# Sustainable Urban Planning Strategies for Cities in Karnataka

## Volume II: Water, Sanitation and Transport

CSTEP
CENTER FOR STUDY OF SCIENCE, TECHNOLOGY & POLICY

# Sustainable Urban Planning Strategies for Cities in Karnataka

# Volume-II

## Sustainable Strategies for Urban Water, Sanitation and Transport

## Final Report

**Submitted by: Center for Study of Science, Technology and Policy (CSTEP)**

**For the Urban Development Department,**

**Funded by the Planning Department, Government of Karnataka**

**September, 2018**

Center for Study of Science, Technology and Policy (CSTEP) is a private, not-for-profit (Section 25) Research Corporation registered in 2005.

Designing and Editing by CSTEP



September, 2018

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## Acknowledgement

CSTEP expresses its gratitude to Shri Mahendra Jain, Additional Chief Secretary and Shri Anjum Parwez, Secretary, Urban Development Department, Government of Karnataka for all their support in this project. The authors would like to thank Dr R. Vishal, Ex-Director, Directorate of Municipal Administration, Government of Karnataka for his valuable inputs. The authors would like to thank Shri A. Ravi, Joint Director, Planning, Urban Development Department, Government of Karnataka for his constant guidance and coordination.

CSTEP researchers wish to thank Shri Chadananda Vatare, Joint Director, Development and Dr. Pratibha D'Souza from Directorate of Municipal Administration, Government of Karnataka for sharing valuable information and data for this project. The authors also thank Shri Shamanth Kuchangi, Technical Head, Directorate of Urban Land Transport for his support in sharing data on the urban transportation plans in Karnataka.

The authors gratefully acknowledge the inputs and valuable suggestions by Vivek Vaidyanathan, Anantha Lakshmi P, Dr. Pratima Singh and Trupti P Deshpande in this project.

Last but not the least, this work would not have been possible without the valuable support and encouragement from Dr. Anshu Bharadwaj, Executive Director, Dr. Jai Asundi, Research Coordinator and Thirumalai N.C., Project Manager and CSTEP's editorial team.

## Abbreviations and Acronyms

| | |
|---|---|
| ACIWRM | Advanced Center for Integrated Water Resources Management |
| ABR | Anaerobic Baffled Reactor |
| AMRUT | Atal Mission for Rejuvenation and Urban Transformation |
| ARAI | Automotive Research Association of India |
| ASP | Activated Sludge Process |
| BAU | Business As Usual |
| BBMP | Bruhat Bengaluru Mahanagara Palike |
| BIOFOR | Biological Filtration and Oxygenated Reactor |
| BMTC | Bengaluru Metropolitan Transport Corporation |
| BOD | Biological Oxygen Demand |
| BWSSB | Bangalore Water Supply and Sewerage Board |
| CAGR | Compound Annual Growth Rate |
| CAPEX | Capital Expenditure |
| CBO | Community Based Organisation |
| CGWB | Central Ground Water Board |
| Cl | Chlorine |
| CMC | City Municipal Council |
| CMP | City Mobility Plan |
| CNG | Compressed Natural Gas |
| COD | Chemical Oxygen Demand |
| CPCB | Central Pollution Control Board |
| CPHEEO | Central Public Health and Environmental Engineering Organisation |
| CPHEOO | Central Public Health and Environmental Engineering Organisation |
| CSP | City Sanitation Plan |
| CSP | City Sanitation Plans |
| CSTF | City Sanitation Task Force |
| CTs | Community Toilets |
| CTTP | Comprehensive Traffic and Transport Plan |
| DEWATS | Decentralised Wastewater Treatment Systems |
| DHI | Department of Heavy Industries |
| DMA | Directorate of Municipal Administration |
| DP | Dissolved Phosphorous |
| EMPRI | Environmental Management & Policy Research Institute |
| EV | Electric Vehicle |
| FAL | Facultative Aerated Lagoon |
| FAME | Faster Adoption and Manufacturing of Electric Vehicles |
| FS | Faecal Sludge |
| FSSM | Faecal Sludge and Septage Management |
| FSTP | Faecal Sludge Treatment Plant |
| GHG | Greenhouse Gas |
| GIS | Geographical Information System |
| GIS | Geographical Information System |
| GoK | Government of Karnataka |

| | |
|---|---|
| HCVs | Heavy Commercial Vehicles |
| HH | Households |
| IEC | Information Education and Communication |
| IHHL | Individual Household Latrines |
| IPT | Intermediate Public Transport |
| IUWM | Integrated Urban Water Management |
| IUWRM | Integrated Urban Water Resources Management |
| IWRM | Integrated Water Resources Management |
| KEA | Karnataka Evaluation Authority |
| KSNDMC | Karnataka State Natural Disaster Monitoring Centre |
| KSRTC | Karnataka State Road Transport Corporation |
| KTCP | Karnataka Town and Country Planning |
| KUWSDB | Karnataka Urban Water Supply and Drainage Board |
| LCVs | Light Commercial Vehicles |
| M&E | Monitoring and Evaluation |
| MBR | Membrane Bio Reactor |
| MC | Municipal Corporation |
| MIS | Management Information System |
| MLD | Million Litres per Day |
| MoEFCC | Ministry of Environment, Forest and Climate Change |
| MoHUA | Ministry of Housing and Urban Affairs |
| MPCTR | Motorised Per Capita Trip Rate |
| NEMMP | National Electricity Mobility Mission Plan |
| NGOs | Non-Government Organisations |
| NMT | Non-motorised Transport |
| NUSP | National Urban Sanitation Policy |
| NUSP | National Urban Sanitation Policy |
| NUTP | National Urban Transport Policy |
| O&M | Operation and Maintenance |
| OEMs | Original Equipment Manufacturers |
| OG | Outgrowth |
| OPEX | Operation and Maintenance Expenditure |
| OSS | On-site Sanitation Systems |
| PPAC | Petroleum Planning and  Analysis Cell |
| PT | Public Transport |
| PTs | Public Toilets |
| PV | Private Vehicle |
| RO | Reverse Osmosis |
| SBM | Swachh Bharat Mission |
| SBR | Sequential Batch Reactor |
| SLBs | Service Level Benchmarks |
| SPV | Special Purpose Vehicle |
| SRTU | State Road Transport Undertaking |
| SSAPCC | State Specific Action Plan on Climate Change |
| SSS | State Sanitation Strategy |

| | |
|---|---|
| STP | Sewage Treatment Plant |
| STW | Secondary Treated Wastewater |
| TDS | Total Dissolved Solids |
| TMC | Town Municipal Councils |
| TN | Total Nitrogen |
| TP | Town Panchayats |
| TSS | Total Suspended Solids |
| UASB | Up-flow Anaerobic Sludge Blanket |
| UDD | Urban Development Department |
| UGD | Underground Drainage or Networked system |
| ULB | Urban Local Bodies |
| ULB | Urban Local Body |
| UV | Ultraviolet light |
| UVs | Utility Vehicle |
| UWWR | Urban Waste Water Reuse Policy |
| WRD | Water Resources Department |

## Executive Summary

Karnataka is one of the most urbanised states in India. However, increased urbanisation has brought complex challenges, such as meeting citizens’ expectations for a higher quality of life standards while ensuring the sustainability of natural and economic resources. Consequently, cities in Karnataka have been subject to different levels of interventions to improve their liveability conditions through a number of flagship urban development programmes. Unfortunately, the performance of the cities against critical service-level benchmarks indicate that they are yet to accomplish the desired level of liveability and sustainability conditions. Moreover, there are important aspects of sustainability that are not currently measured by the key performance indicators reported by cities.

Recognising the need for implementing more forward-looking approaches in key urban sectors, the Government of Karnataka has introduced a number of new policy guidelines relating to water, sanitation and transport sectors. However, addressing urban sustainability challenges require the consideration of varying geographic contexts as well as the difference in the pattern of urbanisation experienced by cities. Considering the present capacity of Urban Local Bodies, there is a need for providing adequate guidance to the cities to help them identify and implement the right set of strategies. In this context, this study aimed to bridge the gaps between the policy intent and implementation for the three key urban sectors, i.e., water, sanitation and transport.

The Karnataka Urban Waste Water Reuse (UWWR) Policy, released in December 2017, recognises the lack of an integrated approach in urban water planning and mandates the adoption of Integrated Urban Water Management (IUWM) principles. The research and analysis carried out and the recommendations suggested in this report pertaining to the urban water sector are largely motivated by this policy.

First, the study delineates Karnataka into different priority regions based on different levels of water stress experienced. It identifies multiple taluks in and around the Bengaluru–Mumbai Economic Corridor as generally high to very high priority areas based on the water stress faced and the growth pressure experienced. A few smaller patches of high to very high priority regions are spread across the state. Overall, 21 cities in Class-I and II categories are in the high to very high priority regions.

Second, the study suggests sustainable water strategies for cities in the four geographic regions of the state: North Interior, South Interior, Malnad and Coastal regions. A Water Strategy Selection Matrix for identifying the priority strategies for different sizes of cities in each of the four regions has been developed based on region-wise opportunities and constraints. A toolkit has also been developed as an output which allows matching each strategy to the physical and environmental characteristics of a city.

Thirdly, this report elaborates the process of preparation of the Integrated Urban Water Management plans at the city level in line with the recommendations of the UWWR policy.

The growing inclination towards an integrated approach to water is also visible in the sanitation sector. The UWWR policy makes a case for treated wastewater reuse, and the new State Faecal Sludge and Septage Management (FSSM) policy advocates a systems approach to the sector. Despite the novel precedents set by these policies, there are currently no frameworks or tools to aid in the choice of appropriate systems for the 347 cities in Karnataka. There is also a clear need to incorporate FSSM options into City Sanitation Plans, mandated by the National Urban Sanitation Policy (2008), which were envisioned with a sewered system-centric approach. Given these gaps in knowledge and decision-support tools, this study intends to examine different means for the effective implementation of the strategies recommended by the SFSSM policy. The study has developed an FSSM-inclusive city sanitation planning process, based on regional, national and global plans, policies and frameworks. A region-level technology suitability assessment toolkit has also been developed for Karnataka, based on the unique features of the state. This toolkit makes a case for mechanised sanitation system options which have low dependencies on the geographical profile of the cities. To understand how these technologies fare at the city context, a pre-feasibility analysis methodology was demonstrated for four cities (Chitradurga, Raichur, Kolar and Udupi). This exercise compared sewered (or networked) systems and FSSM systems in the four cities against indicators relating to cost, resource requirement, effluent quality and potential revenue from reuse. FSSM systems were found to be more economical and less demanding on land and water. They were also found to be more efficient in treating wastewater and likely to recover their costs through the sale of by-products, although the resale of faecal sludge is still a contentious topic.

Karnataka is witnessing an increasing trend in motorisation and higher per capita number of trips in its cities. Recognising the global and national discourse on clean and low carbon transportation, Karnataka became the first Indian state to launch a policy on Electric Vehicles (EVs) in 2017. This study aimed to identify the suitable transport modes in tier-II cities in Karnataka for the introduction of EVs. The identification of primary emerging mode(s) for 2031 has been done based on different scenarios of EV penetration for different motorised modes and resulting reduction in $CO_2$ emissions. The findings show that Intermediate Public Transport (IPT) segment emerges as the most viable mode for EV intervention in the tier-II cities in Karnataka.

Finally, a set of sustainability indicators pertaining to the urban water, sanitation and transport sectors are suggested. These indicators are meant for allowing cities to draw realistic baselines that can help identify priority intervention areas. The set of indicators together enshrine four principles of sustainability, i.e., (a) social wellbeing and equity, (b) environmental sustainability, (c) economic efficiency and (d) good governance and foresight.

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# 1. Introduction

Karnataka is among the ten most urbanised states in the country. With a decadal growth rate of 31.5%, the share of urban population in Karnataka has grown from 34% in 2001 to 38.7% in 2011. The number of urban centres in the state has also seen an increase, from 237 in 2001 to 347 in 2011. The maximum population share in the state is held by Class-1 cities (68%), while a majority of the cities are in the Class-3 size category (105 among 347 ULBs). Owing to the presence of Bengaluru and Mysuru (two of the largest urban agglomerations in the state), districts in southern Karnataka have consistently showed higher urbanisation than the other regions. At the same time, a number of small and medium towns across the state have emerged as important urban centres. These include the ones located along major industrial corridors being developed in the state.

Increased urbanisation has brought about complex challenges such as enhancing the quality of living standards in cities while ensuring the sustainability of natural and economic resources. A number of flagship programmes are being implemented since last decade which seek to address these challenges. Notable among these are the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Smart Cities Mission (SCM), Heritage City Development and Augmentation Yojana (HRIDAY), Swachh Bharat Mission (SBM), PMAY (Urban) and Mukhya Mantri Nagarothana. However, latest data on the performance of the cities in Karnataka against key service-level benchmarks (SLBs) indicate that the cities are yet to accomplish the desired levels of liveability and sustainability conditions. Moreover, several important aspects of sustainability, especially the ones pertaining to environmental conservation and social equity, are not addressed by the key performance indicators (KPIs) currently measured and reported by cities.

The challenge of creating sustainable and liveable urban settlements is going to intensify in the coming years. Several leading studies have suggested that the combined impact of climate change and unplanned urban growth will result in a higher frequency of extreme events and slow but steady degradation of natural parameters in cities. Key urban service sectors such as water are severely affected by dwindling groundwater resources and degradation of surface water sources vis-à-vis the increased demand for urban and industrial needs. On the other hand, pollution generated from both urban sanitation and transport sectors have started showing a significant impact on land, water and air quality. This, in turn, has a severe effect on human health and the natural ecosystem surrounding cities.

Recognising the enormity of these effects, the Government of Karnataka has introduced several progressive policy documents in the recent past. Being one of the pioneer states in introducing a state-level water policy in 2012, the state has drafted an Urban Waste Water Reuse Policy in 2017. The Policy recommends the preparation of city-level water management plans based on the Integrated Urban Water Management (IUWM) approach.

In the sanitation sector, the concept of Faecal Sludge and Septage Management has been gaining traction at the national level for the past few years. Karnataka is one of the first states to introduce a state-level Faecal Sludge and Septage Management (FSSM) Policy in 2017 and a State Sanitation Strategy (SSS) in 2017. Preliminary activities for the preparation of city level FSSM plans are already in progress.

In the transport sector, the policy on Electric Vehicle and Energy Storage introduced in 2017 intends to accelerate the penetration of electric vehicles in Karnataka. If implemented with appropriate enabling mechanisms, this policy has the potential to significantly reduce emissions from the urban transport sector.

Successful realisation of the intents of the policies discussed above will, however, depend on the extent to which cities are able to implement the necessary actions. The challenges in this regard are two-fold. First, the nature of response to urban sustainability challenges will vary across the different geographic regions in the state, owing to their natural and physical contexts and well as differences in the pattern of urbanisation experienced. Hence, there is a need for formulating strategies based on different city typologies. Second, owing to the overarching theme of decentralisation, various policies mandate that cities prepare their own specific plans and implement them. However, cities (especially small and medium cities) will need considerable handholding and knowledge support in identifying and implementing the most suitable strategies.

This study seeks to answer the key emerging questions across urban water, sanitation and transport sectors in the context set by the aforementioned policies. This report is organised into four chapters. The first three chapters present the research conducted on urban water, sanitation and transport sectors respectively. The fourth chapter provides recommendations on indicators for urban sustainability. Implementing Integrated Urban Water Management Strategies in Karnataka

# 2. Implementing Integrated Urban Water Management Strategies in Karnataka

## 2.1 Background

Water is a critical natural resource for the sustenance and growth of both urban and rural settlements. The demand for water for urban usage in Karnataka has been increasing owing to factors such as rising population, higher quality of life standards and an increased industrial usage. This, in turn, has created significant pressure on the state's water resources. It has been acknowledged in both national and state policy discourses that the present approach of managing the water sector in urban contexts is not cognizant of several important aspects. These include a lack of recognition of the multiple sector demands in urban water planning, their interdependencies and impacts on the water resource as a whole. With the present status of dwindling water resources in many parts of Karnataka, cities across the State are already faced with the challenge of consistently meeting the basic Service Level Benchmarks (SLBs) for water supply. Cognizant of this, the state-level water policies in Karnataka have been advocating for the adoption of an integrated approach in urban water management to secure a more sustainable water future for cities.

Karnataka was one of the first states to draft a State Water Policy, in 2002. The policy envisions water resources planning, development and management through an integrated approach conjunctively for surface and ground water. More recently, the Karnataka Urban Waste Water Reuse (UWWR) Policy, released in December 2017, mandates the adoption of Integrated Urban Water Management (IUWM) principles and preparation of IUWM plans at city level(Government of Karnataka, 2017d). The Government Order[1] in this regard expresses the intent to prioritise cities and towns, and implement mechanisms for waste water reuse.

Implementation of the above policy mandates requires a more nuanced approach which adequately considers the variations between different geographic regions in the State. At the same time, cities, with their present capacity constraints, will need guidance in taking forward the specific actions required by the policies. In this context, this study mainly aims to suggest ways of implementing the UWWR policy in Karnataka. In doing so, the study specifically aims to a) identify the emerging water-stressed regions and cities in Karnataka, b) suggest suitable strategic and technology choices for cities in different geographic

[1] Government Order Number UDD 435 PRJ 2014, Bangalore, Dated 27-12-2017

regions, and c) illustrate a process for preparation of a city level plan for integrated urban water management.

The sections following this introduction give a brief overview of the existing situation of the water sector in Karnataka, the problem statement and the theory of change envisaged for this study. This is followed by a description of the analysis done under this study and the findings and recommendations emerging from the same.

## 2.2 Existing Situation Analysis

The following sections present a brief overview of the present status of the urban water sector in Karnataka.

### 2.2.1 Demand Supply Gap in Urban Water Sector

Domestic water demand is largely determined by the population size. Based on the water requirement norms (CPHEEO, 1999), water demand for the total urban population in the state (23.57 million as per census 2011) was approximately 46 thousand million cubic feet (TMC). With the supply from government sources being roughly 35 TMC, and a demand of 46 TMC, there already exists a demand supply gap of 11 TMC in urban Karnataka (2030 Water Resources Group, 2014). Meagre water availability, inadequate infrastructure to meet the demands of growing urban centres, non-revenue water (NRW), etc. are some of the issues contributing to this gap.

### 2.2.2 Service Delivery Status

In 2011 as per the census, the share of urban households having access to different sources of drinking water was 80%. More recent data on Service Level Benchmarks (SLB) for cities in Karnataka is presented in Figure 2.1. None of the SLBs are met, on an average, in urban Karnataka. The coverage of water supply connections continues to be low, coupled with very low cost recovery for water supply services.

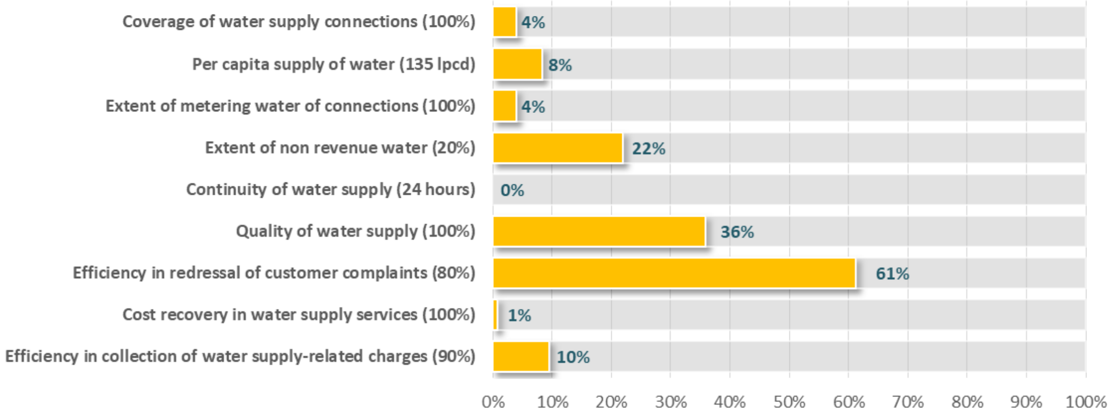



Figure 2.1: Share of Karnataka's cities meeting water related key performance indicators
*(Figures in brackets indicate service level benchmark for the indicator)*
*Source: Report on status of Service Level Benchmark in Karnataka cities, 2017-18, UDD*

### 2.2.3 Status of Water Resources

The rainfall pattern in the state is highly uneven. The occurrence, amount and spatial distribution of rainfall is highly variable across different regions. The normal rainfall in the state ranges between 408 mm to 5051mm. The Malnad and Coastal regions receive the highest annual rainfall, whereas major portions of the North and South Interior regions are comparatively drier (KSNDMC, 2017).

There are seven river systems draining the state, namely Godavari, Krishna, Cauvery, North Pennar, South Pennar, Palar and West flowing rivers. The river systems together cover a geographical area of 190 sq.km and has an annual average yield of 3475 TMC (Water Resources Department, n.d.). However, only 48% of this is economically usable. In addition to the river systems, the state has about 37,000 lakes and tanks, spread over 6.8 lakh hectares of command area (EMPRI, 2015).

The annual replenishable groundwater resource in the state is estimated to be 17 billion cubic metres (bcm) and net groundwater availability is 14.83 bcm. Groundwater development[2] is assessed to be 66% and the annual groundwater draft[3] is 9.76 bcm (CGWB, 2017). A recent report by Central Ground Water Board (CGWB) has indicated that the groundwater in 22 out of 30 districts in the state have alarming levels of chemical concentrations, which can be attributed to over exploitation (Times of India, 2017). It needs to be noted that the municipal supply represents only a portion of the total water resources

[2] Ratio of annual ground water draft and net annual ground water availability
[3] Existing gross amount of groundwater extracted for irrigation, domestic and industrial uses

actually accessed or used by the city's population. Extraction of groundwater from private bore wells is widely practiced in most of Karnataka's cities. Such unsustainable extraction has led to considerable decline in the groundwater levels in many locations in the state. This, coupled with water quality issues, are further reducing the effective usability of the available water.

### 2.2.4 Urban Water Policy Context

Multiple water planning exercises have been proposed by various national level policies from time to time. A review of the National Water Policy, 2012, the Draft National Water Framework Bill, 2016 and the National Water Mission suggests the following:

- Both supply side and demand side management measures are required to improve the water scenario in the country.

-The principle of Integrated Water Resources Management (IWRM) should be adopted, taking a river basin as the unit for holistic planning, development and management of water resources.

- River Basin Authorities to be formulated to ensure integrated management of the water resources. The Authority will be responsible for the preparation of a River Basin Master Plan in coordination with plans for national economic and social development, land use, rural and urban development, environmental protection and plans for waste water treatment and reuse.

- A Water Security Plan to be prepared by the lowest administrative unit to ensure effective management even at the local level.

- The National Water Mission as a part of the National Action Plan on Climate Change (NAPCC) mandates the preparation of a State Specific Action Plan on Climate Change (SSAPCC) for the water sector, based on a vulnerability assessment of the state to climate change. The Plan is mandated to project climate change scenarios, identify vulnerable areas and water intensive sectors, and suggest relevant strategies for adaptation and mitigation.

In Karnataka, almost two decades after the Karnataka State Water Policy of 2002, the State Water Resources Board and Water Resources Data and Information Centre, proposed by the State Policy, have not yet been setup in the state.

Over the last decade, the Government of Karnataka (GoK) has made several regulatory decisions to address the state of groundwater in various parts of the state. The Karnataka

Ground Water (Regulation for protection of sources of drinking water) Act was legislated in 1999, in-line with the Model Groundwater Bill prepared by the Government of India, to prioritise drinking water and protect drinking water sources. Subsequently, in 2011, the Karnataka Ground Water (Regulation and Control of Development and Management) Act was passed to control the indiscriminate exploitation of groundwater resources in the state.

GoK's UWWR Policy 2017, provides guidance on urban waste water treatment and reuse. The policy covers all Class I and II urban centres in the state, and includes the following aspects pertaining to urban water management:

- Advocates for adoption of the Integrated Urban Water Management (IUWM) approach in water management for urban areas
- Proposes that all major towns in the state need to develop an Integrated Urban Water Resources Management Plan (IUWRM). This has to be a multi-sectoral initiative, incorporating waste water reuse principles and necessary implementation plans for the same
- Recommends that at least 10 major cities should develop integrated water resource management plans by 2020
- Emphasises the need for using secondary treated waste water as the primary water supply for industries (if a Sewage Treatment Plant (STP) is located within 30 km of the industry)

### 2.2.5 Status of Water Management Plans

Currently, the ACIWRM has initiated the preparation of a River Basin Plan for the Tungabhadra sub-basin. It has also proposed to develop Community-based Land and Water Management Plans (LWMP) with the support of state universities, other organisations and relevant stakeholders. These plans are to be piloted in the Tungabhadra sub-basin. It has been proposed that the LWMPs will be developed in line with the River Basin Plan for the region, which is under preparation (ACIWRM, n.d.).

### 2.2.6 Agencies and Mandates

The Urban Development Department (UDD) governs and monitors the urban water supply and sanitation sector in Karnataka. The Bangalore Water Supply and Sewerage Board (BWSSB) and Karnataka Urban Water Supply and Drainage Board (KUWSDB) are two parallel utilities functioning under the UDD to provide water supply, sanitation and sewerage services to the Bruhat Bengaluru Mahanagara Palike (BBMP) and other urban areas in the state, respectively.

The state level Water Resources Department (WRD) has a number of offices under its umbrella to govern surface and groundwater resources, across Karnataka. These include the Karnataka Lake Conservation and Development Authority (KLCDA)[4], Minor Irrigation Department (MID)[5], Watershed Development Department (WDD)[6], Groundwater Directorate (GWD)[7] and Karnataka Groundwater Authority (KGA)[8]. The Karnataka State Pollution Control Broad is mandated with monitoring and controlling water pollution. The Advanced Centre for Integrated Water Resources Management (ACIWRM) acts as a think tank to the WRD, and engages in research and analysis, has developed a knowledge base, and serves as a coordinating agency.

### 2.2.7 Gaps in exiting urban water planning paradigm in Karnataka

The gaps in water sector for Karnataka cities are as follows:

- Aging infrastructure, non-revenue water, over-extraction of groundwater, improper drainage systems, insufficient water recycling and reuse options are creating heavy pressure on the watersheds.
- A service delivery approach to urban water management which is indifferent to the stress on water resources and also cross-sectoral interdependencies is highly unsustainable. This, in turn, negatively impacts the availability of water in a city for different uses; puts pressure on municipal finances; and deteriorates the overall environmental and liveability conditions in the city.
- Unlike sanitation (City Sanitation Plans) and transport (City Mobility Plans) sectors, there is no comprehensive planning exercise carried out at the city level for water sector. The preparation of the IUWRM plan recommended by the UWWR policy is yet to be implemented as a mandate.

[4] All lakes in Karnataka state located within the limits of Municipal Corporations and BDA or any other water bodies or lakes notified by the government from time to time are managed by the KLCDA.
5 The mandates of the department includes restoration and rejuvenation of water bodies, strengthening the various components of the tank system and protection and preservation of the water bodies with an atchkat ((agricultural area irrigated by the lakes) between 40 and 2000 hectares.
6 The Watershed Development Department work towards the development and strengthening of community based institutional arrangements for sustainable natural resource management in the state.
7 The main functions of the GWD include groundwater monitoring, quality assessment, site selection of borewells and imparting groundwater awareness.
8 The KGA, in consultation with various expert bodies (including the CGWB), has the power to notify areas to regulate and control the development and management of groundwater.

- Land cover and land use plans which have significant impact on both altering and preservation of the water ecosystem of a city, do not necessarily demonstrate adequate consideration of the water cycle in a city.
- Sustainable water planning strategies to be adopted by cities will require a regional approach in order to consider for variations in soil type, vegetation, groundwater levels, aquifer structures, rainfall pattern etc. There is no strategic guidance available for Karnataka in this regard.
- Multiple agencies are responsible for different parts of the water cycle. This calls for greater coordination among agencies which is lacking at present.

## 2.3 Problem Statement

Despite progressive policy mandates, cities and city-regions in Karnataka are yet to adopt an IUWM approach in urban water planning. The following strategic gaps exist in implementing the IUWM approach in Karnataka's cities:

- Absence of regional strategies which are considerate of opportunities and constrains faced by cities in different geographic regions
- Absence of a comprehensive guidance on carrying out a city level water sector planning exercise in coordination with multiple agencies.

## 2.4 Theory of Change

The present situation of the urban water sector calls for a paradigm shift to change the *status quo*. The adoption of an IUWRM approach in urban water planning can guide cities towards water sustainability while being cognizant of the opportunities and constrains existing in a watershed.

The type and priority of strategic interventions, in this regard, need to be contextualised. Strategic interventions and the choice of technologies need to consider regional variations of various physical parameters posing different constraints on the success of different strategies. The implementation of an IUWRM approach in Karnataka needs to be institutionalised through a robust planning mechanism, at the city level. The UWWR Policy for Karnataka creates an opportunity for the adoption of an Integrated Urban Water Management Framework in cities. The implementation of this policy needs to take into account the contextual specifications of water stress across different parts of Karnataka, and planning instruments at the local level, built on the principles of IUWM.

## 2.5 Objective

The objective of this part of the study is (1) to identify strategic priorities for sustainable urban water planning in different regions of Karnataka, and (2) to elaborate the components of a city-level IUWRM plan, recommended by the UWWR Policy for Karnataka.

## 2.6 Research Questions

The following research questions were examined for this part of the study:

1. Which are the cities and regions that are emerging to be water-stressed, and hence need priority attention?
2. What are the suitable strategic and technology choices relating to water that ought to be adopted for cities in different regions of Karnataka, based on their environmental and socio-economic context?
3. What steps and components should a city-level IUWRM plan entail, as proposed in the UWWR Policy 2017?

## 2.7 Research Design

Figure 2.2 presents the broad steps undertaken for examining the research questions mentioned above. The methodology, data collection and analysis pertaining to each of the four research questions are presented in the following sections.

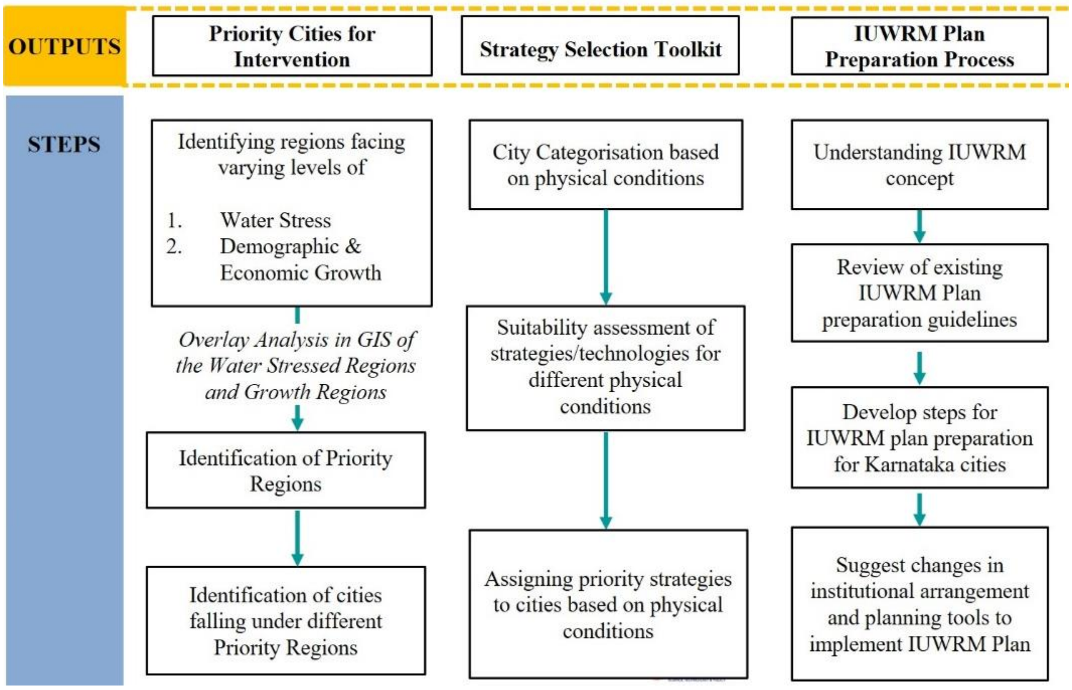



Figure 2.2: Research design for water sector

*Source: CSTEP*

## 2.8 Identifying Priority Cities for Interventions

This section examines the first research question of the study. The objective is to identify cities and regions that are experiencing water stress and growth pressure and hence need priority attention. The research presented under this section has been divided into two stages. Stage A focussed on delineating Karnataka into regions experiencing different levels of water stress and growth pressure based on a selected set of criteria. State level water stress and growth maps form the outputs of this stage. In stage B, the output maps from Stage A were used to carry out an overlay analysis in Geographic Information System (GIS), to develop a composite map showing regions and cities emerging as high to low priority areas. The methodology followed to identify the priority cities is described below.

### 2.8.1 Methodology

**Stage A. Identification of regions falling under different levels of water stress[9] and growth pressure**

A multi-criteria decision making (MCDM) approach, in conjunction with the overlay analysis technique in Geographic Information System (GIS), have been used to identify the water stressed and growth regions. There are different techniques within the MCDM approach which can be used, like Analytic Hierarchy Process (AHP), Ordered Weighted Averaging (OWA), Simple Additive Weighting, Simple Multi-Attribute Rating Technique (SMART), etc. (Aşılıoğlu, 2015).

The SMART technique (Rahim, 2016) has been used in the current analysis to identify the water stressed and growth regions[10]. The main steps followed in this stage are listed below.

*Step 1: Criteria selection:* A set of criteria have been selected which are considered to either directly or indirectly contribute towards water stress and growth. The selection is based on

[9] Water stress has been defined by the United Nations as following:

"Water stress refers to the ability, or lack thereof, to meet human and ecological demand for fresh water. Both water consumption and water withdrawals provide useful information that offers insight into relative water stress.

