatic billing systems, compare readings with historical data, improve the management of the client's account, and collect demographic data and establish consumption patterns to find anomalies.
4. Inspect and address unauthorized consumption
5. Carry out sectorization of network, pressure regulation, surveillance systems by minimum flow, flow control by sectors, maintenance and check unique points, minimum repairing times.
6. Set up mechanism to pay a maintenance fee to the water meter supplier to replace them in case of failure and to renew them every 12 years, at the end of their useful life.
7. Reduce the leak detection and repair time, like in case of Murcia it has been reduced to 2.5 days through hydraulic zoning and microsectorization. NRW water was under 14 percent in 2014, compared to 40 percent in 1975[3].

O&M cost recovery

By having developed a system able to recover the water losses from the water supply network and, more importantly, keeping the high efficiency achieved over time, the O&M costs have been offset by selling the recovered water.

Water conservation[4]

Conserving water as a source of life is one of the main goals of Murcia city with regards to sustainable development. In Murcia, 10,75 % of treated water is reused for agricultural, environmental, and recreational purposes. The remaining 89,25 % is returned to the public waterways.

8. Indian best practices concerning potable water management: Formation of NRW cell & water audit in Surat city

Surat Municipal Corporation (SMnC) constituted an NRW Cell in 2007 with the mandate to plan, develop, implement, and monitor an action plan for reduction of NRW, conducting periodic water audits, undertaking leakage mapping and repairs in a phased manner. The NRW cell is formed with six main objectives as below, to achieve the targeted benchmark of NRW (% reduction) and to ensure streamlined implementation.

- Enhance efficiency in transmission and distribution network
- Achieve equity in distribution
- Achieve financial recovery
- Create awareness for water conservation
- Conduct periodic water audit (every 3 years)
- Implement efficiency and equity measures as per requirement

[3] Source: A report on Water Scarce Cities, Thriving in a Finite World, World Bank
[4] Source: https://www.emuasa.es/en/retorno

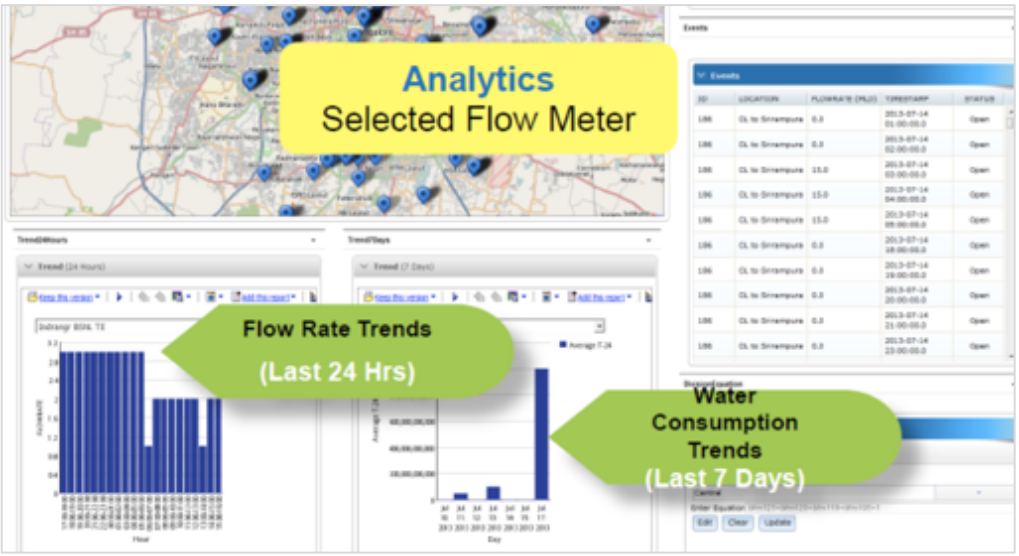
The achievement towards the leakage mapping initiative demonstrates the value of creating dedicated institutional mechanisms to tackle critical aspects like NRW reduction. Areas like NRW reduction will require more than 'mission-mode' actions; this include integrated planning, sustained institution building and diligent process transformation. To ensure this, a city water supply network audit was undertaken from 2017 to 2020. The audit will mostly cover technical components of the network including design, aging infrastructure, selection of appropriate materials, quality of their manufacturing, quality of installation and construction, etc.

9. Indian best practices concerning potable water management: Bulk water metering system in Bangalore city

Bangalore Water Supply and Sewerage Board (BWSSB) has undertaken several initiatives for improvement of water supply infrastructure. However, to achieve desired service levels and to effectively manage the entire water supply system it is necessary to do proper control and management of water flows. This required both generation of the system level data, assessment, and analysis of it to further process into useful information.

BWSSB has undertaken two related initiatives, in 2006-07, BWSSB received funding under the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) for installation of 218 bulk meters. Then in 2013, it implemented a software application, Intelligent Operation of Water (IOW) developed by IBM company on a pilot scale to monitor and regulate the flow of water across the system. Refer Exhibit E 5.

Exhibit E 5 BWSSB - Water Operations Dashboard



Source: NIUA[5] – 'Compendium of Good Practices - Water Supply and Sanitation projects in Indian cities,' report by IMaCS company, August 2014.

One of its kind BWSSB's initiative provides a glimpse into the possibilities when ICT applications are combined with system- wide metering. An integrated system based on an IT application helps the utility in not only capturing the data/ information from various components of the water supply system but also enables the water operators to use it as a tool for decision making.

[5] NIUA- National Institute of Urban Affairs, India

10. Key recommendations

Key recommendations are framed based on the learning from Murcia, Surat, and Bangalore; and reviewing the ongoing and proposed initiatives in water management by Solapur city. These are listed below -

1. Supply side management measures includes
   i. NRW management –
      a. Institutional - setting up a NRW cell as a part of the PHE department
      b. Technical – comprehensive water audit, metering, flow and pressure management, leak and loss reduction measures, energy saving measures etc.
      c. Commercial - O&M cost recovery and tariff rationalisation
   ii. Technological and smart interventions with use of Information and Communication Technology (ICT)
      a. Use of smart IT system – installation of Supervisory Control and Data Acquisition (SCADA) system
      b. Smart metering – bulk metering and consumer metering in phase wise manner
      c. Monitoring through Command and Control Center (CCC) or a dashboard
      d. Mobile app for citizen grievance and feedback
   iii. Demand side measures focus on consumers in reducing demand by helping them in using water more efficiently resulting in optimization of the quantum of water supplied and thus saving both energy and water. This includes promoting usage of water efficient appliances, fittings, and fixtures.
   iv. Other water conservation measures include rejuvenation of aquifers, rainwater harvesting, wastewater recycling and reuse for non-potable purposes.
   v. Behavioural change activities – these initiatives need to be taken up with proper communication approaches, key advocacy, and communication interventions so that there is a widespread consultations and participation of various stakeholders.
   vi. Monitoring and evaluation related measures - mainstreaming of Service Level Benchmarks (SLBs), monitoring service standards and outcomes.

Exhibit E 6 Key recommendations

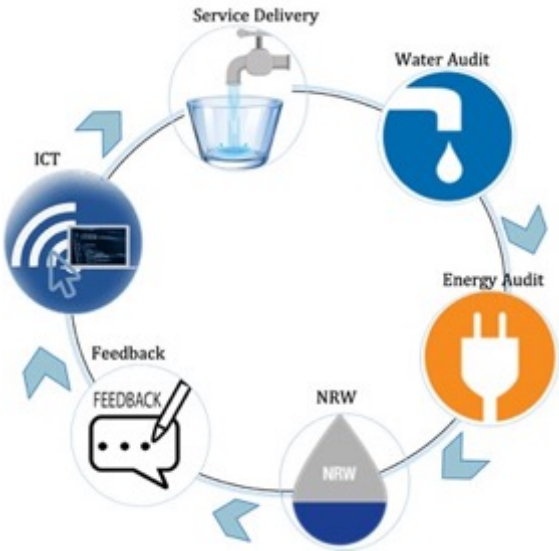
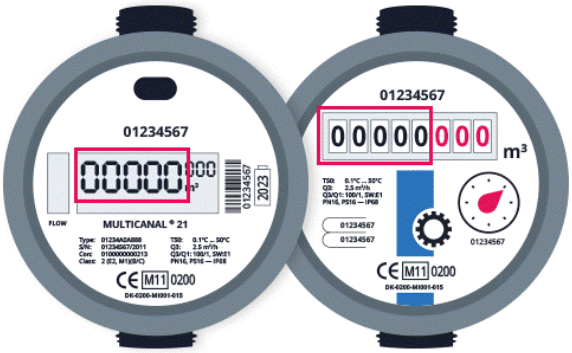
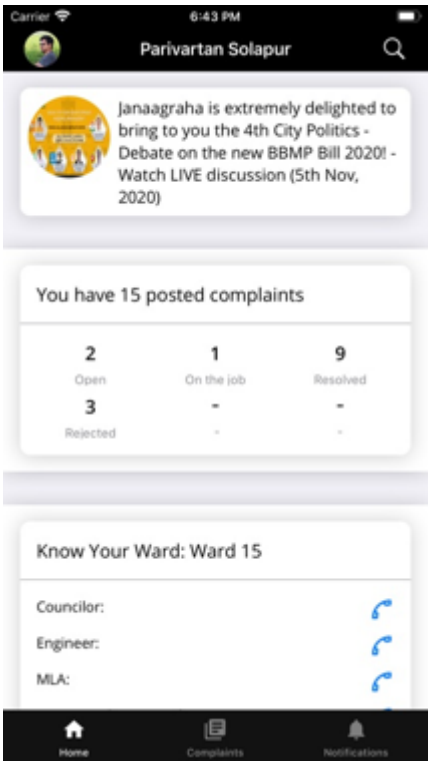


Exhibit E 7 Illustration of smart meter – Murcia[6] and Parivartan app- Solapur[7]





11. Conclusion

Solapur city is expected to witness continuous population growth in future. This will put pressure on the already constrained water sources and water supply system. SMC needs to adopt effective water management measures and use of smart technology to conserve water and improve service delivery. The IUC- India partnership provides opportunity for Solapur city to learn from peer European cities like Murcia as well as from Indian cities who had faced similar challenges and were able to address those by adopting multipronged strategies and use of ICT.

SMC has taken few initiatives for improving the water supply system such as water audit, energy audit, NRW study; and has adopted certain measures to improve feedback system and reporting such as PAS project, Parivatan app etc. It needs to further build on the platform it has created and adopt ICT and benchmarking tools for performance management and accountability in service delivery.

The way forward is to -

- Carry out a more detailed feasibility study
- Participate in International Urban and Regional Cooperation (IURC), which is extension of current IUC- India program.
- Implement few pilot projects as per this report and the earlier studies carried out by SMC

[6] Source: Aguas de Murcia - website
[7] Source: https://appadvice.com/app/parivartan-solapur/1539601084

1. Introduction and Study Objectives

1.1 Introduction

The European Union's International Urban Cooperation (IUC-India) project is supporting the Solapur – Murcia city pairing in relation to the development of an Urban Cooperation Action Plan (UCAP) on Best Practices for Potable Water Management.

1.2 Brief on IUC- India partnership and Solapur and Murcia city pairing

The International Urban Cooperation (IUC) programme enables cities in different global regions to link up and share solutions to common problems. It is part of a long-term strategy by the European Union to foster sustainable urban development in cooperation with the public and private sectors, as well as representatives of research and innovation, community groups and citizens. Through engaging in the IUC, cities will have the chance to share and exchange knowledge with their international counterparts, building a greener, more prosperous future. The IUC programme is an opportunity for local governments to learn from each other, set ambitious targets, forge lasting partnerships, test new solutions, and boost their city's international profile. Its activities will support the achievement of policy objectives as well as major international agreements on urban development and climate change, such as the European Union's (EU) Urban Agenda, the United Nation's (UN) Sustainable Development Goals, and the Paris Agreement.

The Solapur city has focused on international urban cooperation as a useful platform to address some of the city level challenges with support from external advisory and other relevant support. Solapur is paired with the Spanish city- Murcia and have chosen "potable water management" as a topic of cooperation between the two cities.

The city to city pairing agreement was signed on 24th May 2018 by Solapur city and on 4thJuly 2018 by Murcia city. The Solapur city officials visited Murcia city during 11th to 15th March 2019, while the Murcia delegation visited Solapur during 2nd to 7th September 2018.

The first exchange visit was useful to explore various possible areas of cooperation between the two cities, including smart city initiatives, solid waste management, wastewater treatment and potable water management. As a part of the second exchange visit, the delegation from Murcia got a first-hand overview of the different programs and activities implemented in Solapur as a part of national urban development schemes, including smart city initiatives. It was also useful to carry out important site visits and meet the technical staff especially concerning water and wastewater. IUC India prepared an Urban Cooperation Local Action Plan (UCAP) focusing on the needs, challenges, and potential solutions for the water issues in Solapur city.

1.3 Study objectives

As a conclusion from the two visits, it was decided that UCAP will focus on potable water management. The objective is to exchange information on best practices concerning urban water management, reduce non-revenue water as well as water losses and overall strengthening of the water supply system in Solapur.

The purpose of this report on Best Practices in Potable Water Management is to meet the above objective by taking into consideration beneficial practices in Murcia and Solapur, the experience from experts, and best practices from European and Indian cities.

2. Background – Solapur City

2.1 City profile

2.1.1 Background

Solapur, one of the growing cities in Maharashtra State in India, is situated within the basin of river Bhima, and plays a critical role in the district administration of Solapur district. It is an important trading place with many small and medium industries within and outside of its city limits. The city has fusion of four linguistics viz., Marathi, Kannada, Hindi, and Telugu. It is historically regarded as an industrial city prominently having the textile units.

The population of Solapur city was 9,51,000 as per Census 2011, which may increase to 12,27,327 (1.2 million) in 2021 (projected pop[8]). It is the fifth most populous city in Maharashtra, 49th most populous city in India and 43rd largest urban agglomeration in India.

2.1.2 Location and connectivity

Solapur is in the south-western region of the Indian state of Maharashtra at 17°.10" and 18°.32" North-latitude and 74°.42" and 76°.15" East longitude. The city is 400 km away from Mumbai and 300 km away from Hyderabad. It lies centrally in the basin of river Bhima and the watershed of river Adila (a tributary of river Sina). It is rested on hard rock (Basaltic lava flows) and acts as a gateway to Bhima and Krishna Basin. The city has an average elevation of 458 meters above mean sea level. Solapur is one of the most important cities and acts as a connecting bridge for the transportation between the Southern and Western part of India. The city is located at the Tri-junction of Telangana, Karnataka & Maharashtra and is well linked by air, railways, and road.

Exhibit 2-1: Location - Solapur

Source: Wikipedia & Maharashtra Remote Sensing Applications Centre

2.2 History, macroeconomic and topography

2.2.1 History

Solapur is an ancient historical place dating back to 90 BC. It is anciently called as sonnalage, evident from the inscriptions of Shivayogi Shri. Siddheshwar. Eventually with change in ruling dynasties, the name changed, and it is called as Sandalpur during Mughal rule and pronounced as

[8] Source: Revised City Development Plan for Solapur, 2041.

Sholapur during British rule. In the nineteenth century, the city was a part of Ahmednagar district. After independence, the city was a part of the State of Bombay. In 1960, it became an independent district in the state of Maharashtra.

Exhibit 2-2 Solapur - landmarks

Source: google photos

2.2.2 Topography

As per the district gazetteer of Solapur 1984, the elevation of Solapur city is about 458m (avg. elevation) above sea level, on the water shed of the River Adila, a feeder of the River Sina which it joins at Nandur about eight miles to the south-west of the city.

The rock (monotonously covered by Deccan Trap Basaltic lava flows) on which the city is built is a hard 'murum' almost approaching trap. Except to the north and the east where there is some rich cotton soil, the rock in places near the surface is barely covered by soil. In the rains the surroundings of the city turn green and pleasant whereas at other times the city is dry in appearance.

2.2.3 Geology

The City is occupied by lava flows of the Deccan Basalt formation, which constitute the main rock formation, on the other side black cotton soil is found abundantly in the region. The depth of soil in different areas in the city varies from 7.5 cm to more than 90 cm. It is estimated that around 10% of the area has shallow soil with a depth of 7.5 cm.

2.2.4 Economic activities

One of the key growth drivers for the industrial development in Solapur was commencement of railway services in the year 1860. The North – South railway line provides good transportation that laid a base for trade & industries in Solapur. There are approximately 98 medium and 8,986

smaller industries. The reputed 'Chaddars' (Solapur bed sheets) have created fame for the city and it's the first product in Maharashtra to get a Geographical Indication tag. The handloom and power loom weaving industry has created many employment opportunities. Apart from this, the beedi industry in Solapur is leading in Maharashtra and has an established market in oilseeds.