[10] In the SMART technique, a list of criteria is selected which contribute to water stress and growth and each criteria is relatively weighted adding up to 100. Classes under each criteria are then weighted on a 1-4 scale based on each class's contribution to water stress or growth. These are then normalised by multiplying with the overall weightage of the criteria.

a literature survey of similar studies carried out globally, and at the national level (Brown, 2011; Gain, Giupponi, & Wada, 2016; Modak, 2017).

*Step 2: Assigning weightages for each criterion:* Each criterion selected in step 1 is given a relative weightage. The weightages have been assigned based on its relative importance in determining the water stress and growth of a region, and expert opinions.

*Step 3: Delineation of classes within each criterion and assigning weightages for each class:* Values for each criterion is divided into ranges and each range is weighted on a 1–4 scale based on its contribution to water stress/growth. Higher weightage for a range on the 1-4 scale indicate higher water stress/growth pressure.

*Step 4: Preparation of weighted maps for each criteria:* Based on the weightages assigned in the previous step, weighted maps are prepared for each criteria.

*Step 5: Preparation of final overlay maps for water stress and growth:* This step is carried out by overlaying the criteria maps (from step 4), based on assigned weightages for each criterion in step 2. The final weightages are categorised into ranges to form high, medium and low categories for water stress and growth.

**Stage B. An overlay analysis to derive a composite priority map**

The final water stress map and growth map were overlaid to identify priority regions and cities for water-related interventions. At this stage, the water stress map was given double the weightage than that of the growth map. An open source software (QGIS-version 2.18.16) has been used to do the overlay analysis in GIS.

### 2.8.2 Data Collection and Analysis

The analysis has been carried out using secondary data collected from government websites, reports, and in certain cases, directly from department offices. The list of data collected and their respective sources can be accessed in Annexure I (A).

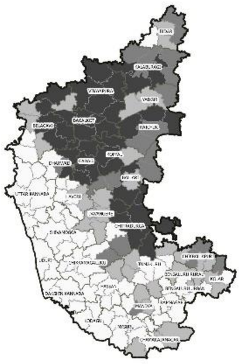
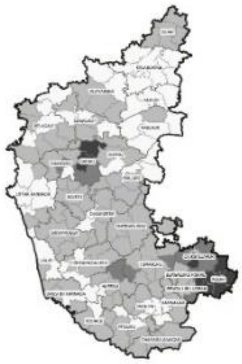
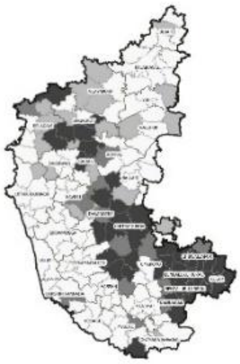
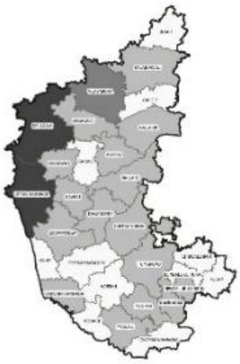
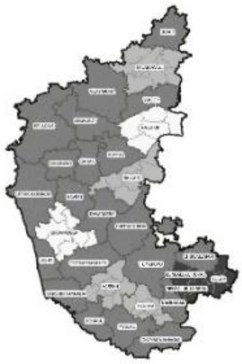
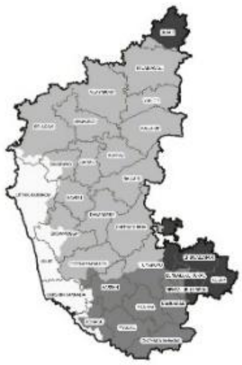
The relative weightages assigned for each criterion to identify the water stressed and growth regions are indicated in Table 2.1. A brief description of each criterion can be referred to in Annexure I (B). The justification for weightage assignment can be referred to in Annexure I (C).

Table 2.1: Relative weightages of criteria for delineation water stressed region

| Rank | Criteria | Relative Weightage | Unit of Analysis |
|---|---|---|---|
| **Water Stress** | | | |
| 1 | Drought vulnerability | 20 | Taluk |
| 2 | Stage of groundwater development | 15 | District |
| 3 | Depth to groundwater level | 14 | Taluk |
| 4 | Categorisation of regions as safe, semi-critical, critical and over-exploited | 10 | Taluk |
| 5 | Future utilisation of groundwater resources (for domestic and industrial uses) | 9 | District |
| 6 | Future groundwater availability for irrigation | 9 | District |
| 7 | Average per capita quantum of water supplied | 8 | District |
| 8 | Continuity of water supply | 8 | District |
| 9 | Water yield in river basins | 7 | River Basin |
| **TOTAL** | | **100** | |
| **Demographic & Economic Growth** | | | |
| 1 | Decadal growth rate of urban population | 15 | District |
| 2 | Share of urban population | 10 | District |
| 3 | Total industrial area | 9 | District |
| 4 | Bengaluru Mumbai Economic Corridor (BMEC) | 9 | State |
| 5 | Decadal growth rate of total population | 8 | District |
| 6 | Gross District Domestic Product (GDDP) | 7 | District |
| 7 | Total population | 6 | District |
| 8 | Literacy rate | 6 | District |
| 9 | Per capita income | 6 | District |
| 10 | Proximity to national highways | 6 | State |
| 11 | Work force participation rate (WPR) | 6 | District |
| 12 | Proximity to railway line | 6 | State |
| **TOTAL** | | **100** | |

*Source: CSTEP*

Each criterion is further classified into ranges, and each range has been weighted in such a way that a higher weightage indicates higher water stress/growth. The ranges and the weightages assigned for each range can be referred to in Annexure I (D). A snapshot of the weighted maps is shown in Figure 2.3 and Figure 2.4. The darker shades indicate higher weightage and hence higher stress/growth with respect to the criteria.

| Weighted Criteria Maps - Water Stress | | |
|---|---|---|
| 1. Drought vulnerability | 2. Stage of groundwater development | 3. Depth to groundwater level |
|  |  |  |
| 4. Categorisation of regions as safe, semi-critical, critical and over-exploited | 5. Future utilisation of groundwater resources for domestic and industrial uses | 6. Future groundwater availability for irrigation |
|  |  |  |
| 7. Average per capita quantum of water supplied | 8. Continuity of water supply | 9. Water yield in river basins |
|  |  |  |

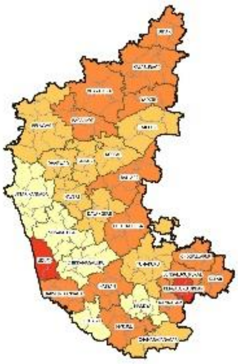
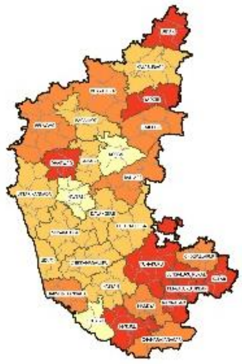
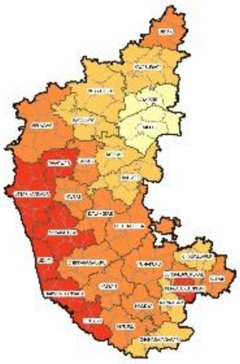
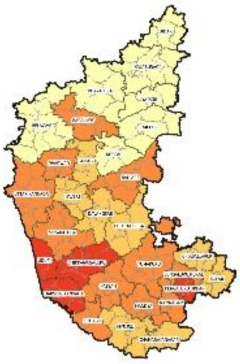
Legend

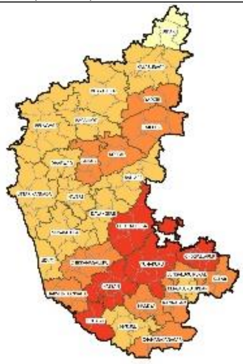
State Boundary
District Boundary
Taluks

Weightage
1
2
3
4

Figure 2.3: Weighted criteria maps for water stress

*Source: CSTEP*

| Weighted Criteria Maps - Demographic & Economic Growth | | |
|---|---|---|
| 1 Decadal growth rate of urban population | 2. Share of urban population at the district level | 3. Total industrial area at the district level |
|  |  |  |
| 4. Bengaluru Mumbai Economic Corridor (BMEC) | 5. Decadal growth rate of total population | 6. Gross District Domestic Product (GDDP) |
|  |  |  |
| 7. Total population at the district level | 8. Literacy rate at the district level | 9. Per capita income at the district level |
|  |  |  |

| 10.Proximity to national highways | 11.Work force participation rate (WPR) at the district level | 12.Proximity to railway line |
|---|---|---|
|  |  |  |

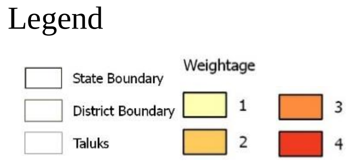



Figure 2.4: Weighted criteria maps for demographic and economic growth

*Source: CSTEP*

A GIS-based overlay analysis of the maps illustrated in Figure 2.3 and Figure 2.4 was carried out by assigning the relative weightages, mentioned in Table 2.1. The resultant water stress and growth maps are shown in Figure 2-5 and Figure 2.6.

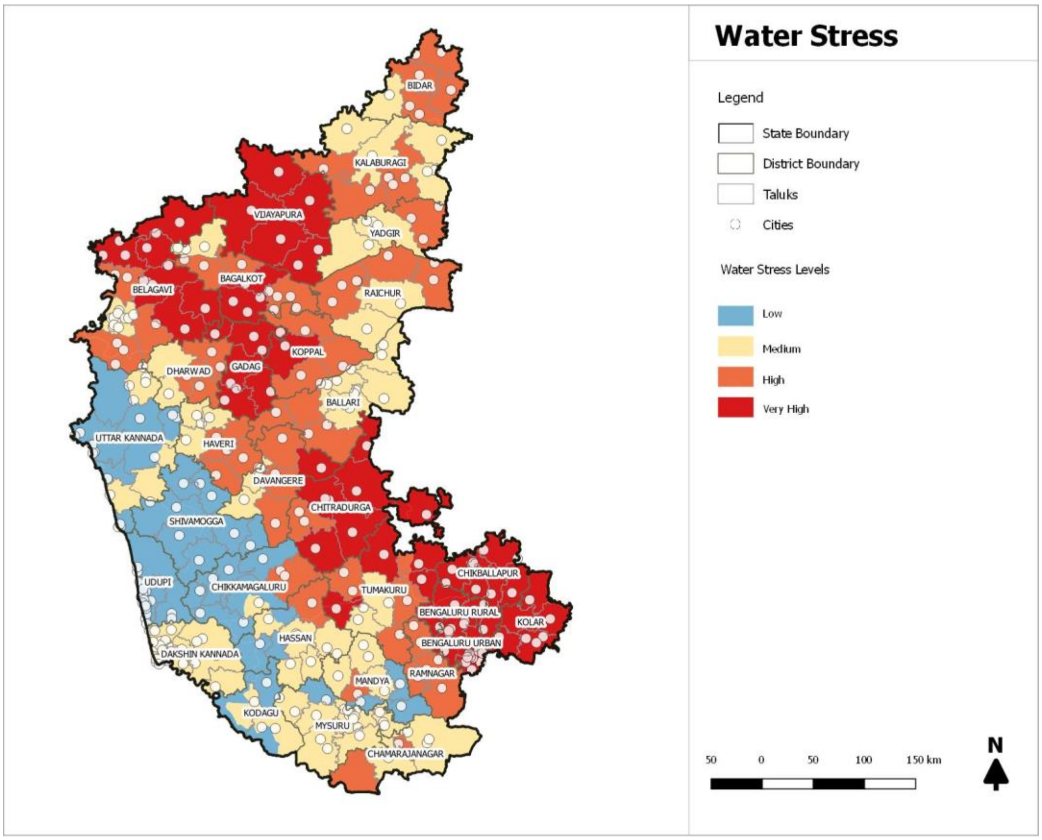



Figure 2-5: Water stress map

*Source: CSTEP*

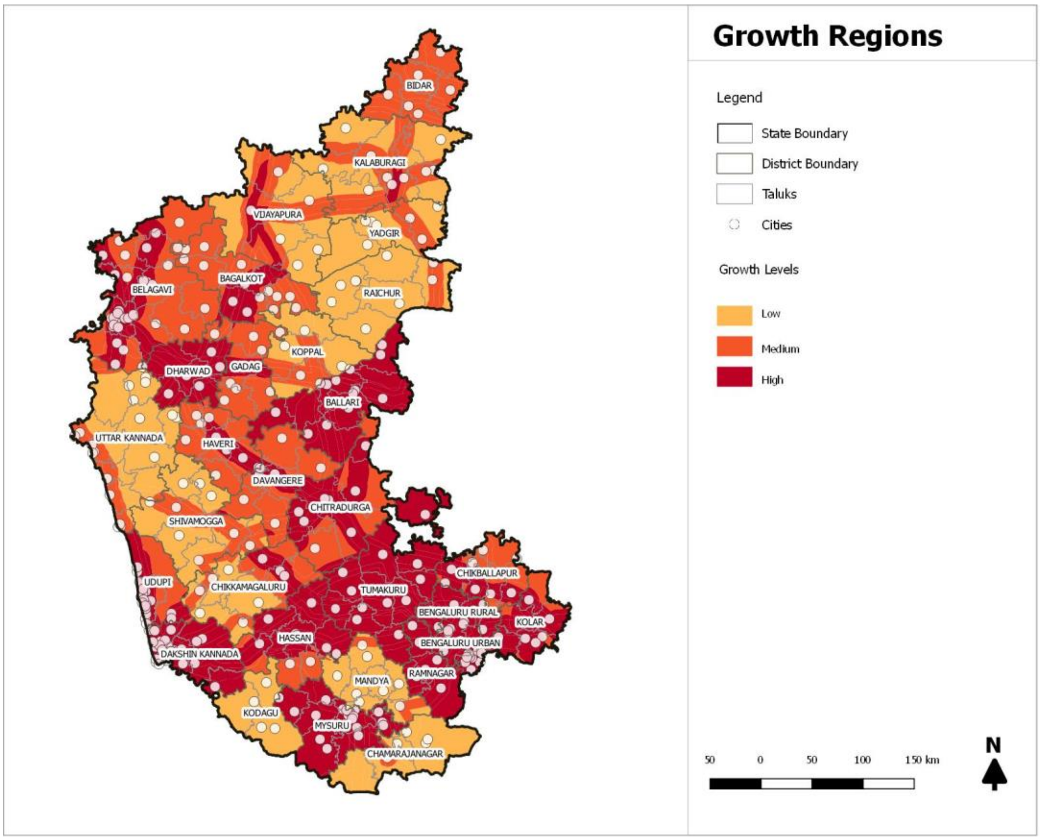



Figure 2.6: Growth pressure map

*Source: CSTEP*

The output from the combined overlay, showing the priority regions, is shown in Figure 2.7. The map identifies five priority regions across the state, i.e., very low, low, medium, high and very high. The list of cities falling under the different priority regions can be referred accessed in Annexure I (E).

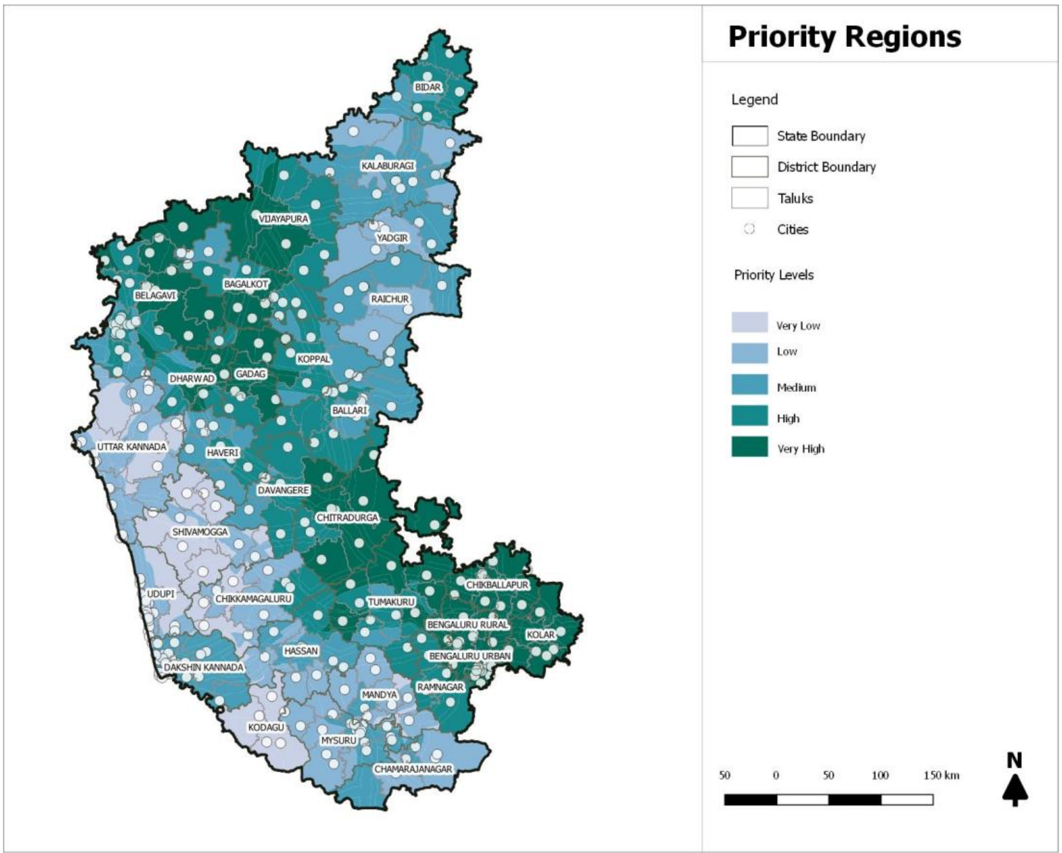



Figure 2.7: Priority regions for water related interventions in Karnataka

*Source: CSTEP*

A demonstration of how the weightages of each parameter are added to arrive at the priority level for an area is shown in the Table 2.2 and Table 2.3 below taking the example of Tumakuru taluk.

Table 2.2: Status of Tumakuru taluk in water stress criteria

| Rank | Criteria | Relative Weightage (a) | Range (b) | Range Scale (1-4) (c) | Total criteria score (a*c) |
|---|---|---|---|---|---|
| 1 | Drought vulnerability | 20 | Very Slightly Vulnerable to Slightly Vulnerable | 1 | 20 |
| 2 | Stage of groundwater development | 15 | 50-100% | 2 | 30 |
| 3 | Depth to groundwater level | 14 | 10-30 m | 2 | 28 |
| 4 | Categorisation of regions as safe, semi-critical, critical and over-exploited | 10 | Over exploited | 4 | 40 |
| 5 | Future utilisation of groundwater resources (for domestic and industrial uses) | 9 | 4000-8000 hectare metre | 2 | 18 |

| Rank | Criteria | Relative Weightage (a) | Range (b) | Range Scale (1-4) (c) | Total criteria score (a*c) |
|---|---|---|---|---|---|
| 6 | Future groundwater availability for irrigation | 9 | 1-30000 hectare metre | 3 | 27 |
| 7 | Average per capita quantum of water supplied | 8 | 95-115 lpcd | 2 | 16 |
| 8 | Continuity of water supply | 8 | <5 hours per day | 4 | 32 |
| 9 | Water yield in river basins | 7 | Cauvery Basin (425) | 3 | 21 |
| TOTAL | | 100 | N.A | N.A | 232 |

| Water Stress Situation of Tumakuru Taluk | | | | |
|---|---|---|---|---|
| Water Stress Level | Low | Medium | High | Very High |
| Score Range | 70-140 | 140-210 | 210-280 | Above 280 |

*Source: CSTEP Analysis*

Based on the criteria considered and relative weightages assigned, Tumakuru taluk lies in the high water stressed region. As the scores indicate, the major contributor of water stress in the taluk is the criteria *categorisation of regions as safe, semi-critical, critical and over-exploited* which deals with the stage of groundwater development and long term trend of ground water levels in the area.

Table 2.3: Status of Tumakuru taluk in growth pressure criteria

| Rank | Criteria | Relative Weightage (a) | Range (b) | Range Scale (1-4) (c) | Total criteria score (a*c) |
|---|---|---|---|---|---|
| 1 | Decadal growth rate of urban population | 15 | 10-20 % | 2 | 30 |
| 2 | Share of urban population | 10 | 20-40 % | 2 | 20 |
| 3 | Total industrial area | 9 | Above 1500 acres | 4 | 36 |
| 4 | Bengaluru Mumbai Economic Corridor (BMEC) | 9 | N.A | 3 | 27 |
| 5 | Decadal growth rate of total population | 8 | 1% -20% | 2 | 16 |
| 6 | Gross District Domestic Product (GDDP) | 7 | 20-40 crore rupees | 2 | 14 |
| 7 | Total population | 6 | 20 to 50 lakhs | 3 | 18 |
| 8 | Literacy rate | 6 | 70 to 80 % | 3 | 18 |
| 9 | Per capita income | 6 | 1,00,000-1,50,000 rupees | 3 | 18 |
| 10 | Proximity to national highways | 6 | 5 km buffer | 4 | 24 |

| Rank | Criteria | Relative Weightage (a) | Range (b) | Range Scale (1-4) (c) | Total criteria score (a*c) |
|---|---|---|---|---|---|
| 11 | Work force participation rate (WPR) | 6 | Above 50% | 4 | 24 |
| 12 | Proximity to railway line | 6 | 10 km buffer | 3 | 18 |
| **TOTAL** | | **100** | **N.A** | **N.A** | **263** |
| **Growth Pressure Situation of Tumakuru Taluk** | | | | | |
| **Growth Level** | **Low** | **Medium** | **High** | | |
| **Score Range** | **120-170** | **170-220** | **Above 220** | | |

*Source: CSTEP Analysis*

As the figures in the above table indicate, Tumakuru taluk lies in a region experiencing high growth pressure. The criteria pertaining to industrial development (total industrial area and BMEC) and urbanisation (share and growth rate of urban population) have primarily contributed to this status of the taluk. Table 2.4 below shows the calculation for arriving at the priority level score for the Tumakuru taluk. This calculation forms the basis of the overlay analysis carried out in the GIS software.

Table 2.4: Calculation for determining the priority level for Tumakuru taluk

| **Total Criteria Score** | | | | **Priority level Score** |
|---|---|---|---|---|
| Water Stress (a) | | Growth Pressure (b) | | (a)*2 + (b) |
| 232 | | 263 | | 727 |
| **Priority Level of Tumakuru Taluk** | | | | |
| Very Low | Low | Medium | High | **Very High** |
| 300-400 | 400-500 | 500-600 | 600-700 | **Above 700** |

*Source: CSTEP Analysis*

### 2.8.3 Findings and Discussions

The overlay analysis, carried out in the previous stage, indicate that the *high* and *very high priority* regions are majorly located along the BMEC industrial belt[11]. An assessment of the water stress map and growth map, independently, indicate that this region shows high demographic and economic growth, and at the same time experiences high water stress.

[11] Refer Figure 2.4 for viewing the BMEC corridor region

The priority regions in the *high* and *very high* categories mainly lie in the South and North Interior Regions[12], which are naturally drier and arid in comparison with the rest of the state. The natural conditions, coupled with the high demographic and economic growth factors, are responsible for creating a water stressed situation in this region.

The number of cities and total population falling under different priority regions is shown in Figure 2.8. Findings of this study show that approximately 13 million people (55% of the urban population in the state) reside in the region that has been categorised as *very high priority*. The South Interior Region of the state has the highest share of cities falling under the *very high priority* category.

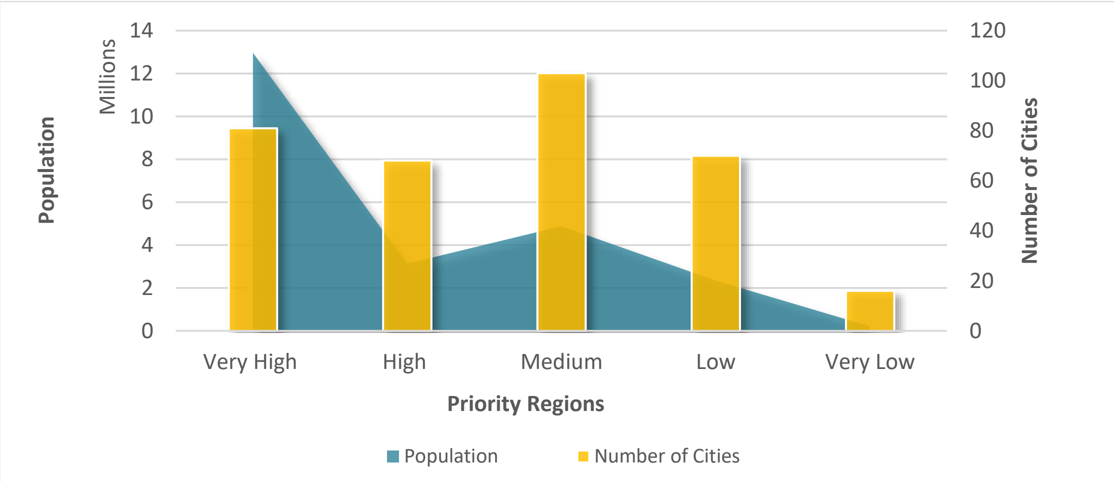



Figure 2.8: Number of cities and population falling in priority regions

*Source: CSTEP Analysis*

The list of cities falling under different priority regions can be referred to from Annexure I (F).

### 2.8.4 Recommendations and Conclusion

The overall urban water situation in the state calls for the immediate adoption of sustainable measures immediately in all cities in Karnataka to secure their water future. However, from the perspective of implementation of policy mandates by respective departments and agencies, it is imperative to prioritise efforts in this front. The UWWR Policy 2017 recommends that 10 major cities should develop their IUWRM Plan by 2020. Based on the

[12] Refer Figure 2.9 for map showing different regions in the state.

findings presented above, it is recommended that the Class I and Class II cities falling under the *very high priority region* (refer Table 2.5) be selected for this initiative in the first phase.

Table 2.5: Distribution of class I and class II cities in different priority regions

| Priority Region Category | Number of Class I Cities (above 1,00,000 population) | Number of Class II Cities (50,000-1,00,000 population) |
|---|---|---|
| Very High Priority Region | 9 *(Bengaluru, Hubballi-Dharwad, Vijaypura, Tumakuru, Gadag, Robertsonpet, Chithradurga, Kolar, Bagalkot)* | 12 (*Doddaballapur, Gokak, Chintamani, Chikkaballapura, Nipani, Tiptur, Sira, Mulbagal, Hosakote, Hiriyur, Challakere, Sidlaghatta)* |
| High Priority Region | 5 | 8 |
| Medium Priority Region | 7 | 10 |
| Low Priority Region | 5 | 9 |
| Very low Priority Region | 0 | 0 |
| Total | 26 | 39 |

*Source: CSTEP Analysis*

It is further recommended that these cities are capacitated with adequate human and financial resources to prepare their respective IUWRM Plans. An important step towards enabling sustainable water planning would be to develop spatial data platforms which are able to generate analysis at multiple levels.

Further, these cities will need to start align various urban planning efforts with water sector plans. This is specifically important for cities which are already included under various flagship urban development missions and are receiving investments to develop their infrastructure.

Also, water being a connected ecosystem spreading over areas beyond the boundaries of urban areas, it is necessary to adopt a regional planning approach. This can be done at a river basin or sub-basin level, following the provisions of various water policies.

## 2.9 Sustainable Water Strategies for Different Regions in Karnataka

This section examines the second research question of the study. The objective is to suggest sustainable urban water strategies for different regions in Karnataka which are cognizant of:

a) the differences in the geographic and environmental characteristics of the regions, and b) the different priority levels identified in the previous stage.

The output from this part of the research is a Water Strategy Selection Matrix (WSSM) which can guide cities in different regions in selecting suitable water strategies. Further, a toolkit has been designed to provide easy access to the detailed description of strategies and technologies considered. The methodology followed to derive the research outputs is described below.

### 2.9.1 Methodology

*Step 1. City categorisation based on physical conditions*

Karnataka is broadly divided into four regions, namely North Interior, South Interior, Malnad and Coastal, based on its physiographic characteristics (KSNDMC, 2017). This regional classification has been considered as the four regional categories in this study.

*Step 2. Creating a compendium of sustainable strategy options for cities*

An in-depth literature survey has been carried out and a large number of strategies and technology options have been compiled into a compendium. The strategies listed in the compendium cover both supply-side and demand-side strategies, and are categorised into following four broad groups:

1. Water Source: Strategies/technology options which can be adopted to improve the condition of water sources like source augmentation
2. Water Consumption: This includes different water efficient fixture options like low flow showers, aerator taps and faucets, flow regulators, sensor pipes, dual flush toilets etc.
3. Water Treatment: Includes technology options for groundwater and surface water treatment
4. Water Supply and Distribution: Strategies to improve the water supply and distribution in cities, like reduction in non-revenue water, etc.

*Step 3. Multi-criteria assessment of strategies to assess suitability in different regions*

A multi-criteria assessment was carried out for each strategy/technology option to understand its suitability in different geographical and environmental situations. The criteria used to assess the strategies included groundwater level, soil texture (clayey, loamy, sandy, silty, gravel, etc.), rainfall intensity, agro-climatic zones and temperature.

Relevant information such as capital and operational expenditure, and skill and energy requirement for implementing the strategy/technology option have been included in the compendium to aid decision-making.

*Step 4. Developing guidelines for selecting priority strategies for different city categories*

A guidance framework has been developed for different sizes of cities in each of the four regions based on their physical and environmental parameters.

*Step 5. Developing an Excel-based toolkit where the most suited strategies for a selected city can be viewed.* The aim of the toolkit is to ease navigation and help with finding matching strategies/technologies for each city based on its physical and environmental characteristics.

### 2.9.2 Data Collection and Analysis

Data was collected and analysed from secondary sources, mainly government websites, reports and department offices. The list of data collected and their respective sources for this section of the study can be referred to in Annexure I (G).

The four geographic regions (refer Figure 2.9) were assessed against the *water stress* and *demographic and economic growth* maps described in the previous section. Table 2.6 presents a summary of the region-wise assessment.

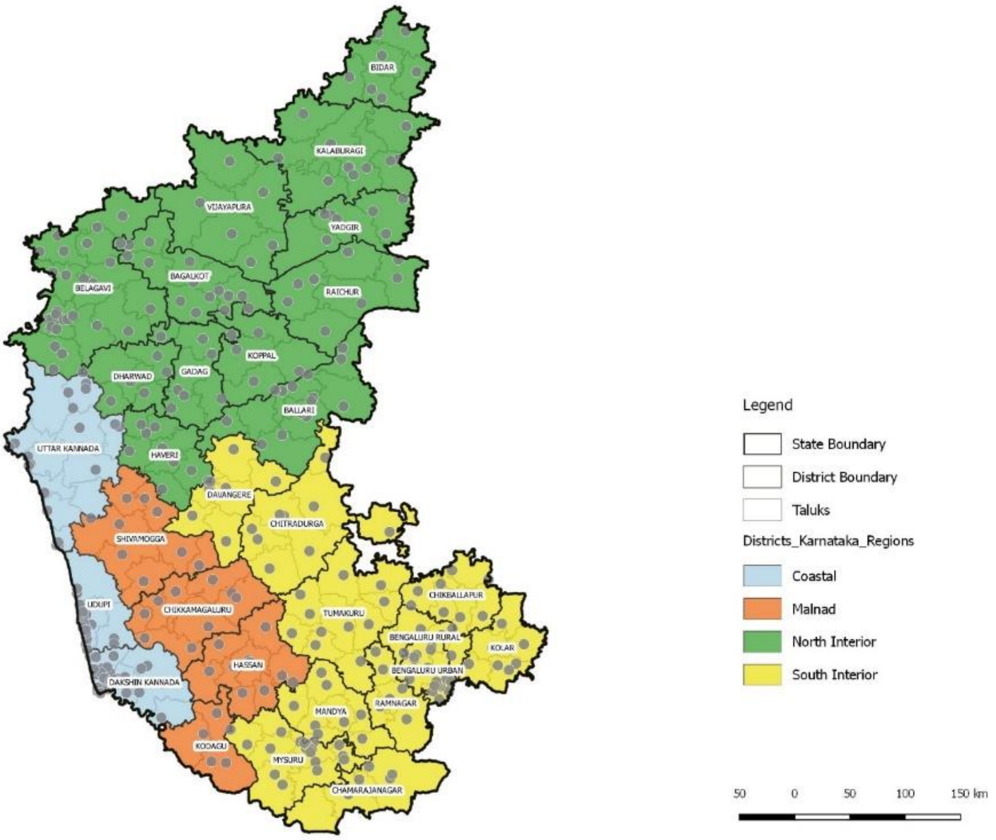
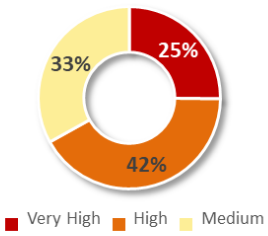
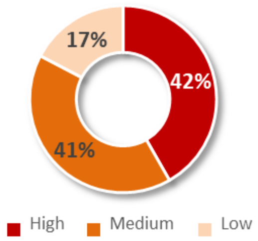



Figure 2.9: Four geographic regions in Karnataka

*Source: KSNDMC*

Table 2.6: Summary of region wise assessment

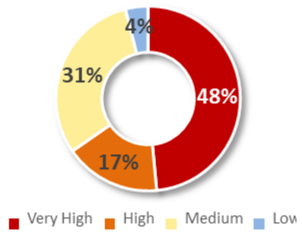
| **North Interior Region** | |
|---|---|
| Region is characterised by low to moderate rainfall, high groundwater table except for a very few areas, with a level to gently sloping terrain. 62% of the cities are located in taluks which face high to very high drought vulnerability. | |
| *Number of urban centres* | **127** |
| *Urban population* | **71.9 lakhs** |
| *Share of urban population* | **31%** |
| *Major towns* | **Hubballi-Dharwad (9.4 lakhs)** |
| Share of cities facing different levels of water stress in the region   | Share of cities facing different growth levels in the region   |

**South Interior Region**

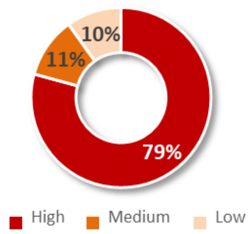
Region is characterised by low to moderate rainfall, low groundwater table (27 % of the cities have groundwater only beyond 30m), and a level to gently sloping terrain.

| | |
|---|---|
| *Number of urban centres* | **101** |
| *Urban population* | **1.3 crores** |
| *Share of urban population* | **57%** |
| *Major towns* | **Bengaluru (84.9 lakhs)** |

Share of cities facing different levels of water stress in the region




Share of cities facing different growth levels in the region

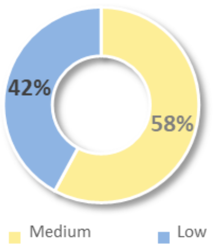



**Coastal Region**

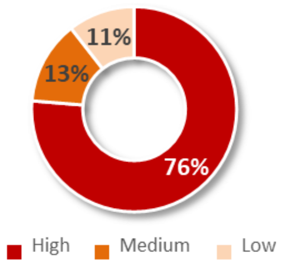
Region is characterised by heavy rainfall, a high water table and very gentle sloping terrain.

| | |
|---|---|
| *Number of urban centres* | **76** |
| *Urban population* | **17 lakhs** |
| *Share of urban population* | **7%** |
| *Major towns* | **Mangalore (4.9 lakhs)** |

Share of cities facing different levels of water stress in the region




Share of cities facing different growth levels in the region

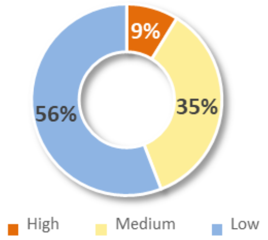



**Malnad Region**

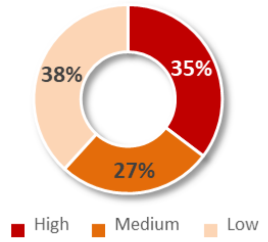
Region is characterised by low to heavy rainfall, moderate to high groundwater table, and steeply sloping terrain.

| | |
|---|---|
| *Number of urban centres* | **34** |
| *Urban population* | **13 lakhs** |
| *Share of urban population* | **6%** |
| *Major towns* | **Shivamoga (3.2 lakhs)** |

Share of cities facing different levels of water stress in the region




Share of cities facing different growth levels in the region




*Source: CSTEP Analysis*

Further details of each region can be accessed in Annexure I (H).