The Kirloskar group, one of the oldest industries in India was established on 5 April 1900, has driven the rise of industrialization in Solapur. The company was hived off to Kirloskar Ferrous Industries Limited (KFIL). The company is a major industry in Solapur and is instrumental in generating good revenue for the city. Other major industries that have their presence in Solapur are BF-NTPC Energy Systems Ltd (BFNESL), a Joint Venture between forgings maker Bharat Forge Ltd and power generation company NTPC Ltd. and the city is home to Precision Camshafts Limited, one of the largest manufacturers in camshafts in the world.

2.3 Climate

2.3.1 Temperature

Solapur has a tropical climate with very hot summers and pleasant winters. In summers, the city experiences higher temperature throughout the year, reaching highest up to 45°C – 47°C in April-May months and minimum temperature is 28° C. In winters the maximum temperature is 27°C and the minimum is 13°C. The relative humidity is in the range of 20-90% and the average evaporation is 7.6 mm/day, the city often receives locally developed heavy thunderstorms in May.

2.3.2 Rainfall

The city falls under the category of dry (arid and semiarid) climate, the monsoon lasts from June to the end of September, with irregular, erratic scanty rainfall, with annual average of around 500 mm to 700 mm (20 - 30 inch). It is included in rain-shadow zones and drought prone regions of part of south-central India.

2.3.3 Wind direction

The average wind speed in Solapur is 3.9 m/s with the maximum wind speed of around 11 m/s. Windrose of Solapur shows that predominantly wind blows from the West and about 19.73% of all wind directions, where wind speed and direction are typically distributed.

2.4 Solapur Municipal Corporation (SMC)

Solapur city is administered by the Solapur Municipal Corporation (SMC). It is one of the oldest Municipal Council (erstwhile) in India established in the year 1852. It was given the status of Municipal Corporation on 1st May 1964, with 23.23 Sq.km jurisdiction area. It is governed under Maharashtra Municipalities Act, 1965.

Today SMC's jurisdiction encompasses an area of 178.57 sq.km., with a residing population of 1.03 million (estimated for the year 2020) which grew from 9,51,000 in 2011 (as per Census 2011). Solapur expected tremendous development in late nineties which resulted in the city limits expansion of its city limits from 33.03 sq.km. to 178.57 sq.km. in the year 1992. The city is currently subdivided into eight administrative zones and further sub-divided in to 51 wards. The timeline of original city expansion is presented in Exhibit 2-3.

Exhibit 2-3: Chronology of events in extension of Solapur municipal limits

Year	City Limit Details	Extension	Area (in Sq.km)
1967	Original City Limit		23.23
1979	Vijapur and Hotgi road area included in SMC	First Extension	2.30
1989	Salgarwadi, Beedi Kamgar Vasahat and S.No. 23 of Shelgi added in SMC	Second Extension	7.50
1992	Thirteen surrounding villages merged in SMC	Third Extension	145.54
Total	**Area as on 05/05/1992**		**178.57**

Source: Revised CDP - Solapur, 2041

SMC oversees the engineering works, health, sanitation, water supply, administration, and taxation in the city, and deals with activities like developing new layouts and roads, town planning and land acquisition.

2.5 Demographics

2.5.1 Historical population

Solapur has grown rapidly as an industrial town in the 1970s. This is also reflected in the population growth during the same period. The decadal growth was very high between 1971 and 1991.

Exhibit 2-4 Historical population and growth rate of Solapur city

Year	Population	Decadal Growth (%)
1961	3,38,000 (0.33 million)	-
1971	3,98,361 (0.39 million)	17.86
1981	5,14,660 (0.51 million)	29.24
1991	6,04,215 (0.60 million)	17.36
2001	8,72,424 (0.87 million)	44.39
2011	9,51,558 (0.95 million)	9.07

Source: Census of India & Revised CDP for Solapur, 2041.

As per Census 2011, SMC population was 9,51,118 (0.95 million). The population, with the inclusion of its suburbs, has increased to 12,50,000 as reorganized in 2012. The population growth during 1991-2001 is exponential. However, the high population growth during this period was a result of increase in the city limits from 33.03 sq.km. to 178.57 sq.km. in the year 1992, by merging of 13 villages in the city limits.

During 2001 to 2011, the decadal population growth has come down to 9.07% from the decadal growth rate of 17.36% in 1981-91. This depicts that the annual population growth 2001 to 2011 is below the natural growth rate i.e. 0.87% per annum.

2.5.2 Projected population

As per the revised City Development Plan (CDP) for Solapur, the geometric projection method was adopted, and the projected population for the year 2021, 2031 and 2041 is shown in the Exhibit 2-5. The projected population for the year 2041 is 2.4 million.

Exhibit 2-5 Projected Population (2041) - SMC

Year	2011 (Actual)	2021	2031	2041
Population	9,51,558	12,27,327	15,83,016	20,41,786
Growth Rate (%)		28.98	28.98	28.98

Source: Revised CDP - Solapur, (April 2015)

2.5.3 Average household size

As per Census 2011, the total number of Households (HHs) in Solapur city was 188,000 compared to 1,61,000 HHs in 2001. The average HH size i.e. average number of persons per HH has reduced from 5.41 person to 5.05 person during 2001-2011.

As per Census 2011, the national average of HH size is 4.85 person and the Maharashtra state's average HH size was 4.6 person which is lesser than Solapur' HHs size of 5.05.

2.5.4 Literacy rate

The city houses major educational facilities like schools and degree colleges which also serve nearby towns and villages. However, the literacy rate of Solapur city has declined from 76.8 % in 2001 to 73.3 % in 2011. The reduction in the literacy rates is probably due to out-migration of the educated population for better employment and higher education opportunities.

2.5.5 Sex ratio

The trend in the sex ratio (number of females per 1,000 male) of Solapur city shows that the average sex ratio of the city has improved from 962 in 2001 to 978 in 2011. It is higher than the average sex ratio of the Solapur district (938), Maharashtra state (929) and India (940). The table below presents the increase in sex ratio over the last decade.

Exhibit 2-6: Trend in sex ratio of Solapur

S.N.	Year	Male	Female	SMC	State	Country
1	2001	4,44,734	4,27,690	962	922	933
2	2011	4,81,064	4,70,494	978	929	940

Source: Revised CDP - Solapur, (April 2015)

2.5.6 Migration trends

The migrant population was around 23% of the city's population as per Census 2001. Majority of the migrants are from adjoining states of Karnataka (67%) followed by Andhra Pradesh (21%) and Other major states such as Gujarat (3.00%), Rajasthan (2.13%), Uttar Pradesh (1.59%) and Chhattisgarh (1.12%).

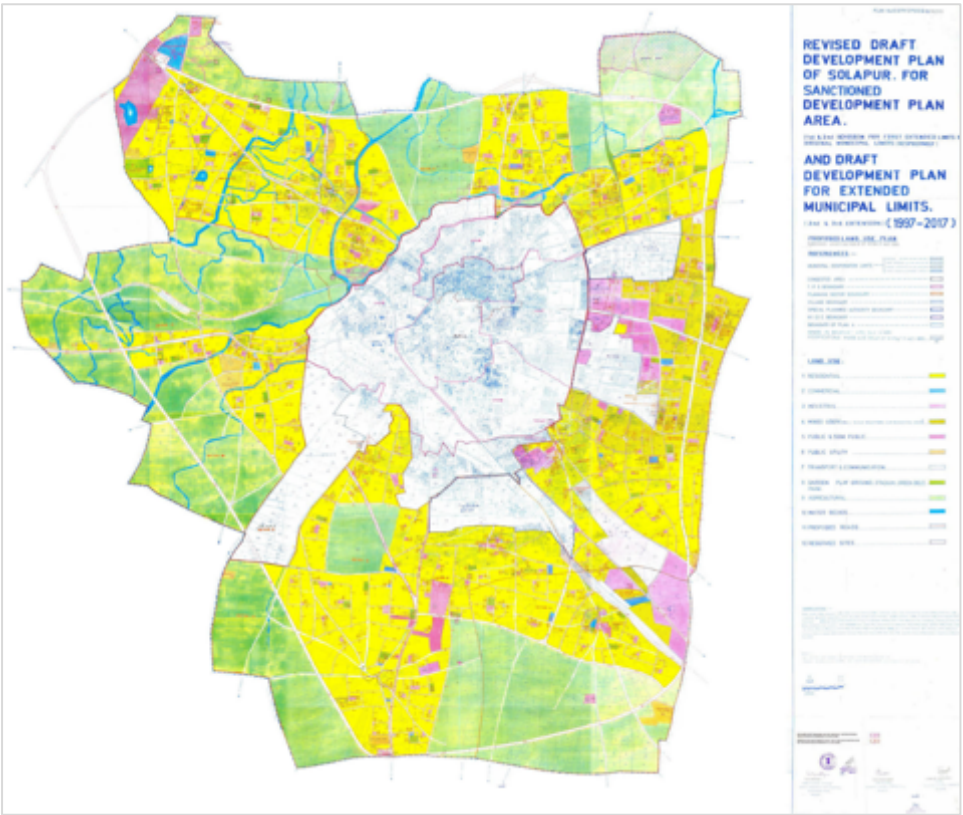
The main social cause for the migration is – newly married and moved into a household. Shifting for job/ employment opportunities are only 17% (work, employment, and business) of total migrants.

2.6 Land use pattern

The Development Plan for Solapur city was prepared in 1997, describes the existing (1994) as well as the proposed (2017) land use pattern for Solapur. As per the Development Plan, 25% of the city area was developed and it consisted of various urban amenities along with the residential area. The total undeveloped area constituted about 75% of the total land under the SMC. This was mainly due to the expansion of the city limit to 178.57 sq.km. including the addition of 13 villages, the area around which remained undeveloped because of lack of infrastructure. As per the Master Plan, the population of the city would increase to 2.05 million by 2031.

As per the City Master Plan and the revised City Development Plan 2041, the growth of the city is observed in the direction along the roads connecting to Hyderabad, to Akkalkot and to Mangalore. The land use map of Solapur city is shown in Exhibit 2-7.

Exhibit 2-7: Land Use map of Solapur City



Source: Solapur Municipal Corporation; http://www.solapurcorporation.gov.in/

3. Major challenges in Solapur water supply system

3.1 Solapur water supply system

Solapur is a dry area which receives erratic and inadequate rainfall during monsoon season. The major source of water is Ujani Dam which receives water from five upstream dams located near Pune city. Thus, the water availability for Solapur city largely depends on the rainfall in the catchment areas of upstream dams located within Pune region. A brief about the existing water supply system in Solapur, its components, key challenges, and its causes are discussed in this section.

3.1.1 Demand, supply, and gaps

As per SMC, Solapur receives water from three sources, Ekrukh Tank near village Hipparga about 7 km north of the main city, Bhima River at village Takli about 40 km south of the city and Ujani dam reservoir about 100 km west of the city.

As shown in the Exhibit 3-1, the total estimated water demand of the city is 200 MLD in 2020, 253 MLD in 2031 and 327 MLD in 2041. However, the current supply is around 112 MLD (2019-20)[9] which is 56% of the current demand, due to inadequate allocation from sources, large amount of evaporation losses in the Ujani dam, inadequate rainfall within Solapur catchment area and distribution network related issues. The water treatment capacity is 213 MLD[10].

The gap in supply is around 76 MLD in 2021. This gap will reduce to 31 MLD in 2031 as the ongoing source augmentation scheme of 110 MLD capacity will be operational. The water supply demand projection till 2041 is presented in the Exhibit 3-1.

Exhibit 3-1: Solapur - water supply demand projections

Indicator / Year	2016	2020	2031	2041
Population (projected) -CDP	11,88,315*	12,27,327	15,83,016	20,41,786
Daily water demand (MLD) as per	188	200	253	327
Current supply, MLD	112	112	222**	222**
Gap, MLD	**76**	**88**	**31**	**105**

*Source: Revised CDP- Solapur, 2041; * Estimated, ** Assuming completion of 110 MLD capacity source augmentation work, and commencement of water supply.*

[9] Source: Public Health Engineering (PHE) Department, SMC
[10] Source: Performance Assessment Project, Solapur

3.1.2 Groundwater – inadequacy and overexploitation

Exhibit E 8 Overexploitation of ground water in Indian cities

Geologically the area within Solapur city is covered by Deccan basalt. There is no continuity in groundwater flow mainly at deeper depths. The shallow aquifers get recharged during monsoon but due to urbanization and development associated with it, these are also not replenished fully. Due to water shortage many housing societies resort to groundwater resulting in overexploitation of groundwater. At the same time there are very few efforts towards water conservation and rainwater harvesting, thus making situation more challenging. There are 3,270 no. of tube wells, 306 no. of bore wells, and 4 no. of open wells in Solapur city[11], which clearly shows dependency on groundwater.

3.1.3 Need to explore opportunities for wastewater recycling and reuse

The existing sewage treatment capacity is 102.5 MLD and the utilisation is 89.35 MLD. The treated wastewater is discharged into a nalla (stream) near STP. Given that Solapur is water scarce region, there is an opportunity for recycling of wastewater and reuse for non-potable purposes as an alternative to fresh water supply to these non-potable usages.

3.1.4 Connections and lack of metering

As per SMC records, currently there are only 9,271 metered connections, which is 8.3% of the total water connections (i.e., 1,12,031). Out of these metered connections, only 478 connections i.e. 0.43% of total 1,12,031 connections have functional meters. Refer to the Exhibit 3-2.

[11] Source: SMC

Exhibit 3-2: Water supply connections in Solapur (2019-20)

Category	Metered – functional	Bulk Supply – metered functional	Metered non-functional	Non-metered	Total
Domestic	142	168	5,527	1,00,957	1,06,794
Non-Domestic (Commercial / institutional / industrial)	168	---	3,266	---	3,434
Public Taps	---	---	---	1,803	1,803
Total	**310**	**168**	**8,793**	**1,02,760**	**1,12,031**
	Total metered connections - functional: 478		**Total metered - nonfunctional: 8,793**		
	Total metered connections: 9,271				
As a % of total connections	**0.28%**	**0.15%**	**7.9%**	**91%**	**100%**

Source: SMC and status for FY 2019-20, Performance Assessment (PAS) Project, Solapur

3.1.5 Water is supplied once in four days and coverage need to be further increased

In current situation, SMC supplies water once in four days. The water is supplied to each area at different timings on specified dates as per the water supply schedule. Accordingly, the Elevated Storage Reservoir (ESR) and Ground Storage Reservoir (GSR) are filled one day prior to the scheduled date. In some areas, water is supplied directly with bypass pumping arrangement, because of which that area gets more water than other areas. Average water supply hours for each area varies between 2 to 2.5 hours[12].

The current water supply system covers 80% of the total population of the city with piped water supply.

3.1.6 Higher NRW and low revenue collection

3.1.6.1 Non-revenue water – components and status

NRW is the difference between the volume of water put into a water distribution system and the volume that is billed to customers. NRW comprises three components: physical (or real) losses, commercial (or apparent) losses, and unbilled authorized consumption.

- Physical losses comprise leakage from all parts of the system and overflows at the utility's storage tanks. They are caused by poor operations and maintenance, the lack of active leakage control, and poor quality of underground assets.
- Commercial losses are caused by customer meter under registration, data-handling errors, and theft of water in various forms.

[12] As per the RfP on water audit of Solapur city published in the year 2020 by SMC

- Unbilled authorized consumption includes water used by the utility for operational purposes, water used for firefighting, and water provided for free to certain consumer groups.

In Indian scenario, ascertaining NRW levels in a urban water supply system is a challenging task due to several reasons such as - inadequate metering (both consumer and bulk), lack of up to date household level data, no regular water audit, and inadequate measures to identify losses in the system. Therefore, in this study, the review of previous assessments and references about NRW levels is undertaken.

In 2006, SMC carried out water audit study which revealed 44% of physical losses in Solapur city. To reduce losses, SMC implemented a project under Urban Infrastructure Development Scheme for Small and Medium Sized Towns (UIDSSMT) where 214 km of old water supply pipelines were replaced, and storage capacity was enhanced by 23.5 ML.

In 2015, to assess levels of physical losses, city undertook a study on assessment of Non- Revenue Water (NRW). According to this study, the physical losses were around 29.2% and the overall NRW was 57%. The city has adopted a seven-year improvement program and a project costing INR 2,680 million for refurbishment of the water supply network[13]. As per the Smart City Proposal of Solapur city, the water supply distribution network need to be strengthened by reducing the leakages followed by installation of smart meters at household level with a target of reducing NRW levels from 57% to 15%.

As per SMC records, the physical losses in the system are 25% and the NRW was 29% in the year 2019-20. Therefore, there is a need for periodic assessment of NRW levels to address it in comprehensive manner.

3.1.6.2 Water revenue collection

In 2019-20, the total volume of water produced was 112 MLD against the volume of water billed that was 106 MLD. Thus, 6% of water is unbilled, which is part of the Non-Revenue Water (NRW). The current collection efficiency of revenue from the water supply is low at 44.8% and that of arrears is even lower at 21.2% only. Refer to the Exhibit 3-3.

Exhibit 3-3: Water supply revenue – demand, collection and balance (2019-20)

Amount in INR crore	Demand	Collection	Balance	Collection Efficiency
Current	45.25	20.25	25.00	44.8%
Arrear	65.48	13.87	51.61	21.2%
Total	**110.73**	**34.12**	**76.61**	**30.8%**

Source: status FY 2019-20, Performance Assessment (PAS) Project, Solapur; The revenue includes user charges and tax/ cess for water service only.

[13] Source: Smart City Proposal of Solapur city submitted under Smart City Mission

3.1.6.3 Water supply O&M cost recovery is low

SMC currently reports water supply O&M cost recovery on the Performance Assessment System (PAS) portal. CEPT University has received a grant from the Bill & Melinda Gates Foundation for Performance Assessment System (PAS) Project[14].

As per the PAS reporting for 2019-20, annual O&M cost of water supply system is INR 625.4 million while the total water revenue demand is INR 452.5 million i.e. O&M cost recovery is 72.4%. Major component of the O&M cost is electricity charges and fuel cost (48%), followed by staff cost (24%).

Understanding the importance of reducing energy costs, SMC with the help of Energy Efficiency Services Limited (EESL), carried out the energy audit of all water supply and sewerage system under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) program in Feb 2019. This will enable replacement of inefficient pump sets in public water works and sewerage systems with energy efficient pump sets at no upfront cost to the SMC. The investment will be recovered in the form of fixed annuity. The total project cost estimated by EESL is INR 12.4 million and the estimated Operating Expenditure (OPEX) is 4% of the project cost.

[14] The performance measurement framework draws on the Government of India's ongoing initiative of standardised Service Level Benchmarks (SLB) for urban water supply and sanitation sectors developed by the Ministry of Urban Development (MoUD). This activity now covers 6 states and 900+ cities in India and has become a major repository of urban water and sanitation database in India.

3.2 Ongoing initiatives

3.2.1 Ongoing source augmentation project

The broad objective of the augmentation to Solapur Water Supply Project is to lift adequate raw water from Ujani Dam to meet the water demand of Solapur City for the year 2035. The project is designed to supply 110 MLD raw water from Ujani dam to WTP at Pakni and Soregaon. The project will be developed on Design, Build, Maintain, Operate and Transfer (DBMOT) basis. The Project shall be funded by SMC through Corporate Social Responsibility (CSR) funds from National Thermal Power Corporation (NTPC) and funding from Solapur City Development Corporation Limited (SCDCL). The project has been awarded to a private contractor in September 2019 and the survey work is in progress.

3.2.2 Ongoing water audit study

SMC has floated a tender to carry out city wide water audit in the year 2020[15]. The key tasks involved / outputs expected from this study are as follows

- Carrying out initial water system survey, collecting data and submission of pre-feasibility report
- Updating water distribution network maps, GIS mapping of all water networks for Solapur city, carrying out water audit of various sub-works in existing water supply scheme, preparation of deficiency report
- Preparing Detailed Project Report (DPR) including digital water system network maps, suggestions for improvement as per deficiency report and suggestions for the Improvements in existing water supply scheme

3.2.3 Urban Cooperation Action Plan (UCAP) for Solapur

The UCAP for Solapur city is prepared by IUC- India under the pairing agreement between Solapur and Murcia cities. The objective of UCAP is to exchange information with Solapur on best practices concerning urban water management. Thus, reducing NRW, loss of water, water leakages and strengthening the overall water supply network within the city.

Based on good practices at Murcia and experience from Murcia experts, this report on best practices in potable water management is developed in relation to assessment, identification of leakages, measures to reduce leakages, and initiatives to improve water management, etc.

3.2.4 Solapur Climate Action Plan

ICLEI South Asia is implementing EU funded project on Adopting Integrated Urban Water Management in Indian cities (AdoptIUWM). The aim of the project is to build the capacity of Indian local authorities to undertake water sector reforms through the adoption of Integrated Urban Water Management (IUWM) principles and practices in their planning and implementation processes.

The recommended structural and non-structural measures for the water sector.

[15] As per the RfP on water audit of Solapur city published in the year 2020 by SMC

- Reduce pressure and dependency on Ujani dam by incorporation of local ponds in the water supply network.
- Develop a programme to control water leakage loss and prevent water wastage (app or SCADA like system)
- Implement Sustainable Urban Drainage Systems (SUDS) to address climate change impacts
- Use of abandoned borewells for recharge and water ATM to ensure supply on daily basis - 24x 7 supply,
- Take up micro catchment conservation of Bhima and Sina River
- Take up revival of Shelgi lake and conservation of all nallahs in the city.
- Explore bioremediation for pollution control at Kambar Lake.

3.2.5 Solapur Smart City Plan

Solapur is one of the 100 potential cities selected under the Smart City Mission of Government of India. SMC has prepared a Smart City Proposal (SCP) under this mission and formed an SPV called 'Solapur-City Development Corporation Ltd' (SCDCL), to manage the smart city projects.

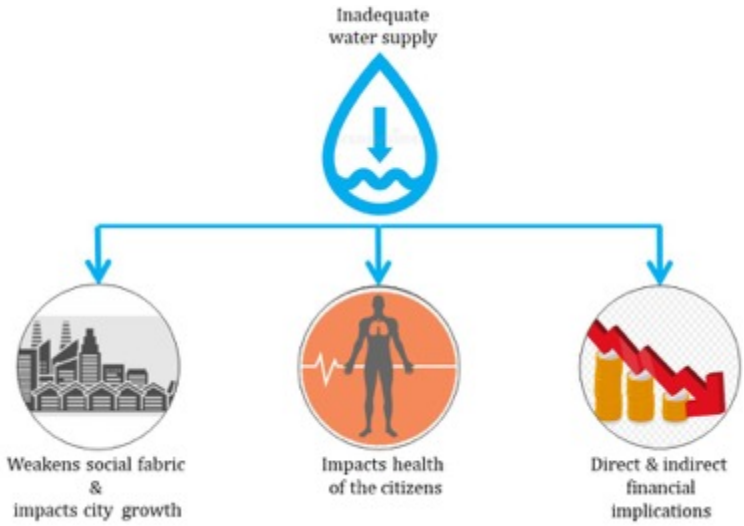
Key projects identified under SCP related to improving water supply system of Solapur city are as follows-

- Developing Ujani- Solapur water supply scheme of 110 MLD capacity
- Rejuvenation of Siddheshwar lake
- Carrying out water audit
- Improvements to water distribution system (Dayanand - Ujani bypass) and developing water supply scheme for 3 villages
- Development of Command and Control Centre, developing smart kiosks
- Temporary flow measurements using Ultrasonic flow meters in selected areas
- Construction of Utility Ducts
- Construction of tertiary treatment plant and installation of SCADA system for Sewage Treatment Plants (STPs)

3.3 Impacts of water shortages

The intermittent and inadequate water supply along with the losses in the system majorly affect the overall social fabric of the city, impact health of citizens and has substantial financial implications. These impacts are highlighted in this section.

Exhibit E 9 Impacts of water shortages



3.3.1 Social impacts

Intermittent and inadequate water supply causes inconvenience to the consumers, mostly the poor. Because of inadequate service standards, the households need to engage in a range of coping mechanisms. One of the major coping mechanisms is dependence on multiple sources of water. Households depend either on small-scale private players like tankers or on self-provisioning, typically through tube-wells or hand-pumps. The vulnerable population of the society such as urban poor, woman and girl child are most impacted by the intermittent and inadequate water supply.

3.3.2 Health impacts

Intermittent supply can negatively impact water supply infrastructure and result in adverse health effects and higher costs to households due to unsafe water quality, limited water quantities, reliance on alternative sources, and additional expenditures to store, treat, and supplement the intermittently delivered water.

In Indian cities the deleterious effect of intermittency on water quality, shows that both the initial flushing of water through empty pipes-as well as periods of low pressure-corresponded with periods of increased turbidity and bacterial contamination.

Consumers are advised to treat water coming from intermittent water supply. As water becomes stagnant in-service reservoirs, bleaching powder is often used to maintain a residual chlorine level.

The inadequate and intermittent supply substantially impacts safe sanitation and hygiene, especially in urban poor and vulnerable sections of the society.

3.3.3 Financial implications

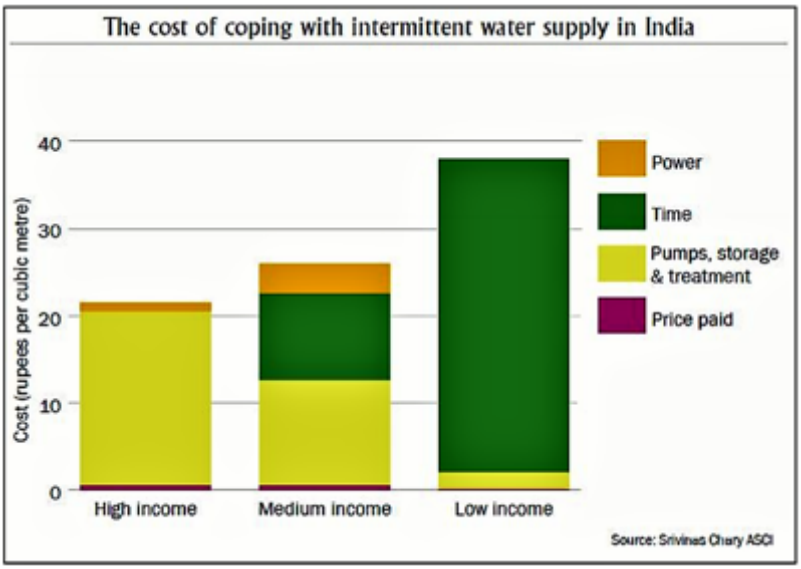
Due to intermittent and inadequate supply, consumers need to store water between supplies and tend to throw away remnant store. This causes water wastage and storage costs. Often, one person per household is devoted to storing the water at supply times thus causing wastage of their effective manhours and economic loss. In the absence of continuous storage mechanisms, the households invest in storage devices - the poor store water in jerrycans and small tanks, while middle-class households invest in underground and/or overhead tanks.

The research shows that maintenance costs are higher in the intermittent supply systems: the pipes are alternately exposed to air and water and corrode faster. They need to be repaired and changed more often to control leakage and avoid bursts. Operation costs, i.e. pumping costs, are also higher since pumps work for 20 to 24 hours to fill storages, whereas they only balance consumption when needed in continuous systems[16]. Solapur is a very well-known textile hub, and these are water intensive industries. There are direct and indirect financial implications of water shortages, it hampers continuity and growth of the economic activity such as industries. The industries need to rely on other unreliable and costly sources of water such as tanker supply and groundwater, which is already depleting. Exhibit 3-4 illustrates the cost of coping with intermittent water supply in India.

Because of the poor service provided and the low quantities of water sold, tariffs are often low in such systems. Low tariffs add to problems related to excessive pumping, since utilities that lack funds struggle to meet operating and maintenance costs if there are long pumping hours. No money is then available to invest in adapted infrastructures to extend the network and its supply hours. This cycle is hard to break without reducing leakage and rehabilitating pipelines.

Non-revenue water is a major parameter since illegal pumping, leaks and non-metered or free water drastically reduce the income. Planned augmentations should improve the water supply system to meet the total demand and extend supply hours.

Exhibit 3-4 Cost of coping with intermittent water supply in India



Source: Research article on Intermittent Water Distribution by Florian Faure (seecon international gmbh) and M.M. Pandit (Indian Water Works Association (IWWA)

When the service improves, higher tariffs can be applied. These are well accepted once consumers are aware that intermittent supplies are not the norm, and that a better service can be achieved. The willingness to pay is not an obstacle, since often consumers pay more in case of intermittent water supply: material costs are important for storage, treatment, or pumping, and so are the costs in time.

[16] Source: Research article on Intermittent Water Distribution by Florian Faure (seecon international gmbh) and M.M. Pandit (Indian Water Works Association (IWWA)

4. Policy Framework

A broad analysis of the existing policy framework related to urban water supply prevalent at the national, sub-national and local level is given in this chapter.

4.1 National Water Policy

As per Census 2011, over 71.2% of India's urban households had access to drinking water within their premises; up from 65.4% during Census 2001. Another 20.7% households had a water source within 100m of their premises. Over 8% of India's urban households need to move beyond 100 m from their premises to access drinking water; this has come down only marginally from the levels of 9.4% of households during Census 2001 and is a cause for concern.

The Government of India (GoI) has formulated the National Water Policy in 1987, which was subsequently reviewed and revised in the year 2002 and 2012. The National Water Policy has been shared with all States/ Union Territories (UTs) for appropriate action. As per the available information, 16 States/UT have formulated and adopted their State Water Policies.

Based on the findings and learnings from existing situation, the National Water Policy has proposed a framework for creation of a system of laws and institutions and for a plan of action with a unified national perspective. The framework has been developed based on the few concerned priorities as follows -

- Water Framework Law – Need for a National Framework Law as an umbrella statement of general principles governing the exercise of legislative and/or executive (or devolved) powers by the Centre, the States, and the local governing bodies.
- Uses of Water – The Centre, the States, and the local bodies (governance institutions) must ensure access to a minimum quantity of potable water to all its citizens, available within easy reach of the household.
- Adaptation to Climate Change - special focus should be given towards mitigation at micro level by enhancing the capabilities of community to adopt climate resilient technological options.
- Enhancing Water Available for Use - The availability of water resources and its use by various sectors in various basin and States in the country need to be assessed scientifically and reviewed at periodic intervals, (say, every five years).
- Demand Management and Water Use Efficiency – The 'project' and the 'basin' water use efficiencies need to be improved through continuous water balance and water accounting studies.
- Water Pricing – Pricing of water should ensure its efficient use and reward conservation.
- Conservation of River Corridors, Water Bodies, and Infrastructure,
- Project Planning and Implementation,
- Management of Flood & Drought,
- Water Supply and Sanitation, Institutional Arrangements,

- Trans-Boundary Rivers,
- Database & Information System, Research & Training Needs,
- Implementation of National Water Policy.

Recommendations

Key recommendations of the National Water Policy 2012 are as follows -

- An immediate need for comprehensive legislation for optimum development of inter-State rivers and river valleys, with appropriate powers to plan, manage and regulate utilization of water resource in the basins.
- Initialization & strengthening of community water management and to sensitize & encourage communities to adapt utilization of water as per local availability.
- Water quality and quantity are interlinked and need to be managed in an integrated manner, consistent with broader environmental management approaches inter-alia including the use of economic incentives and penalties to reduce pollution and wastage.
- Planning and management of water resources structures, such as, dams, flood embankments, tidal embankments, etc., should incorporate coping strategies for possible climate changes. The acceptability criteria in regard to new water resources projects need to be re-worked in view of the likely climate changes. Based on the water stress conditions and climate change, the water resources projects should be planned as per the efficiency benchmarks to be prescribed for various situations.
- Legally empowered dam safety services need to be ensured in the States as well as at the Centre. Appropriate safety measures, including downstream flood management, for each dam should be undertaken on top priority.
- States should be encouraged and incentivized to undertake reforms and progressive measures for innovations, conservation, and efficient utilization of water resources. The State Water Policies may need to be drafted/revised in accordance with National policy keeping the basic concerns and principles as also a unified national perspective.

4.2 Maharashtra State water policy

State of Maharashtra had framed its Water Policy in 2003 which was subsequently revised/reviewed in 2011 & 2019. Water being the state subject, the Government of Maharashtra (GoM) has known the importance of policy framing and its immediate need/action in the cities. Despite the challenges and concerns, since adaptation of this policy, significant positive changes have occurred in the water scenario of the State.