### 2.9.3 Findings and Recommendations

A Water Strategy Selection Matrix (WSSM) for identifying the priority strategies for different sizes of cities[13] in each of the four regions was developed based on region-wise opportunities and constraints, and the various strategy and technology options available. Table 2.7 lists down the strategic interventions suggested in the matrix for the four regions. These are categorised based on the major components of an urban water cycle, namely water source, supply & distribution and consumption.

Table 2.7: List of strategic interventions for urban water management

| Components | Sub-components | | Description |
|---|---|---|---|
| 1. Water source | 1.1 | Surface water source augmentation | Surface water source augmentation through water body restoration/conservation techniques, especially for towns drawing water beyond 10 km of the city limit |
| | 1.2 | Ground water source augmentation | Groundwater source augmentation through artificial recharge where Ground Water Level (GWL) is more than 20 m. |
| | 1.3 | Green infrastructure strategy (a) | Green infrastructure strategies like swales, pervious pavements, etc. and overall reduction in hardscapes, while planning in low density cities |
| | 1.4 | Green infrastructure strategy (b) | Incentivising rainwater harvesting measures like using rooftop recharge |

[13] Different sizes of cities considered – (1) Small Towns –population less than 1 lakhs, (2) Medium Towns- 1 to 5 lakh population, (3) Large Towns- population above 5 lakhs

| Components | Sub-components | | Description |
|---|---|---|---|
| | | | through abandoned wells (for cities with high density). |
| | 1.5 | Water conservation | Water conservation measures including reviving indigenous water systems, if any |
| 2. Water supply and distribution | 2.1 | Reduction in NRW share (a) | Conducting water audits, especially in cities with NRW more than 20% |
| | 2.2 | Reduction in NRW share (b) | Reduction in NRW through water audits, leak detection surveys, implementation of SCADA system, etc. |
| 3. Water consumption | 3.1 | Water efficient fittings and fixtures | Encouraging low consumption through promotion of water efficient fixtures like low flow showers, aerator taps and faucets, flow regulators, sensor pipes, dual flush toilets etc. |

*Source: CSTEP*

The strategic interventions listed in Table 2.7 are suggested for different sizes of cities in each of the four regions in different orders of priority. The order of priority is based on what is best suited to the physical and environmental characteristics of the region and the size of the city. The priority levels considered are indicated in Table 2.8 below.

Table 2.8: Description of priority level considered in WSSM

| Priority Level | Description |
|---|---|
| A | Very high priority strategy for the region and city size |
| B | High priority strategy for the region and city size |
| C | Medium priority strategy for the region and city size |
| D | Low priority strategies for the region and city size |

*Source: CSTEP*

The following points summarise the rationale used for suggesting priority water strategy in the WSSM for each region and city size described in the subsequent sections

- Water conservation measures, like reviving indigenous systems, have been suggested as a high priority strategy for small towns, since it can considerably improve the overall water situation in these towns[14]. The impact of reviving a historic water system in improving the water supply situation in a medium/large city

[14] Towns in Karnataka where such systems have been restored and have resulted in improvements in water system include Naubad (Bidar), Chitradurga and Vijaypura.

may be lesser than a smaller city. The priority is thus lesser for this strategy for a medium/large city.

- Surface water source augmentation measures are recommended as a higher priority strategy for medium and large cities which are drawing water from more than 10 km from the city and where the groundwater is available in shallow depths (less than 10 metres below ground level (mbgl).
- Similarly, groundwater source augmentation measures are suggested for cities which are located in areas having lower groundwater table (greater than 20 mbgl).
- Rainwater harvesting measures are suggested with a higher priority for cities in regions receiving moderate (700 mm to 1000 mm) to heavy (above 1000 mm) rainfall. Though this strategy is suggested for cities in regions with low rainfall (less than 700 mm), it has been given a lower priority since water harvesting measures on a large scale may not necessarily solve the water stress situation, but could be another supplementary source of water for the cities.
- Leak detection surveys and implementation of Supervisory control and data acquisition (SCADA) systems have been suggested for medium and large cities, though it has been positioned as a high priority strategy for large cities in the region, given the improved financial position.

The following sections summarise the WSSM for each region.

**North Interior Region**

Majority of the cities in the North Interior Region need to prioritise water conservation measures, followed by source augmentation (because of the high drought vulnerability and low rainfall patterns). Adding green infrastructure components [15]is also an option for the cities in the region, albeit depending on the spatial structure (highly dense/low dense). Since the region receives only low to moderate rainfall, with an average of about 728 mm annually, rain water harvesting as a primary strategy has not been prioritised. Table 2.9 below indicates the suggested priority levels for different strategies suitable for the region. Refer to Table 2.7 for the detailed description of each strategic option.

[15] Green infrastructure refers to a group of water management practices which mimics the natural water cycle. Examples include green roofs, permeable surfaces, green walls, swales, rain water harvesting measures etc.

Table 2.9: WSSM for cities in North Interior Region

| Priority level | Small towns | | Medium towns | | Large towns | |
|---|---|---|---|---|---|---|
| A | 1.5 | Water conservation measures | 1.1 | Surface water source augmentation measures | 2.2 | Measures for reduction in Non- Revenue Water (NRW) share |
| B | 1.1 | Surface water source augmentation measures | 1.2 | Ground water source augmentation measures | 1.1 | Surface water source augmentation measures |
| C | 1.2 | Ground water source augmentation measures | 1.5 | Water conservation measures | 1.2 | Ground water source augmentation measures |
| D | 1.3 | Green infrastructure strategies | 1.3 | Green infrastructure strategy | 1.3 | Green infrastructure strategy |
| | 2.1 | Reduction in Non-Revenue Water (NRW) share (a) | 2.2 | Reduction in Non-Revenue Water (NRW) share (b) | 1.4 | Green infrastructure strategy |
| | 1.4 | Green infrastructure strategies | 1.4 | Green infrastructure strategy | 3.1 | Water efficient fittings and fixtures |
| | | | 3.1 | Water efficient fittings and fixtures | 1.5 | Water conservation |

*Source: CSTEP*

### South Interior Region

The cities falling in this region need to prioritise source augmentation measures, especially for groundwater, along with other water conservation measures (because of low groundwater table in majority of the area). Since the region receives moderate rainfall, rain water harvesting, as a supplementary source of water, needs to be a key focus for the cities in this region. More than 50% of the urban population resides in this region, which leads to a greater water demand. The cities also need to prioritise integrating green infrastructure measures for resource sustainability. Table 2.10 below indicates the suggested priority levels for different strategies suitable for the region. Refer to Table 2.7 for the detailed description of each strategic option.

Table 2.10: WSSM for cities in South Interior Region

| Priority level | Small towns | | Medium towns | | Large towns | |
|---|---|---|---|---|---|---|
| A | 1.5 | Water conservation measures | 2.2 | Reduction in NRW share (b) | 2.2 | Reduction in NRW share (b) |
| B | 1.4 | Green infrastructure strategy (b) | 1.2 | Ground water source augmentation | 1.2 | Ground water source augmentation |
| C | 1.3 | Green infrastructure strategy (a) | 1.4 | Green infrastructure strategy (b) | 1.4 | Green infrastructure strategy (b) |
| D | 1.1 | Surface water source augmentation | 1.3 | Green infrastructure strategy (a) | 1.3 | Green infrastructure strategy (a) |

| Priority level | Small towns | | Medium towns | | Large towns | |
|---|---|---|---|---|---|---|
| | 1.2 | Ground water source augmentation | 1.1 | Surface water source augmentation | 1.1 | Surface water source augmentation |
| | 2.1 | Reduction in NRW share (a) | 3.1 | Water efficient fittings and fixtures | 3.1 | Water efficient fittings and fixtures |

*Source: CSTEP*

## Coastal Region

Since this region receives very high rainfall, harvesting this resource is the most sustainable strategy for the Coastal Region. Apart from the RWH, conservation measures for reviving and maintaining surface water bodies, like de-silting, etc. also need to be followed. Source augmentation, both in terms of surface and groundwater, through recharge structures also needs to be a focus area for these cities. Table 2.11 below indicates the suggested priority levels for different strategies suitable for the region. Refer Table 2.7 for the detailed description of each strategic option.

Table 2.11: WSSM for cities in Coastal Region

| Priority level | Small towns | | Medium towns | | Large towns | |
|---|---|---|---|---|---|---|
| A | 1.4 | Green infrastructure strategy (b) | 1.4 | Green infrastructure strategy (b) | 2.2 | Reduction in NRW share (b) |
| B | 1.1 | Surface water source augmentation | 1.1 | Surface water source augmentation | 1.3 | Green infrastructure strategy (a) |
| C | 2.1 | Reduction in NRW share (a) | 1.3 | Green infrastructure strategy (a) | 1.4 | Green infrastructure strategy (b) |
| D | 1.3 | Green infrastructure strategy (a) | 2.2 | Reduction in NRW share (b) | 1.2 | Ground water source augmentation |
| | | | 3.1 | Water efficient fittings and fixtures | 1.1 | Surface water source augmentation |
| | | | | | 3.1 | Water efficient fittings and fixtures |

*Source: CSTEP*

## Malnad Region

This region receives moderate to heavy rainfall, hence RWH can be one of the primary strategies that the region can focus on. Source augmentation, both in terms of surface and groundwater, through recharge structures also needs to be addressed by these cities. Table 2.12 below indicates the suggested priority levels for different strategies suitable for the region. Refer Table 2.7 for the detailed description of each strategic option.

Table 2.12: WSSM for cities in Malnad Region

| Priority level | Small towns | | Medium towns | | Large towns | |
|---|---|---|---|---|---|---|
| A | 1.4 | Green infrastructure strategy (b) | 1.4 | Green infrastructure strategy (b) | 2.2 | Reduction in NRW share (b) |
| B | 1.1 | Surface water source augmentation | 1.1 | Surface water source augmentation | 1.3 | Green infrastructure strategy (a) |
| C | 1.2 | Ground water source augmentation | 1.2 | Ground water source augmentation | 1.4 | Green infrastructure strategy (b) |
| D | 2.1 | Reduction in NRW share (a) | 2.2 | Reduction in NRW share (b) | 1.1 | Surface water source augmentation |
| | 1.3 | Green infrastructure strategy (a) | 1.3 | Green infrastructure strategy (a) | 1.2 | Ground water source augmentation |
| | | | 3.1 | Water efficient fittings and fixtures | 3.1 | Water efficient fittings and fixtures |

*Source: CSTEP*

A large number of strategy and technology options under the components and sub-components mentioned in Table 2.7 have been compiled from an in-depth literature survey. This list of strategies and technologies can be accessed in a toolkit format, available in the following link (http://cstem.cstep.in/uoapp/#/state). The toolkit allows the users to select a city and view the following details

- District, taluk and region (North Interior/ South Interior/Malnad/ Coastal) where the city is located and the city size (small/medium/large)
- Water stress, growth pressure and priority levels of the city derived from the analysis carried out in the 1$^{st}$ section of the study.
- WSSM relevant to the city described in Table 2.9, Table 2.10, Table 2.11 and Table 2.12.
- List of strategy and technology options under the components and sub-components mentioned in the guidance framework
- Demographic information of the city including population, city class, civic status, area, density, sex ration, literacy rate and population growth rate.
- Service delivery status of the city for water supply and sanitation

- Environmental parameters of the region where the city is located including agro-climatic zone, drought vulnerability, depth to groundwater table, soil texture, average annual rainfall, temperature and relative humidity

***Example of toolkit usage for Tumakuru city***

*If Tumakuru city is selected, the guidance framework described for medium towns will show up in the toolkit. This is because Tumakuru lies in the South Interior Region and has a population of around 3 lakhs (in the 1-5 lakh range categorised as medium town). The city lies in the high water stress and growth pressure zones and comes under the high priority category identified in this study. The first priority for the city that the guidance framework suggests is to carry out measures to reduce the NRW share. Different strategy/technology options for the same can be viewed in the toolkit including conducting water audits, leak detection surveys, managing distribution system pressure through SCADA system, AMR (Automatic Meter Reading) etc. The guidance framework also suggests to prioritise source augmentation measures, especially for groundwater, because of low groundwater table (more than 20 m,bgl). Measures suggested in the toolkit for the same include direct methods like construction of contour bunds, trenches, percolation tanks etc. and also indirect methods like induced recharge, fracture sealing cementation techniques etc. Since the region where Tumakuru is located receives moderate rainfall (900 mm)[1], focus on rain water harvesting, as a supplementary source of water is also suggested.*

A screenshot of the toolkit with Tumakuru as the selected city is shown in Figure 2.10. The steps to be followed by the user can be referred from Annexure I (I).

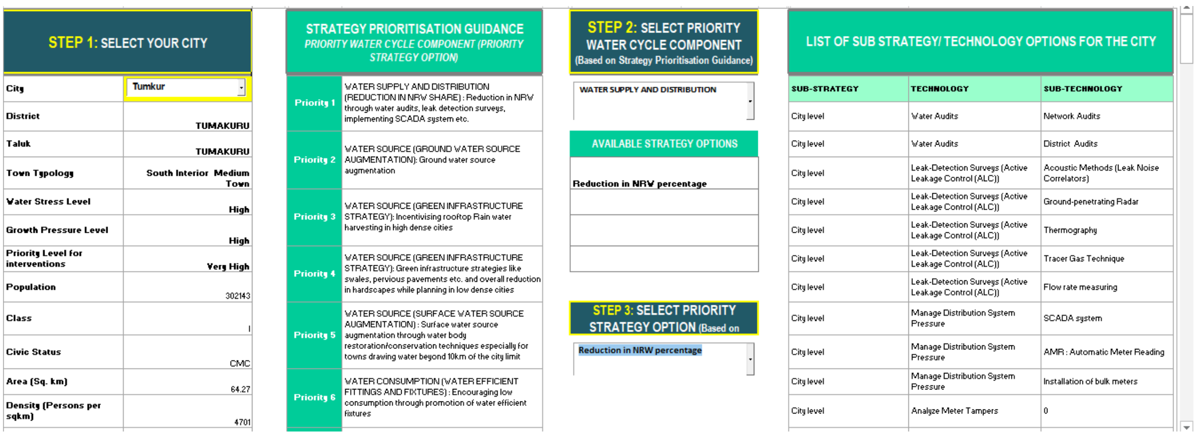



Figure 2.10: Screenshot of strategy selection toolkit
*Source: CSTEP*

### 2.9.4 Conclusion

The findings and recommendation presented in this section highlights the need for a regional approach in planning for ecosystem services such as water. In order to implement the strategic choices discussed in this report, cities will need to build capacities in planning for urban water sector. It is to be noted that selection of specific technologies will require further feasibility analysis at a city level. The WSSM and the toolkit discussed can help in pre-feasibility assessment of strategies and technology choices. This toolkit is aimed to act as a reference document for the urban local bodies (ULBs), while conceiving city specific projects at a pre-feasibility stage. Further contextual analysis will be required to identify the most suitable strategy.

The strategies and technologies discussed above can be adopted at different stages of an urban water cycle. Finally, these need to feed into an integrated water planning exercise for the city enshrining the principles of IUWM as mandated by the UWWR policy.

## 2.10 IUWRM Plan Preparation Process

This section examines the third research question of the study. The objective is to develop broad steps that should be followed for preparing a city level Integrated Urban Water Resource Management (IUWRM) plan as proposed in the Waste Water Reuse Policy, 2017.

### 2.10.1 Methodology

The key activities carried out for developing the IUWRM Plan preparation process, at the city level, are as follows:

1. Understand the concept of IUWRM and how it has been applied in different cities across the globe
2. Review the existing IUWRM Plan preparation guidelines
3. Based on the above-mentioned activities, develop steps for IUWRM Plan preparation for Karnataka’s cities

### 2.10.2 Data Collection and Analysis

Secondary data on the various international guidelines and frameworks available for IUWRM was collected and analysed. The guidelines brought out by agencies like the United Nations, World Bank, and government agencies of different countries were only considered for reference in this section of the study. The analysis and recommendations are presented in the following sections.

**Concept of Integrated Urban Water Resource Management**

The World Bank defines IUWM as a "flexible, participatory and iterative process, which integrates the elements of the urban water cycle (water supply, sanitation, storm water management, and solid waste management) with both the city's urban development and river basin management to maximize economic, social and environmental benefits in an equitable manner"(World Bank, 2012a)[16].

The basic principles of IUWM (refer Figure 2.11) include the ones suggested by various other water sustainability frameworks. These include SuDS (Sustainable Drainage Systems) in the UK, LID (Low Impact Development) and green infrastructure in the US and Canada, WSUD (Water Sensitive Urban Design) in Middle East and Australia, etc. The nine broad principles of IUWM is shown in Figure 2.11.

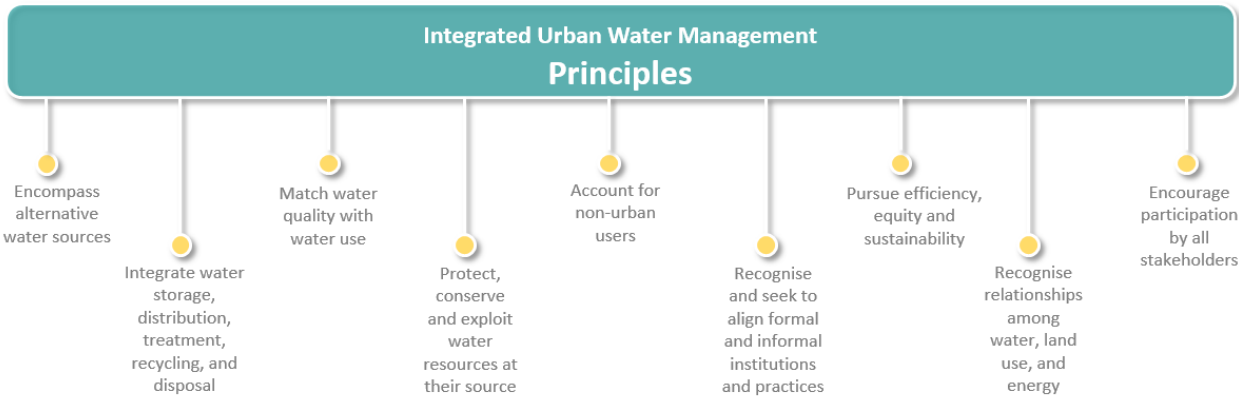



Figure 2.11: Principles of Integrated Urban Water Management
*Source: Adapted from a report on Integrated Water Resource Management by Akica Bahri, GWP, TEC*

**Review of IUWM planning frameworks**

Several international organisations and research programmes have attempted to develop comprehensive frameworks which guide cities towards an IUWRM approach. All the frameworks revolve around the main principles of water resource management described in the previous section.

[16] Refer Annexure I (J) for further details on IUWRM

The Water Partnership Program (WPP)[17] has been evolving and improving the framework for IUWRM over the years. The initial framework divided the process into four separate phases. The *engagement phase* is to identify the main stakeholders and build consensus on using an IUWRM approach; the *assessment phase* is to identify problems related to the sector in urban areas and identify possible strategies to solve them; the *participatory planning stage* helps in reviewing and finalising the strategies; and finally the *implementation and monitoring phase*. The generic process developed by WPP can be applied to cities in different stages of experimenting with the IUWRM approach (World Bank, 2012b). A more recent approach by the WPP suggests development of IUWM in three broad phases, namely engagement, diagnostic and strategic planning. The integration of different urban sectors and between the urban sectors and water shed was further emphasised in the recent framework (World Bank, 2016).

The Commonwealth Scientific and Industrial Research Organisation (CSIRO)[18] also suggested three main phases, each elaborated with a set of activities. The first phase provides strategic directions on urban water management; the second phase suggests shortlisting of options for the same; and third phase suggests selection of the most suited management option, including the development of a design and implementation plan for the selected option. The activities include stakeholder engagement, consensus on objectives, measure and criteria, understanding of existing system, system performance assessment, and implementation planning (Maheepala, 2010).

In India, the Adopt IUWM project (Adopting Integrated Urban Water Management in Indian cities) [19] involves in capacity building of selected Indian ULBs to undertake water sector reforms by adopting IUWM principles. Measures undertaken as a part of this project include (1) revival of abandoned bore wells in peri-urban areas using rooftop harvesting and reuse of treated waste water in defunct community toilets in Solapur (2) closing the water loop of a selected slum in Ichalkaranji to reduce the pollutant load on the drain along which

[17] By the World Bank
[18] An Australian Federal Government Agency
[19] Supported by European Union and in partnership with ICLEI European Secretariat and Association of Flemish Cities and Municipalities (VVSG)

the slum is located. Details of some of the cities across the globe which have successfully implemented IUWRM practices can be accessed in Annexure I (K).

### 2.10.3 Findings and Recommendations

In Karnataka, the planning instruments at a city level include the master plan, city sanitation plan and Faecal Sludge and Septage Management (FSSM) plan, and city mobility plans. Presently, there is no planning instrument which guides the management of the urban water sector in the state. The UWWR Policy 2017 mentions the need for preparing an IUWRM Plan. This section suggests and elaborates on a process and the set of activities that should be performed to prepare IUWRM plans for cities in Karnataka (refer Figure 2.12).

| | | | | |
|---|---|---|---|---|
| **STEP 1** Rapid Situation Assessment | **STEP 2** Stakeholder Identification and Mapping | **STEP 3** Stakeholder Consultation Workshop I | **STEP 4** Identification of linkages between water cycle components and urban sectors | **STEP 5** Water Balance Assessment |
| **STEP 6** Identification of possible areas of intervention in the city | **STEP 7** Development of strategic directions for IUWRM | **STEP 8** Stakeholder Consultation Workshop II | **STEP 9** Selection of suitable structural and non-structural measures for the city | **STEP 10** Development of implementation, monitoring and evaluation framework |
| **STEP 11** Stakeholder Consultation Workshop III | **STEP 12** Finalisation of IUWRM Plan | | | |

Figure 2.12: Steps for IUWRM Plan preparation process
*Source: CSTEP*

## STEP 1: Rapid situation assessment

| **Suggested Components** | |
|---|---|
| Urban context | Include details of urban areas and urban form, population and density, population growth rate, economic and social context of the city, etc. |
| Water resources | Water shed in which the city is located; climate related data including rainfall, temperature variations; water related extreme events like drought, floods, cyclones, etc. and population affected in the previous years by the same; water supply sources for the city; and water assets of the city. |
| Access to services | Coverage of services, including water supply, sanitation, solid waste management, storm water drainage infrastructure, status of waste water treatment and reuse, and available infrastructure for the same. |
| Institutional mapping | Mapping the urban and water governance situation of a city; major service providers (public and private) for the services listed above; river basin |

| | |
|---|---|
| | organisations, if any; NGOs working in the sectors in the city/water shed; and civil society organisations actively involved in the sectors |
| **Secondary Data Requirement** | |
| City Master Plan, Water Utility Plan, City Sanitation Plan, River Basin Master Plan (if these are prepared for the city), GIS maps for the city and water shed, and hydrometeorological data for the water shed | |

## STEP 2: Stakeholder identification and mapping

| **Suggested Components** | |
|---|---|
| Identification of the roles and responsibilities of the stakeholders | |
| Identification of the informal and formal linkages between the stakeholders and associated institutions | |
| Identification and analysis of the regulatory frameworks guiding the stakeholders in planning and decision-making regarding the sectors, and robustness of the same | |
| **Possible Stakeholder List** | |
| • Agencies (public and private) working in the urban and water sectors (including sanitation, storm water drainage, solid waste management)<br>• Agencies responsible for planning and implementation of services<br>• Service providers (including government organisations and private parties)<br>• Members of the city government<br>• River Basin Authority | • NGOs working in the water sectors (including sanitation, storm water drainage, solid waste management)<br>• Academic and research institutions working in the sectors<br>• Stakeholders from other sectors including industries, agriculture, power, environment, transport, etc.<br>• Citizenry<br>• Agencies from other cities which have adopted the IUWRM approach—for knowledge sharing |

## STEP 3: Stakeholder consultation workshop I

All the relevant stakeholders identified in step 2 should be included in the consultation workshop, the proceedings of which should be monitored, documented, and disseminated to all the stakeholders. The first stakeholder consultation workshop should essentially focus on the following: (1) Sensitisation regarding IUWM; (2) Participatory mapping of water cycle related issues; and (3) Identification of the possibilities of water use integration between different stakeholders.

## STEP 4: Identification of linkages

| Suggested Components | |
|---|---|
| Linkages | Linkages between the water shed and other sectors, including industries, agriculture, energy, urban, etc. within the water shed, and analysis of how the existing master plan for the city, if any, considers the interlinkages |
| Impact of Linkages | Identification of how these linkages impact urban services such as water supply, sanitation, solid waste management, drainage, waste water management and urban planning |
| Present Integration Scenario | Identification of existing practices of integration, if any, at both city and water shed level. |
| Resilience of system | Analysis of the existing resilience of the water system to demographic changes, water stress and other climate related extreme events should be carried out. |

## STEP 5: Carry out a Water Balance Assessment (WBA)

| Suggested Components | |
|---|---|
| Components of WBA | Identification of the components of a water balance model[20] should be considered |
| Data Collection | Identification of modalities for data collection for each component |
| Base-lining and Building Future Scenarios | Development of a baseline and projected scenarios of water balance for a city |
| Expert Validation | Expert consultation to validate the water balance model of a city |

## STEP 6: Identification of possible areas of intervention in a city

The possible areas of intervention in the water system of a city should be identified based on the above-mentioned steps. The interventions may be focused on the following (but not limited to): infrastructure planning and development; infrastructure choice; water supply source including identification of alternate sources; water supply system; sanitation; storm water and drainage management; solid waste management impacting the water system in the city; institutional arrangement for effective implementation of IUWRM; etc.

[20] Tools like SWMM (Storm Water Management Model) can be used for the water balance assessment

## STEP 7: Develop strategic directions for Integrated Urban Water Resource Management

Strategic Directions for IUWM should be suggested based on the identified intervention areas.

| **Suggested Components** | |
|---|---|
| Infrastructure Planning and Development | • Simultaneous planning of all urban water components—moving away from the traditional siloed approach.<br>• Improved planning based on interlinkages between different urban sectors. |
| Infrastructure Choice | • Consideration of green infrastructure choices including rain water harvesting and other water sensitive urban design options. |
| Water Supply Source | • Possibilities of using alternate water supply sources for the city. |
| Sanitation | • Exploration of possibilities for using both centralised and decentralised options for sanitation management.<br>• Exploration of possibilities of reusing waste water and sludge. |
| Storm Water and Drainage Management | • Prioritisation of potential collection and reuse of storm water.<br>• Consideration of natural drainage system of the city. |
| Solid Waste Management | • Perusal of reduce, reuse, recycle principle for efficient solid waste management. |
| Institutional Arrangement | • Promotion of institutional arrangement looking at the water system comprehensively. |

## STEP 8: Stakeholder consultation workshop II

The objective of this consultation workshop should be to build consensus among different stakeholders on the strategic directions for integrated water management in the city. Short-term, medium-term and long-term targets, activities and outcomes for the city should be decided and agreed upon by the stakeholders.

## STEP 9: Selection of suitable structural and non-structural measures and for the city

Structural measures include technologies or infrastructure options that can bring about an overall improvement in the water management of a city. It may include options like rain water harvesting, recycling and reuse of waste water, restoration and preservation of natural waterscapes, etc. Non-structural measures include instruments like regulations, policies, urban planning and land-use regulations, etc., which can bring about an overall improvement in the water management of a city.

| Suggested Components | |
|---|---|
| Structural Measures | Selection of structural measures that contribute towards achievement of the targets identified and finalised for the city in step 8<br>The water technology toolkit, described in the previous section, may be used for identifying the most suitable technology options for the city |
| Non- Structural Measures | The identified technologies should be evaluated against institutional, social, economic and technical setting in order to select the most suitable ones. |

## STEP 10: Development of implementation, monitoring and evaluation framework

| Suggested Components | |
|---|---|
| Mechanisms | Develop mechanisms for review, monitoring and incorporation of feedbacks. A possibility for revision and amendment of the Plan should be embedded in the process. |
| Roles and Responsibilities | Define the roles and responsibilities of institutions and stakeholders in the Plan preparation process |

## STEP 11: Stakeholder consultation workshop III

The roles and responsibilities developed in step 10 need to be discussed and agreed upon during the third stakeholder consultation workshop.

## STEP 12: Finalisation of the IUWRM Plan

Any suggested amendments from the workshop is to be incorporated and the IUWRM Plan finalised.

## Requisites for effective implementation of IUWRM Plan

In order to ensure seamless integration of the IUWRM Plan with the land-use planning process, is it required that some revisions are made in the relevant acts and regulatory guidelines. Following are some recommendations for revisions in the Karnataka Town and Country Planning (KTCP) Act, 1961 in this regard:

### *Content of Master Plan*

Chapter III, Section 12 of the KTCP Act, 1961 spells out the broad contents of a master plan. Incorporating the following is recommended:

- The master plan has to consider the IUWRM Plan, if already prepared for the city, while proposing new developments or any land-use changes.

- The total water requirement for the proposed development should be cognizant of the suggestions and recommendations mentioned in the IUWM Plan.
- If an IUWRM Plan is not in place at the time of preparation of the master plan, then the same has to be prepared as a subset of the master plan document itself. All the steps mentioned in the prior section need to be embedded in the master plan preparation process itself.

***Institutional Arrangements***

It is recommended that the planning authority or ULB (whichever is responsible for master plan preparation for a specific city) forms a separate committee to look into the preparation of the IUWRM Plan. It should include the following members:

- Members from the planning authority
- Members from the Water Supply Board/Water Supply Department of the ULB
- Members from the ULB dealing with solid waste management in the city
- Members from the ULB dealing with sanitation and drainage in the city
- Senior geologist from the District Groundwater Office
- Members from the District Watershed development department.

The committee can work in coordination with the Advanced Centre for Integrated Water Resource Management (ACIWRM), which acts as a think tank to the Water Resources Department for preparing the IUWRM Plan for the city.

### 2.10.4 Conclusion

Creating sustainable pathways for the urban water sector in Karnataka will require interventions in both long term strategic planning, as well as adoption of short-term measures at city level. The water stressed regions identified in this study can be prioritised for the preparation of the river basin management plans. The cities identified in those regions can be prioritised for the preparation of the IUWRM plan. Nevertheless, all the cities in the four geographic regions in Karnataka should start adopting easily accessible technology measures as suggested in this study. Finally, regular tracking of the performance of the urban water sector indicators suggested in this report will help cities draw realistic base-lines from time to time, and further identify areas needing priority intervention.

Institutional coordination and synchronisation of different planning exercises is important for achieving the desired intension of sustainable water planning through IUWM approach.

Hence, deliberations on revising the KTCP Act and other relevant regulatory instruments need to be initiated by the DTCP in coordination with other relevant departments.

# 3. Implementing FSSM Approach in Sustainable Urban Sanitation Planning

## 3.1 Background

With increasing urbanisation in Karnataka, one of the critical issues that cities face is ensuring basic services such as water and sanitation for all citizens. However, access to toilets alone is not enough. Services like sanitation must be safe to use and have no adverse effects on human health and surroundings. From a planning and implementation perspective, it is also important to ensure that sanitation services are economically sustainable through their lifetime.