Water Policy Focus Areas

- Engagement of stakeholders for inclusive water governance
- Strategic planning and prioritizing investments
- Continuous monitoring and updating the policies
- Demand Management
- Improving Water Use Efficiency in all water use sectors

- Increasing quantity of usable water
- To adopt good governance through transparent informed decision making to achieve objectives of equity, social justice, and sustainability.
- Encouragement of private sector participation in the planning, development and management of water infrastructure projects

Recommendations

Key recommendations of Maharashtra State Water Policy are as follows

- There should be a balanced and conjunctive use of surface water and groundwater in urban areas.
- Reduction of the Non-Revenue Water (NRW) and Restricting domestic water use within the prescribed norms particularly in urban areas is a key issue which needs to be addressed on priority.
- Focus on accurate data base required for informed decision making and trained human resources to handle modern tools and techniques.
- Mapping and Interventions for the removal of encroachment in natural water bodies and drainage channels.
- Replication/application of best practices of water supply projects need to be encouraged.

5. Stakeholder analysis

Key agencies involved in management of the water resources, water supply and distribution; and their roles are described in this chapter.

5.1 Irrigation Department

In 1960, the irrigation department came into existence, which since 2004 Irrigation Department is known as Water Resources Department. The planning & development of irrigation facilities in the Maharashtra State are entrusted with the Water Resources Department (WRD) and Rural Development & Water Conservation Department (RD & WCD).

The Irrigation Department is responsible for the allocation of water from rivers and reservoirs to different user categories such as ULBs, rural local bodies, agriculture, industries and other bulk users.

5.2 Maharashtra Water Resources Regulatory Authority (MWRRA)

MWRRA was established in August 2005 and became operational in mid-2006. The MWRRA establishes a regulatory mechanism for overseeing the relationship between the service provider and water user entities, and within a water user entity, in terms of determination, enforcement and dispute resolution of entitlements and fixation of water charges.

The three main functions of the authority are as follows -

- Regulate the water resources within the Maharashtra State
- Regulate and facilitate sustainable, equitable and adequate supply of groundwater within the Maharashtra State, for which the Maharashtra Groundwater (Development and Management) Act, 2009 has been enacted, which empowers MWRRA to regulate groundwater resources of the State also.
- Carry out audits of the bulk water use through a separate office established at Aurangabad viz. Chief Auditor, Water & Irrigation, Maharashtra State.

Other key functions of the authority are as follows -

- Determine the criteria, regulate and enforce the distribution of entitlements for the various categories of use and the distribution of entitlements, within each category of use.
- Establish a water tariff system for levying water charges on various categories of water users with a view to establishing a stable and self-sustainable management of service delivery to such users.
- Review and sanction water resources projects, with a view to ensuring that a project proposal is in conformity with the Integrated State Water Plan (ISWP).

5.3 Groundwater Surveys & Development Agency (GSDA)

The Project Agreement between International Development Association and Government of Maharashtra required that the State shall establish the Groundwater Agency, especially for the development of minor irrigation schemes based on groundwater. As per the agreement, the State

Government has established the Groundwater Surveys & Development Agency (GSDA) during the year 1972.

GSDA is one of the nation's leading institutions concerned with groundwater surveys, exploration, assessment, monitoring, development, management, and regulation of groundwater resources for irrigation, drinking and industrial needs. It is also concerned with training, research and consultancy for the planning, development, and management of groundwater.

The GSDA engaged, in the exploration, development and augmentation of groundwater resources in the State through various schemes. This mainly includes, drilling of bore wells/tube wells under Rural Water Supply Programme, rendering technical guidance under minor irrigation programme by locating suitable dug well sites, strengthening of groundwater sources by water conservation measures, artificial recharge projects for induced groundwater, specific studies related to the periodic status of groundwater availability and protecting the existing groundwater resources through technical assistance under Groundwater Act etc.

The Groundwater (Management and Development) Act of 2009 (GMDA). Under this Act, the Maharashtra Water Resources Regulatory Authority (MWRRA), functioning as the State Groundwater Authority, has issued a public notice to "Notify" 76 overexploited and 7 critical watersheds in Districts of Ahmednagar, Amravati, Aurangabad, Buldana, Jalgaon, Jalna, Latur, Nashik, Osmanabad, Pune, Nashik, Satara and Solapur, to prohibit sinking wells deeper than 60 meters.

5.4 District Collectorate

The Solapur district comprises six Revenue Sub-Divisions, 11 Revenue Tehsils, 91 Revenue Circle and 1,144 Revenue Villages. The administration of the Taluka is run by the Tahsildar. The District Collector / Magistrate is mainly responsible for the District Administration. The District Collectorate sees over the law and order in the district. The Tahsildar of the Taluka is responsible for the law and order situation in their respective Talukas. The district collectorate plays important role in managing the water bodies-rivers and lakes.

5.5 Solapur Municipal Corporation

Solapur city is administered by the Solapur Municipal Corporation (SMC), which is governed under Maharashtra Municipalities Act, 1965. SMC's jurisdiction encompasses an area of 178.57 sq.km, with a residing population of 1.03 million (estimated for the year 2020). The city is currently subdivided into eight administrative zones and further subdivided in to 51 wards.

SMC oversees the engineering works, health, sanitation, water supply, administration, and taxation in the city, and deals with activities like developing new layouts and roads, town-planning and land acquisition.

5.6 Solapur City Development Corporation Limited (SCDCL)

Solapur City Development Corporation Limited (SCDCL) is an SPV formed under the Smart City Mission of Government of India. The SCDCL is responsible for implementation of various projects identified under the Smart City Proposal (SCP). Module-I of the SCP includes projects related to the Area based Development where a pilot area within Solapur City has been identified. The

Module-II includes projects related to the Pan city initiative which are related to Information Communication and Technology (ICT).

6. Global best practices in potable water management – Murcia (Spain)

6.1 Murcia city profile [17]

Murcia city is in south- eastern Spain, with a population of 4,47,182 inhabitants (2018). The city lies on the Segura River. It has Mediterranean climate with high temperatures during the summer, mild winters, and low precipitation. The city is separated in the south and a north part by a series of mountains.

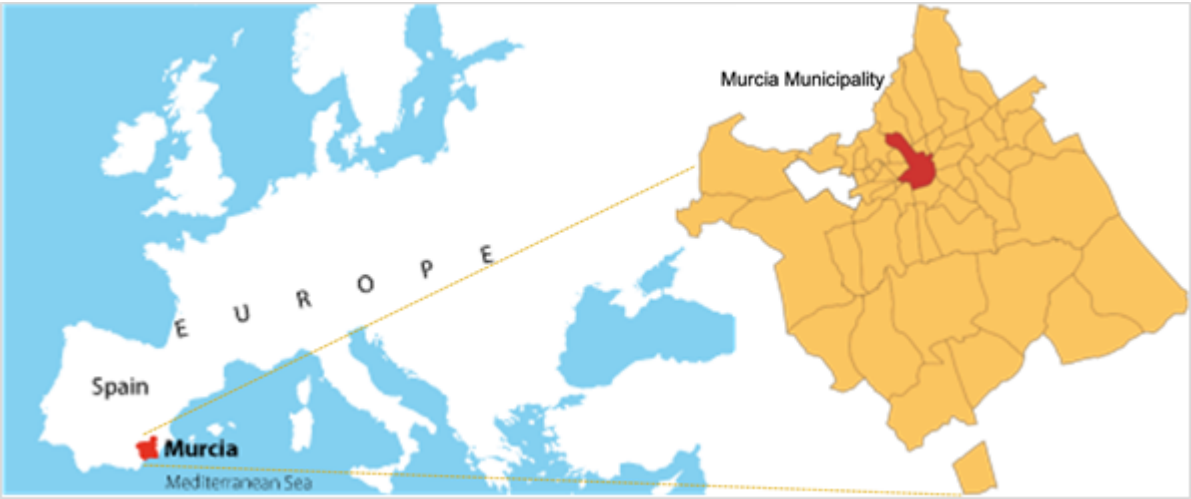
The city, as the capital of the comarca Huerta de Murcia is called Europe's orchard due to its long agricultural tradition and its fruit, vegetable, and flower production and exports.

6.1.1 Location

The city of Murcia is in the valley formed by the confluence of the river Segura and its tributary Guadalentín. This locates Murcia in the geographic centre of an influential area. Historically, the development of the city and also of the region of Murcia (called Reign of Murcia during many centuries) has been determined by two facts: to be a bordering territory during many centuries, and to be part of the geographical periphery, which also means, political and economic periphery. Due to its central position in this territory, the socio-economic strength of the Mediterranean coast brings new chances for the development of the city.

Murcia is bounded by the municipal districts of Santomera and Beniel, and the region of Alicante to the East; by Fuente Alamo, Torre Pacheco and San Javier to the South; by Alhama de Murcia, Librilla, Mula and Campos del Río to the West; and by Las Torres de Cotillas, Molina de Segura and Fortuna to the North. Murcia is the capital of the Region, focusing on its administration and its public services.

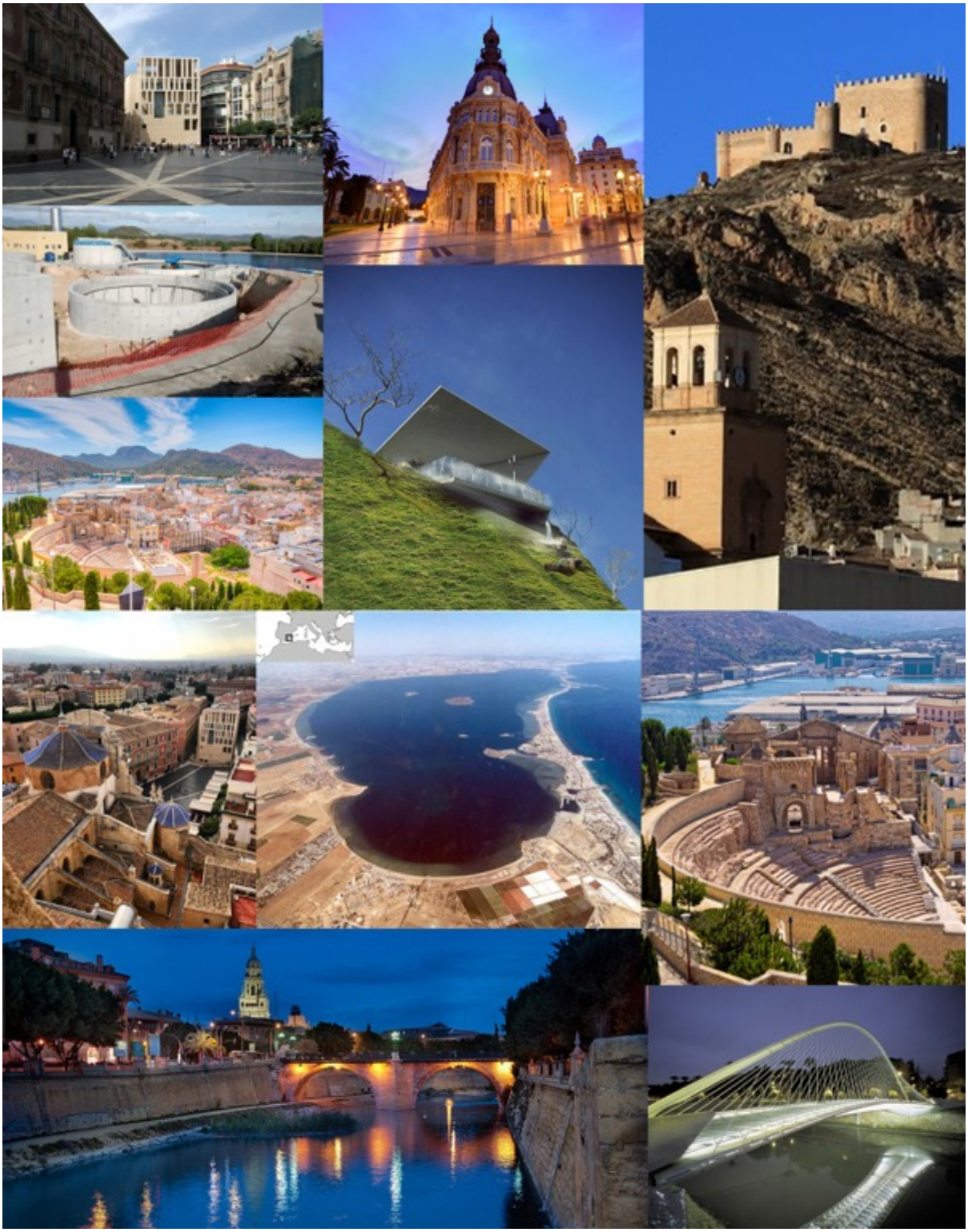
Exhibit 6-1 Location – Murcia



Source: The Region of Murcia; http://www.spainproductsfrommurcia.com/region-of-murcia

[17] Based on information provided by Murcia Municipality, and http://www.greendigitalcharter.eu/wp-content/uploads/2014/06/Emuasa-Smartwater_W.pdf

Murcia city



6.1.2 Geography

Murcia is located near the center of a low-lying fertile plain known as the huerta (orchard or vineyard) of Murcia. The Segura River and its tributary, the Guadalentín, run through the area. The city has an elevation of 43 metres (141 ft) above sea level and its municipality covers approximately 882 square kilometres (341 sq mi).

The Segura river's Valley is surrounded by two mountain ranges, the hills of Guadalupe, Espinardo, Cabezo de Torres, Esparragal and Monteagudo in the north and the Cordillera Sur in the south. The municipality itself is divided into southern and northern zones by a series of mountain ranges, the Cordillera Sur (Carrascoy, El Puerto, Villares, Columbares, Altaona, and Escalona).

6.1.3 Climate

Due to Mediterranean climate, the temperature in Murcia reaches an annual average of 18º degrees, with hot summers and mild winters, and with scant and irregular rain.

The daily average temperature ranges from 10.5 °C (51 °F) in January to 27.5 °C (81.5 °F) in August. In winter it is 10 °C (50 °F) and light frosts at night. In summer, especially in July and August, the temperature can reach 38/40 °C (100/104 °F). Rainfall is scarce, only 300 millimeters (12 inches) per year; in particular, winter is drier than it normally is in Mediterranean climates; in summer, it almost never rains. Owing to the scarcity of rainfall, the landscape is arid and sometimes, it can snow in the higher areas of the province.

6.1.4 Major economic activities

Murcia predominantly acts as a centre for agriculture and tourism. The city has a marked administrative and commercial character, where the main economic activity is the service sector. Therefore, its streets and avenues are full of shops (catering trade, estate agents', companies). Other economic sectors related to industry, building, and agriculture, are also present in Murcia. Industry mainly focuses on product manufacture, and the most developed sectors are - food industry, chemical industry, transport materials, material producing and changing, and textile. Murcia’s economy shows a progressive growth and its labour market is increasing.

6.1.5 Murcia municipality

The 881.86-square-kilometre (340.49 sq mi) territory of Murcia's municipality is made up of 54 pedanías (suburban districts) and 28 barrios (city neighbourhood districts). The barrios make up the 12.86-square-kilometre (4.97 sq mi) of the main urban portion of the city. The historic city center is approximately 3 square kilo-meters (1 sq mi) of the urbanised downtown portion of Murcia.

6.2 Best practices in water management in Murcia

Murcia is a pioneer in potable water management. It currently has the distribution network with the largest number of smart sensors in Spain, which allows it to monitor, log, and analyse the water-flow and pressure of each point of the municipal network continuously. This enables them to detect anomalies in the network instantaneously (breaks, invisible leaks, abnormal consumption, and so forth.). Murcia`s supply system has one of the highest efficiency rates in

Spain, in this aspect teams specialized in the detection and location of leaks also play a determining role.

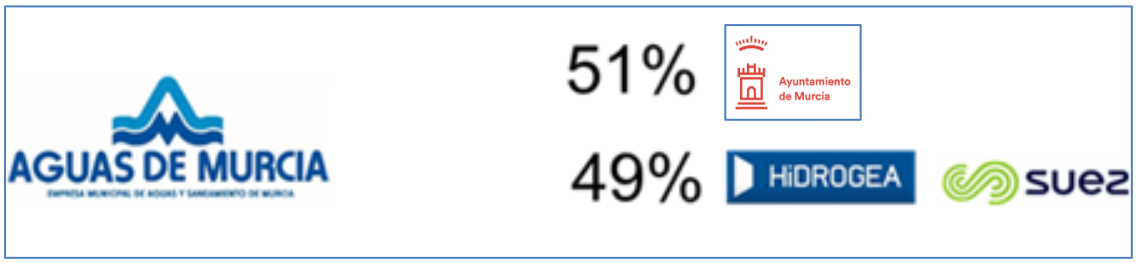
6.2.1 Background

The daily water demand of Murcia city is 67 million liters per day (MLD) and the population served is the same as a total population of the city i.e. 4,53,258 inhabitants (2019 data).

The water management company was created as municipal service in 1982. Aguas de Murcia is Murcia's municipal water and sewer system company, which manages the complete water cycle for the whole town. It was founded in 1989, with a 51% shareholding owned by (Murcia City Council) and the remaining 49% owned by Hidrogea in the Suez Group on PPP basis for 50 years.

The capital works and investments related to the water supply system are managed by the management board, whereas the O&M costs are administered by the steering committee.

Exhibit 6-2 Aguas de Murcia - SPV structure



Source: https://www.emuasa.es/en/presentacion

6.2.2 Key challenges in potable water supply in Murcia

Main limitations in the performance of the company's activity are related to: (i) Population dispersion (<881km^2), (ii) Uniqueness of its orography (part of the municipality encased by mountains), (iii) Water shortage (driest basin in Europe, 365mm annual rainfall) and higher NRW levels during initial stage, (iv) High agricultural activity (> 2.6 million tons/year of fruits and vegetables produced in the region).

6.2.3 Key interventions in water supply management

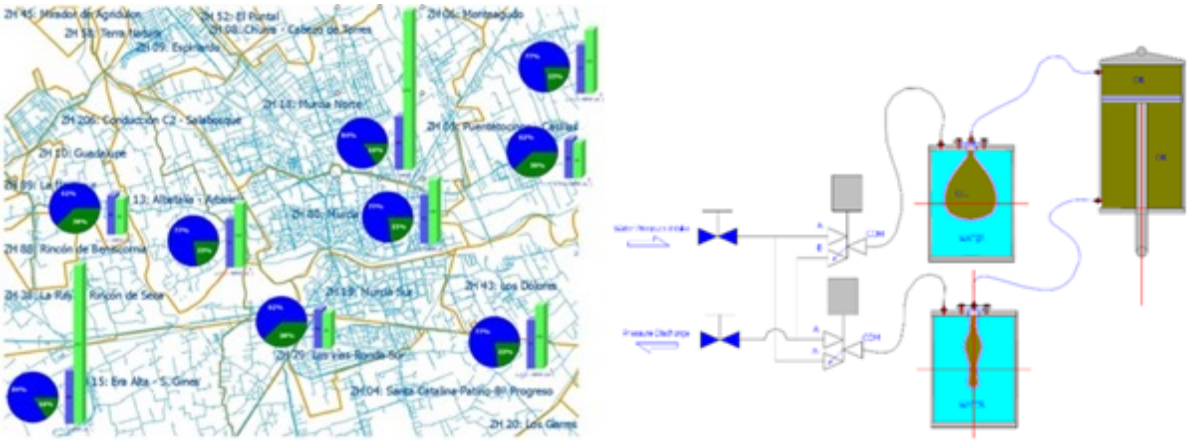
Efficient operation of water supply is based on the sectorization and management of the network pressure by dividing the network into small and easy-to-manage sectors with regulated pressure. In addition, in those more meshed and complex areas, to optimize control, a second dynamic fragmentation is applied during the night, allowing it to subdivide into small sectors only at night and with pressure control according to the demand curve. This management mechanism has been called dynamic micro sectoring of the network with night pressure management.

Murcia's water network is divided into 188 hydraulic zones and 297 micro sectors. This enables a continuous and precise control, allowing the instantaneous detection of leaks, anticipating damage to public and private infrastructures.

Micro sectorization has been possible due to an innovative device developed by Hidrogea that activates butterfly valves and allows the valves to be operated, either in open/closed mode, or by means of multicriteria pressure set points. The device is very versatile, and its implantation cost is very low, since it can be installed in existing valves without civil works and electrical

installation. Also note its robustness, reliability, and sustainability since it is operated by taking advantage of the pressure of the network as an energy source.

Exhibit 6-3Micro sectors and their NRW levels



Source: Murcia municipality

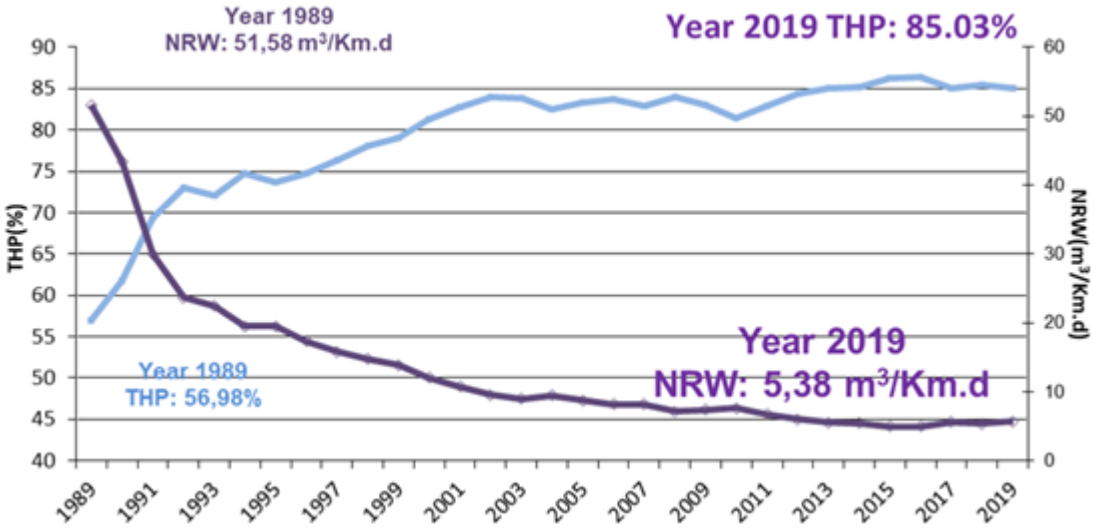
6.2.4 Key strategies in NRW reduction

Efficient management of NRW brings economic, environmental, socio-sanitary, and technological benefits. In relation to means aimed to optimize use and consumption of the resource, different corrective actions have been defined depending on the deficiency/ problem detected, which are as follows -

1. **Consumptions not invoiced:** Reduction of municipal consumptions not invoiced, control and reduction of the number of unbilled (not invoiced) customers, and meter installation campaigns.
2. **Measurement errors:** Establishment of equipment calibration plans, definition and/or improvement of a program of devices renovation, installation and maintenance programs, installation of equipment to reduce under measures, and improvement of the quality of interior installations to avoid internal leaks.
3. **Reading errors:** Analysis of billing records vs. usual consumption patterns and data, review of suspicious consumption by changing manual counter to remote reading electronic ones, and review of clients with limited data (inaccessible or internal meters).
4. **Erroneous data:** Billing analysis, automatic billing systems, comparison of readings with historical data, improvement of the management of the client's account, collection of demographic data and establishment of consumption patterns to find anomalies.
5. **Unauthorized consumption:** Inspections to detect illegal connections and manipulations of meters, misuse of fire hydrants and others, prepaid structures, anti-fraud campaigns, campaigns for leaks including review of installation.
6. **Real losses - visible and invisible leaks:** Sectorization of network, pressure regulation, surveillance systems by minimum flow, flow control by sectors, maintenance and check unique points, minimum repairing times.
7. **Regular maintenance:** Payment of a maintenance fee to the water meter supplier to replace them in case of failure and to renew them every 12 years, at the end of their useful life.

Exhibit 6-4 shows the evolution of NRW and the technical performance (THP) of the network achieved since Aguas de Murcia assumed the management of the service (1989).

Exhibit 6-4 evolution of NRW and the technical performance (THP) of the network since 1989



Source: Murcia municipality

In Murcia, the leak detection and repair time has been reduced to 2.5 days through hydraulic zoning and microsectorization. Non-revenue water was under 14 percent in 2014, compared to 40 percent in 1975[18]. Most importantly, amount of Non-Revenue Water (NRW, water produced and "lost" before reaching the customer) has declined to 5.69 m3/km day in 2019, meaning a technical performance of 85,03%.

6.2.5 O&M cost recovery

O&M costs have been recovered through the savings obtained by the recovered water from the water supply network losses. 75% of the supplied water is brought to the upstream water supply institution. By having developed a system able to recover the water losses from the water supply network and, more importantly, keeping the high efficiency achieved over time, the O&M costs have been offset by selling the recovered water. This model has proved to be profitable enough for avoiding the increase of water tariffs.

6.2.6 Water conservation[19]

Conserving water as a source of life is one of the main goals of Murcia city with regards to sustainable development. In Murcia, 10,75 % of treated water is reused. It is used for agricultural, environmental, and recreational purposes. The remaining 89,25 % is returned to the public waterways. Unused treated water is returned to the river or natural waterways, with the aim of altering natural systems as little as possible.

[18] Source: A report on Water Scarce Cities, Thriving in a Finite World, World Bank
[19] Source: https://www.emuasa.es/en/retorno

7. Indian best practices in potable water management – Surat and Bangalore

There few case studies from Indian cities which shows urban water supply systems can indeed be transformed in a relatively shorter time. Cities like, Nagpur is attempting to scale up positive results from delivering 24x7 water supply in a demonstration zone, to the entire city. The efforts of Bengaluru, Pimpri Chinchwad and Surat towards improvements in efficiency and information management made a shift from asset creation towards a greater focus on improved service delivery efficiencies. This report analyses two case studies - NRW cell at Surat and bulk water metering system in Bangalore.

7.1 Indian case study 1: Formation of NRW cell & water audit in Surat city

7.1.1 Surat city profile

Surat is the second largest city in Gujarat state in India, in terms of population and area and is known as the commercial capital of Gujarat and it comprises 58%, the highest percentage of migrant population in India. Surat Municipal Corporation (SMnC) is spread over 326 sq.km and had a population of 4.4 million at the time of Census 2011. SMnC is considered as one among the better municipal corporations in India and has won several awards under the National Urban Awards program instituted by Government of India to recognize excellence in urban service delivery.

7.1.2 Water supply scenario in Surat

As of 2014, SMnC's gross average daily water supply is about 980 MLD translating to a per capita supply of about 147 LPCD. SMnC has 7 water distribution zones, viz. Western, Eastern, Central, North, South, Southeast and Southwest with 17 water distribution stations, four pumping stations and a distribution network of over 3,000 km. As of 2014, 94% of SMC's population is covered with piped water supply.

Surat has taken many steps to make its water distribution system more risk resilient. One of such innovative measures is the redundancy built into its water distribution network. This system is known as the grid network/layout. In it, the waterworks and treatments plants are connected to water distribution stations with the interconnections such that water can be supplied to the distribution stations from any of the treatment plants[20]. (Refer Exhibit 7-1).

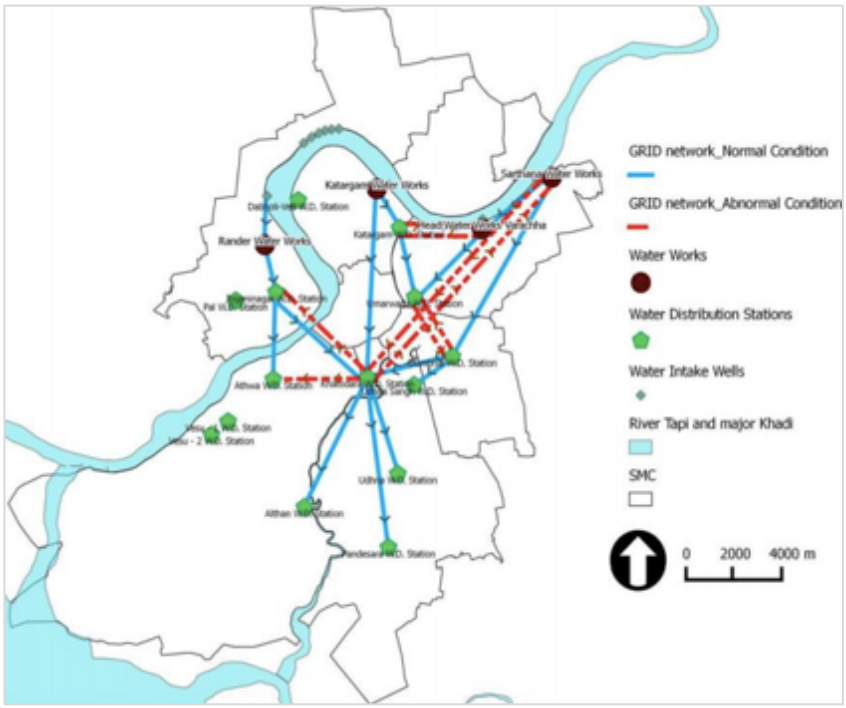
SMnC has set up NRW cell as a part of the constant endeavour to achieve the targeted benchmark NRW levels of 15%. This case discusses the objectives of the NRW cell and traces the outcomes of the leakage mapping exercise carried out by this NRW cell. Building on this experience, the case seeks to identify some pointers for strengthening institutional mechanisms to tackle cross-cutting aspects like NRW reduction.

SMnC has set up an NRW cell to bring focus on measuring and tackling of the Non-Revenue Water in the city. Under the Service Level Benchmark (SLB) framework, SMnC has reported NRW at

[20] Source: Meeting the Challenges of Climate-Proofing a Water System: How Surat Learned & Adapted, Dec 2018.

20.4%. But in the absence of volumetric metering at consumer level and critical points in the water supply system, SMnC's reported NRW scores a 'D' (as per the guidelines given in the SLB hand book of MoHUA) with respect to reliability levels under the SLB framework, suggesting that this is a serious cause for concern.

Exhibit 7-1: GRID water supply network system



Source: Meeting the Challenges of Climate-Proofing a Water System: How Surat Learned & Adapted, Dec 2018

7.1.3 The initiative: NRW cell in Surat

SMnC constituted an NRW Cell in 2007 with the mandate to plan, develop, implement, and monitor an action plan for reduction of NRW, conducting periodic water audits, undertaking leakage mapping and repairs in a phased manner.

The NRW cell is formed with six main objectives as below, to achieve the targeted benchmark of NRW (% reduction) and to ensure streamlined implementation.

- Achieve efficiency enhancement in transmission and distribution network
- Achieve equity in distribution
- Achieve financial recovery
- Create awareness for water conservation
- Conduct periodic water audit (every 3 years)
- Implement efficiency and equity measures as per requirement

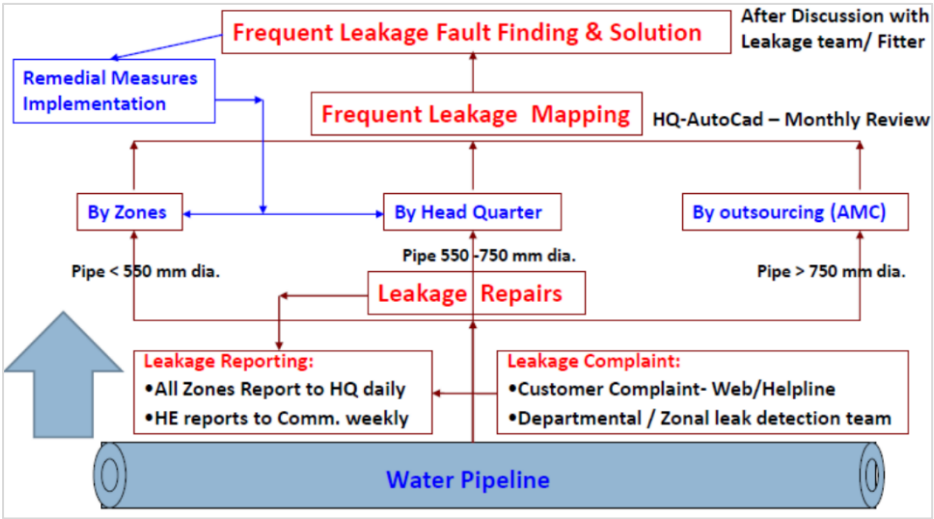
As of action plan, SMnC initiated two major activities – (a) Water audit of core city area of 112.28 sq. km. and (b) initial leakage mapping exercise.

1. The NRW cell identified leakage mapping as a priority initiative and involved identification of leakages based on current and historical complaints from citizens/areas received either

through web or helpline numbers and ground level assessment by SMnC's Hydraulic department.

2. After discussions with leakage team the fitters in various areas identified and the observed frequent leakage points were then transferred to headquarters for mapping on AutoCAD.
3. Leakage repairs were done at three levels based on the size of the pipes i.e.,
   - Leakages in pipe sizes > 750 mm: by outsourcing by SMnC to private operators
   - Leakages in pipe sizes 550- 750 mm: by SMnC
   - Leakages in pipe sizes < 550 mm: by zonal offices
4. Leakage Repairs reporting was done at two levels; all zones report to headquarters daily and the Engineering Head reports to the Commissioner on a weekly basis. (Refer Exhibit 7-2).