Currently, there are different options available for sanitation systems which can be used depending on a city's unique constraints, such as Onsite systems, Faecal Sludge and Septage Management (FSSM) systems, and Networked system (Annexure II (A)). FSSM includes the conveyance, treatment and possibly reuse of the raw or partially digested semisolids collected in On-site Sanitation Systems (OSS) (Eawag/Sandec, 2008). Ministry of Housing and Urban Affairs (MoHUA) launched the National FSSM Policy in 2017, following which, the Government of Karnataka (GoK) initiated steps towards adoption of the FSSM approach in sanitation planning in cities last year. Karnataka's state policy on FSSM spells out the roadmap for operationalising FSSM in urban areas across the state. The GoK has also released the updated State Sanitation Strategy (SSS), 2017 under the directive of the National Urban Sanitation Policy (NUSP). The strategy shares the goals of NUSP with an added focus on FSSM.

Although the SFSSM policy clearly defines strategies for implementing FSSM across the state, the recommendations of the policy need to be affirmed through application in existing urban contexts. This study mainly examines the ways of application of the FSSM approach along with existing sanitation practices. In doing so, the study specifically aims to (a) suggest directions for integrating FSSM components in existing City Sanitation Plan (CSP) preparation processes, (b) identify suitable sanitation technologies for different typologies of cities in Karnataka, and (c) demonstrate a methodology for pre-feasibility analysis for selecting sanitation technologies based on specific city contexts.

The sections following this introduction provide a brief overview of the existing situation of the sanitation sector in Karnataka, the problem statement and the theory of change envisaged for this study. This is followed by a description of the analysis performed under the study and the findings and recommendations emerging from the analysis.

## 3.2 Existing Situation Analysis

The following sections present a brief overview of the urban sanitation sector in Karnataka.

### 3.2.1 Status of Sanitation in Karnataka

An aggregated assessment of the performance of 347 Karnataka cities against Service Level Benchmarks (SLBs), as defined by MoHUA shows that only a small share of cities meet the benchmarks for all the Key Performance Indicators (KPI). Merely 4% of the cities have 100% coverage of toilets and none of the cities in the state have 100% coverage of networked systems. Similarly none of the cities meet the benchmarks for other indicators such as collection efficiency of sewage network, adequacy of sewage treatment capacity, quality of sewage treatment, etc, (refer Figure 3.1).

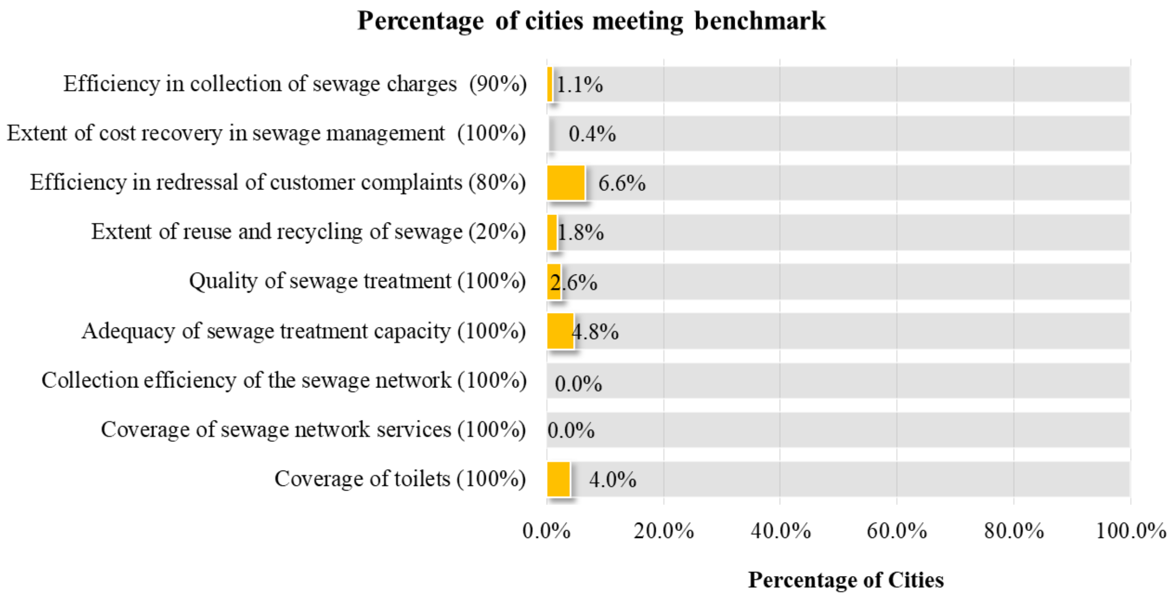



Figure 3.1: Aggregated assessment of Karnataka's cities against sanitation sector KPIs (2017)

Source: UDD, GoK 2017

An oversight of the SLBs is the lack of benchmarks for coverage of OSS. These systems are often the dominant (if not sole) type of sanitation, especially in smaller towns and cities. Most OSS are not designed to treat faecal matter effectively and thus require an effective FSSM system to treat the faecal sludge collected in the storage facility. Dumping of untreated or partially treated faecal sludge causes unregulated release of nutrients into the environment and exposure to various pathogens found in faecal matter. In the case of sewerage networks, 55% of urban households in the state are connected to the sewerage network. Of the total installed capacity of the STPs (800 MLD), 39.3% is not in use, which only aggravates the existing problem (UDD, n.d.).

### 3.2.2 Sanitation Policy and Planning in Karnataka

Following the guidelines of the NUSP, the state has developed a State Sanitation Strategy in 2017. Its main objective is to provide safe and affordable sanitation to all cities in Karnataka with an integrated and scientific approach (Government of Karnataka, 2017b). The strategy shares the goals of NUSP with an added focus on FSSM, but does not particularly include FSSM in the planning process.

The State Faecal Sludge and Septage Management (SFSSM) Policy recommends sanitation strategies for cities based on two main criteria—the percentage of households (HH) dependent on OSSs and the population of cities. The nodal agency for implementation of the policy is the Directorate of Municipal Administration (DMA). Under the policy, a task force on FSSM will be formed to prepare the implementation roadmap. The government will also roll out state-level guidelines and a standard operating manual, which will help formulate city-level strategies and FSSM-related interventions for specific contexts (Government of Karnataka, 2017c).

Currently, only eight cities[21] of Karnataka have prepared a CSP under the directive of the NUSP policy. The DMA has recently initiated tenders for preparation of CSPs for other cities in the state. DMA is also pursuing preparation of FSSM plans in smaller cities in the state as a parallel effort.

Another recent policy initiated by the GoK in this context is the Urban Waste Water Reuse Policy, 2018. The policy emphasises on increasing the use of secondary treated waste water, including the waste water generated from sanitation, as the primary water supply option for industries and thermal power plants (if an STP is located within 30 km of the industry, and if an STP is located within 50 km of the power plants).

### 3.2.3 Gaps in Existing Sanitation Policy and Planning in Karnataka

A review of existing policy documents, plans and guidelines[22] revealed the following major gaps in the existing sanitation planning process in urban Karnataka:

- The existing CSPs often refer to access to toilets as complete sanitation coverage. This often overlooks the other components of the sanitation value chain, which comprise the toilet or the user interface, collection and storage of FS, emptying of FS and conveyance, treatment and reuse or disposal of the end products (Ministry of Housing and Urban Affairs, 2013). As a result, there is a clear gap in addressing FSSM as a part of sanitation planning exercises.

[21] Belagavi, Ballari, Kalaburgi, Hubballi- Dharwad, Mangaluru, Mysuru, Shivamogga and Tumakuru

[22] State Sanitation Strategy, Existing City Sanitation Plans of Karnataka cities, State FSSM Policy, Waste Water Reuse Policy, etc.

- Even when FSSM is considered, underground drainage (UGD) or networked systems are often preferred over FSSM systems. However, the suitability of UGD systems in different city contexts is rarely discussed. Such systems cannot work efficiently in smaller cities with less population, and their construction and maintenance are time- and cost-intensive. Further, smaller cities are often found to have the need for immediate intervention, in which case the UGD system cannot be a feasible option.
- The SFSSM policy advocates for onsite and decentralised sanitation systems and identifies the need to select contextually suitable decentralised technologies. However, there is no comprehensive guidance available for the cities in Karnataka to select technologies which are suitable to their geographic and socio-economic contexts and also to the city's own goals and targets.
- In a way, the SFSSM policy advocates for a systems approach[23] in sanitation planning, comprising all the components of the sanitation value chain. However, there is an absence of a demonstrable methodology which the cities can adopt when choosing between various technology options for a complete sanitation value chain while comparing between multiple technology options for each of its components.

## 3.3 Problem Statement

Cities in Karnataka are less likely to make the desired shift towards a more sustainable sanitation planning and service provision paradigm unless the recommendations made by the FSSM policy are made implementable through more tangible and demonstrable guidance. The last mile between policy intention and implementation must be bridged. Although 85% of urban households have some form of latrine facility, cities often lack suitable infrastructure and strategies for the safe management of sanitation waste. The lack of emphasis on safe collection, conveyance, treatment and disposal/reuse of wastewater and/or faecal sludge is a threat to human health and the environment. Also, the overemphasis on underground sewerage systems as the most suitable means for addressing urban sanitation issues has left smaller cities wanting for cost-effective solutions.

Further, the CSP and FSSM planning exercises are currently being conducted independent of each other. This is a cause for concern because planning for access to sanitation without giving adequate consideration to management of the waste generated from the use of sanitation facilities is likely

[23] Systems approach identifies the interactions between different parts or stages of the sanitation value chain. This approach ensures planning, management and incorporating technology options for each stage of the value chain to form a complete sanitation system. This approach ensures that the sanitation system is most appropriate and sustainable for a specific community and its economic and environmental situation. (Strande, Ronteltap, & Brdjanovic, 2014)

to deter the goal of safe sanitation services. Faecal sludge and septage can be minimal to severe health and environmental hazards in both short and long terms, depending on the treatment and disposal mechanisms practiced. Not integrating FSSM in city sanitation planning processes can also result in increased investment requirements at a later stage.

## 3.4 Theory of Change

The current practice of sanitation planning in Karnataka's cities needs a paradigm shift to achieve the goal of sanitation for all in a socially equitable, environmentally safe and economically sustainable manner. In this context, the adoption of a systems-based approach is a priority in order to ensure adequate attention is given to each component of the sanitation value chain. Integrating an FSSM approach would mean that planning for collection, treatment, recycling, reuse and safe disposal becomes an integrated part of sanitation planning in a city.

The Karnataka State FSSM Policy creates an opportunity for adoption of a systems-based approach through FSSM practices. Judicious implementation of the FSSM policy by applying contextually suitable technologies supported by a comprehensive planning process can lead to a sustainable sanitation service paradigm.

## 3.5 Objective

The objective of the study is to help the GoK implement the intentions of the state FSSM policy in cities across Karnataka by:

- Suggesting ways of integration of FSSM components in the CSP planning process
- Identifying strategic priorities and technology options for sustainable urban sanitation planning for cities in different regions in Karnataka
- Demonstrating a methodology for pre-feasibility assessment of suitable technologies for a select set of cities in the state

## 3.6 Research Questions

The following research questions were examined for the study:

- How can the current City Sanitation Plan (CSP) preparation process be improved to include FSSM strategies?
- What are the suitable strategic and technology choices for cities in different regions of Karnataka?

1. How can a pre-feasibility analysis be conducted to determine the choice of technology in a city, including the potential for waste water reuse?

The subsequent sections will focus on addressing these research questions.

## 3.7 Research Design

The research follows a three-pronged approach which has been designed around the key research questions discussed above. Figure 3.2 details the broad steps involved in examining and addressing these questions.

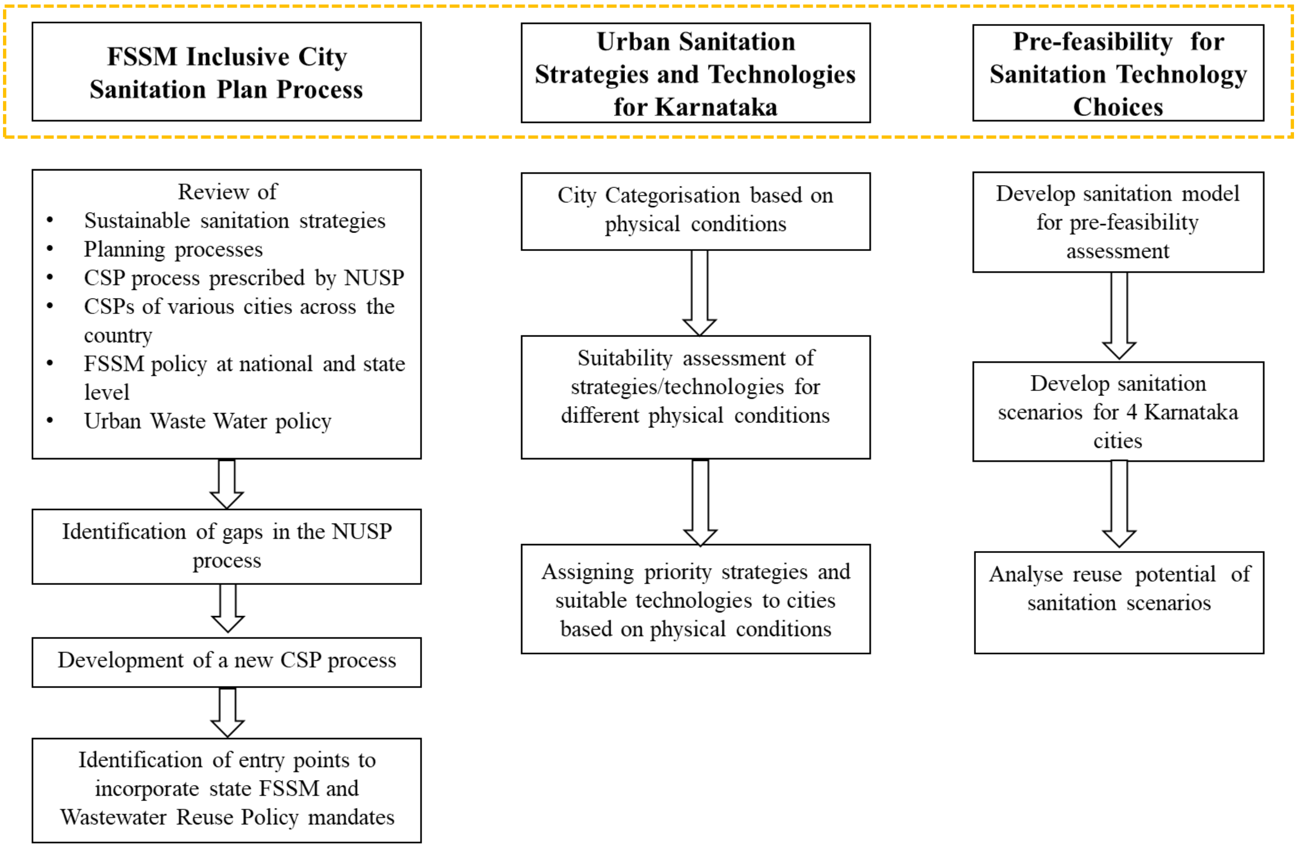



Figure 3.2: Research design for sanitation sector

*Source: CSTEP*

The subsequent sections present descriptions of the methodologies adopted, data collected and analyses carried out for all research questions under this study.

## 3.8 Including FSSM Components in City Sanitation Plans

The research question addressed in this section examines the possibilities and identifies the entry points for incorporating FSSM components into the CSP preparation process, in line with the Karnataka State Sanitation Strategy and the Karnataka State FSSM Policy, 2017.

As per the NUSP, every city has to prepare a CSP. CSPs include the city's vision and development goals for its sanitation sector, along with timelines and action plans to achieve the goals. However, the CSPs in their present form do not give adequate importance to FSSM components. In light of the new FSSM policy in the state, it is essential that the CSP preparation process is revised to incorporate the relevant components of FSSM.

### 3.8.1 Methodology

The methodology followed for identifying entry points in the existing CSP process to incorporate FSSM components is summarised in Figure 3.3.

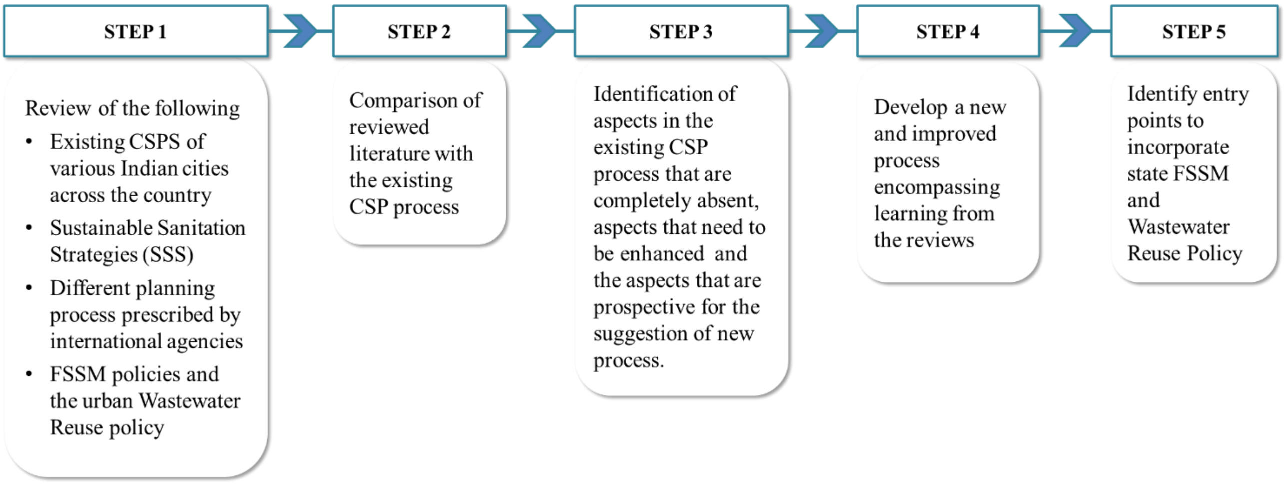



Figure 3.3: Methodology for preparation of FSSM inclusive city sanitation planning process

*Source: CTSEP*

### 3.8.2 Data Collection and Analysis

The analysis has been carried out using secondary data collected from government websites, reports and, in certain cases, directly from department offices. The list of data collected and the respective sources are provided in Annexure II (B).

Literature review was carried out to identify the means and ways of planning for complete and inclusive sanitation systems. The different types of literature reviewed are as follows:

- **National and state level policies, missions, strategies, etc.,** such as National Urban Sanitation Policy, National FSSM Policy, Karnataka FSSM Policy, Karnataka Urban Waste Water Policy, Karnataka State Sanitation Strategy, Andhra Pradesh State Sanitation Strategy and Swachh Maharashtra Mission
- **Sustainable sanitation strategies adopted globally** such as Improvement of Faecal Sludge Management Strategy (FSM) in Thailand, Citywide Sanitation Strategy by Water and Sanitation Program and Indonesia Sanitation Sector Development Program
- **Planning frameworks and processes** suggested by different international and local sanitation planning agencies, such as Sanitation 21 (S21) planning framework by IWA,

GIZ, Eawag, FSM toolbox programme by Asian Institute of Technology, Community-Led Urban Environmental Sanitation Planning (CLUES) by Eawag, Guiding Principles for Better Sanitation Planning by Sustainable Sanitation Alliance, Sanitation Planning Process by Sustainable Sanitation and Water Management Toolbox

- **CSPs from different Indian cities** such as Shimla, Hubli-Dharwad, Varanasi, Kanpur, and Kochi

The literature review helped in understanding the scope and strategies, timelines, stakeholders, institutional responsibilities, etc. that form the basis for a robust and comprehensive city sanitation planning process. This review exercise helped articulate gaps or lags in the existing planning process as well as identify key focus or priority areas. Some of the identified priority areas include the adoption of a systems approach that is, planning for each stage of the sanitation value chain; inclusive planning for all user groups and integration with other sectors. This exercise also suggested control and enforcement mechanisms such as formalisation of the informal sector, community participation in monitoring and maintenance of infrastructure, training and capacity building as well as training for FSSM. The learnings from the review led to the development of a new sanitation planning process, which is discussed below.

### 3.8.3 Findings and Discussions

Based on the review of literature and understanding of the existing scenario in Karnataka, the major elements that need to be included in the CSP preparation process have been identified as follows:

- Inclusion of all components of FSSM (i.e., baselining, planning and management, implementation operation and maintenance, monitoring and evaluation, capacity building and awareness) in line with the NUSP and Karnataka SSS
- Assessment of resource recovery and reuse potential (in line with the Karnataka Urban Wastewater Reuse policy)
- Consideration of the entire value chain (i.e., toilet or the user interface, collection and storage of FS, emptying of FS and conveyance, treatment and reuse or disposal of the end products) at all stages of sanitation planning
- Rapid assessment of environmental and social impact of proposed strategies and technologies
- Identification of linkage with other relevant policies and schemes in city-specific contexts

Apart from these, the study recognises the need to uphold the agenda of 'Sanitation for all at all times' by addressing vulnerabilities based on gender, age, disability, social and economic status, etc.

### 3.8.4 Conclusion and Recommendations

Based on the findings described above, a revised process for the preparation and implementation of CSPs has been designed, as shown in Figure 3.4. This study recommends that the CSP preparation process be divided into four broad buckets (as mentioned below) and a specific line of activities be incorporated under these categories to ensure an FSSM-inclusive output.

1. Exploratory actions: They will include stakeholder mapping and rapid assessment of existing plans and policies.

2. Preliminary actions: The present CSP preparation process includes baseline data collection. However, this exercise needs to be modified to include disaggregated datasets to facilitate socially relevant analyses. Moreover, an analysis of opportunities and constraints through stakeholder mapping and consultation needs to be conducted at this stage.

3. Strategy development: This is one of the most important stages of the CSP preparation process. This study recommends strengthening the outputs from this stage by incorporating a rapid environmental and social impact assessment of proposed strategies.

4. Action plan: The action plans should be able to facilitate the implementation of proposed strategies and hence need to suggest specific activities and responsibilities for different stakeholders. Specific interventions to ensure the smooth integration of the CSP with other plans and policies should also be spelt out in the action plan.

Once the CSP is prepared, the activities during CSP implementation and post-implementation stages can be further modified to include the following:

5. The staff of ULB and any other organisation engaged in implementation (such as community-based organisations) should be trained in contract management for better service delivery in the implementation stage.

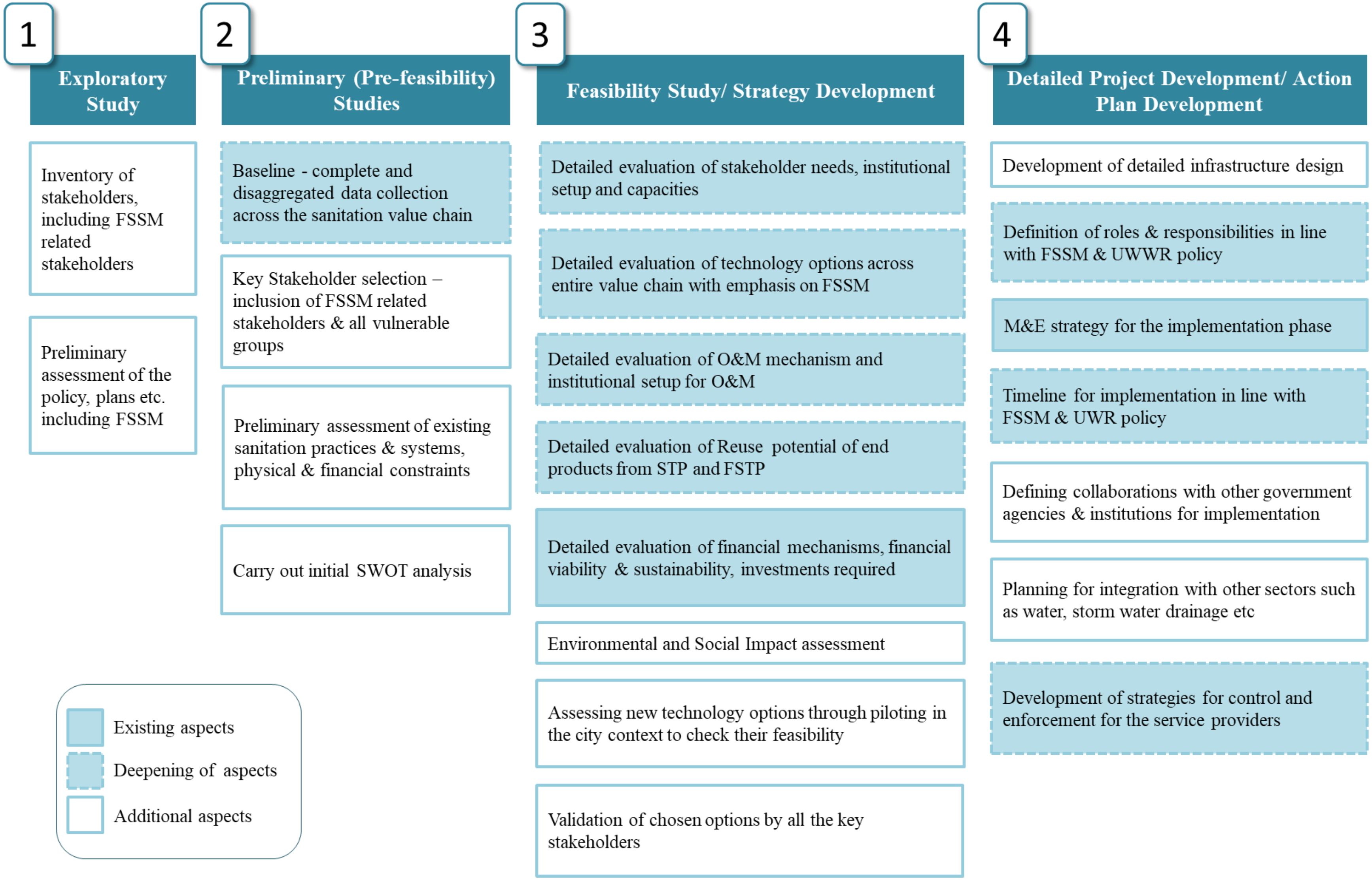
6. The Monitoring and Evaluation stage needs to include database preparation (with disaggregated data) and maintenance, including GIS-enabled monitoring systems for spatial data.

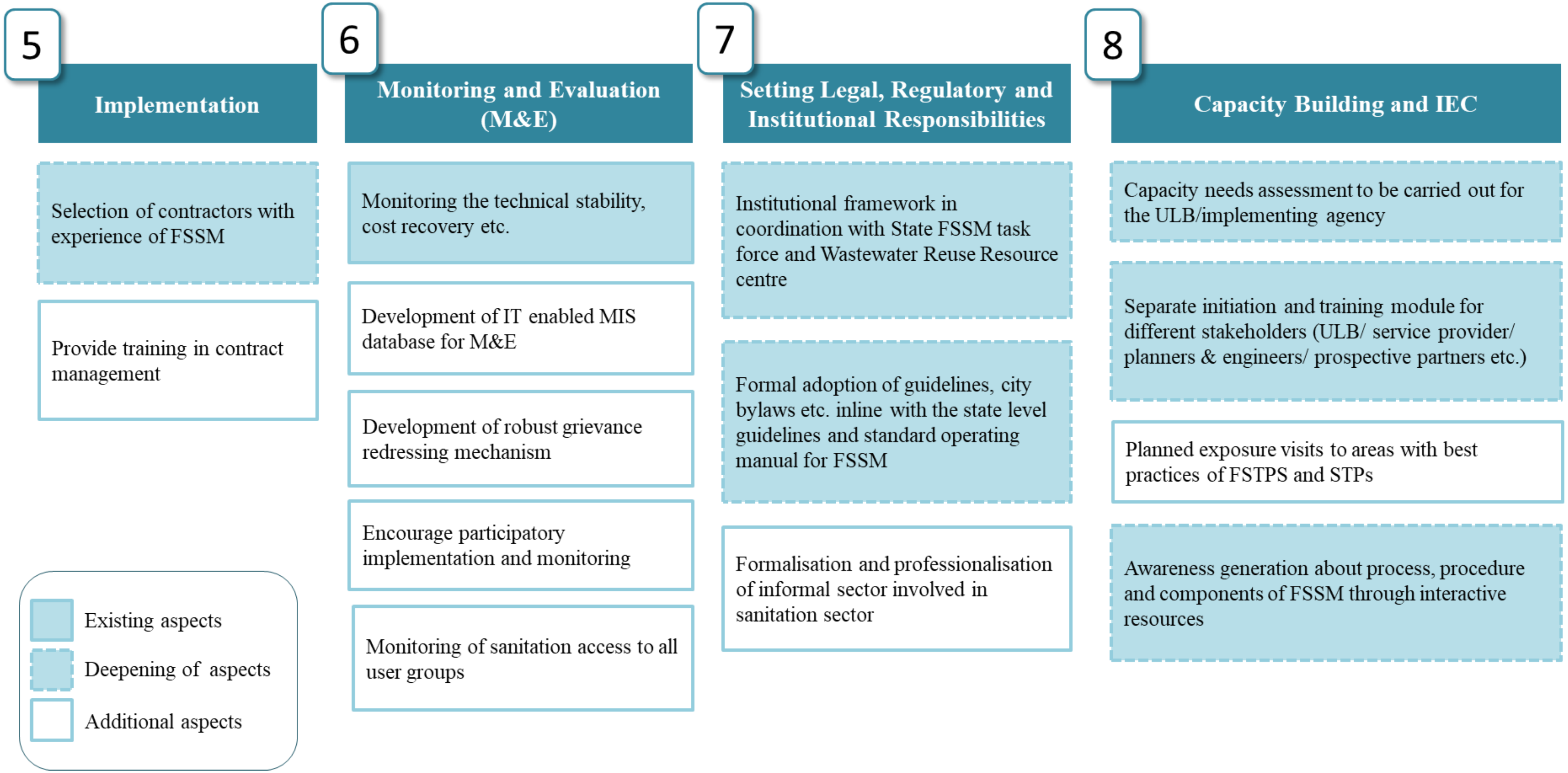
 

7. A mechanism for effectively incorporating the contribution of the informal sector in the sanitation value chain needs to be prepared.

8. Continuous capacity building sessions for specific groups of personnel employed in the sector will be required throughout the implementation and post-implementation periods of the CSPs.

Figure 3.4: FSSM inclusive CSP preparation process






*Source: CTSEP*

## 3.9 Urban Sanitation Strategy and Technology Selection for Different Regions in Karnataka

Based on geographical conditions, Karnataka can be divided into four distinct regions (Coastal, Malnad, North Interior and South Interior). To ensure effective application of the systems approach in urban Karnataka, the choice of technologies and associated strategies must take into account regional variations as well as the different city contexts. This section of the study examines suitability of various technology options at each stage of the sanitation value chain.

### 3.9.1 Methodology

This section outlines the process followed to conduct a suitability assessment of technologies and to develop the urban sanitation strategy. Key steps include city categorisation, multi-criteria technology assessment and development of toolkits and support resources. These steps have been described below:

**Step 1: City Categorisation Based on Population and Suggested System Type**

All the 347 cities in Karnataka are grouped as indicated in the SFSSM policy, based on type of strategic intervention and city size. The strategic interventions are:

- Full-scale FSSM with a dedicated treatment facility or co-treatment at STP (Sewage Treatment Plant), if present within a 10 km radius, with sufficient capacity
- Combined FSSM and networked system with provision of Decentralised Wastewater Treatment Systems (DEWATS), dedicated treatment (Faecal Sludge Treatment Plant, or FSTP) or co-treatment (STP) facility as per site conditions
- Complete networked system (centralised or decentralised) with FSSM for only un-served population; provision of dedicated treatment (FSTP) or co-treatment facility (STP) as per site conditions.

For different categories of cities (small, medium and large) based on the percentage of OSS, the suggested strategies are given in Table 3.1.

Table 3.1: Strategic intervention for city group

| Percentage of HH using OSS | City population size | | |
|---|---|---|---|
| | Small towns <1 lakh) | Medium towns (1-5 lakh) | Large towns (>5 lakh) |
| >75% | FSSM | FSSM | FSSM+DEWATS |
| 50%-75% | FSSM | FSSM+DEWATS | FSSM+DEWATS |
| 25%-50% | FSSM | FSSM+DEWATS[24] | UGD/DEWATS+FSSM |
| <25% | FSSM+DEWATS | UGD[25]/DEWATS+FSSM | UGD/DEWATS+FSSM |

*Source: State FSSM Policy, Karnataka, 2017*

**Step 2: City Categorisation Based on Geographic Regions**

The cities in each of these categories were divided based on the region of Karnataka where they were located. This categorisation helped in defining the physical parameters such as rainfall patterns, soil characteristics, ground water depth, terrain, elevation and slope, which guided the selection of suitable sanitation technologies.

**Step 3: Multi-Criteria Assessment of Technologies**

About 75 well-established technologies across the sanitation value chain were categorised into 19 groups based on their suitability to different physical criteria. These criteria depend on the part of the sanitation value chain to which the technologies belong. Annexure II (D) describes the features of each technology group.

**Step 4: Preparation of a Toolkit**

An MS Excel–based toolkit for selecting a suitable set of technology options for each city was created to facilitate easy uptake and use by stakeholders.

### 3.9.2 Data Collection and Analysis

For assessing the suitability of different technologies to different regions in Karnataka, the cities were first categorised based on different features. Profiles of the 75 technologies were curated from various secondary sources, and their suitability to the different regions were analysed. Results from the analyses conducted have been briefly summarised below. The data collected and the respective sources for this section are provided in Annexure II (B).

[24] Decentralised Wastewater Treatment Systems
[25] Underground Drainage

## City Profiling

The analysis shows that 92% of the cities in Karnataka have a population less than 1 lakh (refer to Figure 3.5). More than half of the cities have at least 50% households dependent on onsite sanitation systems (refer Figure 3.6). Most of these OSS are simple systems, such as single or twin pits and septic tanks that provide partial treatment/stabilisation at best.

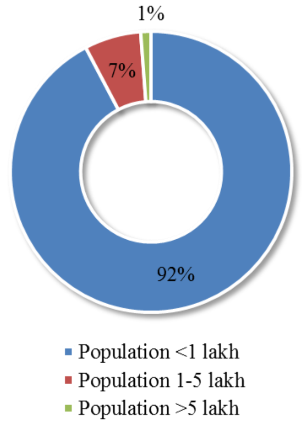



Figure 3.5: Share of cities based on population size

*Source: Census 2011*

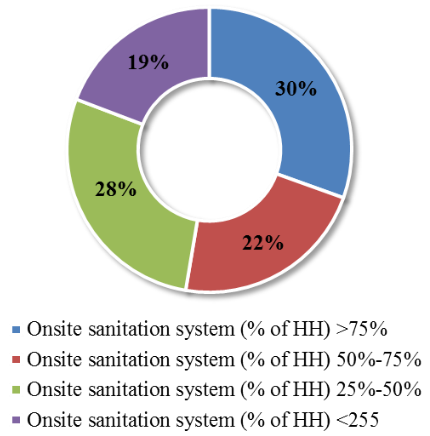



Figure 3.6: Share of cities based on Percentage share of OSS Households

*Source: Census 2011*

For the successful implementation of appropriate sanitation infrastructure, it is essential to consider the state's varying geographic regions. Depending on their location, physical features of the cities would vary. Figure 3.7 shows the locations of the 347 cities considered, while Table 3.2 shows the city parameters considered.

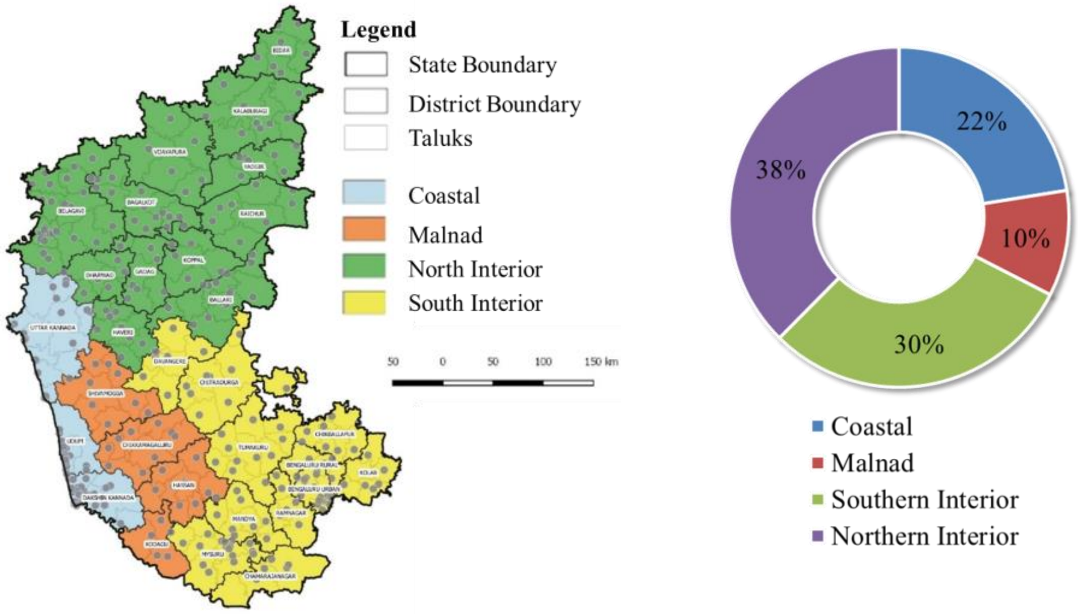



Figure 3.7: Share of cities located in different geographical regions

*Source: CSTEP*

Table 3.2: Parameters for city profiling

| Parameter | Unit | Value | | Range |
|---|---|---|---|---|
| Water consumption | | Low | | Less than 30 |
| | Litres per capita daily (LPCD) | Medium | | Between 30 and 60 |
| | | High | | Greater than 60 |
| Rainfall | | Very high | | Greater than 2000 |
| | Millimetres (mm) | High | | Between 1000 and 2000 |
| | | Medium | | Between 700 and1000 |
| | | Low | | Less than700 |
| Require specific soil type | | Sandy | | |
| | N/A | Clayey | | |
| | | Loamy | | |
| | | Rocky/Mountainous | | |
| | | Multiple | | |
| Groundwater level | Metres below ground level (m bgl) | Deep | | Less than 10 |
| | | Shallow | | Greater than10 |

*Source: CTSEP*

The analysis (refer to Figure 3.8, Figure 3.9 and Figure 3.10) shows that a large number of cities fall in the region of deep groundwater level. The predominant soil type is mainly sandy or clayey, with most of the parts receiving low to medium rainfall. Because of the high variability of these parameters among the regions, the analysis was done at a sub-region level (district/taluk level).

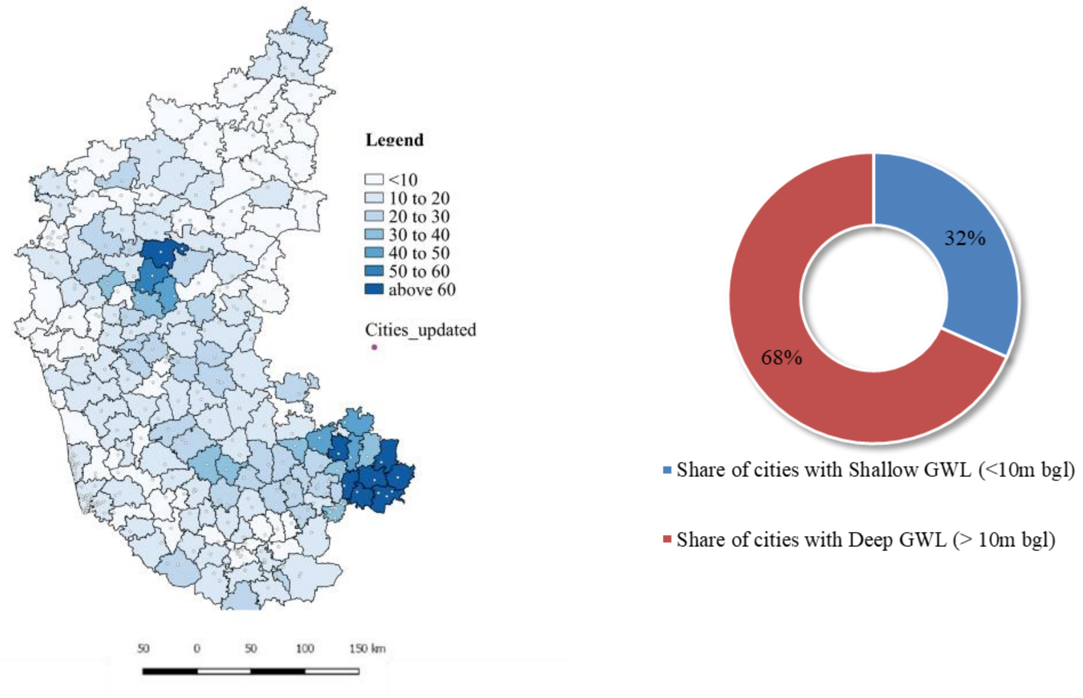



Figure 3.8: Share of cities based on ground water depths

*Source: CTSEP Analysis*

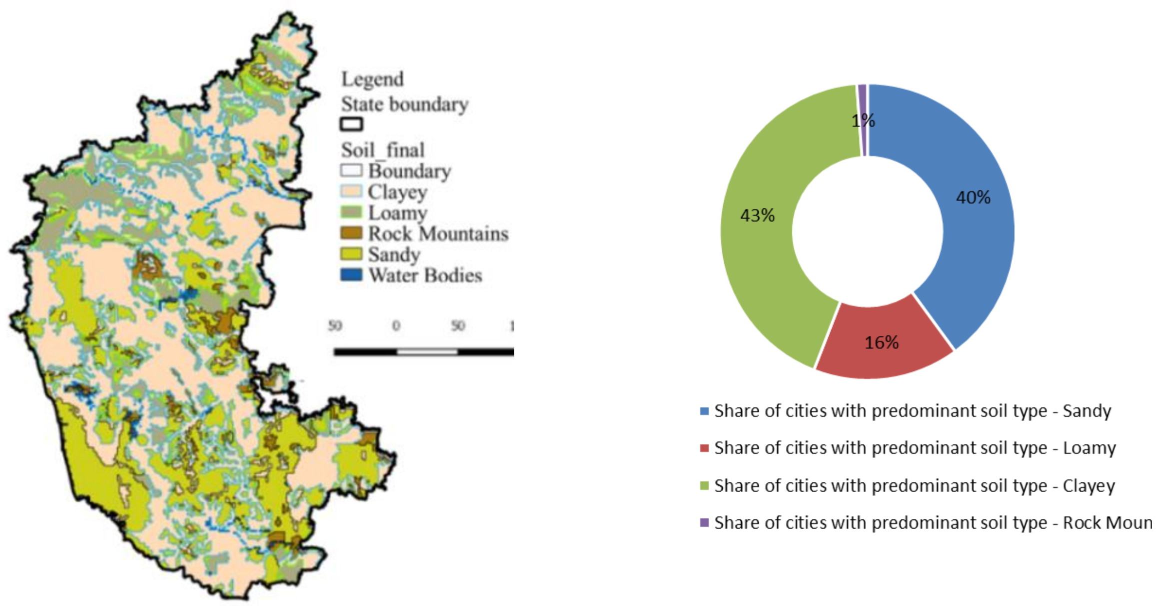



Figure 3.9: Share of cities based on soil type

*Source: CTSEP Analysis*

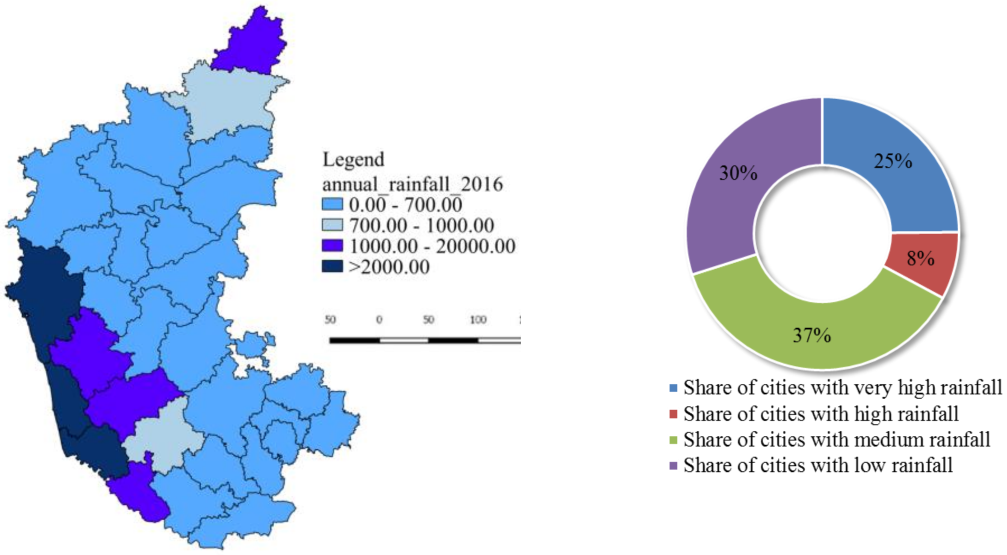



Figure 3.10: Share of cities based on rainfall

*Source: CTSEP Analysis*

## Technology Profiling

For the different geographical regions, parameters such as groundwater level, rainfall, soil type and water consumption were analysed to derive the limiting parameters[26] affecting the technologies at each stage of the value chain. These limiting parameters (refer Table 3.3) were further used to sieve out technology groups. A description of each group of technologies is given in Annexure II (D).

Table 3.3: Limiting parameters for sanitation technologies

<table>
<tr><th colspan="4">Toilet/User Interface</th></tr>
<tr><td rowspan="5">These groups mainly describe the different types of toilets available, such as cistern flush toilets and dry toilets</td><td rowspan="2">Technology groups</td><td colspan="2">Limiting factor (does not work in the following conditions)*</td></tr>
<tr><td>Water consumption</td><td>Groundwater level</td></tr>
<tr><td>U1</td><td>medium, low</td><td></td></tr>
<tr><td>U2</td><td>Low</td><td></td></tr>
<tr><td>U3</td><td>high, medium</td><td>shallow</td></tr>
<tr><th colspan="4">Onsite Collection/ Storage</th></tr>
<tr><td>These groups mainly describe the different types of onsite storage</td><td>Technology groups</td><td colspan="2">Limiting factor (does not work in the following conditions) *</td></tr>
</table>

[26] Parameters or factors that define a system and determine its behavior and boundaries

| | | | | |
|---|---|---|---|---|
| technologies available, such as twins pits, septic tanks and biogas digester | | **Water consumption** | **Groundwater level** | **Soil type** |
| | S1 | high, medium | shallow | clay, rocky |
| | S2 | high, medium | | clay, rocky |
| | S3 | high, low | shallow | clay, rocky |
| **Conveyance** | | | | |
| These groups mainly describe the different types of conveyance systems, such as vacuum trucks, sewers lines and small bores | **Technology groups** | **Limiting factor** (does not work in the following conditions)* | | |
| | | **Water consumption** | **Slope** | **Soil type** |
| | C1 | | | |
| | C2 | medium, low | <1% | rocky |
| | C3 | Low | | |
| **Treatment** | | | | |
| These groups mainly describe the different types of treatment technologies for primary treatment, effluent treatment, sludge treatment and disinfection | **Technology groups** | **Limiting factor** (does not work in the following conditions)* | | |
| | | **Groundwater level** | **Soil type** | **Rain fall** |
| | T0 | | | |
| | T1 | | | High |
| | T2 | shallow | | |
| | T3 | shallow | clay, rocky | |
| | T4 | shallow | | Low |
| | T5 | shallow | clay, rocky | High |
| **Disposal or Reuse** | | | | |
| These groups mainly describe the different types of disposal and reuse options for the treated sludge and wastewater | **Technology groups** | **Limiting factor** (does not work in the following conditions)* | | |
| | | **Groundwater level** | **Rainfall** | **Soil type** |
| | R1 | shallow | | |
| | R2 | shallow | medium, low | |
| | R3 | shallow | | clay, rocky |
| | R4 | | | |

*Note: Blank cells imply that this factor does not influence the technology groups*
*Source: CTSEP*

## Technology Selection

A tool has been prepared to select technologies across the sanitation value chain based on the geographical profiles of the different cities. Figure 3.11 describes the share of cities in each of the four regions of Karnataka that are suitable for each technology group. A brief description of the technology groups are given in Annexure II (D), while the complete assessment for all treatment technologies is given in Annexure II (E).

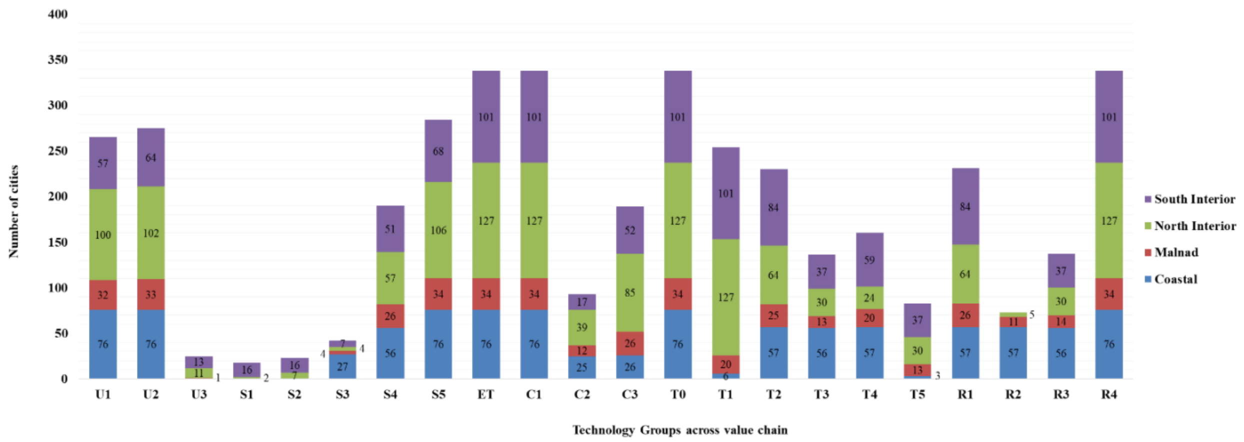



Figure 3.11: Share of cities that are suitable for each technology group

*Source: CTSEP Analysis*

**<u>Toolkit preparation</u>**

Based on the analyses carried out, a toolkit of technologies has been developed to provide an easily-navigable single point resource for decision-making. This toolkit contains key information beyond technology suitability for the different regions of Karnataka, such as cost, land, and energy and skill requirement. The toolkit can be accessed at (http://cstem.cstep.in/uoapp/#/state).

### 3.9.3 Findings and Discussion

The study shows that for different parts of the value chain, technologies that are less dependent on natural mechanisms fared better across various contexts. Some key findings are summarised below:

- In the case of treatment, technologies that employ highly mechanised processes such as MBR (Membrane Bioreactor), SBR (Sequential Batch Reactor) and ASP (Activated Sludge Process), i.e., technologies covered in the T0 group, are suitable for most of the city groups. These technologies are the least influenced by geological and hydrological parameters.
- Treatment technologies that depend more on natural processes such as unplanted drying bed, constructed wetlands and anaerobic filter (technologies covered in T1,T2 ,T3, T4 and T5 groups) are suitable for certain city groups only as they are highly influenced by geological and hydrological parameters such as depth to groundwater, predominant soil type and rainfall.

- In the case of collection and storage technologies, most of the cities show suitability to S5 group (Biogas digester, Biotank etc.) since they are not influenced by any of the geological and hydrological parameters but are influenced by the water going into the system.
- In the case of user interface / toilets, technologies such as cistern flush and pour flush (groups U1 and U2) are suitable for most cities, while technologies such as composting toilets and dry toilets (technologies in group U3) are suitable for a few cities with deep groundwater level and low water consumption.
- Emptying equipment (group ET) is usually attached with vacuum trucks or FSM trucks (group C1), both of which are not influenced by any of the geological and hydrological parameters. However, parameters like the quality of road network need to be considered in the case of group C1. Meanwhile, sewers (groups C2 and C3) are suitable for certain cities only as they are affected by the parameters of ground slope, soil type and water consumption.
- Reuse or disposal options such as non-portable use in fire protection, landscaping and use in industrial processes (group R4) are suitable for all cities as these options are not influenced by any of the geological and hydrological parameters. However, the quality of treated waste should meet the reuse standards for the group R4. Meanwhile, other groups (R1, R2 and R3) are suitable for specific cities as they are affected by groundwater level, soil type and rainfall patterns.

### 3.9.4 Conclusion and Recommendations

Based on the findings described above, a pre-feasibility assessment of technologies needs to be carried out in city-specific contexts in addition to a regional assessment. This is due to the fact that the most widely applicable technologies require a high investment and have external resource dependencies (such as skilled labour and energy). Thus, even when a technology can work in a given physical condition, its effective implementation would depend on the socio-economic and institutional settings of a city. The subsequent section demonstrates a method to conduct such a city-level assessment.

## 3.10 Pre-Feasibility Analysis Guide for Selection of Sanitation Technologies at the City Level

While region-level selection helps identify technologies ideal for a region, decision-makers at the city-level have to grapple with many other key questions such as the required system capacity, estimated capital and operating cost, resource requirements (if any) and potential environmental impact. Further, at the city level, it is also important to determine whether a networked (sewered) system or a non-networked FSSM system would be appropriate. Despite the strategies outlined by the SFSSM policy, a framework or tool to carry out such a pre-feasibility analysis is not available to the cities. In this regard, this section presents a pre-feasibility assessment through which cities can develop scenarios using recommended technologies to observe their impact on various indicators. Please refer to Annexure II (E) for more details.

### 3.10.1 Methodology

The study tries to understand the suitability of system-level decisions by conducting a detailed pre-feasibility assessment for specific cities. The assessment involved the creation of scenarios (using different technologies relating to the suitable groups) as recommended by the sieving tool. These scenarios were then compared based on deciding factors or indicators such as the capital and operational costs, operating ratio of the facilities, water consumption, land requirements, quality of the end products and potential of reuse options. For this exercise, four cities with different profiles were chosen. The details of the method are given below.

**Step 1: Selection of Cities**

Four cities in Karnataka with different physical and environmental characteristics were chosen. These characteristics included water stress, agro-climatic zone, groundwater level, predominant soil type, per capita water supply and geographical location. Smaller cities (mainly city municipal councils, or CMC) were preferred as the conventional networked systems have already been chosen as the preferred system type for city corporations. Cities covered under AMRUT (Atal Mission for Rejuvenation and Urban Transformation) scheme were chosen as they have the funding available for quick uptake and implementation of recommended technologies. The profiles of the selected cities are presented in Table 3.4.

Table 3.4: Selected cities for pre-feasibility study

| Selected City | Civic status | District | AMRUT cities | Water stress | Ago-climatic zones | Ground water | Soil type | Water supply (lpcd) |
|---|---|---|---|---|---|---|---|---|
| Kolar | CMC | Kolar | Yes | Very High | Eastern Dry | Deep | Sandy | 50 |
| Chitradurga | CMC + OG | Chitradurga | Yes | Very High | Central Dry | Deep | Clayey | 105 |
| Raichur | CMC | Raichur | Yes | High | Northeast Dry | Shallow | Clayey | 170 |
| Udupi | CMC + OG | Udupi | Yes | Low | Coastal | Deep | Sandy | 105 |

*Source: CSTEP*

## Step 2: Baselining the Selected Cities for Scenario Development

A baseline was developed for each of the cities to observe the potential impact of the chosen technologies on certain key indicators (described in the subsequent section). Here, the baseline represents a 'business as usual' scenario in which the access to sanitation remains unchanged. The main parameters considered for baselining were population data and types of sanitation system available in the city. The current population numbers were estimated by projecting 2011 Census data to 2018. The developments under the Swachh Bharat Mission for the selected cities were considered while calculating the shares of different types of existing sanitation systems. However, it was assumed that the share remains the same as in the 2011 Census data.

## Step 3: Development of Scenarios for Technology Selection for City-Level Sanitation System

To assess the impact of different types of sanitation systems, two scenarios (FSSM scenario and UGD/Network scenario) were created for each of the cities. For developing each scenario, a set of key input parameters were identified. Output parameters were calculated based on the cost, resource requirements and performance of the technologies used in the selected system (as shown in Table 3.5) with respect to the city's requirements (e.g., the total cost of building toilets is based on the number of toilets that need to be built and the cost of each toilet). These output parameters were developed into indicators on the basis of which the scenarios were compared against the baseline. The assumptions and formulas for calculating different outputs are given in Annexure II (F). The indicators and the performance of all four cities are given in the subsequent section.

Table 3.5: **Input output parameters for the scenarios**

| Input parameters | Output parameters |
|---|---|
| • Population and area of the city (2018, 2030)<br>• Population growth rate<br>• Coverage of households with different sanitation systems<br>    ○ HH having toilets and storage<br>    ○ HH having toilets (but no storage/collection)<br>    ○ HH having sewerage system<br>    ○ HH having Decentralised FSSM/DWATS system<br>    ○ HH having no toilets<br>• Per capita water supply<br>• Average volume of existing storage units | • Change in coverage of households with different sanitation systems<br>• Number of toilets to be constructed<br>• Number of storage tanks to be constructed<br>• Plant capacity to be set up<br>• Quantity of treated wastewater<br>• Quantity of treated sludge generated (manure)<br>• Scenario costs (capital and operation cost)<br>• Cost for toilet<br>• Cost for storage units<br>• Cost for conveyance<br>• Cost for treatment |

| Input parameters | Output parameters |
|---|---|
| • Price at which treated wastewater and sludge are sold<br>• Percentage of households for which de-sludging is done by ULBs in the city<br>• User charges for collection of FS by ULB<br>• Capital and operational costs of the selected technology<br>• Land required by the selected technology<br>• Removal efficiency of the selected technology[27] | • Contingency costs<br>• Revenue generated from reuse<br>• Revenue generated from user charges<br>• Operating ratio<br>• Land requirement for setting up the plant<br>• Quality of treated wastewater |

*Source: CTSEP*

**Step 4: Brief Assessment of Treated Water Reuse Potential**

In light of the recent Urban Waste Water Reuse Policy, the treated effluent[28] water quality was estimated based on the system efficiency for each of the scenarios and compared against the reuse standards, as prescribed by Urban Water Reuse Policy, the CPHEOO (Central Public Health and Environmental Engineering Organisation) and revised CPCB (Central Pollution Control Board) norms (Vishnoi, 2015). For treated effluent whose quality did not meet the recommended standards, suitable advanced wastewater treatment methods have also been suggested.

### 3.10.2 Data Collection and Analysis

Secondary data sourced from government websites, reports and, in certain cases, directly from department offices were used to generate the required city-based information. An extensive literature review for selected technologies was used to generate system-level information. The data collected and the respective sources for this section are provided in Annexure II (B).

### Sanitation Scenarios Created for the Selected Cities

The baseline parameters calculated from the census and SBM data used for scenario development are shown in the Table 3.6

[27] Removal efficiency of technologies and quality of treated wastewater were calculated in terms of the following parameters: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Nitrogen (TN), Dissolved Phosphorous (DP), Total Dissolved Solids (TDS), Total Hardness ($CaCO_3$),
Alkalinity ($CaCO_3$), Chlorine and Silica ($SiO_2$)
[28] Treated at least up to secondary treatment (i.e. biological treatment)

Table 3.6: Baseline for the cities

| Baseline parameters | Kolar | Raichur | Chitradurga | Udupi |
|---|---|---|---|---|
| Present population (2018) | 1,69,207 | 2,84,221 | 1,67,975 | 1,93,196 |
| No. of households | 36,632 | 55,996 | 36,235 | 42,402 |
| % of homes having toilets and storage | 22% | 20% | 33% | 82% |
| % of homes having toilets (but no storage/collection) | 3% | 5% | 3% | 0% |
| % of homes having sewerage system | 68% | 34% | 51% | 15% |
| % of homes having decentralised system | 0% | 0% | 0% | 0% |
| % of homes having no toilets | 7% | 41% | 13% | 3% |

*Source: CSTEP (projection of Census 2011 data)*

The systems developed for each scenario for all four cities are given in Table 3.7. The systems were designed using technologies chosen from the suitable groups identified for each of Karnataka's regions as given in section 3.9.

Table 3.7: Sanitation systems used in scenario development

| Components of value chain | FSSM Systems | | | |
|---|---|---|---|---|
| | Kolar | Raichur | Chitradurga | Udupi |
| User interface/toilet | Cistern Flush / Pour Flush | Cistern Flush / Pour Flush | Cistern Flush / Pour Flush | Cistern Flush / Pour Flush |
| Onsite collection/ storage | Conventional septic tank with soak pit | Conventional septic tank with soak pit | Conventional septic tank with soak pit | Conventional septic tank with soak pit |
| Emptying | Motorised diaphragm pump | Gulper | Gulper | Motorised diaphragm pump |
| Conveyance | Big trucks (10-15m$^3$) | Big trucks (10-15m$^3$) | Big trucks (10-15m$^3$) | Big trucks (10-15m$^3$) |
| Primary treatment | Anaerobic Baffled Reactor (ABR) | Imhoff Tank | Anaerobic Digester | Imhoff Tank |
| Effluent treatment | Activated Sludge Process (ASP) | Biological Filtration and Oxygenated Reactor (BIOFOR) | Sequential Batch Reactor (SBR) | Facultative Aerated Lagoon (FAL) |
| Disinfection | Chlorination | Chlorination | Chlorination | Ultraviolet (UV) light treatment |
| Sludge treatment | Unplanted Drying Bed | Solar Drying | Co-composting | Planted Drying Bed |
| **Components of value chain** | **Networked Systems** | | | |
| | **Kolar** | **Raichur** | **Chitradurga** | **Udupi** |
| User interface/toilet | Cistern Flush | Cistern Flush | Cistern Flush | Cistern Flush |
| Conveyance | Conventional gravity sewers | Conventional gravity sewers | Conventional gravity sewers | Conventional gravity sewers |
| Effluent treatment | Up-flow Anaerobic Sludge Blanket | Membrane Bioreactor (MBR) | Sequential Batch Reactor (SBR) | Biological Filtration and Oxygenated Reactor (BIOFOR) |
| Disinfection | Ultraviolet light (UV) | Ultraviolet light (UV) | Ozonation | Ozonation |

*Source: CSTEP*

## Comparison of Different Sanitation System Scenarios Created for the Study Cities

A diverse set of indicators was developed and used to compare the two scenarios. These indicators have been designed to show the potential impact of the scenarios on key factors that will influence the choice of sanitation systems in the cities. These indicators include access to sanitation, resource requirement, costs, environmental impact and the potential for reuse. The scenario comparisons for these indicators are given below:

### Coverage of Sanitation Systems

Change in the coverage (i.e. the percentage of households having access to complete sanitation systems) in the improved scenarios from the baseline condition is presented in Figure 3.12.

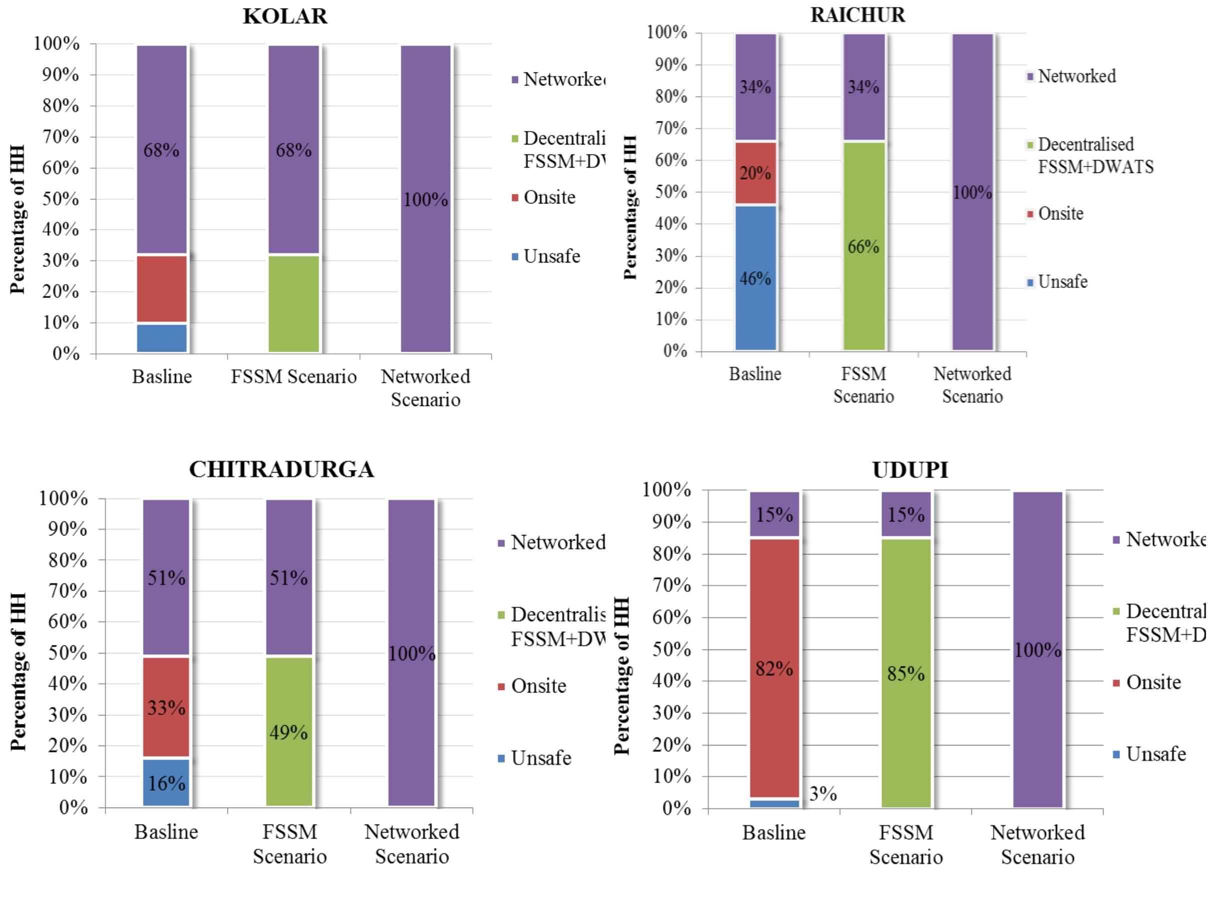



Figure 3.12: Change in the coverage of sanitation systems

*Source: CSTEP Analysis*

### Plant Capacity, Water and Land Requirement

Results from the scenario comparison reveal that for the same baseline situation, an FSSM system requires a smaller plant capacity than a networked system (refer to Table 3.8). This is because the septage collected from the onsite sanitation systems is more concentrated (since it consists only of excreta and flush water), while the influent to networked systems is highly diluted (due to the disposal of grey water along with excreta and flush water). This pattern was observed in the case of land requirement as well—networked systems required more land for plant installation as they had higher plant capacities.

Table 3.8: Details of treatment plant to be installed in the cities

| Scenarios | Kolar | Raichur | Chitradurga | Udupi |
|---|---|---|---|---|
| | Plant Capacity (m%e) - design flow | | | |
| FSSM | 0.032 | 0.41 | 0.096 | 0.15 |
| Networked | 2.4 | 25.9 | 7.6 | 15.8 |
| | Land Required ($m^2$) for plant installation | | | |
| FSSM | 142 | 786 | 198 | 758 |
| Networked | 7268 | 77906 | 8203 | 62063 |

*Source: CSTEP Analysis*

Networked systems also require high volumes of low-strength water to maintain a uniform flow rate (refer Figure 3.13).