Exhibit 7-2: Leakage Mapping Mechanism



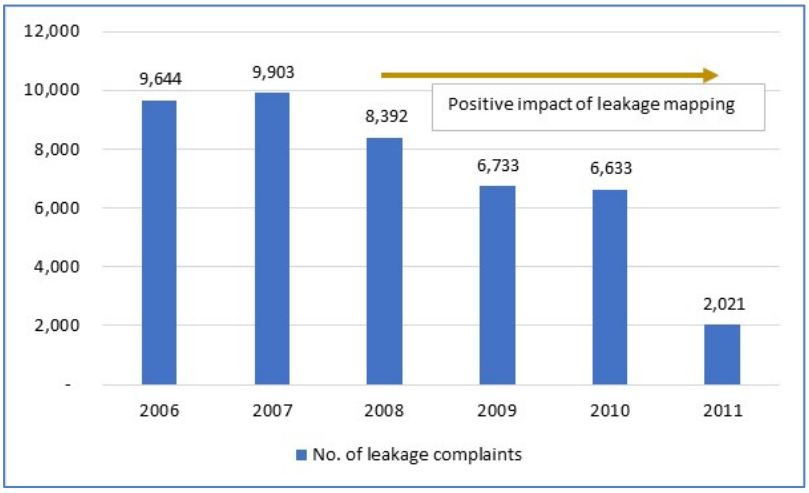
Source: SMnC & NIUA - Compendium of Good Practices Water Supply and Sanitation projects in Indian cities; iMac's, August 2014

This initiative of leakage mapping was carried out in the Central Zones and few other areas of the city (e.g., most of old city). Also, few pipelines in the marked areas were replaced stage-wise from 2010 to 2011. After successful implementation in the identified areas, the same initiative was extended to other zones of the city. After mapping leakages in all zones of Surat, corrective action of changing the required pipelines, faulty valves etc. has been initiated. SMnC carried out the leakage mapping and leak repair works internally (except for larger leakages) with the available conventional technologies and tools.

The early-stage leakage mapping exercise has made constructive and impactful results as follows:

1. Reduction in leakages per km length of pipeline: Encouraged by the successful results of the leakage mapping and rectification exercise, SMnC's NRW Cell had planned to appoint a Consultant to carry out the water audit of the core area of SMnC spread over 150 sq. km.
2. Reduction in number of complaints: 30% of leakages were reduced annually in all the zones as per the reduced level of complaints received. Refer to Exhibit 7-3.

Exhibit 7-3: Reduction of leakages per km length during 2006-11



Source: "NRW reductions and management in water supply distribution system," SMnC, 2011

3. Better tracking of complaints: Day to day reporting of the leakage repairs is undertaken by all the zones to the SMnC head office and weekly reporting of the same to the Municipal Commissioner is done by Engineering head.
4. Leak repairs and water savings: SMnC reported comprehensive identification and repair of over 185 frequent leakage points and over 110 contamination points post creation of the NRW cell. It also estimated savings to the extent of 708 ML of potable water translating to a net savings in water costs and road reinstatement costs of INR 21.2 million annually.

7.1.4 Comprehensive water audit

Key activities involved are - (a) identification of District Metered Areas (DMAs), (b) planning, designing and construction of DMAs and analysis of DMA wise flow data as per the guidelines given in AWWA manual. (c) marking approx. 50 DMAs comprising 1,500 to 2,500 consumers each, (d) carrying out detailed water audit study in representative areas of appx. 150-250 connections each, (e) installation of bulk meters, flow meters, valves, and related accessories.

The scope of DMA wise water audit covered – assessment of consumption of water usage by different beneficiaries, identification of illegal connections by matching data collected during the survey and from billing records of SMnC, and carrying out survey of approximately 1,00,000 consumer properties.

Comprehensive Water Audit report for Water Supply System included Study for District Metering Area (DMA), leak detection and reduction study and suggestions on leak reduction plan.

7.1.5 Lessons learnt and replicability

The achievement towards the leakage mapping initiative demonstrates the value of creating dedicated institutional mechanisms to tackle critical aspects like NRW reduction. Areas like NRW reduction will require more than 'mission-mode' actions; this includes integrated planning, sustained institution building and diligent process transformation.

7.1.6 Surat - Smart City Center (SMAC)

Surat has launched Smart City Center (SMAC) as an Integrated Command and Control Center (ICCC) on 25 June 2016. This is a centralized system to monitor various functions and services of the city. In the first phase, it covered, property tax system, health survey application and complaint management system, monitoring city operations through CCTV Network, water, and sewage treatment plant – SCADA, intelligent transit management system (ITMS) and Swachh Bharat (Swachhata App).

Automated sensors and systems send various data sets to the SMAC, which are analyzed to avail important information to make decisions. All the online applications and mobile applications of SMC for people-centric services would be monitored from one place at the Smart City Centre.

7.2 Indian case study 2: Bulk water metering system in Bangalore city

7.2.1 Bangalore - city profile

Bengaluru, a multifunctional metropolitan and the capital city of Karnataka, is one of the fastest growing cities in India, and is known as the 'Silicon Valley of India'. The Local Planning Area (LPA) of Bangalore Development Authority (BDA) spreads over an area of about 1,219.50 Sq Km (area under LPA of BDA as per Revised Master Plan-2015) with a population of ~85 Lakh (8.5 million) as per Census 2011. The LPA of BDA comprises of the major part of the Bruhat Bangalore Mahanagara Palike (excluding area under BMICAPA) and 251 villages in the periphery of BBMP[21].

7.2.2 Bangalore's water supply scenario

River Cauvery is the major source of water supply to the Bengaluru city, where it receives about 910 MLD. Water treatment is done at Torekadanahalli Water Treatment Plant (WTP). The elevation difference between the water treatment plant at TK Halli and the city reservoirs is about 400 m and distance between them is about 100 km. Water is pumped to the city reservoirs through three stages of pumping to the city reservoirs. Refer Exhibit 7-4, for an overview of BWSSB Water supply service levels.

Exhibit 7-4: BWSSB Service Level Benchmark

Sr. No	Service Level	Benchmark	Current Status
1	Coverage of connection	100%	51%
2	Per Capita Supply	135 lpcd	96 lpcd
3	Metering of connections	100 %	98%
4	Non-Revenue Water	20 %	46%
5	Continuity of supply	24 hrs	5 Hrs
6	Quality and treatment	100 %	83%
7	Redressal of customer complaints	80 %	87%
8	Cost recovery	100 %	92%
9	Collection efficiency	90 %	97%

Source: NIUA – Compendium of Good Practices Water Supply and Sanitation projects in Indian cities, August 2014

BWSSB has undertaken several initiatives for improvement of water supply infrastructure. However, to achieve desired service levels and to effectively manage the entire water supply system it is necessary to do proper control and management of water flows. This required both generation of the system level data, assessment, and analysis of it to further process into useful information.

BWSSB has undertaken two related initiatives, in 2006-07, BWSSB received funding under Jawaharlal Nehru National Urban Renewal Mission (JnNURM) for installation of 218 bulk meters.

[21] Source: "Revised Master Plan for Bengaluru – 2031 (Draft), Volume 1 – Vision Document.

Then in 2013, it implemented a software application, Intelligent Operation of Water (IOW) developed by IBM on a pilot scale to monitor and regulate the flow of water across the system.

7.2.3 The initiative: bulk metering and monitoring application

There are two relative initiatives involved in the implementation process, viz, installation of bulk meters and development & implementation of software application, where it captures and tracks information from these bulk meters for monitoring and regulating the water supply system.

A DPR was prepared in 2006 by BWSSB for procurement and installation of bulk meters and for setting up a monitoring system for Bengaluru's water distribution network. The project was sanctioned under JnNURM at a cost of INR 137 million. At the time of initiation of the project, BWSSB had six water supply zones.

Chetas Control System Private Limited (selected in the competitive bidding) and BWSSB officials together handled the installation of flow meters at critical points and locations including inlet & outlet of all Ground Level Reservoirs (GLRs) and Elevated Service Reservoirs (ESRs) and on feeder mains which feed water directly to distribution network. All the inlet and outlet flow meters were given an ID, based on the location and were geo-referenced. For an instance, if a particular location of flow meters is investigated and a specific flow meter is selected, the rate of flow and consumption till that hour can be obtained. Each flow meter measures the rate of flow of water at a given moment of time. The flow at that time is transmitted through Global System for Mobile Communications (GSM) network and is transferred to the central server. A specific quantity of the flow was assigned to a flow meter based on the requirement of the service area and the availability of water. If it goes below or above the set limit it triggers an alarm, which helps to increase or decrease the flow from that flowmeter.

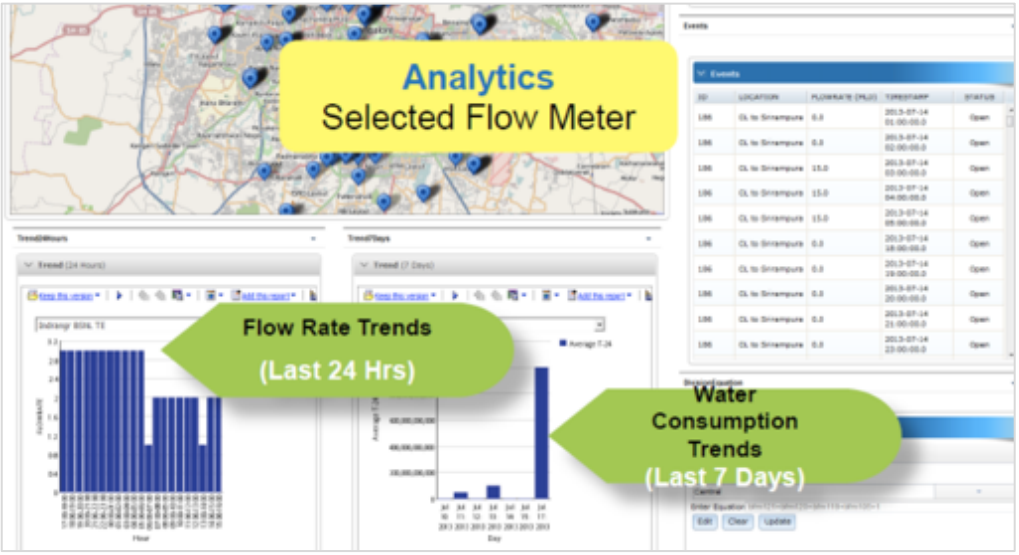
While the above system provided for installation of bulk meters and acquisition of information, an ICT application was required to capture the data for analysis, decision making, online tracking and monitoring. This is done through implementation of IT software, Intelligent Operations for Water (IOW), developed by IBM, which captures data from the bulk meters and transmit it to the users for analysis.

In December 2013, IBM entered into an agreement with BWSSB to implement a pilot project to install IOW without any cost. Besides helping BWSSB to monitor the flow of water in 100 bulk flow meters, IOW facilitated the regulation of water as required, which in turn helped in equitable distribution of water in different areas. With the help of this software, BWSSB identified leakages in the system by analysing the real time monitoring of the flows and then minimising leakages in the system to further reduce Non-Revenue Water (NRW). After evaluating the benefits of implementing IOW, BWSSB considered implementing it in other parts of the city.

The communication between the bulk flow meters and the IOW system is through GSM transmitters fitted to the ultrasonic bulk flow meters installed by BWSSB. Readings from the bulk flow meters relayed by the GSM transmitters to a mobile phone tower installed at one of the BWSSB offices. The GSM modem installed in the BWSSB office receives the real-time data through the mobile phone tower and transmits it to a centralised server that is connected to different offices monitoring the data.

A water information hub that is part of IOW provides predictive and historical analysis, which helps in tracking leakages and other types of transmission and distribution losses. The software has been customised to BWSSB's bulk flow on the State Data Centre and the water management system is based on IBM's Intelligent Operations Centre and Integrate Information Core platforms. Refer Exhibit 7-5.

Exhibit 7-5: Water operations Dashboard



Source: NIUA – 'Compendium of Good Practices Water Supply and Sanitation projects in Indian cities,' iMac's, August 2014.

7.2.4 Lessons learnt

One of its kind BWSSB's initiative provides a glimpse into the possibilities when ICT applications are combined with system- wide metering. An integrated system based on an IT application helps the utility in not only capturing the data/ information from various components of the water supply system but also enables the water operators to use it as a tool for decision making.

For effective decision making, water utilities and ULBs will need to use technology to capture, generate and relay information on water flows at a central location, but also leverage the spatial distribution of the same through integration on a Geographic Information System (GIS) platform to transition towards real-time information analysis for effective decision making.

Given the complex interplay of variables in large urban water supply systems, there is clearly a need for shifting to remote monitoring through building a comprehensive system that enables data capture at various locations and relaying of information through appropriate networking and software applications.

In case of adoption of this intervention into the cities it's important for the ULB's to ensure is clarity of objectives of technology adoption; to ensure that use of technology leads to achievement of core service delivery objectives which is to provide universal, affordable and equitable water supply to citizens while minimising NRW consistently and reliably.

8. Recommendations

This chapter provides key recommendations to reduce the water losses, effectively use of technology and ICT, increase the supply of potable water, and improve service levels in Solapur city.

1. **Supply side management measures include**
   i. **NRW management –**
      a. Institutional - Setting up NRW cell at SMC to comprehensively plan, manage, and monitor various activities to reduce NRW
      b. Technical – comprehensive water audit, metering and flow & pressure management, leak and loss reduction measures, energy saving measures etc.
      c. Commercial – measures for O&M cost recovery and tariff rationalisation

   ii. Technological and smart interventions with the use of ICT
      a. Use of smart IT system - SCADA system
      b. Smart metering – bulk metering and consumer metering to effectively measure, monitor and control the flow
      c. Monitoring through Command and Control Center (CCC) or through a dashboard
      d. Mobile app for citizen grievance and feedback

Exhibit 8-1: ICT based Smart Metering helps in reduction of NRW

2. **Demand side measures** focus on consumers in reducing demand by promoting usage of water more efficiently resulting in optimizing the quantum of water supplied and thus saving both energy and water. This includes promoting usage of water efficient appliances, fittings, and fixtures.
3. **Other water conservation measures** include rejuvenation of aquifers, rainwater harvesting, wastewater recycling and reuse for non-potable purposes
4. **Behavioural change activities** – communication approaches, key advocacy, and communication interventions,

5. **Monitoring and evaluation related measures** - mainstreaming of Service Level Benchmarks (SLBs), monitoring service standards and outcomes

8.1 Supply side measures

Reducing water loss is a key strategy in supply side management. It involves changing the design, construction, and operation and maintenance of systems, as well as user behavior. It may also include introduction of water-saving measures.

Best practices - Highlight

In Zaragoza, Spain, water savings have been a major focus since 1996. The municipality has improved its water loss management with water-saving devices and by the monitoring of flows and pressures with a supervisory control and data acquisition system, linked to a geographic information system and simulation model (SWITCH, 2011).

Singapore has achieved significant reductions in unaccounted-for water and now has one of the world's lowest non-revenue water rates[22].

8.1.1 Key strategies for NRW management

Extent of NRW is an important indicator for assessing the efficiency in service operations of a water supply system as well as for identifying physical loss of water during supply and reducing it to the extent possible[23]. However, in the absence of reliable measures to quantify water losses, the NRW values are less reliable.

8.1.1.1 Institutional - set up NRW cell in Solapur

Setting up institutional mechanism for effectively managing NRW is very important. SMC needs to set up a NRW Cell with the mandate to plan, develop, implement, and monitor an action plan for reduction of NRW, conducting periodic water audits, undertaking leakage mapping and repairs in a phased manner.

A NRW cell can be formed with six main objectives as given below, to achieve the targeted benchmark of NRW (% reduction) and to ensure streamlined implementation.

- Enhance efficiency in transmission and distribution network
- Achieve equity in distribution
- Ensure financial recovery
- Create awareness for water conservation
- Conduct periodic water audits (every 3 years)
- Implement efficiency and equity measures as per requirement

[22] Source: Public Utility Board, Singapore
[23] Source: Urban water supply and wastewater policy framework by MoHUA.

8.1.1.2 Technical aspects

Comprehensive water audit

Comprehensive water audit report for the water supply system includes study for District Metering Areas (DMAs), leak detection and reduction study and suggestions on leak reduction plan.

In September 2020, SMC has already initiated a process of appointing a consultant for carrying out the water audit of the water supply system of Solapur city. The scope of work for conducting water audit and leakage detection is as follows -

- Identify the system boundaries, and collect and record system data
- Provide meters at select bulk supply locations and carry out measurement of water supplied to the distribution system
- Prepare the Detailed Project Report (DPR) based on the water audit and consumer survey covering -
    - Suggest measures to restrict and reduce Non-Revenue Water (NRW) from the network, suggest measures for efficient utilization of various components included in the water supply system.
    - Prepare GIS map for water network from source to consumer end of entire Solapur city
    - Provide key recommendations for improvement to existing water supply scheme
    - Prepare of a proposal for operation & maintenance of the system
    - Carry out the financial analysis for the calculation of payback period & cost benefit analysis

The outputs of the water audit are expected to be used to address some of the interventions proposed under the NRW study carried out under CBUD by SMC. The NRW Cell shall be given the responsibility of implementing various actions/measures proposed as per the water audit study either internally or through appointment of external contractors. Energy audit need to be mandated at prescribed intervals for efficient functioning of electro-mechanical equipment in the system.