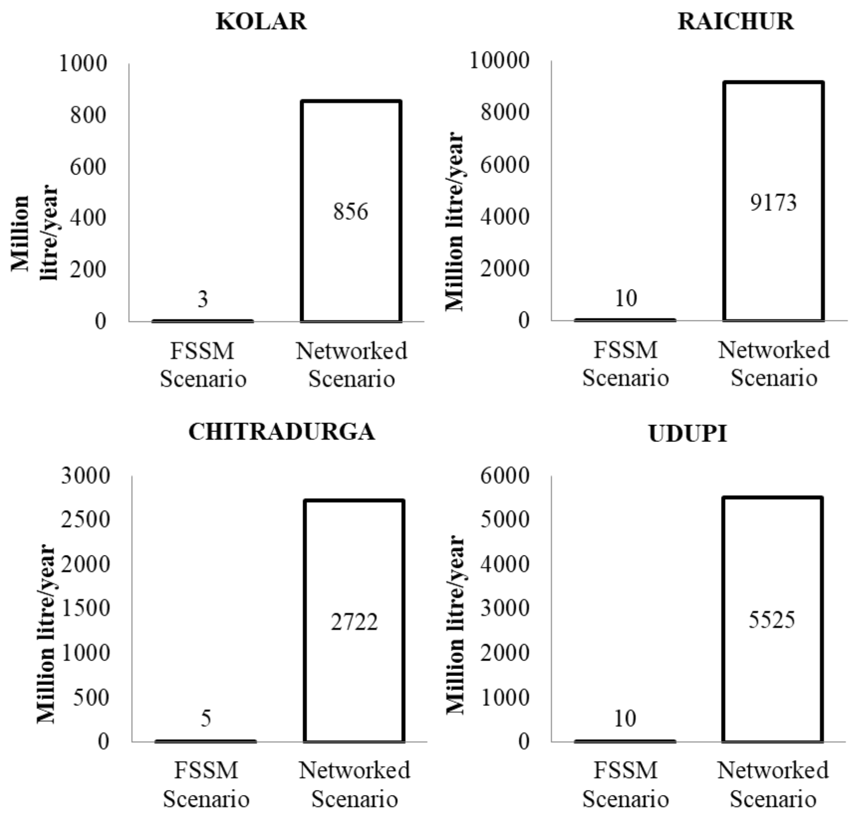



Figure 3.13: Water consumed by the sanitation system

*Source: CSTEP Analysis*

## Cost of Sanitation Systems

The scenario comparison highlights that the capital required for installing the sanitation system is higher for the networked scenario than the FSSM scenario. The major portion of the estimated cost in the FSSM scenario is incurred in the construction of storage (onsite), which is the responsibility of the individual HH. In contrast, in the case of the networked scenario, the major portion of the intervention cost is incurred in the construction of the sewer network (conveyance) for carrying the sewage to the treatment plant. This is the responsibility of the ULB, laying more burden on the municipal fund (refer Figure 3.14). Similar to the indicator capital expenditure, O&M expenditure required for running the sanitation system is considerably higher for the networked scenario than for the FSSM scenario. The share of O&M expenditure for conveyance is higher than other parts of the value chain for most scenarios (refer Figure 3.15).

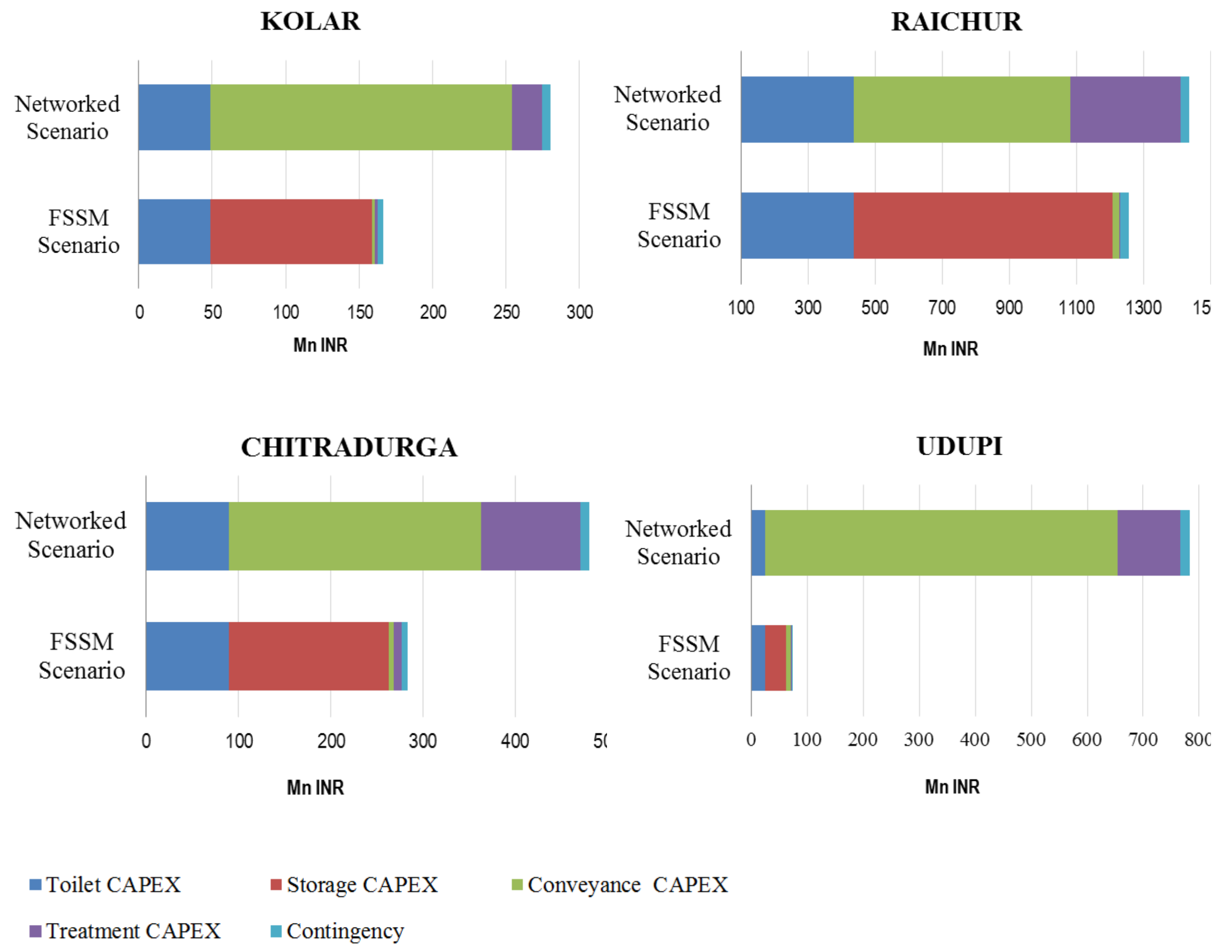



Figure 3.14: Capital expenditure for sanitation system

*Source: CSTEP Analysis*

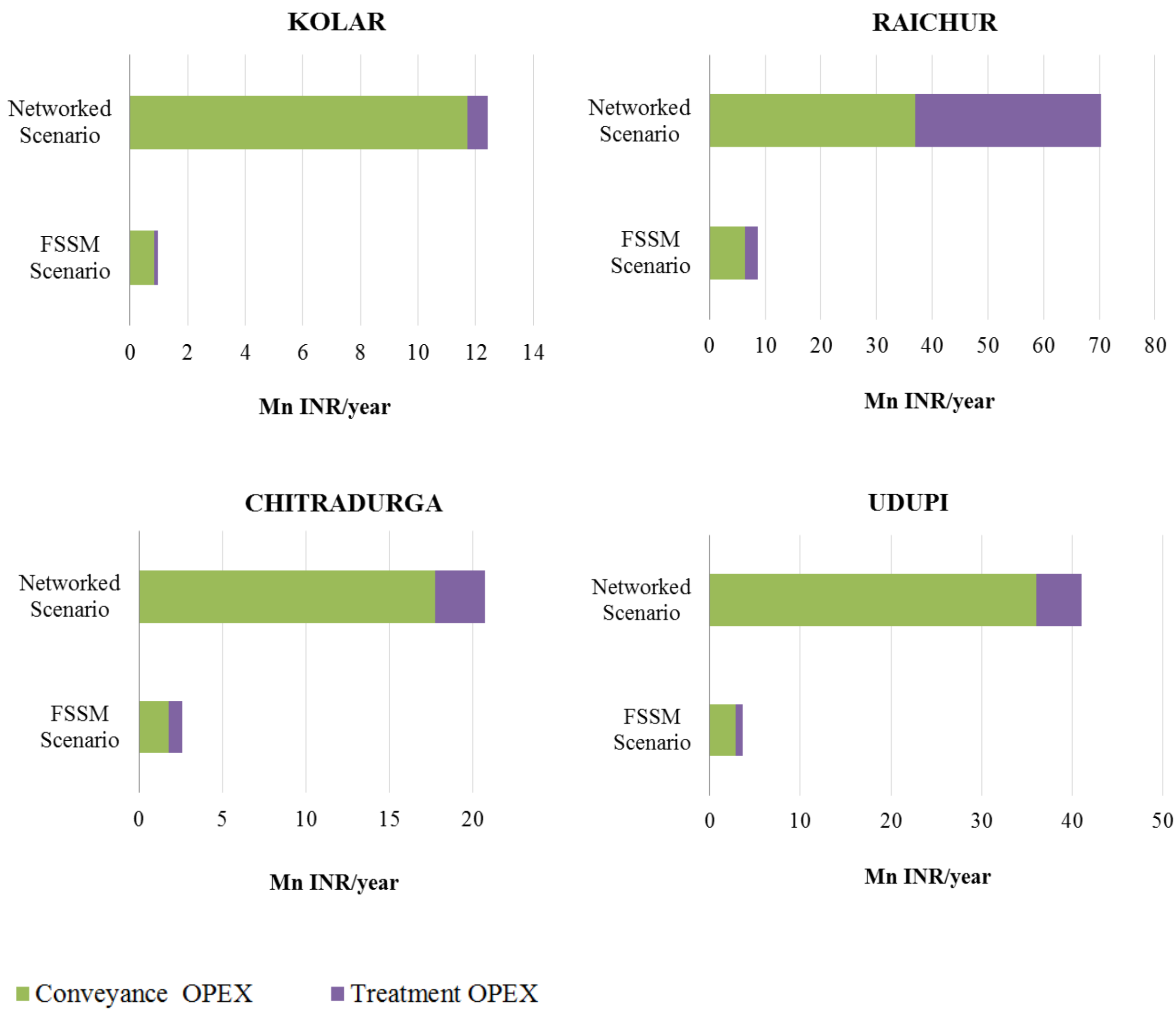



Figure 3.15: Operation and maintenance expenditure for sanitation system

*Source: CSTEP Analysis*

## Revenue Generated and Operating Ratio of the Sanitation Systems

It is observed that if the end products from the FSTP or STP are sold for reuse, a substantial amount of revenue is generated (Figure 3.16). The total quantity of treated sludge produced in the FSSM scenario is comparatively higher than in the networked scenario, while it is understandably the opposite in the case of treated wastewater.

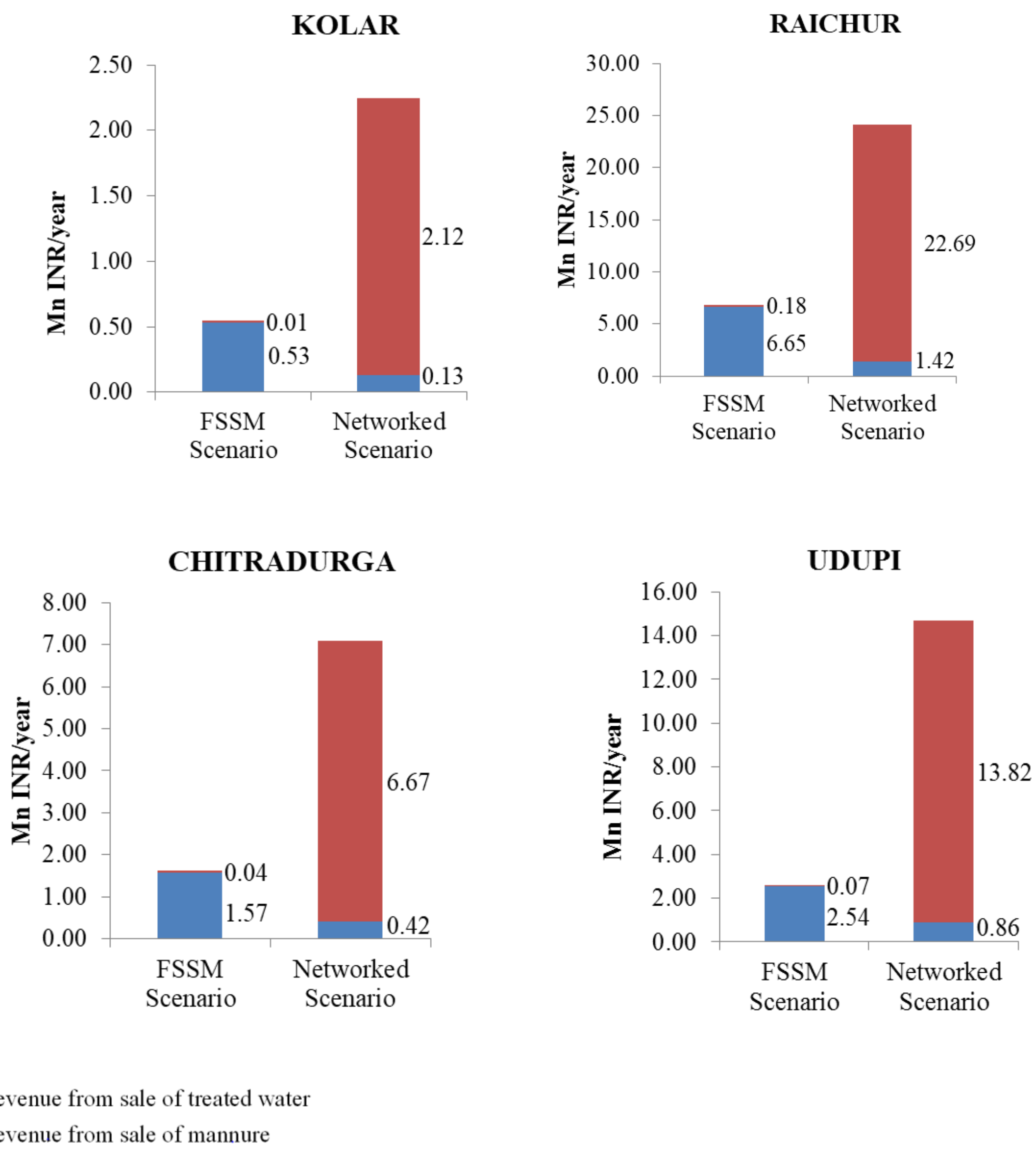



Figure 3.16: Revenue from Reuse

*Source: CSTEP Analysis*

Although the revenue generated in the networked scenario is considerably higher, it is not sufficient to compensate the investment required to set up and manage the system. Thus, it is observed that FSSM scenarios for all cities have a higher operating ratio[29] than the networked system (refer Table 3.9).

[29] Operating ratio is the point at which the operating expenditure breaks even with the operating revenue generated from user charges and reuse of end products.

Table 3.9: Operating ratio for treatment plants

| Scenarios | Kolar | Raichur | Chitradurga | Udupi |
|---|---|---|---|---|
| FSSM | 0.90 | 0.88 | 0.84 | 0.84 |
| Networked | 0.71 | 0.49 | 0.66 | 0.54 |

*Source: CSTEP Analysis*

## Quality of Treated Waste Water

For each scenario, the quality of treated wastewater is determined and then checked with the standards prescribed in the Urban Waste Water Reuse Policy. The input quality is taken as per general characteristics of sewage suggested in the CPHEEO manual. The output quality is based on the removal efficiency of subsequent treatment technologies that the effluent passes through. The standards met by each city for both scenarios are provided in Annexure II (G). The estimated output quality for the scenarios and cities are given in the

Table 3.10 below.

Table 3.10: Quality of treated waste water

| Parameter | Quality Standard for discharge into inland surface water | Input quality | Unit | Kolar | | Raichur | | Chitradurga | | Udupi | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | FSSM | Network | FSSM | Network | FSSM | Network | FSSM | Network |
| | | | | Output quality | | | | | | | |
| BOD | 30 | 250 | mg/l | 2 | 49 | 1 | 7 | 1 | 7 | 5 | 44 |
| COD | 250 | 500 | mg/l | 3 | 75 | 4 | 30 | 7 | 60 | 9 | 75 |
| TSS | 100 | 450 | mg/l | 17 | 35 | 3 | 13 | 2 | 9 | 17 | 79 |
| TN | | 20 | mg/l | 1 | 13 | 1 | 2 | 4 | 6 | 1 | 2 |
| DP | 5 | 10 | mg/l | 1 | 5 | 4 | 7 | 1 | 2 | 3 | 6 |
| TDS | 2100 | 900 | mg/l | 176 | 504 | 176 | 504 | 176 | 504 | 176 | 504 |
| Total Hardness ($CaCO_3$) | | 160 | mg/l | 160 | 160 | 160 | 160 | 160 | 160 | 160 | 160 |
| Alkalinity ($CaCO_3$) | | 200 | mg/l | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Cl | 1 | 130 | mg/l | 130 | 130 | 130 | 130 | 130 | 130 | 130 | 130 |
| Silica ($SiO_2$) | | 24 | mg/l | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |

*Source: CSTEP Analysis*

## Potential Reuse of Treated Effluent

Based on the output quality calculated, various reuse options for the treated water (for each city) are listed in Table 3.11. For all cities, further treatment would increase the potential for reuse of the effluent. The reuse options are recommended as per the standards met by the output water quality, as mentioned in Annexure II (G).

Table 3.11: Reuse options for the four cities

| **Kolar** | |
|---|---|
| **FSSM Scenario** | **Networked Scenario** |
| *Direct use - The quality of the treated wastewater is suitable for the following use directly* | |
| • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in agriculture | • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Use in agriculture |
| *Requires additional treatment before use - The quality of the treated wastewater is suitable for the following use with suggested advanced wastewater treatment* | |
| • Discharge into water bodies<br>• Use as cooling water for industries<br>• Use in petroleum and coal industry | • Use in petroleum and coal industry<br>• Use in pulp and paper industry |
| **Raichur** | |
| **FSSM Scenario** | **Networked Scenario** |
| *Direct use - The quality of the treated wastewater is suitable for the following use directly* | |
| • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Discharge into water bodies<br>• Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in agriculture | • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Use in agriculture |
| *Requires additional treatment before use - The quality of the treated wastewater is suitable for the following use with suggested advanced wastewater treatment* | |
| • Use as cooling water for industries<br>• Use in petroleum and coal industry<br>• Use in textile industry | • Discharge into water bodies<br>• Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in petroleum and coal industry |
| **Chitradurga** | |
| **FSSM Scenario** | **Networked Scenario** |
| *Direct use - The quality of the treated wastewater is suitable for the following use directly* | |

| | |
|---|---|
| • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Discharged into water bodies<br><br>• Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in agriculture | • Disposal into public sewers<br>• Disposal onto land for irrigation<br><br>• Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in agriculture |
| *Requires additional treatment before use - The quality of the treated wastewater is suitable for the following use with suggested advanced wastewater treatment* | |
| • Use in textile industry<br>• Use in petroleum and coal industry<br>• Use in pulp and paper industry | • Discharge into water bodies<br>• Use in petroleum and coal industry<br>• Use in pulp and paper industry |
| **Udupi** | |
| **FSSM Scenario** | **Networked Scenario** |
| *Direct use - The quality of the treated wastewater is suitable for the following use directly* | |
| • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in agriculture | • Disposal into public sewers<br>• Disposal onto land for irrigation<br>• Use in agriculture |
| *Requires additional treatment before use - The quality of the treated wastewater is suitable for the following use with suggested advanced wastewater treatment* | |
| • Use in textile industry<br>• Discharge into water bodies<br>• Use as cooling water for industries | • Use in the construction industry for soil compaction, dust control or as washing aggregate<br>• Use in petroleum and coal industry<br>• Use in pulp and paper industry |

*Source: CSTEP Analysis*

The recommended additional treatments for the aforementioned uses are given below:

Table 3.12: Type of additional treatment

| Type of Use | Additional Treatment Required | Form of Additional Treatment |
|---|---|---|
| Discharge into water bodies | Total Suspended Solids | • Coagulation and flocculation |
| Use as cooling water for industries | Chlorine | • Adsorption<br>• UV De-chlorination<br>• Chemical removal |
| | Silica | • Ion exchange<br>• Electrocoagulation<br>• Hollow-fibre tight ultrafiltration |
| Use in petroleum and coal industry | Alkalinity ($CaCO_3$) | • Reverse Osmosis (RO)<br>• Use of Chloride Anion Dealkalisers<br>• Use of Split Stream Dealkalisation |
| Use in pulp and paper industry | Alkalinity ($CaCO_3$) | • Reverse Osmosis<br>• Use of Chloride Anion Dealkalisers<br>• Use of Split Stream Dealkalisation |

| Type of Use | Additional Treatment Required | Form of Additional Treatment |
|---|---|---|
| | Hardness | • Nano-filtration<br>• Membrane filtration – RO<br>• Lime softening |
| Use in textile industry | Total Dissolved Solids and Hardness | • Nano-filtration<br>• Membrane filtration – RO<br>• Lime softening |
| Use in the construction industry for soil compaction, dust control or as washing aggregate | Phosphorus | • Chemical precipitation<br>• Assimilation<br>• Enhanced biological phosphorus removal (EBPR) |

*Source: CSTEP Analysis*

### 3.10.3 Findings and Discussion

The pre-feasibility assessments in all four cities depict a similar story. FSSM is observably cheaper (in terms of both capital and operation costs) and less resource-intensive, in all four contexts. The effluent from FSSM is also estimated to be of a better quality. However, in terms of suitability of the systems, a few key considerations must be kept in mind:

- Since FSSM systems cater only to the highly concentrated effluent from On-Site Sanitation Systems, there will still be a requirement to treat grey water at the city level. Thus, in the case of FSSM systems, cities may incur an additional cost of installing and operating a wastewater management system.
- The total cost of installing a system may not be incurred by the ULB alone. In the case of FSSM systems, the bulk of the cost goes into building toilets and storage options; the burden of constructing and maintaining the infrastructure is thus shared with the community.
- Since the operating ratio in the case of FSSM systems is higher, the chances of cost recovery are higher. In absolute numbers, however, the volume of treated water received from networked systems is much higher.
- There is a possibility of greater resource recovery through the sale of treated faecal sludge, which has many potential uses (such as fuel and fertiliser). However, given the stigma associated with handling human excreta, considerable community buy-in must be earned before these options can be rolled out effectively.
- For all cities, the responsibility of additional treatment (Table 3.12), if required, may be borne either by the ULB or the industry/buyer purchasing the treated water, depending on their demand.

### 3.10.4 Conclusion and Recommendations

The conclusion and key recommendations based on the findings are as follows:

- When choosing the appropriate sanitation systems, decision makers should consider all forms of domestic liquid waste, including but not limited to greywater, septage, faecal-sludge, blackwater, etc. Therefore, the integrated urban water management plan (as proposed by UWWR policy) should be aligned to the CSP.
- The role of the community should be clearly articulated across all sections of the CSP. This is because the community is not just a user or an end-point; rather, it comprises the stakeholders who will be involved either directly or indirectly in the implementation and maintenance of the sanitation infrastructure.
- The eventual use of the treated water should be determined taking into account local conditions such as water stress in the area, industries and agricultural lands nearby and acceptability by the citizens.
- To maximise the reuse potential from the sanitation sector, cities should inculcate the concept of circular economy into their water/wastewater management plans. Ultimately, for the efficient operation of water supply and sanitation in a city, all plans pertaining to these sectors as well as to land-use and city development must be harmonised.

# 4. Introducing Electric Vehicles in Urban Transport in Karnataka

## 4.1 Background

Indian cities are witnessing an increasing trend in motorisation. With higher travel demand in cities, the ownership of vehicles and per capita trip rate (PCTR) are on the rise. Karnataka is one of the top states in India with respect to the number of registered motorised vehicles (Ministry of Statistics and Programme Implementation, 2016) . Although vehicular emissions are not the only source of air pollution, the transport sector has been identified as a significant contributor, hence a key area of concern (Bhavnani, Shekhar, & Sharma, 2018). Higher consumption of oil by the urban transport sector deteriorates air quality and affects the quality of life and health of citizens. There have been efforts to promote public transport (PT) and non-motorised transport (NMT), as advocated by the National Urban Transport Policy (NUTP). However, increased travel demand and income levels in the cities have created a trend of people opting for personalised vehicles (PVs), and various modes of intermediate public transport (IPT) such as auto rickshaws and radio taxis.

Efforts are being made at the national level to promote the use of alternate fuels, and clean and low-carbon transportation, to control and reduce emissions. Karnataka was the first Indian state to launch a policy on electric vehicles (EVs), titled 'Electric Vehicle and Energy Storage Policy' in 2017 (henceforth referred to as the EV policy). The policy suggests the creation of an enabling environment for the promotion of the EV sector, in the state. The policy covers all elements of the EV business like EV manufacturing, charging infrastructure development, consumers demand incentives, etc. that will aid to promote the EV sector in the state. The adoption of EVs will help reduce oil consumption, thereby reducing the emission of carbon dioxide ($CO_2$) and other pollutants.

In this context, the purpose of this study was to suggest strategies for introducing EVs in suitable modes, as a low-carbon transportation option for different categories of cities. The study also takes into consideration the recommendations made by the National Electric Mobility Management Plan (NEMMP) 2020, City Traffic and Transportation Plans (CTTPs) and City Mobility Plans (CMPs) available for cities in Karnataka.

The next section of this chapter gives a broad overview of the urban transport situation in Karnataka, its impact on the environment, and the present policy and regulatory scenario. This is followed by a description of the methodology adopted for this study, analyses done, findings and discussion, and lastly the conclusion and recommendations.

## 4.2 Analysis of the Existing Transport Scenario

### 4.2.1 Vehicle Growth and Its Impact on the Environment

As per the latest statistics of vehicle registration in the state, the total number of vehicles in Karnataka is around 1.7 million, with an annual increase of 9.69% (Transport Department, 2016). Out of the total registered vehicles, two-wheelers account for about 70% of the vehicular composition. With a rapidly growing automobile market and rising per capita income in the state[30], the increase in the share of PVs is persistent.

Statistics from the Central Pollution Control Board (Central Pollution Control Board, 2014) show that many cities in India exceeded the permissible levels of $CO_2$ emissions in 2012. Another study indicated that the share of retail diesel consumption, in the transport and non-transport sectors in Karnataka, were 76% and 24%, respectively (Nielsen, 2013). The share of oil consumption by vehicle and fuel type, in 2012–13, is shown in Table 4.1.

Table 4.1: Share of diesel and petrol consumption by vehicle type in Karnataka (2012-13)

| Vehicle type | Share of diesel consumption in Karnataka | Vehicle type | Share of petrol consumption in Karnataka |
|---|---|---|---|
| Three-wheelers | 5.92% | Three-wheelers | 5.15% |
| Cars and Utility Vehicles (UVs) (Private) | 18.62% | Cars | 29.24% |
| Cars and UVs (Commercial) | 9.87% | UVs | 4.73% |
| Heavy Commercial Vehicles (HCVs)/Light Commercial Vehicles (LCVs)/Buses | 42.02% | Two-wheelers | 59.81% |
| | | Others | 1.07% |

*Source: Report on All India Study on Sectoral Demand of Diesel & Petrol, Nielsen, 2013*

Table 4.1 shows that HCVs/ LCVs/ Buses consumed the maximum amount of diesel, followed by private cars and UVs. Diesel consumption by buses was significantly high. Two-wheelers were the largest consumers of petrol. The consumption of petrol by cars and UVs in Karnataka were slightly higher than the average consumption levels in the southern states[31].

[30] Per capita income in the state has increased by 10.9% (from INR 1,57,436 in 2016-17 to INR 1,74,551 in 2017-18) (Department of Planning, Programme Monitoring and Statistics, 2017).
[31] The southern states include Kerala, Tamil Nadu, Andhra Pradesh, Telangana and Karnataka.

Commonly occurring air pollutants from the road transport sector include significant quantities of $CO_2$, and smaller quantities of other pollutants such as Particulate Matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SOx), etc. The road transport sector of Karnataka contributed 15.09 Tg[32] of $CO_2$ emissions in 2003-2004 (Ramachandra & Shwetmala, 2009). The composition of the emissions commonly varies with the type of vehicle, their efficiency, and the type of fuel consumed. The growth in number of vehicles in Karnataka, and India as a whole, is set to intensify the demand for oil, and subsequently increase the levels of $CO_2$ emissions.

### 4.2.2 Urban Mobility Plans

CTTPs and CMPs are urban mobility plans prepared for a 20-year period. Till date, 14 cities in Karnataka[33] have developed their own urban transport plans [Refer Annexure III (A)]. The plans focus on developing equitable and cost effective transportation solutions, following a methodology, which is aligned with the NUTP recommendations. The plans suggest various strategies and proposals for the improvement of the urban transport situation, while catering to increased demand. Three types of scenarios are discussed in the CTTPs and CMPs of the 14 cities in Karnataka, for 2031. These are: a) business as usual scenario; b) highway network improvement scenario; and c) highway network improvement and bus augmentation scenario. A review of the recommendations by the CTTPs and CMPs for Karnataka’s cities reveals an emphasis on the development of NMT and pedestrian facilities, along with the promotion of PT systems. At present, the CTTPs and CMPs are the most reliable data sources for city level mobility situations; they provide guidance to city authorities for implementing sustainable urban transport strategies.

### 4.2.3 Status of Urban Mobility Indicators

The figures provided in this section represent the status of key urban mobility indicators, such as mode share, trip length and trip rate. The sources of this data are the CTTPs and CMPs prepared in 2009 and 2011. It is to be noted that Bengaluru has been excluded from this analysis. Being the largest city in the state, the indicators for Bengaluru, when compared with

[32] Greenhouse gas emission records are expressed as teragrams of $CO_2$ equivalent (Tg of $CO_2$). One teragram is equal to 1012 grams or one million metric tons.
[33] Belgaum, Bellary, Bengaluru, Mangalore, Mysore, Gulbarga, Hubli-Dharward, Bidar, Bijapur, Chitradurga, Davanagere, Shimoga, Tumkur and Udupi.

other cities in Karnataka show substantial difference. Hence, Bengaluru's data could impact the state average and skew it.

Mode Share[34]: In 11 Karnataka cities, two-wheelers accounted for the highest share in motorised mode, followed by PT (buses) and IPT (auto rickshaws) (refer Figure 4.1)


Figure 4.1: Mode share in Karnataka cities (in 2009, 2011)

*Source: CSTEP analysis based on Comprehensive Traffic and Transport Plans and City Mobility Plans*

Trip Length[35]: The average motorised trip length, in 11 Karnataka cities, was 4.90 km. PT trips travel up to 5.90 km, followed by four-wheelers at 5.09 km. Two-wheelers and IPT trips travel up to 4.32 km and 4.29 km, respectively (refer Figure 4.2).

[34] Mode share or modal split is the process of separating passenger trips by the mode of travel. It is usually expressed as a fraction, ratio or percentage of the total number of trips (L.R Kadiyali, 2008).
[35] Trip length is defined as the length of a trip measured in distance (Texas Department of Transportation, 2013).

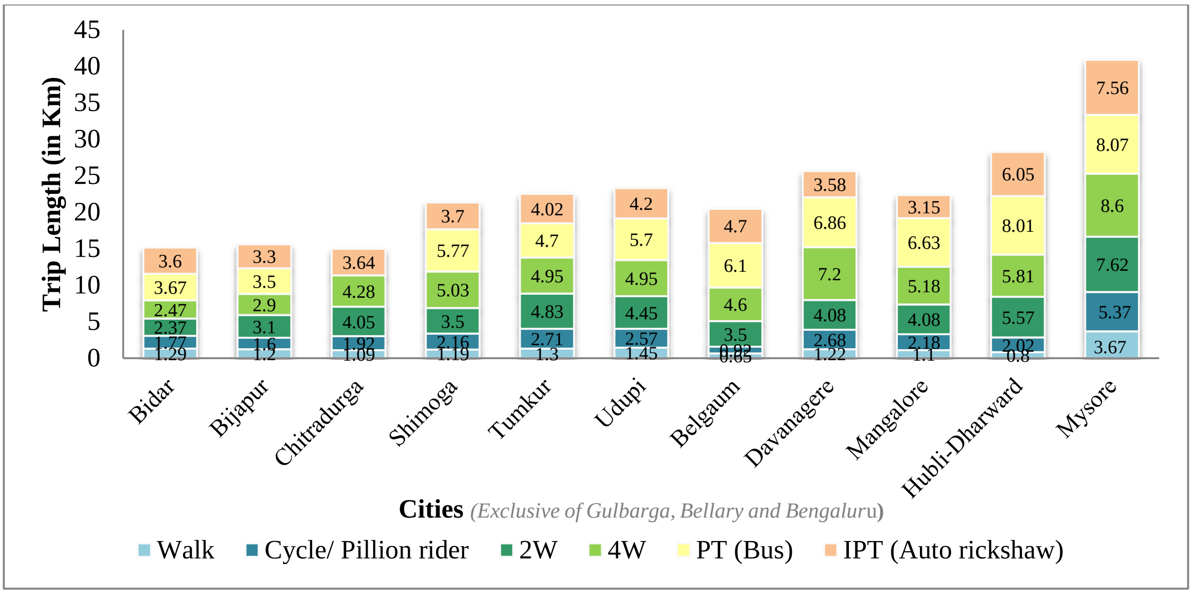



Figure 4.2: Trip lengths in Karnataka cities (in 2009, 2011)

*Source: CSTEP analysis based on Comprehensive Traffic and Transport Plans and City Mobility Plans*

Trip Rates[36]: The average Per Capita Trip Rate (PCTR) in 13 Karnataka cities was 0.99 and the Motorised Per Capita Trip Rate (MPCTR) was 0.72. Emerging cities like Belgaum, Hubli-Dharward and Mysore had higher MPCTR as compared to the state average (refer Figure 4.3).