Metering and flow and pressure management

In Solapur, currently there are only 9,271 metered connections, which is 8.3% of the total water connections (i.e. 1,12,031). Out of these metered connections, only 478 connections (0.43% of total) have functional meters. Adoption of universal metering and volumetric tariff plays an important role in efficiently managing the water supply system.

1. Flow and Pressure Management system: For the efficient operation and monitoring network, bulk flow meters are to be installed at all raw water, clear water discharge lines, and all inlets of DMAs and at all bulk water supply points. At present there are bulk flow meters in the raw water mains, treated water mains, and outlets of the service reservoirs. However, there is no centralised data transmission system and hence data is not being reviewed and analysed. In the absence of SCADA, the data from the flow totalizers shall be downloaded and with the data

correlation, a simple excel spreadsheet can be developed to estimate the production, pumping, and supply losses.

2. In the first phase, SMC needs to provide meters for bulk supply and non-domestic users. Generally, there might be resistance from citizens and political representatives for consumer metering at domestic levels. Hence, SMC needs to carry out widespread IEC activities and door to door surveys as a preparatory stage for metering of domestic consumers.
3. The free connections shall also be metered and regulated such that there is free supply up to a pre-determined quantity and losses are well controlled by SMC. Illegal connections shall be identified through water audit and community participation.
4. SMC shall explore an option of levying a meter rent (preferably as % of water consumption bill). Testing and calibration of meters can be the responsibility of SMC, along with its repair and replacement. SMC shall make a provision in the form of depreciation fund/sinking fund at about 5% of assessment/bill and these funds may be used towards replacements and repairs.
5. The staff responsible for water supply shall also be made responsible for the leakage, theft identification and their control.

Leakage identification and reduction

Based on research, it is observed that the quantum of leak in the service pipes is about 50% of the total leaks occurring in the distribution system. Hence a continuous monitoring of the transmission, distribution and service connections is required. Leaks on customers' pipes at ferrule connection point and customer premises account for more than a quarter of all leaks. Hence following key interventions need to be taken up by attending all visible leaks and strengthening leak reporting system.

8.1.1.3 Commercial aspects

O&M cost recovery

As all the existing water sources are far away from the city and sources are not reliable, SMC is incurring sizeable O&M costs with low recovery of user charges. Hence any saving in revenue water is treated as recovery of O&M expenditure and without incurring capital expenditure to create additional sources and treatment facilities.

SMC currently reports O&M cost recovery on the Performance Assessment System (PAS) portal. CEPT University has received a grant from the Bill & Melinda Gates Foundation for Performance Assessment System (PAS) Project[24].

Energy charges for running the water pumps or wastewater treatment facilities are a major drain on the annual water budgets of the SMC. Understanding the importance of reducing energy costs, SMC with the help of Energy Efficiency Services Limited (EESL), carried out the energy audit of all water supply and sewerage system under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) program in Feb 2019. This will enable replacement of inefficient pump

[24] The performance measurement framework draws on the Government of India's initiative of standardised Service Level Benchmarks (SLB) for urban water supply and sanitation sectors developed by the Ministry of Housing and Urban Affairs (MoHUA). This activity now covers 6 states and 900+ cities in India and has become a major repository of urban water and sanitation database in India.

sets in public water works and sewerage systems with energy efficient pump sets with no upfront cost to the SMC. The investment will be recovered in the form of fixed annuity. The total project cost estimated by EESL is INR 12.4 million and the estimated OPEX is 4% of the project cost.

Tariff rationalisation

Over-consumption of water to be controlled by escalating tariff blocks. Lifeline access of 20 lpcd (as per World Health Organisation (WHO)) can be subsidized whereas at consumption level of 135 lpcd, full cost recovery should be built into tariff. Consumption beyond the benchmark should attract progressively increasing tariffs. This will lead not only to sustainable consumption but also revenue generation and promotion of equity.

Currently, there are two categories under tariff order – (a) flat monthly rate: INR 230/ HH for residential, and INR 963 for other non-domestic consumers, and (b) volumetric rate per kl: INR 11.25 / kl for residential and INR 35.1 / kl for other non-residential users.

Once a city takes up a metering drive with properly designed IEC campaigns, it can set a telescopic tariff. For example, for the first 8 kL per month, minimum charges and from 8 to 20 kl, 1.5 times the minimum charges and so on in such a way that the entire O & M expenditure is recovered.

8.1.1.4 Phasing of NRW management related interventions and estimated costs

MoHUA has carried out the NRW assessment in six Indian cities under the Capacity Building for Urban Development (CBUD) program in 2015-16. Solapur city was also part of this study, under which key recommendations have been made to reduce NRW and improve the water management system. A summary of these interventions, phasing and broad cost estimates are provided in the Exhibit 8-2.

Exhibit 8-2: Strategies for NRW reduction in Solapur – as per NRW study under CBUD

Interventions	Technical	Commercial
Short term Estimated cost of implementation: INR 12 crore, Incremental O&M cost: INR 18 lakh/ year	• Conduct regular stakeholder consultations • Identify and attend all visible leaks • Strengthen leak reporting system	• Conducting door to door surveys • Regularising illegal connections • Metering all unmetered / dysfunctional commercial connections

Medium term
 	
Estimated cost of implementation: INR 130 crore,
 	
Incremental O&M cost: INR 8.2crore
	• Conduct topographical surveys and updating network maps
	• Carry out broad zoning and DMA design
	  ○ Hydraulic zones for intermittent supply
	  ○ Hydraulic zones when the system switches to continuous supply
	• Set up flow and pressure management system
	• Provide isolation valves
		• Metering all service connections
		• Setting up mechanism to improve the tariff system
		• Improving the Bill payment system
		• Establishing meter testing bench
		• Establishing consumer service centres and bill collection centres

Interventions	Technical	Commercial
	• Conduct leak detection survey • Carry out repair or replacement of leaky pipes and appurtenances	
Continuous Estimated cost of implementation: INR 63 lakh	• Carry out IEC activities • Carry out capacity building programs	---

Source: Final Report on Developing strategy for reduction of NRW in Solapur city, August 2015; IUC- India analysis

8.1.2 Use of Information and Communication Technology (ICT)

Information and Communication Technology (ICT) increasingly uses sensors to collect widespread and near-real-time data from multiple infrastructure systems. However, the sensor-acquired data will be useless unless and until they are physically interpreted and turned into actionable information.

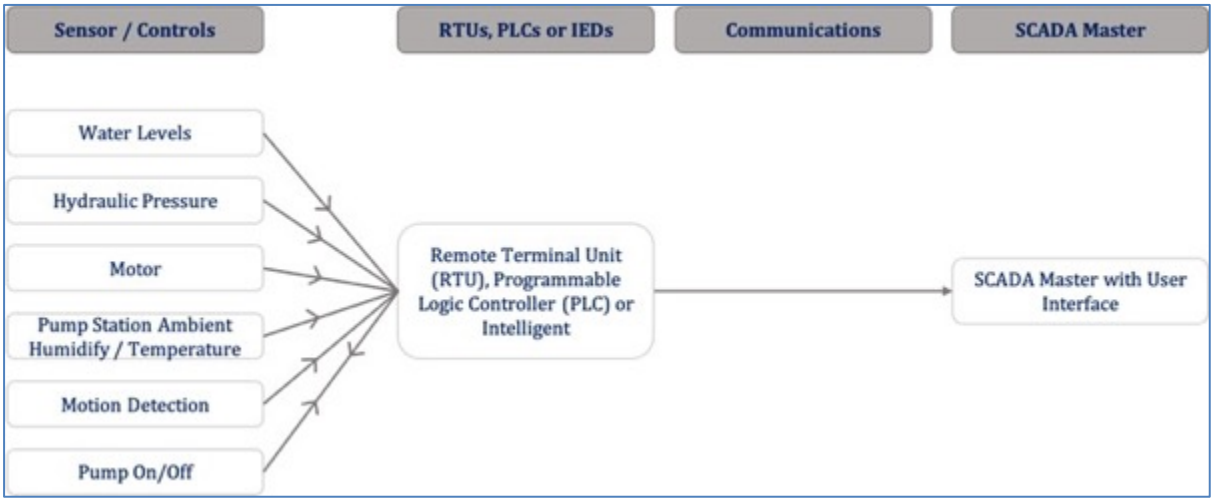
8.1.2.1 Use of smart IT system - SCADA system

Supervisory control and data acquisition (SCADA) is a control system architecture comprising computers, networked data communications and graphical user interfaces (GUI) for high-level process supervisory management, while also comprising other peripheral devices like programmable logic controllers (PLC) and discrete proportional-integral-derivative (PID) controllers to interface with process plant or machinery.

The SCADA based reporting system allows the city engineers a graphical insight into the flow, level, pressure & efficiency monitoring along with insights into possible issues on a day to day basis. It uses a spectrum of communication technologies like broadband, WLAN and GPRS to achieve the real time data transmission.

Solapur has used SCADA for STP and Pimpri Chinchwad city has established SCADA for water supply and sewerage system in 2010. Refer Exhibit 8-3 for broad components of the SCADA system.

Exhibit 8-3 SCADA system – components



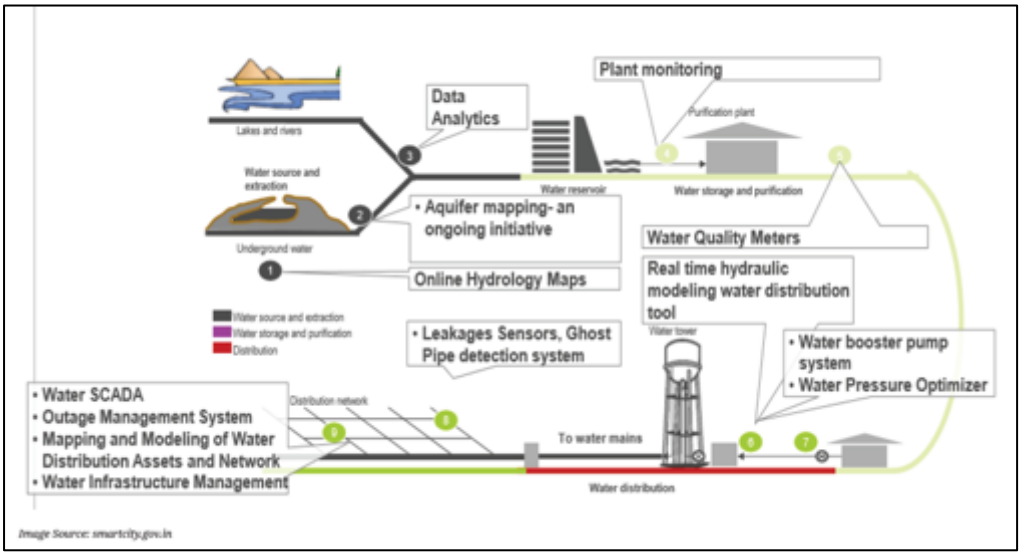
8.1.2.2 Install smart bulk and consumer meters

By installing Internet of Things (IOT) enabled smart bulk meters, SMC will be able to collect real time data on flow & direction of water. Similarly, by installing smart consumer meters, SMC will be able to capture, monitor and control the consumption at consumer end. These are very critical components of the NRW assessment and overall water balance.

Given the complex interplay of variables in large urban water supply systems, there is clearly a need for shifting to remote monitoring through building a comprehensive system that enables data capture at various locations and relaying of information through appropriate networking and software applications.

Refer Exhibit 8-4 illustrates use of ICT for improving water supply management and Exhibit 8-5 provides screenshot of dashboard created by Pune Municipal Corporation for grievance redressal.

Exhibit 8-4 Use of ICT for improving water supply management

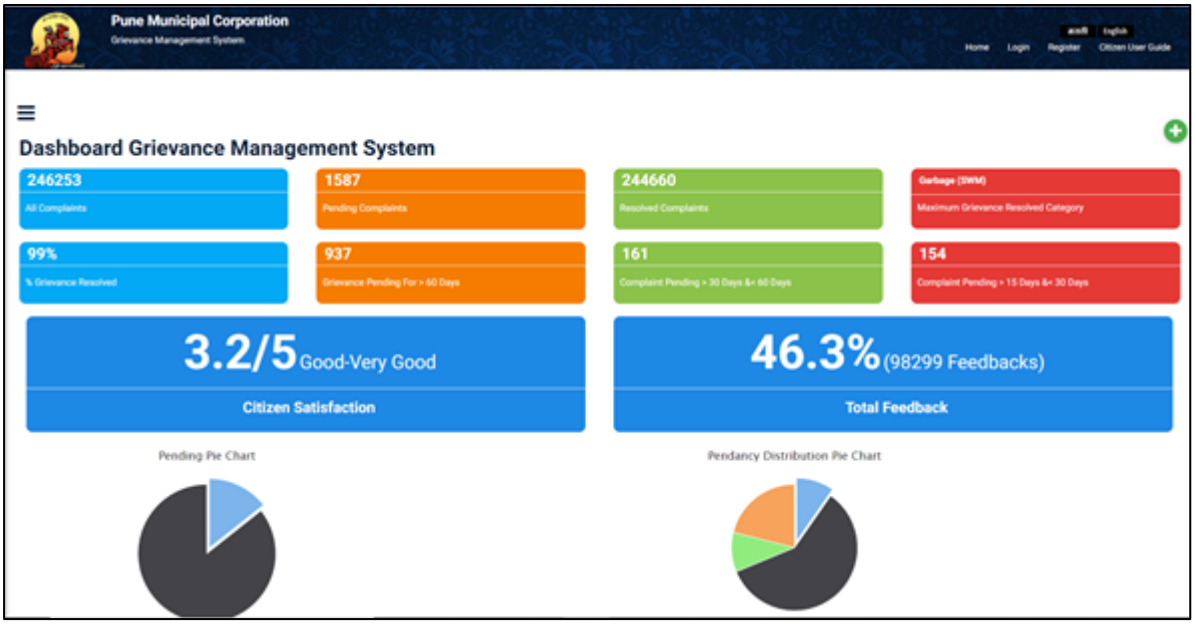


Source: smartcity.gov.in

8.1.2.3 Mobile app for citizen grievance and feedback

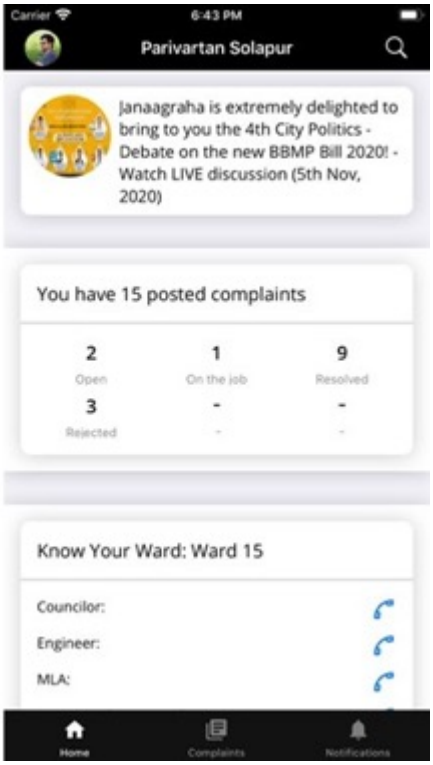
Parivartan Solapur is an official platform for grievance redressal built by Janaagraha in partnership with SMC. It allows citizens to post cleanliness related issues in their neighborhood communities for resolution by health/sanitation officials. This application is created to help citizens connect with the right government authority for addressing the civic grievances. Citizens can post a complaint in simple steps or vote up on the complaints raised by fellow citizens to emphasize on the magnitude of complaint. This platform can be extended to cover other services such as water supply so that the water supply management can be done effectively.

Exhibit 8-5 Pune - Dashboard for grievance management system



Source: Pune Municipal Corporation website

Exhibit 8-6 Illustration of smart meter – Murcia[25] and Parivartan app- Solapur[26]



8.2 Demand management

8.2.1 Behavioral change in water use and consumption

Key to managing demand has been facilitating behavioral change in water use and consumption. Key levers for this are – public engagement, pricing and metering, and legislative/ building codes.