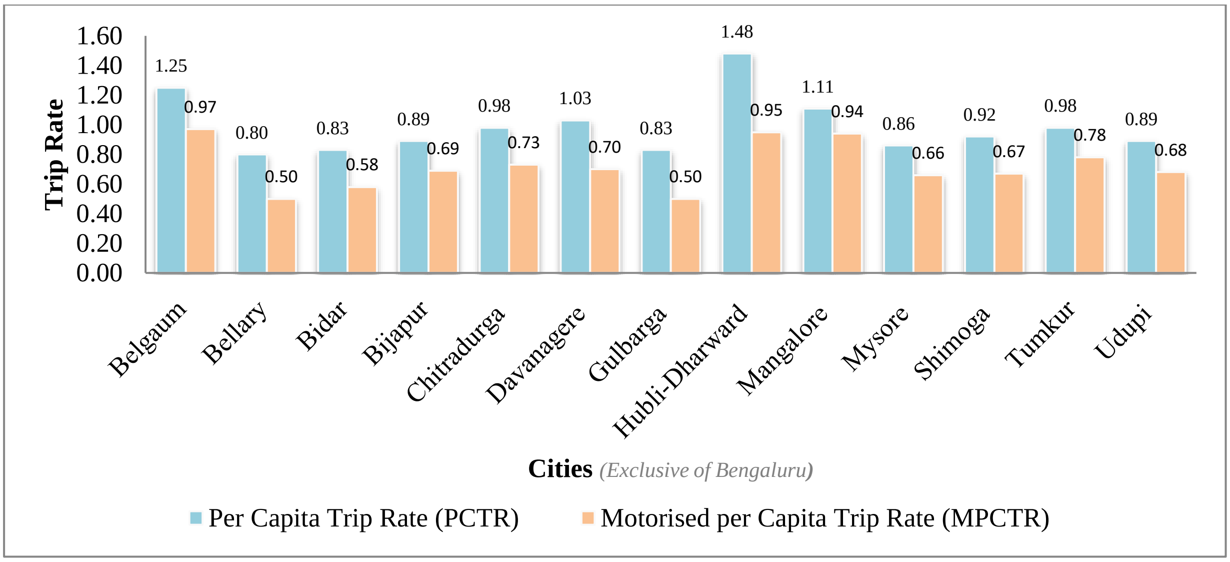



Figure 4.3: Trip rates in Karnataka cities (in 2009, 2011)

*Source: CSTEP analysis based on Comprehensive Traffic and Transport Plans and City Mobility Plans*

[36] Trip rate denotes the number of trips made by an individual in a given time period, usually considered on daily or peak hour basis (RITES, 2011). Trip rates are calculated as PCTR (which include walk and cycle trips along with motorised mode trips per person) and MPCTR (which considers only motorised trips per person).

### 4.2.4 Institutional Framework

This section gives an overview of the current policy landscape pertaining to the adoption of low-carbon transportation options, both at the national and state levels.

**National Policy Scenario**

National Electricity Mobility Mission Plan (NEMMP) 2020

The primary focus of the NEMMP, mandated in 2012, is on faster manufacturing and adoption of EVs in India. Three critical areas have been identified for intervention, namely in: a) demand incentives; b) supply-side incentives; and c) power and charging infrastructure. Additional essential factors considered in the Plan include research and skill development incentives. The Plan proposes a target of selling 5-7 million EVs by 2020, across various vehicle and technology segments (Department of Heavy Industries, 2012).

FAME India Scheme (Faster Adoption and Manufacturing of Electric Vehicles)

The FAME India Scheme, notified in 2015, aims to support the ecosystem of hybrid/electric vehicles, and promote the development and uptake of EVs. The Scheme targets all vehicle sizes and types (from hybrid to full electric), and covers four key focus areas, namely: a) technology development; b) demand creation; c) pilot project; and d) charging infrastructure. The cities covered under the Scheme include cities under the Smart Cities Mission, major metro cities, North-eastern states, and all cities with a population greater than 1 million. The demand incentives are based on a combination of battery type, fuel efficiency, and vehicle size (Department of Heavy Industries, 2015). Phase-I of the Scheme is extended till September 2018. A Phase-II of the Scheme is likely to focus on EVs in public transport and high speed two-wheelers (Vashisht, 2018) and (The Economic Times, 2018).

**State Policy Scenario**

Electric Vehicle and Energy Storage Policy 2030

The Government of Karnataka released the Electric Vehicle and Energy Storage Policy in 2017. The policy estimates that Karnataka will attract investments worth INR 31,000 crore and create around 55,000 employment opportunities in the EV sector.

The policy aims to:

- Lower pollution levels by reducing dependency on fossil fuels
- Develop EV manufacturing zones and charging stations in public and private spaces

- Develop business models to support economic applications for EVs.

The policy proposes the establishment of a Special Purpose Vehicle (SPV), involving stakeholders from the state transport and energy departments, industrial boards, civic agencies, private sector companies, etc. The policy's targets will be achieved by providing incentives, concessions, and special initiatives to manufactures, researchers and skill development professionals, to enable the growth of the EV manufacturing and infrastructure ecosystem (Government of Karnataka, 2017a).

**Agencies and Mandates**

The Directorate of Urban and Land Transport (DULT) is the assigned nodal agency for the planning and implementation of urban transport projects in the state. However, not all urban transport development projects are planned and undertaken by DULT. The State Transport Department is in-charge of issuing permits for taxis and auto rickshaws, and providing approvals for the fare structure of buses for the different state transport corporations. The State Transport Department is also equipping itself for the launch of e-rickshaws in Bengaluru (Mukherjee, 2017). The implementation of the EV Policy will require coordination between the urban local bodies (ULBs), DULT, transport department, and energy department (for the energy storage part) of the Government of Karnataka.

## 4.3 Problem Statement

There is at present no comprehensive strategic guidance for medium and small cities in Karnataka to implement the intent of the EV policy.

Bengaluru has been receiving importance under the low-carbon mobility initiatives, especially in the PT segment, amongst the various cities in Karnataka. However, the second tier cities, which are likely to experience steady population growth and mobility demand, need early intervention to enable the adoption of low-carbon transportation strategies. The EV policy creates the required regulatory environment for exploring EVs as a potential intervention across cities in the state. The CTTPs and CMPs were initiated in 2009–11, when EV-related discussions in India were in a nascent stage. Hence, these plans do not include any scenario with EVs in motorised mode, and do not assess their impact on emissions from the transport sector. Likewise, identifying the right strategy for EV penetration in the cities of Karnataka cannot adopt a one-size-fits-all approach.

## 4.4 Theory of Change

Growth in urbanisation and motorisation has drastically impacted fuel consumption and emission intensities. Conventional transportation modes have direct emissions, primarily $CO_2$ and greenhouse gases (GHGs) that are harmful to human health and the environment. Globally and nationally, low-carbon transportation has emerged as a key focus area in urban transport planning. In this context, EVs are emerging as a viable option for reducing the carbon footprint and emissions from the urban transport sector. EVs produce zero direct tailpipe emissions, as they do not emit 'exhaust gases' from the source of power (fuel). Even though some varieties of EVs use gasoline engines along with an electric motor, the emission levels are relatively lesser as compared to vehicles running on conventional fuel. Thus, a push towards the adoption of EVs provides cities with the right opportunity to shift towards clean and low-carbon transportation systems.

The EV policy creates the required stimulus for the adoption of EVs in Karnataka's cities. However, the implementation of this policy needs to take place in-line with the existing and planned mobility strategies. Identification of low-hanging options, which have a higher possibility of success, considering the current and emerging mode share, need to be considered.

## 4.5 Objective

The objective of the study was to suggest strategies for introducing EVs in suitable modes, for a set of emerging cities in Karnataka, in light of the EV Policy 2030.

## 4.6 Research Question

The following research question was examined for this part of the study:

1. What are the emerging primary mode(s) of transportation for different city categories where penetration of EVs should be prioritised based on impact on $CO_2$ emissions?

## 4.7 Research Design

Figure 4.4 presents the broad steps undertaken for examining the research question, mentioned above.

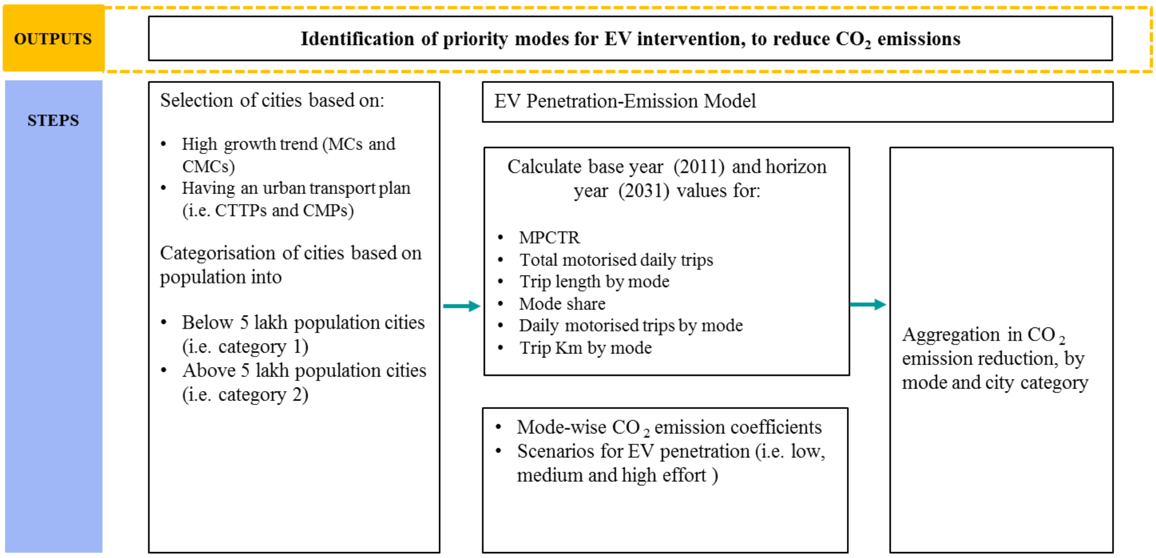



Figure 4.4: Research design for urban transport

*Source: CSTEP*

Based on the research design illustrated above, a methodology for calculating emissions for different scenarios of EV penetration in different categories of cities was developed. The detailed methodology, analysis and findings are discussed in the following sections.

## 4.8 Identify Emerging Primary Mode(s) where Penetration of EVs should be Prioritised

### 4.8.1 Methodology

The methodology followed for identifying the emerging primary mode(s) of transportation for different city categories, where the penetration of EVs should be prioritised, based on impact on $CO_2$ emissions, is described below.

### Step 1: Selection and Categorisation of Cities

The 13 cities[37] considered in this study for calculation and consolidation of data are either Municipal Corporations (MCs) or City Municipal Councils (CMCs). The 13 cities have been categorised into two groups, as mentioned in Table 4.2. All the analyses presented in the report are based on the aggregated analysis conducted for these two categories of cities.

Table 4.2: Categories and names of cities considered for analysis

| City category | Number of cities having CTTPs or CMPs |
|---|---|
| City Category 1:<br>Below 5 lakh population | 7 cities<br>(Bidar, Bijapur, Bellary, Chitradurga, Shimoga, Tumkur and Udupi) |
| City Category 2:<br>Above 5 lakh population | 6 cities<br>(Belgaum, Davanagere, Mangalore, Mysore, Gulbarga, Hubli-Dharward) |

*Source: CSTEP*

### Step 2: Development of EV Penetration-Emission Model

An *EV Penetration-Emission Model* has been developed for the two categories of cities considered in the study. The base year considered is 2011 and the horizon year is 2031. The model assesses $CO_2$ emissions from various motorised modes, based on different scenarios of EV penetration. The flow of the model is shown in Figure 4.5.

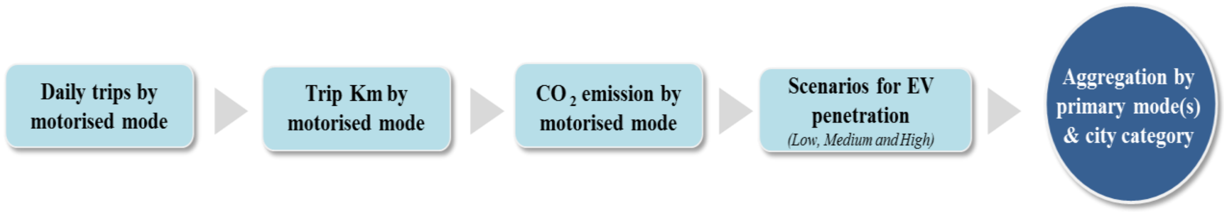



Figure 4.5: EV penetration-emission model flow

*Source: CSTEP*

The input-output parameters considered in the model are given in Table 4.3. The calculations and assumptions, for the factors specified in Table 4.3, are given in Annexure III (B).

[37] In Karnataka, till date, 14 cities have developed their own urban transport plans. There exists a significant difference between Bengaluru and other emerging cities, both in terms of population, and the complexity of the urban mobility situation. Also, Bengaluru has parallel on-going initiatives for the adoption of EVs. Hence, Bengaluru has not been considered for the analysis and results presented in this report.

Table 4.3: EV penetration-emission model, input-output parameters

| Input | Calculation | Output |
|---|---|---|
| Population<br>Motorised Per Capita Trip Rate (MPCTR) | = Population * MPCTR | Daily motorised trips (in million) |
| Daily motorised trips<br>Mode share | = Daily motorised trips *Mode share | Mode-wise daily motorised trips (in million) |
| Mode-wise daily motorised trips<br>Trip length by mode | = Mode-wise daily motorised trips * Trip length by mode | Trip km by motorised mode [38] (in million passenger kilometres[pkm]) |
| Trip km by motorised mode<br>Factor of $CO_2$ emission (in g/pkm) | = Trip km by motorised mode * Factor of $CO_2$ emission (in g/pkm) | Total and motorised mode wise $CO_2$ emission (in tonne) |
| Mode share<br>EV penetration percentage w.r.t to low, medium and high effort scenarios | = Mode share * respective mode wise EV penetration percentage | Total and mode wise $CO_2$ emission w.r.t the scenarios (in tonne) |

*Source: CSTEP analysis based on the 'Study on Traffic and Transportation Policies and Strategies in Urban Areas in India', Wilbur Smith Associates (Ministry of Urban Development, MoUD 2008)*

Assumptions for $CO_2$ Emission Factor and Fuel Type

The $CO_2$ emission factors (measured in grams per passenger kilometre [g/pkm])[39] considered in this study for motorised modes of transport are based on the reports published by the (The Automotive Research Association of India (ARAI), 2008) and (The Energy and Resource Institute (TERI), 2012). The fuel types considered in the model for various motorised modes, and the emission factors considered for each of the modes, are provided in Table 4.4.

Table 4.4: Motorised modes, fuel type, and $CO_2$ emission factor

| Motorised Mode | Two-wheelers | Four-wheelers | PT (Bus) | IPT (Auto rickshaws) |
|---|---|---|---|---|
| Fuel Type | Petrol | Petrol<br>Diesel | Diesel | Compressed Natural Gas (CNG) |
| Emission Factor (g/pkm) | 36.5 | 146.00 (Petrol)<br>188.60 (Diesel) | 17.2 | 89.27[40] |

*Source: CSTEP analysis based on, 'Life Cycle Analysis of Transport Modes' report by TERI (2012) and ARAI standards (2008)*

[38] Trip km by modes is the respective total trip km travelled by a defined mode of transport (i.e. Trip km by mode = Mode-wise daily motorised trips x Trip length by mode) and is expressed in passenger km.
[39] The $CO_2$ emission factor for various modes is based on the passenger occupancy of each mode.
[40] The $CO_2$ emission factor of auto rickshaws is 2.45 times that of two-wheelers, based on specific $CO_2$ emission factors by ARAI The $CO_2$ emission coefficient value for CNG auto rickshaws is considered based on average emissions across different types of two-wheelers and three-wheelers (auto rickshaws).

## Step 3: Scenario Development

The model assesses the reduction in $CO_2$ emissions by 2031 for the two categories of cities under different EV penetration scenarios. EV scenarios were applied against two different mode share scenarios for 2031. Four major scenarios of EV penetration have been considered, as described below.

1. *Do-nothing* scenario: This scenario calculates the $CO_2$ emissions from all motorised modes, based on an average projected mode share, with no EV-based interventions.
2. *Low-effort* scenario: This scenario considers a certain amount of EV penetration (percentage) in each mode, which can be achieved through low-effort interventions, considering the current level of preparedness of cities and the EV ecosystem.
3. *Medium-effort* scenario: This scenario considers a certain amount of EV penetration (percentage) in each mode, which is likely to be achieved through medium-level intervention efforts.
4. *High-effort* scenario: This scenario considers a certain amount of EV penetration (percentage) for each mode, which will require a high degree of effort.

EV Penetration Percentages considered for developing $CO_2$ Emission Scenarios for 2031

The specific EV penetration percentages considered for each mode under each scenario is shown in Table 4.5. These have been arrived at based on literature review and case studies available in both the Indian and global contexts [refer Annexure III (C)].

It is to be noted that the EV penetration percentages considered for different modes are different under the same scenario. This is because each mode is differently positioned to receive EV-related interventions, considering the current policy ecosystem, technology and infrastructure availability, and ease of adoption. For example, a high EV penetration share in the IPT mode could actually mean a higher percentage value as compared to a high EV penetration share in PTs.

Table 4.5: Mode-wise EV penetration (percentage) considered in different scenarios

| Scenario | Projected mode share (2031) as per CTTP/CMP scenario | EV penetration rate |
|---|---|---|
| **Scenario 1: Do nothing** | | |
| 1a | CTTPs/CMPs moderate-case | 2W - 0%, 4W (Pvt. Car) - 0%, PT (Bus) - 0%, IPT (Auto rickshaw) - 0% |
| 1b | CTTPs/CMPs best-case | |

| Scenario | Projected mode share (2031) as per CTTP/CMP scenario | EV penetration rate |
|---|---|---|
| **Scenario 2: Low-effort scenario** | | |
| 2a | CTTPs/CMPs moderate-case | 2W - 5%, 4W (Pvt. Car) - 5%, PT (Bus) - 1%, IPT (Auto rickshaw) - 25% |
| 2b | CTTPs/CMPs best-case | |
| **Scenario 3: Medium-effort scenario** | | |
| 3a | CTTPs/CMPs moderate-case | 2W - 15%, 4W (Pvt. Car) -15%, PT (Bus) - 05%, IPT (Auto rickshaw) - 50% |
| 3b | CTTPs/CMPs best-case | |
| **Scenario 4: High-effort scenario** | | |
| 4a | CTTPs/CMPs moderate-case | 2W - 35%, 4W (Pvt. Car) - 20%, PT (Bus) - 20%, IPT (Auto rickshaw) - 100% |
| 4b | CTTPs/CMPs best-case | |

*Source: CSTEP*

Mode Shares considered for 2031[41]

The CTTPs and CMPs suggest mode shares for cities, for two primary scenarios: a) Business as Usual (BAU); and b) best case scenario. However, it is likely that many cities will not be able to achieve the best case scenario's mode share by 2031. Hence, a moderate mode share, between BAU and best case scenario's mode shares, has been calculated for this study. Table 4.6 summarises the mode shares considered for developing the scenarios under this study.

Table 4.6: Estimated mode share for base year (2011) and horizon year (2031)[42]

| **2011 mode share** | | | | |
|---|---|---|---|---|
| City Category | 2W | 4W (Pvt. Car) | PT (Bus) | IPT (Auto rickshaw) |
| City Category-1 | 55% | 11% | 08% | 26% |
| City Category-2 | 42% | 10% | 22% | 26% |
| **2031 mode share: CTTPs /CMPs moderate case** | | | | |
| City Category-1 | 54% | 11% | 15% | 20% |
| City Category-2 | 35% | 09% | 27% | 29% |
| **2031 mode share: CTTPs/ CMPs best case** | | | | |
| City Category-1 | 50% | 11% | 24% | 15% |
| City Category-2 | 27% | 06% | 41% | 26% |

*Source: CSTEP analysis*

[41] A BAU mode share based on the base year's (2011) trend has not been considered for developing the penetration-emission scenarios. This is because it was considered that the cities will adopt some of the proposed interventions by the CTTPs and CMPs towards improving their mobility conditions, if not all.
[42] The CTTPs and CMPs were initiated in 2009–11, when the EV related discussions in India were in the nascent stage. Hence, these plans do not include mode share estimates with EV penetration.

Trip Lengths considered for 2031

The trip lengths estimated in this study denote the average length of trips covered by motorised modes (in distance) in a city. The rate of increase in trip lengths (decadal 18% increase) from 2011 to 2031 (considered for this study) is based on a published report titled 'Study on Traffic and Transportation Policies and Strategies in Urban Areas in India' (Wilbur Smith Associates, 2008). Table 4.7 indicates the average trip lengths in the base year (2011) and estimates for the horizon year (2031), for the two categories of cities addressed in this study.

Table 4.7: Estimated trip length for base year (2011) and horizon year (2031)

| City category | | Walk | Cycle | 2W | 4W (Pvt. Car) | PT (Bus) | IPT (Auto rickshaw) | Avg. Trip length |
|---|---|---|---|---|---|---|---|---|
| Base year 2011 | City Category-1 | 1.25 | 2.12 | 3.71 | 4.13 | 4.17 | 3.53 | 3.15 |
| | City Category-2 | 1.49 | 2.63 | 4.92 | 6.18 | 7.05 | 4.87 | 4.52 |
| Horizon year 2031 | City Category-1 | 1.59 | 2.69 | 4.71 | 5.24 | 5.29 | 4.48 | 4.00 |
| | City Category-2 | 1.84 | 3.26 | 6.10 | 7.65 | 8.73 | 6.03 | 5.60 |

*Source: CSTEP analysis*

### 4.8.2 Data Collection and Analysis

Data was collected through a detailed review of secondary literature, obtained from various published documents like CTTPs, CMPs, ARAI standards, and a report titled 'Life Cycle Analysis of Transport Modes' by The Energy Resource Institute ( TERI, 2012). The sources from which data was collected is summarised in Table 4.8

Table 4.8: Data sources

| Sl. No | Data point | Source |
|---|---|---|
| 1 | Population of study area (Local Planning Area) | • CTTPs and CMPs |
| 2 | Motorised per capita trip rate (MPCTR) | • CTTPs and CMPs |
| 3 | Trip lengths | • CTTPs and CMPs (for base year 2011)<br>• Study on 'Traffic and Transportation Policies and Strategies in Urban Areas in India' (for horizon year 2031) |
| 4 | Mode share | • CTTPs and CMPs |
| 6 | $CO_2$ emission coefficients | • Report on 'Life Cycle Analysis of Transport Modes'<br>• ARAI standards |

*Source: CSTEP*

As per the methodology described in the previous section, the $CO_2$ emissions for 2031 (horizon year), under different EV penetration scenarios, in different modes, for each of the two city categories were examined.

Based on the EV penetration percentages considered for various motorised modes (as mentioned in Table 4.5 ), the $CO_2$ emissions from each mode, under each of the scenarios, have been calculated for 2031. The emission values for low, medium and high-effort scenarios were then compared with that of the Do-nothing scenario, to arrive at the $CO_2$ emission reductions, in tonnes per mode. The total reduction in $CO_2$ emissions were calculated for CTTPs/CMPs moderate case and CTTPs/CMPs best case mode share scenarios, for 2031.

**Reduction in $CO_2$ Emissions under the EV Scenarios for Category 1 Cities**

In all three EV penetration scenarios, PVs and IPTs are the highest contributors of $CO_2$ emissions from the urban transport sector. Based on EV penetration (percentages) scenarios, IPTs show a higher reduction in $CO_2$ emissions as compared to other modes, for both mode-share cases (refer Table 4.9). The PV segment, specifically two-wheelers, emerges as the next potential segment which can contribute substantially to $CO_2$ emission reduction through EV penetration.

Table 4.9: Mode-wise $CO_2$ emissions and $CO_2$ reduction under different scenarios for category 1 cities in CTTPs/CMPs moderate and best case mode share (2031)

| Category-1 (below 5 lakh population cities) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTTPs/CMPs moderate-case mode share | | | | | | CTTPs/CMPs best-case mode share | | | | | |
| | 2W (Petrol) | 4W (Petrol ) | 4W (Diesel) | PT (Bus) | IPT (Auto) | Total | 2W (Petrol) | 4W (Petrol ) | 4W (Diesel) | PT (Bus) | IPT (Auto) | Total |
| Do nothing scenario | 317.64 | 226.91 | 87.56 | 46.47 | 264.04 | 942.63 | 295.51 | 212.47 | 81.98 | 73.82 | 205.09 | 868.88 |
| Low effort scenario | 301.76 | 215.57 | 83.18 | 46.01 | 198.03 | 844.54 | 280.74 | 201.85 | 77.88 | 73.08 | 153.82 | 787.37 |
| Medium effort scenario | 270.00 | 192.87 | 74.42 | 44.15 | 132.02 | 713.46 | 251.19 | 180.60 | 69.69 | 70.13 | 102.55 | 674.15 |
| High effort scenario | 206.47 | 181.53 | 70.04 | 37.18 | 0.00 | 495.22 | 192.08 | 169.98 | 65.59 | 59.06 | 0.00 | 486.70 |
| **Mode wise CO2 emissions reduction (in tonne) w.r.t 'Do nothing' scenario** | | | | | | | | | | | | |
| Low effort scenario | 15.88 | 11.35 | 4.38 | 0.46 | 66.01 | 98.08 | 14.78 | 10.62 | 4.10 | 0.74 | 51.27 | 81.51 |
| Medium effort scenario | 47.65 | 34.04 | 13.13 | 2.32 | 132.02 | 229.16 | 44.33 | 31.87 | 12.30 | 3.69 | 102.55 | 194.73 |
| High effort scenario | 111.18 | 45.38 | 17.51 | 9.29 | 264.04 | 447.41 | 103.43 | 42.49 | 16.40 | 14.76 | 205.09 | 382.18 |

*Source: CSTEP analysis*

The total $CO_2$ emission reduction, for each EV penetration scenario, and for each of the considered mode share conditions (i.e. CTTPs/CMPs moderate case mode share and CTTPs/CMPs best case mode share), are shown in Figure 4.6.

In the *low-effort* scenario, the total amount of $CO_2$ emissions decreases by 10.39% (with a reduction of 98 tonnes) in the CTTPs/CMPs moderate case mode share and 9.44% (with a reduction of 82 tonnes) in the CTTPs/CMPs best case mode share.

In the *medium-effort* scenario, the total amount of $CO_2$ emissions decreases by 24.39% (with a reduction of 230 tonnes) in the CTTPs/CMPs moderate case mode share, and 22.44% (with a reduction of 195 tonnes) in the CTTPs/CMPs best case mode share.

In the *high-effort* scenario, the total amount of $CO_2$ emissions decreases by 47.51% (with a reduction of 448 tonnes) in the CTTPs/CMPs moderate case mode share, and 43.96% (with a reduction of 382 tonnes) in the CTTPs/CMPs best case mode share.

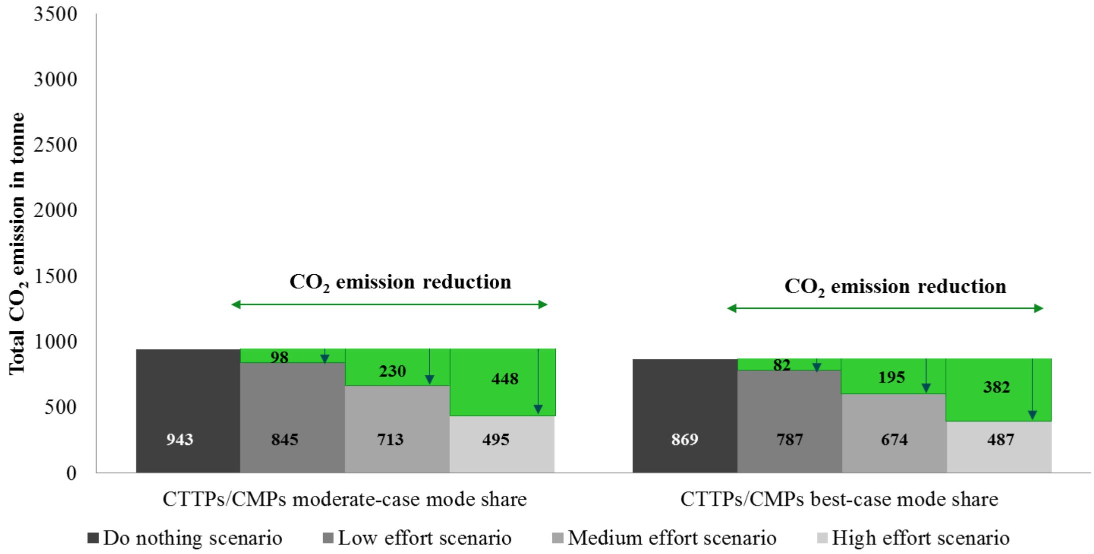



Figure 4.6: Total $CO_2$ emission and $CO_2$ reduction in different scenarios w.r.t the 'Do nothing scenario, for category 1 cities by 2031

*Source: CSTEP analysis*

### Reduction in $CO_2$ Emissions under the EV Scenarios for Category 2 Cities

In all three EV penetration scenarios, PVs and IPTs once again emerge as the highest contributors of $CO_2$ emissions from the urban transport sector. Based on the EV penetration scenarios (percentages), IPTs show a higher reduction in $CO_2$ emissions as compared to other modes, for both mode-share cases, as shown in Table 4.10. The PVs are the second potential segment, with both two-wheelers and four-wheelers, showing almost equal reduction in $CO_2$ emissions across the scenarios.

Table 4.10: Mode-wise $CO_2$ emissions and $CO_2$ reduction under different scenarios for category 2 cities in CTTPs/CMPs moderate and best case mode share (2031)

| Category-2 (above 5 lakh population cities) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mode wise CO2 emissions (in tonne)** | | | | | | | | | | | | |
| | CTTPs/CMPs moderate-case mode share | | | | | | CTTPs/CMPs best-case mode share | | | | | |
| | 2W (Petrol) | 4W (Petrol ) | 4W (Diesel) | PT (Bus) | IPT (Auto) | Total | 2W (Petrol) | 4W (Petrol ) | 4W (Diesel) | PT (Bus) | IPT (Auto) | Total |
| Do nothing scenario | 631.16 | 595.29 | 229.69 | 328.76 | 1226.36 | 3011.26 | 484.22 | 441.54 | 170.37 | 496.74 | 1075.75 | 2668.63 |
| Low effort scenario | 599.61 | 565.52 | 218.21 | 325.48 | 919.77 | 2628.58 | 460.01 | 419.47 | 161.85 | 491.77 | 806.81 | 2339.91 |
| Medium effort scenario | 536.49 | 505.99 | 195.24 | 312.32 | 613.18 | 2163.23 | 411.58 | 375.31 | 144.82 | 471.90 | 537.88 | 1941.49 |
| High effort scenario | 410.26 | 476.23 | 183.76 | 263.01 | 0.00 | 1333.25 | 314.74 | 353.24 | 136.30 | 397.39 | 0.00 | 1201.67 |
| **Mode wise CO2 emissions reduction (in tonne) w.r.t 'Do nothing' scenario** | | | | | | | | | | | | |
| Low effort scenario | 31.56 | 29.76 | 11.48 | 3.29 | 306.59 | 382.68 | 24.21 | 22.08 | 8.52 | 4.97 | 268.94 | 328.71 |
| Medium effort scenario | 94.67 | 89.29 | 34.45 | 16.44 | 613.18 | 848.04 | 72.63 | 66.23 | 25.56 | 24.84 | 537.88 | 727.13 |
| High effort scenario | 220.91 | 119.06 | 45.94 | 65.75 | 1226.36 | 1678.01 | 169.48 | 88.31 | 34.07 | 99.35 | 1075.75 | 1466.96 |

*Source: CSTEP analysis*

The total $CO_2$ emission reduction for each EV penetration scenario, and for each of the considered mode-share conditions (i.e. CTTPs/CMPs moderate-case mode share and CTTPs/ CMPs best-case mode share), are shown in Figure 4.7.

In the *low-effort* scenario, the total amount of $CO_2$ emissions decreases by 12.69% (with a reduction of 382 tonnes) in the CTTPs/CMPs moderate case mode share, and 12.33% (with a reduction of 329 tonnes) in the CTTPs/CMPs best case mode share.

In the *medium-effort* scenario, the total amount of $CO_2$ emissions decreases by 28.16% (with a reduction of 848 tonnes) in the CTTPs/CMPs moderate case mode share, and 27.28% (with a reduction of 728 tonnes) in the CTTPs/CMPs best case mode share.

In the *high-effort* scenario, the total amount of $CO_2$ emissions decreases by 55.73% (with a reduction of 1678 tonnes) in the CTTPs/CMPs moderate case mode share, and 54.96% (with a reduction of 1467 tonnes) in the CTTPs/CMPs best case mode share.