Learning from Singapore[27]

The campaign to manage demand in Singapore is known as the "3P approach" and encourages everyone (People, Public, Private) to take ownership of water resource management. Also central to this approach is the Active, Beautiful, Clean Waters (ABC Waters) Programme, which enhances Singapore's water infrastructure bringing people closer to water, so they can better appreciate, cherish, and ultimately value that water.

As a result of the campaign and ABC Waters Program, reduction per capita use reduced from 165 liters/day in 2003 to 152 liters/day in 2013, with an aim to drop to 147 liters/day by 2020. Overall, Singapore's water demand management strategy has achieved a total volumetric impact of 18,18,000 m^3/year.

8.2.1.1 Public engagement

Encourage users to install water saving devices. Citizens need to be encouraged to take ownership of their surrounding water bodies. Adoption by schools and community groups can take an active

[25] Source: Aguas de Murcia - website
[26] Source: https://appadvice.com/app/parivartan-solapur/1539601084
[27] Source: https://www.waterscarcitysolutions.org/water-demand-management-strategy/

part in their management, encouraging this. This has benefits for both water quality and conservation as it engages the public in understanding the value of water.

8.2.1.2 Pricing and metering

Through Information and Communication Technology (ICT) monitoring, any readings that are abnormally high or low are singled out for further investigation. These measures contribute directly to a reduction in per capita use.

8.2.1.3 Legislative/ building codes

Legislative measures need to be enforced to deter water wastage. The citizens should be encouraged to install dual flush toilets and low flow taps; this includes renovations and new builds. To aid compliance the SMC needs to conduct spot checks on residential buildings to ensure that the mandatory requirements are being followed.

8.2.2 Water Use efficiency in Fittings / Fixtures:

To improve water use efficiency following measures need to be taken up

- Promote use of smart water saving fittings (taps/faucets, flushing tanks, water closets, urinals, bidets, and bathtubs) may be promoted through citizen information as well as fiscal incentives to manufacturers
- Promote use of water saving automatic taps; air-mixing taps and soft closing taps may also be promoted through citizen awareness programme.
- Showers with consumption displays and with announcements for wastages may also be promoted.
- Fittings with automatic controls shall be mandated for high footfall locations.

8.2.3 Others

The introduction of permanent water demand management measures to encourage consumers to use less water through advertising, education, pricing, and appliance redesign.

For example, unit costs for water demand management depend on the quality and type of water saving devices; leakage management costs depend on the cost of water production and leakage control strategies; greywater costs depend on the treatment choices; stormwater costs depend on whether structural and/or nonstructural measures are applied; rainwater harvesting costs depend on whether simple storage tanks or pumping to elevated reservoirs are required.

8.3 Water conservation measures

8.3.1 Need to explore opportunities for wastewater recycling and reuse

The existing sewage treatment capacity is 102.5 MLD and the utilisation is 89.35 MLD. There is an opportunity for recycling of wastewater and reuse for non-potable purposes as an alternative to fresh water supply to these non-potable usages.

There is a potential buyer as well. The National Thermal Power Corporation Ltd. (NTPC) has recently developed a 1,320 MW coal based thermal power plant at Fatatewadi about 20 km from Solapur city. The plant needs large quantity of water and is dependent on Ujani dam as a source for fresh water supply. There is opportunity for supply of treated wastewater from Degaon STP of 75 MLD capacity to the NTPC plant. SMC can work out the reasonable selling price of recycled/ secondary treated water to at least recover the O&M cost of the Degaon STP, which is INR 37 million/ annum (translates to INR 1.6 / kl). It will help in reuse of around 65 MLD of wastewater and diverting equal quantity of fresh water.

SMC has reached an understanding with NTPC plant wherein NTPC has agreed to use the recycled wastewater from Solapur city instead of fresh water and divert the fresh water to the city.

Other key recommendations for wastewater recycle and reuse are as follows:

- There are 32 gardens of various sizes in Solapur city including 13 gardens developed under the AMRUT scheme. These gardens span over an approximate area of 100 acres. The secondary treated water from STP or recycled water with further treatment can be used for watering these gardens. Thus, it will help in conserving fresh water sources.
- In case of multistoried constructions and gated communities, internal dual piping for toilet flushing shall be made mandatory. It shall also be mandated for high end users such as hotels, malls, and industries.
- Such building communities and groups of housing implementing dual piping, shall also ensure on-site treatment of wastewater to the water reuse standards of the nation or as per national/ international best practices.
- Supply of treated wastewater to non-potable users such as process water for textile industries, horticulture, gardens, toilet flushing at public toilet complexes, bus stands and railway stations shall be explored.
- SMC may provide incentive on the quantity of wastewater treated and reused for which separate metering may be necessary.
- Incentives may be provided to customers (in water tariff, property tax etc.) for the recycle and reuse of treated wastewater.

8.3.2 Rejuvenation of aquifers

In water scarce areas, aquifers play a particularly important role in the water cycle approach and in support of urban water security. While not present under all cities, where they exist, aquifers are re-emerging as the key element in developing an integrated approach to water security. A significant proportion of the cities in water scarce areas originally developed based on extensive groundwater resources. Hence following measures need to be taken to rejuvenate aquifers

- Groundwater recharge areas need to be delineated, mapped, and protected.
- Low lying areas, lakes and flood plains may be identified and reserved for storing rainwater for better environmental conditions.
- Local nallahs, drains and streams shall have low-level check dams for storing rainwater and improving recharge in the areas

8.3.3 Promoting Rainwater Harvesting (RWH)

Key measures proposed for promoting RWH are as follows -

- RWH and recharge recommended to be made mandatory
- Wherever the number of rainy days is high, rainwater storage & use systems shall be used. Incentives may be provided on the quantum of water consumption avoided from the organized water supply system.
- SMC shall identify and reserve 2-5% of development area for water bodies, either natural or constructed.
- A system of Groundwater Table monitoring wells may be developed at ward level. To be used for assessing efficiency of RWH measures, and warnings against excessive exploitation of groundwater.

8.4 Behavioural change activities

This aims to reach citizens/ stakeholders at all levels through different channels of communication. The main communication approaches suggested are advocacy, interpersonal communication, community-mobilisation, supported and reinforced by mass media.

Advocacy: to influence and engage decision makers to provide policies, funding, organizational support, and commitment for safe drinking water initiatives. The aim is to raise the issue of safe drinking water higher on the policy agenda.

Interpersonal Communication: is one of the key approaches to raise knowledge on the importance of safe drinking water among communities and influence the adoption of safe behaviours regarding drinking water at household and community level.

Community Mobilisation: to initiate dialogue among community members to deal with critical issues of safe drinking water and provide a platform for community participation and ownership for conservation of water.

Mass media, outdoor media, and folk media: will be used in addition to create mass awareness on water quality issues, promote the key identified behaviours and programme information. Simultaneously information from these mediums will provide credibility and reinforcement to interpersonal communication and social mobilisation efforts.

8.5 Monitoring and evaluation related measures

Universal access of safe drinking water is a fundamental need and human right.

8.5.1 Mainstreaming of Service Level Benchmarks (SLBs) for sustainability

Benchmarking is now well recognised as an important mechanism for performance management and accountability in service delivery. It involves the measuring and monitoring of service provider performance on a systematic and continuous basis. Sustained benchmarking can help utilities to identify performance gaps and introduce improvements through the sharing of information and best practices, ultimately resulting in better services to people.

Recognising its importance, the MoHUA, Government of India, has launched the Service Level Benchmarking (SLB) initiative covering water supply, wastewater, solid waste management and storm water drainage.

SMC currently reports water supply related service levels on the Performance Assessment System (PAS) portal. CEPT University received a grant from the Bill & Melinda Gates Foundation for Performance Assessment System (PAS) Project[28].

It is advised to follow the framework suggested in Exhibit 8-8. However, SMC may make minor changes in the frequency or jurisdiction of reporting, considering the size of the city and its prevailing systems.

The endeavour should always be to report performance in as disaggregated a manner as possible, that is, reporting performance at the highest frequency as possible, and at the smallest geographical jurisdiction as possible.

Exhibit 8-7 SLB performance parameters as per MoHUA, GoI

WATER SUPPLY		
S. No.	Indicator	Benchmark
1.	Coverage of Water Supply connections	100%
2.	Per Capita Supply of Water	135 lpcd
3.	Extent of Non-revenue Water	15%
4.	Extent of Metering	100%
5.	Continuity of Water supplied	24 Hours
6.	Efficiency in redressal of customer complaints	80%
7.	Quality of Water Supplied	100%
8.	Cost Recovery	100%
9.	Efficiency in Collection of Water Charges	90%[38]

[28] The performance measurement framework draws on the Government of India's ongoing initiative of standardised Service Level Benchmarks (SLB) for urban water supply and sanitation sectors developed by the Ministry of Urban Development (MoUD). This activity now covers 6 states and 900+ cities in India and has become a major repository of urban water and sanitation database in India.

Exhibit 8-8 Suggested frequency and jurisdiction of reporting

SLB No.	Urban Service	Frequency of Measurement by ULB/Utility	Frequency of Reporting within ULB/Utility	Frequency of Reporting to State/ Central Govt.	Jurisdiction for Measurement by ULB/Utility	Jurisdiction for Reporting within ULB/Utility	Jurisdiction for Reporting to State/ Central Govt.
1.	WATER SUPPLY						
2.1.1	Coverage of water supply connections	Quarterly	Quarterly	Annually	Zone/DMA	Ward	ULB
2.1.2	Per capita supply of water	Monthly	Monthly	Annually	Zone/DMA	Ward	ULB
2.1.3	Extent of metering of water connections	Quarterly	Quarterly	Annually	Zone/DMA	Ward	ULB
2.1.4	Extent of non-revenue water (NRW)	Quarterly	Quarterly	Annually	ULB	ULB	ULB
2.1.5	Continuity of water supply	Monthly	Monthly	Annually	Zone/ DMA	Zone/ DMA	ULB
2.1.6	Quality of water supplied	Monthly	Monthly	Annually	ULB	ULB	ULB
2.1.7	Efficiency in redressal of customer complaints	Monthly	Monthly	Annually	Zone/ DMA	Zone/ DMA	ULB
2.1.8	Cost recovery in water supply services	Quarterly	Quarterly	Annually	ULB	ULB	ULB
2.1.9	Efficiency in collection of water supply-related charges	Annually	Annually	Annually	Zone/DMA	Ward	ULB

Source: Handbook of Service Level Benchmarking, MoHUA

- **Frequency of measurement:** Frequency of measurement of the performance indicator refers to the frequency at which the performance level will be assessed and not the frequency at which the data elements will be measured. For each indicator, the minimum frequency at which the performance should be measured is mentioned. It can then be reported at the same frequency or a lower frequency.
- **Jurisdiction of measurement:** This refers to the geographic jurisdiction for which performance should be measured, and not the point of data collection. Typically, measuring urban service delivery performance at a sub-city level makes more sense for city level stakeholders, than only city level performance indicators. For instance, for an urban citizen or municipal councillor, it would be useful to know the performance of a particular service in that ward, especially in relation to other wards.

An assessment system with a set of key performance indicators for urban water and sanitation and links the planning and fund allocation process to performance. It includes three major components of performance measurement, performance monitoring and performance improvement.

Exhibit 8-9 Illustrative performance report card

Sector: *Water Supply* SLB: *Coverage of Water Supply Connections*

Reporting Frequency: *Annual* Reporting Period: *FY 2008-09*

Reporting Jurisdiction: *Limits of **** Municipal Corporation* Performance Report submitted to: *State Government*

All figures are in %

Time Period	Performance Achieved	Performance Targeted	Performance Achieved as per Reliability of Measurement Level	Action Plan to Achieve the Target
FY 2008-09 (baseline)	71	B		
FY 2009-10		75		• All backlog applications for new connections will be cleared in the next 12 months
FY 2010-11		85		• Major source augmentation and transmission project will be completed
				• Regularisation of all illegal connections in north of the city
FY 2011-12		90		• Distribution improvement project will be taken up • Standposts will be replaced in slums in Ward nos ___ to ___ • Regularisation of all illegal connections in south of the city
FY 2012-13		95		• Standposts will be replaced in slums in Ward nos ___ to ___

Source: Handbook of Service Level Benchmarking, MoHUA

8.5.2 Monitoring Service Standards and Outcomes

Reliability of measurement: The performance measurement is only as reliable for meaningful management decisions as the systems that generate the data to compute the performance. Typically, four levels of reliability of data systems have been specified: 'A', 'B', 'C', and 'D,' with 'A' being of highest reliability and 'D' being lowest.

Reliability of measurement highlights a hitherto ignored aspect in performance management of urban services—the need to design, implement and institutionalise robust systems and processes that will provide data of high reliability, on a repeat basis, and in a consistent manner.

9. Conclusion and way forward

Solapur city is expected to witness continuous population growth in future. This will put pressure on the already constrained water sources and the water supply system. SMC needs to adopt effective water management measures and use of smart technology to conserve water and improve service delivery. Summary of recommendations is as follows:

1. **Supply side management measures include**
   i. **NRW management** –
      a. Institutional - Setting up NRW cell at SMC to comprehensively plan, manage, and monitor various activities to reduce NRW
      b. Technical – comprehensive water audit, metering and flow & pressure management, leak and loss reduction measures, energy saving measures etc.
      c. Commercial – measures for O&M cost recovery and tariff rationalisation

   ii. Technological and smart interventions with the use of ICT
      a. Use of smart IT system - SCADA system
      b. Smart metering – bulk metering and consumer metering to effectively measure, monitor and control the flow
      c. Monitoring through Command and Control Center (CCC) or through a dashboard
      d. Mobile app for citizen grievance and feedback

Exhibit 9-1: ICT based Smart Metering helps in reduction of NRW

2. **Demand side measures** focus on consumers in reducing demand by promoting usage of water more efficiently resulting in optimizing the quantum of water supplied and thus saving both energy and water. This includes promoting usage of water efficient appliances, fittings, and fixtures.
3. **Other water conservation measures** include rejuvenation of aquifers, rainwater harvesting, wastewater recycling and reuse for non-potable purposes
4. **Behavioural change activities** – communication approaches, key advocacy, and communication interventions,

5. **Monitoring and evaluation related measures** - mainstreaming of Service Level Benchmarks (SLBs), monitoring service standards and outcomes

The IUC- India partnership provides opportunity for Solapur to learn from its peer European cities like Murcia as well as other Indian cities who have faced similar challenges and adopted multipronged strategies to address those.

SMC has taken a few initiatives for improving water supply system such as water audit, energy audit, NRW study; and has adopted certain measures to improve feedback system and reporting such as PAS project, *Parivatan* app etc. It needs to further build on that and adopt ICT and benchmarking tools for performance management and accountability in service delivery.

The way forward is to -

- Carry out a more detailed feasibility study
- Implement few pilot projects as per this report and the earlier studies carried out by SMC

Annexures

Annexure 1 References

1. Revised City Development Plan for Solapur, 2041.
2. A report on Water Scarce Cities, Thriving in a Finite World, World Bank
3. Public Health Engineering (PHE) Department, SMC
4. Performance Assessment Project, Solapur
5. RfP on water audit of Solapur city published in the year 2020 by SMC
6. Smart City Proposal of Solapur city submitted under Smart City Mission to Government of India
7. RfP on water audit of Solapur city published in the year 2020 by SMC
8. Handbook on Service Level Benchmarks (SLB) for urban water supply and sanitation sectors developed by the Ministry of Urban Development (MoUD).
9. Research article on Intermittent Water Distribution by Florian Faure (seecon international gmbh) and M.M. Pandit (Indian Water Works Association (IWWA)
10. A report on Water Scarce Cities, Thriving in a Finite World, World Bank
11. Urban water supply and wastewater policy framework by MoHUA
12. Meeting the Challenges of Climate-Proofing a Water System: How Surat Learned & Adapted, Dec 2018.
13. Revised Master Plan for Bengaluru – 2031 (Draft), Volume 1 – Vision Document.
14. http://www.greendigitalcharter.eu/wp-content/uploads/2014/06/Emuasa-Smartwater_W.pdf
15. https://www.emuasa.es/en/retorno
16. Aguas de Murcia - website
17. https://appadvice.com/app/parivartan-solapur/1539601084
18. https://www.emuasa.es/en/retorno
19. Website of Public Utility Board, Singapore
20. Aguas de Murcia - website
21. https://appadvice.com/app/parivartan-solapur/1539601084
22. https://www.waterscarcitysolutions.org/water-demand-management-strategy/

This report is prepared by Mahesh Harhare, Urban Development Expert for IUC - India.

The images on the cover page are taken from Facebook page of Solapur Smart City.