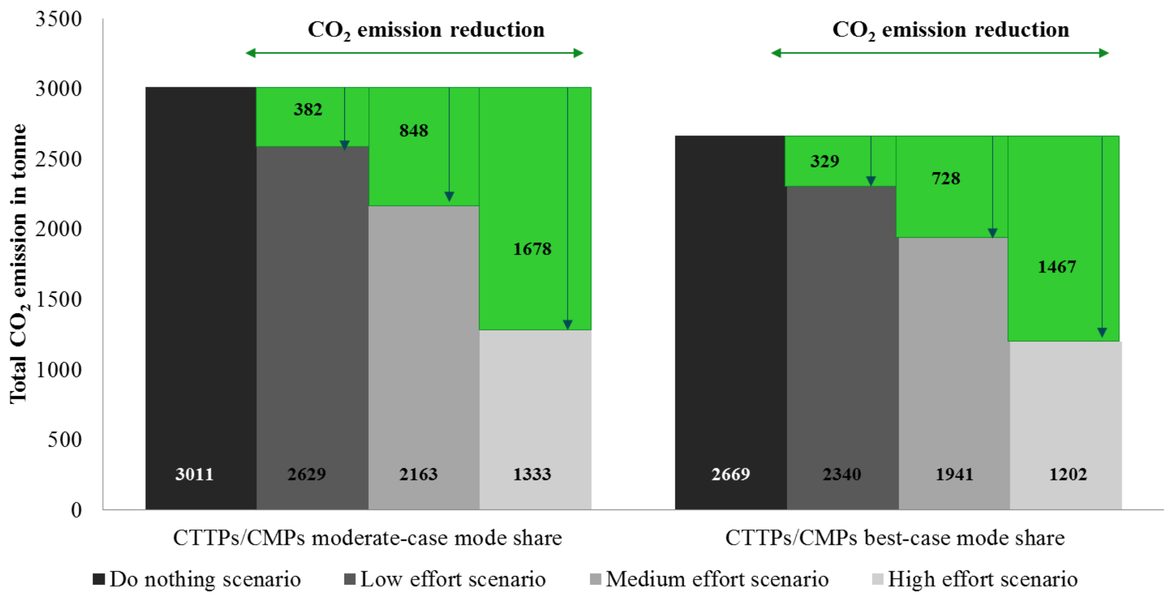



Figure 4.7: Total $CO_2$ emission and $CO_2$ reduction in different scenarios w.r.t the 'Do nothing scenario, for category 2 cities by 2031

*Source: CSTEP analysis*

### 4.8.3 Findings and Discussions

The analyses presented in the previous section reveal that in both categories of cities, PVs and IPTs are the highest contributors to the total $CO_2$ emissions from the urban transport sector. However, considering the percentage of EV penetration across motorised modes, and the relative reduction in $CO_2$ emissions, IPTs emerge as the most viable mode for EV intervention. Table 4.11 summarises the primary emerging mode(s) of EV penetration that shows reduction in $CO_2$ emissions across the three scenarios (i.e., low-effort, medium-effort and high-effort).

The PV segment, when considered together with both two-wheelers and four-wheelers, emerge as the second priority mode for EV intervention. It is to be noted that PTs are unlikely to have a significant impact on $CO_2$ emission reduction, in both categories of cities. This is due to an already lower $CO_2$ emission value per trip in both city categories.

Table 4.11: Primary emerging mode(s) across the scenarios

| Scenarios | Low-effort scenario | Medium-effort scenario | High-effort scenario |
|---|---|---|---|
| Category 1 cities<br>Category 2 cities | 1. IPT (Auto rickshaws)<br>2. PVs (Two-wheelers and four wheelers)<br>3. PT (Buses) | | |

*Source: CSTEP analysis*

The following section highlights the findings from the literature review on existing potential and drawbacks for EV penetration in different urban transport modes. This can suitably inform strategising for EV penetration in the urban transport sector, in Karnataka.

<u>Pricing, Infrastructure and Investment Requirement</u>

One of the larger deterrents to the adoption of EVs is the initial high purchase price. The initial costs offered by manufactures for e-buses lie anywhere in the price range of INR 1.5–3.0 crore (India Today, 2016) as compared to conventional diesel and CNG buses (A/C and non A/C) which fall in the price range of INR 0.30–0.85 crore (UIPT India). Similarly, the EV two-wheeler segment saw most of its sales in the price range of INR 35,000–60,000, which were low powered bikes of 250 watts, and minimal sales of higher powered bikes which cost about INR 80,000–90,000 (Bhavnani et al., 2018).The high cost of EVs is largely attributed to the imported vehicle components and large battery size. It is anticipated that retail sales of EVs (specifically in PVs) can increase only when the battery price comes down (Ernst & Young, 2015). Given the direct involvement of the government and state transport corporations, the PT sector is likely to get push towards adoption of EVs. However, the success of electrification in PT would require substantial capital investment and robust charging infrastructure.

<u>Technology Performance</u>

Apart from the high vehicle purchase price, technology performance plays an important role in the adoption of EVs. A study (Majumdar & Jash, 2015) on e-rickshaws in West Bengal identified that the maximum speed of e-rickshaws is 25 km/hr, as compared to 60 km/hr for a conventional auto rickshaw.

<u>Manufacturing Ecosystem</u>

Electrification in the PV and IPT segments would largely depend on the manufacturing ecosystem, along with vehicle purchase price. India has one of the largest e-rickshaw manufacturing markets, with more than 340 original equipment manufacturers (OEMs) as compared to the number of OEMs in the PV segment. Moreover, IPTs also have the benefit of independent assemblers (Ernst & Young, 2015) and have the opportunity to shift to pure EV technology (Society of Indian Automobile Manufactures, 2017). The two-wheeler segment has a large number of OEMs, as compared to a handful in the four-wheeler segment. Hence, the local production capacities of PVs are limited in comparison to electric IPTs (i.e. e-rickshaws) (Bhavnani et al., 2018).

### 4.8.4 Conclusion and Recommendation

The findings of this study recommend that the IPT segment be prioritised for EV penetration efforts in second tier Karnataka cities (i.e. 1–10 lakh population range). The section below briefly describes the measures [based on review of best case practices, which are mentioned in Annexure III (D)] that can be adopted to enable the IPT segment in Karnataka to transition into EV technologies.

1. Formalising electric IPT (i.e. e-rickshaws) as a paratransit mode to PT: Auto rickshaws, if regularised in terms of providing driving licenses and permits, route operations and management, have the potential to emerge as a viable paratransit mode to PT.

2. New and local technologies to reduce cost and increase efficiency: It is necessary to adopt measures, such as developing local and new technologies, to reduce the initial vehicle purchase cost and increase efficiency. Standardising manufacturing norms and encouraging local manufacturing are some ways to reduce the capital cost of vehicles. Additionally, enhancing technology related to the battery and management system (like battery swapping), and evaluation of mileage operation requirement per charge, would help in cost reduction and better performance.

3. Development of charging infrastructure: Charging infrastructure is a key element in the adoption of electric mobility. While provision of charging for PVs can be facilitated largely in public buildings, high-rise buildings, etc., development of common charging stations can be emphasised for IPTs. Common charging stations (such as in auto stands, existing fuel stations, markets, high activity zones and central business districts, etc.) provide better accessibility and can possibly reduce infrastructure costs.

4. Fiscal and non-fiscal incentive mechanisms: Apart from direct fiscal incentives (that are mentioned in the current EV policy and schemes), it is essential to consider indirect additional incentives that may not necessarily be monetary, but can stimulate buyers and manufactures. Some indirect incentives for the IPT segment can include exemption from emissions testing in the initial years, allotted public parking spaces, subsidised public charging availability, etc. that can assist in quicker adoption of electric IPTs.

Sustainable development of the urban transport sector in Karnataka will require interventions in both long-term strategic planning, as well as adoption of short-term measures at the city level. As the first state in India to draft its own EV policy, Karnataka is at present rightly positioned to create an enabling environment for the adoption of EVs in its cities. An early adoption of electric mobility in the identified emerging mode (i.e. IPT) and other primary modes (PVs and PT) can relatively be scaled-up to demonstrate significant reduction in $CO_2$ emission levels.

Along with electrification of motorised modes, promoting the use of NMT will add credibility to the state's decision to pursue low-carbon transportation options. Developing Public Bike Sharing systems in cities will provide commuting options which will help reduce the reliance on motorised modes.

Given the existing challenges, a systematic approach by different stakeholders to integrate viable options such as electrification of vehicles and non-motorised transport can help achieve low carbon urban mobility.

# 5. Sustainability Indicators for Urban Water, Sanitation and Transport

## 5.1 Background

One of the most critical issues cities are facing is to meet the goals of universal accessibility to urban services. This, coupled with enhanced concerns regarding depleting natural resources and impact of service delivery on natural ecosystem and urban finance, calls for regular assessment of baseline and initiate course correction as necessary. The role of carefully designed indicators, therefore, becomes important.

Assessment of municipal service sectors against indicators is not new in India. The Ministry of Housing and Urban Affairs (MoHUA) had introduced a series of Key Performance Indicators (KPIs) in 2008 with nationalised standards known as the Service Level Benchmarks (SLBs). Cities across India including Karnataka periodically report their performance against the KPIs. However, the KPIs in their present form are less effective in assessing all aspects of sustainable urban development enshrined in the Sustainable Development Goals (SDGs). In this contexts, this study aims to suggest a comprehensive set of performance indicators that can help cities measure a more realistic and comprehensive baseline in three sectors, i.e., water, sanitation and transport.

The sections following this introduction give the problem statement and the theory of change envisaged for this study. This is followed by a description of the analysis done under this study and the findings and recommendations emerging from the same.

## 5.2 Existing Situation Analysis

Currently, the KPIs mainly focus on measuring operational efficiency in service delivery. aspect. On analysing several indicator sets from various literature, it was found that in practice, indicators are often chosen based on ease of calculation and data availability. For example indicators such as energy consumption in water, sanitation etc., ecological footprint of a sector, etc. are usually left out. Often an indicator can be calculated in different ways which may lead to confusion and misinterpretation. These issues have also been encountered in the measurement of Service Level Benchmarks for Karnataka cities.

## 5.3 Problem Statement

The reported performance of cities across Karnataka in key service delivery sectors is not comprehensive enough to reflect realistic baselines across all pillars of sustainability. It is noted that the presently reported KPIs mainly focus on efficiency of operations and demand supply gap. Indicators such as equitable access to services, affordability, resource consumption and recovery are often left unexplored.

## 5.4 Theory of Change

The discourse of sustainable development calls for a shift from the current output oriented approach to one that gives importance to processes and outcomes of actions. Hence, cities in Karnataka need to baseline themselves against a set of indicators that are capable of identifying the trade-offs existing in different urban infrastructure and service delivery sectors. A robust and forward-looking set of indicators can also highlight the aspects which need better quality data.

## 5.5 Objective

The objective of the study is to suggest a set of indicators in urban water, sanitation and transport sectors that can be used to assess sustainability of these sectors.

## 5.6 Research Questions

What are the indicators and data points that can be used to assess environmental, social and economic sustainability in urban water, sanitation and transport sectors?

Figure 5.1 presents the broad steps undertaken for examining the research question mentioned above. The methodology, data collection and analysis pertaining research questions are presented in the following sections.

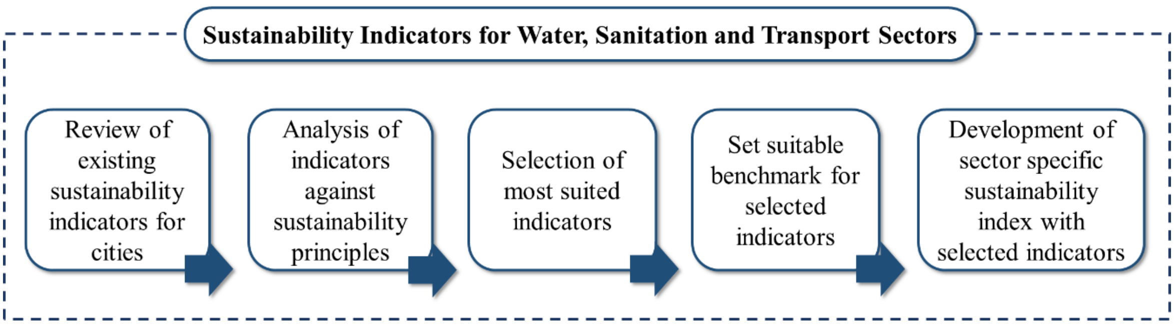



Figure 5.1: Research Design for sustainability indicators

*Source: CSTEP*

## 5.7 Methodology

This study proposes a Sustainability Index for the urban water, sanitation and transport sector, with a set of indicators cutting across the following four principles of sustainability (Bhattacharya et al., 2016). These are cross-cutting, with all the three pillars of sustainable development, i.e., environment, economy and society.

a) *Social Well-Being and Equity:* Overall sector performance, access to and coverage of services, and citizen perception are the three aspects used to assess the overall liveability condition of a city. This principle also assesses how inclusive a city is in providing for the well-being of its citizenry. Access and coverage of poor and participation status are the aspects considered to assess the equity conditions of a city.

b) *Environmental Efficiency:* The principle looks into the status of resource availability in the city, as well as the processes and institutions arranged to ensure sustainable resource optimisation.

c) *Economic Efficiency:* This principle looks into the processes and institutional arrangements required to ensure economic resource optimisation.

d) *Good Governance and Foresight:* Long term vision, robustness and capacity are the three aspects used to assess this principle. It indicates the commitment of a city to tackle future challenges and ensure sustainability as a long-term goal.

The following steps were followed in developing the sustainability index:

Step 1: Indicators have been collected for the sectors from different sources based on an in-depth literature survey, and further shortlisted to match either of the four principles mentioned above.

Step 2: Different ranges are created for each of the selected indicators based on the maximum and minimum values possible. Each range is given a score on a scale of 1–5.

Step 3: The benchmark for each indicator is defined based on literature survey and a benchmark score is suggested (refer Table 5.1).

Step 4: The indicator weightage, formulae for calculating indicator-wise score and a composite score for the sector is suggested further (refer Table 5.1). A tool for self-assessment of a composite sustainability index by cities is available in the following link (http://cstem.cstep.in/uoapp/#/state)

Table 5.1: Formulae for calculating indicator, benchmark and composite sector score

| Indicator | Range | Range Score | Indicator Weightage | Indicator Score for City | Benchmark Score |
|---|---|---|---|---|---|
| Indicator i (out of total indicators n) | Range 1 | 1 | 1/n | Range Score X Indicator Weightage | Benchmark Range Score X Indicator Weightage |
| | Range 2 | 2 | | | |
| | Range 3 | 3 | | | |
| | Range 4 | 4 | | | |
| | Range 5 | 5 | | | |
| Composite Sector Score = Indicator Score 1 + Indicator Score 2 + Indicator Score 3 +…………………. + Indicator Score n | | | | | |

*Source: CSTEP*

## 5.8 Data Collection and Analysis

A large set of national and global literature on sustainability indicators were collected and analysed to arrive at a comprehensive list of indicators for the three sectors (refer Annexure IV (A)). Two main categories of literature regarding urban sustainability indicators have been reviewed for this study, as described below.

The first category of literature examined different aspects of urban sustainability while identifying three dimensions to be considered in measuring urban sustainability. These include: urban quality (quality of urban environment), urban flows (flow of natural resources) and urban patterns (patterns of urban development). Moreover, this rich body of literature helped translate the overarching concept of sustainable development into more concrete principles discussed in the previous section.

The second category pertained to case studies and databases for design and application of indicators. The indicators were collected from different sources and range from global and national to more regional and city contexts.

Analyses of various existing indicators suggest that indicators for all the hard infrastructure sectors; i.e. water, sanitation and transport indicators behave in a similar way. In all the three sectors, efficiency in terms of service operations is the major focus area. However, limitations exist in measuring indicators for climate change, resource utilisation and recovery, ecological footprint, etc. This, in turn, limits the assessment of social equity, good governance and foresight at a city level.

## 5.9 Findings and Discussions

From the indicators analysed, a total of 76 indicators were selected for the water, sanitation and transport sector, which measure and assess the sector's situation in the city.

The suggested sustainability indicators for the urban sectors, along with data requirement, formulae for calculation, and benchmark values for each indicator are given in the tables below (refer Table 5.2, Table 5.3 and Table 5.4)

Table 5.2: *Sustainability indicators for water sector*

| Principle | Category | Indicator | | Formula | Ranges | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| **Social Well-being and Equity** | Access to water | 1 | Access to potable water supply within premises (total) | No. of HHs with piped water supply, bore wells, water tankers, others/ total number of Households (HH) * 100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 2 | Access to potable water supply within premises (slums) | No. of HHs with piped water supply, bore wells, water tankers, others/ total number of HH in slum areas* 100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Access to piped public water supply | 3 | Access to piped public water supply within premises (total) | (Number of HH provided with piped water supply/Total number of HH)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 4 | Access to piped public water supply within premises (slums) | (Number of HH provided with piped water supply in slum areas/Total number of slum HH)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Service delivery | 5 | Continuity of water supply | | 24hrs in a day | 5 | 24hrs |
| | | | | | For a few hours twice a day | 4 | |
| | | | | | For a few hours once in a day | 3 | |
| | | | | | Once in four days | 2.5 | |

| **Principle** | **Category** | **Indicator** | | **Formula** | **Ranges** | **Scale** | **Benchmark** |
|---|---|---|---|---|---|---|---|
| | | | | | Once in two days | 1.5 | |
| | | | | | Once in a week | 1.25 | |
| | | | | | Not predictable | 1 | |
| | | 6 | Quality of water supplied | (Number of test samples that are within prescribed limit/Total Number of water test samples)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Demand supply gap | 7 | Per capita water supply (average) | (Net/actual water supplied - (NRW*Net/actual water supplied))/ (Number of HH provided with piped water supply*Average HH size) | 150<br>135-150<br>75-135<br>30-75<br><30 | 5<br>4<br>3<br>2<br>1 | 150 lpcd |
| | | 8 | Standard deviation of average per capita water supply (total) | (((No. of HH getting average per capita water supply - No. of HH getting in excess/ deficit of average per capita water supply)^2) /Total no. of HH)^(1/2) | 0<br>0-2<br>2-5<br>>5 | 5<br>4<br>2<br>1 | 0 |
| | Water related disaster risk | 9 | Number of different types of water related natural disasters a city is exposed to, including floods, storms, droughts and mud flows | number/year | 0-5<br>5-10<br>>10 | 5<br>2.5<br>1 | 0 |
| | | 10 | No of water-borne diseases recorded in the city in last one year | number/year | | | 0 |

| Principle | Category | Indicator | | Formula | Ranges | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| **Environmental Efficiency** | GW status | 11 | Rate of groundwater depletion | (depth of water level recorded by monitoring wells in present year-depth of water level recorded by monitoring wells in past year) | <0 mbgl<br>0-3mbgl<br>3-5mbgl<br>5m-10mbgl<br>above 10mbgl | 5<br>4<br>3<br>2<br>1 | 0 |
| | Water harvesting/conservation | 12 | Percentage of buildings/properties with water harvesting/ conservation measures (RWH, reuse of waste water, etc.) | (Number of buildings/properties with RWH (rain water harvesting structure or any functional conservation measures)/Total number of buildings/properties (rooftop 30X40 home and above))*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 13 | Share of STW that is reused (20% by 2020, 50% by 2030) | (Amount of water recycled (MLD)/Net/actual water supplied (MLD))*100 | >50%<br>20%-50%<br><20% | 5<br>2.5<br>1 | 50% |
| | | 14 | 50% or more share of public water supplied sourced from a) within 10 km distance from the city, b) between 10-30 km distance, c) beyond 30 km from the city | a) within 10 km distance from the city<br>b) between 10-30 km distance,<br>c) beyond 30 km from the city | | 5<br>2.5<br>1 | Within city limit |
| | Energy and emission efficiency | 15 | Share of energy consumed by water infrastructure and supply network met by renewables | Energy consumed by water infrastructure and supply network met by renewables/ Total energy consumed by water infrastructure and supply network | >10%<br>0-10%<br>0% | 5<br>2.5<br>1 | 10% |
| | Quality of water resources | 16 | Quality of water resources | {No of water bodies meeting KSPCB standards<br>(weightage according to standard A range)/total number of water bodies }*100 | 50% - 100%<br>0-50%<br>0% | 5<br>2.5<br>1 | 100% |

| **Principle** | **Category** | **Indicator** | | **Formula** | **Ranges** | **Scale** | **Benchmark** |
|---|---|---|---|---|---|---|---|
| **Economic Efficiency** | Loss in water supply | 17 | Percentage of NRW | NRW = {(total water produced and put into the distribution and transmission system-total water sold (water supply to customer who are billed for the water provided)]/total water produced and put into the distribution and transmission system]*100} | <20%<br>20%-50%<br>>50% | 5<br>2.5<br>1 | 20% |
| | | 18 | Percentage of households with metered water connection | (Number of metered direct service connections+ Number of metered public stand posts)/(Total number of direct services connections + Total number of public stand posts)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Cost recovery | 19 | Share of Operations & Maintenance (O&M) cost met by water related revenues | (Total annual operating revenue/total annual operating expense) *100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| **Good Governance and Foresight** | | 20 | City level plan for IUWRM prepared/ under preparation/ not initiated | IUWRM prepared<br>under preparation<br>not initiated | | 5<br>2.5<br>1 | Prepared |
| | | 21 | Data for all above indicators are annually collected and updated | Yes/ No | | 5<br>1 | Yes |
| | | 22 | No of public consultations held during IUWRM plan preparation | Number | | | |
| | | 23 | Efficiency in redressal of customer complaints | (Total number of complaints redressed within the month/Total number of water supply related complaints received per month)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 80% |

Table 5.3: *Sustainability indicators for sanitation sector*

| Principle | Category | | Indicator | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| **Social wellbeing and equity** | Access to Toilets | 1 | Access to toilets within premises (total) | [No. of HH having toilets within premises (total)/ Total no. of HH]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 2 | Access to toilets within premises (slum) | [No. of (slum) HH having toilets within premises (total)/ Total no. of (slum) HH]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 3 | Access to community toilets (slums)- user seat ratio for both men and women | Total number of female users in CTs/ Total number of Seats (female community toilet block) | 1seat for <25<br>1 seat for 25<br>1seat for >25 | 5<br>2.5<br>1 | Community Toilet - 1 seat for 25 women |
| | | 4 | | Total number of male users in CTs/ Total number of Seats (male community toilet block) | 1seat for <35<br>1 seat for 35<br>1seat for >35 | 5<br>2.5<br>1 | Community Toilet - 1 seat for 35 men |
| | | 5 | Access to public toilets (user seat ratio for both men and women) | Total number of female user in PTs/ Total number of Seats (female public toilet block) | 1seat for <100<br>1 seat for 100<br>1seat for >100 | 5<br>2.5<br>1 | Public Toilet - 1 seat for 100 women |
| | | | | Total number of male user in PTs/ Total number of Seats (male public toilet block) | 1seat for <250<br>1 seat for 250<br>1seat for >250 | 5<br>2.5<br>1 | Public Toilet - 1 seat for 250 men |
| | Access to complete sanitation system | 6 | Share of toilets connected to complete sanitation system in the city (complete sanitation system - covers each component of the | [Total no. of toilets (IHHL, PT, CT, shared toilets) connected to complete sanitation system/Total no. of toilets (IHHL, PT, CT, shared toilets) etc.]*100 | 100%<br>75%-100%<br>50% -75% | 5<br>4<br>3 | 100% |

| Principle | Category | | Indicator | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| | | | sanitation value chain (toilet, onsite storage/treatment, empting, commence, treatment and reuse/disposal in case both FSSM systems and centralised/decentralised networked systems)) | | 20%-50%<br><20% | 2<br>1 | |
| | | 7 | Share of toilets connected to complete sanitation system – in slum | [ Total no. of toilets(IHHL, PT, CT, shared toilets) in slums connected to complete sanitation system/Total no. of toilets (IHHL, PT, CT, shared toilets) in slums]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Inclusive sanitation | 8 | share of CTs and PTs having separate toilet blocks for men, women, transgender | [Total number of community and public toilets having separate toilet blocks males/females/transgender/Total number of CTs and PTs]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 9 | Share of CTs and PTs meeting Universal Accessibility standards (Accessibility has been defined in terms of toilet location, Visibility, Aesthetic appearance, Signage, separate entrance for men and women, Toilets for special needs-differently abled, transgender.) | [Total CTs and PTs meeting Universal Accessibility standards /Total no. of CTs and PTs]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 10 | Reported incidences of manual scavenging | Number of incidences reported in newspapers, blogs etc. | 0<br><10<br>>10 | 5<br>2.5<br>1 | 0 |

| Principle | Category | | Indicator | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| | Safety | 11 | Number of cases of violence, abuse incidences reported (registered FIR, newspaper reports etc.) to have happened while accessing CT and PTs in last one year | Number | 0<br><10<br>>10 | 5<br>2.5<br>1 | 0 |
| | | 12 | Number of reported incidences (newspaper, media reports etc.) of exposure to faecal matter across the value chain and resultant health hazard | Number | 0<br><10<br>>10 | 5<br>2.5<br>1 | 0 |
| | | 13 | Share of workers involved in sanitation livelihood having access to safety gear | [Total no. of workers involved in sanitation livelihood having access to safety gear/Total workers involved in sanitation livelihood]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Participation | 14 | Number of IEC campaigns held in the city in past one year (city level campaign) | Number of campaigns in an year | | | |
| | | 15 | Share of slum HH (give ranges) participated in at least one IEC campaigns in last one year- | [Total no. of slums HH participated in IEC campaign (last one year)/Total no. of slums HH]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| **Environmental efficiency** | Treatment | 16 | Percentage of installed (FSTP and STP) plant capacity to wastewater and faecal sludge generated | [Total capacity of (FSTP and STP) plants/ Total Waste water and faecal sludge generated]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |

| Principle | Category | | Indicator | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| | | 17 | Percentage of installed plant capacity utilised | (Total amount of waste water and FS treated/Total (STP or FSTP) plant capacity installed (MLD))*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 18 | Percentage of wastewater receiving secondary treatment | [Total wastewater receiving secondary treatment / Total amount of waste water generated (MLD)]*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 19 | Share of faecal sludge generated is treated | (Total amount of FS treated/Total amount of waste water generated (MLD))*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | Recycle and reuse | 20 | Share of secondary treated waste water reused | (Total amount of STW re-cycled and reused/Total wastewater receiving secondary treatment )*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| | | 21 | Share of treated sludge reused (as manure, fuel etc.) | (Total amount of treated FS that is reused/ Total amount of FS treated)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |

| Principle | Category | | Indicator | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| | Energy and emission efficiency | 22 | Share of energy consumed by sanitation infrastructure and supply network met by renewables | Energy consumed by sanitation infrastructure and sewage network met by renewables/ Total energy consumed by sanitation infrastructure and sewage network | >10%<br>0-10%<br>0% | 5<br>2.5<br>1 | 10% |
| **Economic efficiency** | Cost recovery | 23 | Share of O&M cost met by sanitation related revenues | (Total annual operating revenues/Total annual operating expenses)*100 | 100%<br>75%-100%<br>50% -75%<br>20%-50%<br><20% | 5<br>4<br>3<br>2<br>1 | 100% |
| **Good governance and Foresight** | Institutional | 24 | Presence of City level plan with complete FSSM component | Prepared with FSSM<br>Under preparation with FSSM<br>Prepared without FSSM<br>Under preparation<br>Not initiated | | 5<br>4<br>3<br>2<br>1 | Prepared with FSSM |
| | | 25 | Data for all above indicators are annually collected and updated | Yes/ No | | 5<br>1 | Yes |
| | | 26 | No of public consultations held during CSP (with FSSM) plan preparation | Number | | | |
| | | 27 | Efficiency in redressal of customer complaints | [Total number of complaints redressed within the month/Total number of sewage-related complaints received per month]*100 | 80%<br>50% -80%<br>20%-50%,<br><20% | 5<br>4<br>2<br>1 | 80% |

Table 5.4: *Sustainability indicators for transport sector*

| Principal | Category | Indicator | | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| Social Well-being and Equity | Access | 1 | Availability of PT per 1000 population | (Total no. of buses or train coaches available in a city on any given day / Total population of the city) *1000<br><br>Note: 1 train coach is equivalent to 3 buses | > = 0.6<br>0.4 - 0.6<br>0.2 - 0.4<br>< 0.2<br>No PT | 5<br>4<br>3<br>2<br>1 | > = 0.6 |
| | | 2 | Service coverage of PT in the city | Total length in road km of corridors on which PT system ply in the city /City area in sq.km | >= 1<br>0.7- 1<br>0.3 - 0.7<br>< 0.3<br>No PT | 5<br>4<br>3<br>2<br>1 | >= 1 |
| | | 3 | Availability of PT within 500 m (10-15 minute walking distance) | | Yes<br>No | 5<br>1 | Yes |
| | | 4 | PT station infrastructure per 1000 population | (Total no. of bus stops + metro stations + BRT stations /Total population)*1000 | > = 0.6<br>0.4 - 0.6<br>0.2 - 0.4<br>< 0.2<br>No PT | 5<br>4<br>3<br>2<br>1 | > = 0.6 |
| | | 5 | PT stations meeting universal accessibility standards | | Yes<br>No | 5<br>1 | Yes |
| | | 6 | Availability of accessible information to the general public, on PT services | | Yes<br>No | 5<br>1 | Yes |

| **Principal** | **Category** | **Indicator** | | **Formula** | **Range** | **Scale** | **Benchmark** |
|---|---|---|---|---|---|---|---|
| Social Well-being and Equity | | 7 | NMT infrastructure per 1000 population | (Total length of bicycle lanes+ pedestrian lanes in the city in km / Total population)*1000 | > = 0.6<br>0.4 - 0.6<br>0.2 - 0.4<br>< 0.2<br>No NMT infrastructure | 5<br>4<br>3<br>2<br>1 | > = 0.6 |
| | | 8 | Availability of NMT infrastructure (bicycle lanes + pedestrian pathways) with universal access | | Yes<br>No | 5<br>1 | Yes |
| | | 9 | Access IPT within 300 m walking distance | | Yes<br>No | 5<br>1 | Yes |
| | | 10 | Affordability of PT | ((No. of trips or per capita trip rate) * (average cost per trip or expenditure on PT))/ Per capita income | | | Not more the 10% of income |
| | Safety | 11 | Traffic fatalities recorded within a city limit per lakh population in the past calendar year | (Total number of fatalities recorded within a city limit in the past calendar year * 1,00,000) / Population of the city in that year | No fatalities<br>< =2 persons<br>2 to 4 persons<br>4 to 6 persons<br>> 6 persons | 5<br>4<br>3<br>2<br>1 | < =2 persons |
| | Participation and preparedness | 12 | Presence of evacuation plan during emergencies and disaster for PT | | Yes<br>No | 5<br>1 | Yes |

| Principal | Category | Indicator | | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| | | 13 | Citizen participation (stakeholder consultations) in preparation of mobility plan or transit oriented design | | Yes<br>No | 5<br>1 | Yes |
| Environmental Efficiency | Air pollution | 14 | Ambient air quality in a city | Total mean annual concentration levels of $SO_2$ + oxides of nitrogen + SPM + RSPM (in (µg/m3) to the threshold value) | <=5<br>6-9<br>10-13<br>14-16 | 5<br>4<br>2<br>1 | <=5 |
| | NMT network | 15 | Percentage of city covered by NMT network (km) | (Total length of NMT network in a city in km/ Total length of road network in a city in km)*100 | >=50 %<br>50% to 25%<br>25% to 15%<br>< 15% | 5<br>4<br>2<br>1 | >=50% |
| | Non-conventional modes for commute | 16 | Mode share of EVs in a city | (Number of registered EVs in a given year/ Total number of registered vehicles in that year)*100 | >=20 %<br>15% to20%<br>5% to 10%<br>< 5%<br>No EV | 5<br>4<br>3<br>2<br>1 | >=20% |
| | | 17 | Mode share of alternate fuel vehicles in a city | ((Number of registered biofuel+ CNG vehicles in a given year) / Total number of registered vehicles in that year)*100 | >=50 %<br>25% to 50%<br>10% to 25%<br><10 %<br>No alternate fuel vehicles | 5<br>4<br>3<br>2<br>1 | >=50% |
| Economic Efficiency | | 18 | Operating ratio of PT | (Cost per PT mode, inclusive of depreciation, O&M and manpower cost/ Total revenue generated from fare revenue and non-fare revenue sources) | < 0.7<br>0.7 to 1.0<br>1.0 to 1.5<br>>=15 | 5<br>4<br>2<br>1 | < 0.7 |

| Principal | Category | Indicator | | Formula | Range | Scale | Benchmark |
|---|---|---|---|---|---|---|---|
| | | 19 | Staff per bus ratio | Total staff of PT mode for O& M/Total number of PT fleet in a city | <=5.5<br>5.5 to 8<br>8 to 10<br>> 10 | 5<br>4<br>2<br>1 | <=5.5 |
| | | 20 | Travel speeds along major corridors | Average travel speeds of all modes (vehicles) in kmph, along major corridors in a city | 20 to 30 kmph<br>10 to 20 kmph<br><10 kmph | 5<br>3<br>1 | 20 to 30 kmph |
| Good Governance and Foresight | | 21 | Whether the city has any transportation plan or policy | | Physical + institutional integration + delivery plan<br>Only physical plan<br>Only Institutional plan<br>No plan, but intent<br>No plan, no intent | 5<br>4<br>3<br>2<br>1 | Physical + institutional integration + delivery plan |
| | | 22 | Periodic revision and/or up gradation of city mobility plan, integrated mobility plan, etc. | | Yes<br>No | 5<br>1 | Yes |
| | | 23 | Presence of transport applications like apps, GPS, etc. for informed and organised functioning of PT | | Yes<br>No | 5<br>1 | Yes |
| | | 24 | Presence of integrated ticket system and/ or digital ticketing system for PT | | Yes<br>No | 5<br>1 | Yes |

| **Principal** | **Category** | **Indicator** | | **Formula** | **Range** | **Scale** | **Benchmark** |
|---|---|---|---|---|---|---|---|
| | | 25 | Availability of capacity building plan for transport sector | | Yes<br>No | 5<br>1 | Yes |

# 6. Conclusion and Way Forward

The findings and recommendations for the urban water, sanitation and transport sectors present a set of actionable sustainable strategies for cities in Karnataka. The sector-specific policies in the state are aptly positioned to enable the uptake of the recommended strategies and planning exercises by the cities. At the same time, parallel efforts have to be initiated to overcome challenges associated with the preparedness of the cities and urban planning institutions. In this regard, urgent attention must be accorded to the following aspects:

**Quality of data and spatial analysis**

Cities in Karnataka face numerous challenges relating to urban data. These challenges include the inadequate reliability of data, low frequency and fragmentation of data collection, duplication of datasets, and the absence of spatially and temporally disaggregated data. These factors tend to lead to scanty or biased analyses and results. To mitigate this, the development of multi-disciplinary geo-spatial analysis and visualisation platforms in line with the concept of Urban Observatories can be explored.

**Capacity of municipalities**

There are ongoing efforts in building capacities of ULBs under multiple flagship programmes. These need to be effectively improved to include the aspects mandated by the sector policies discussed in this report. Moreover, added focus is required in capacity building requirements for spatial data collection, management and analysis.

**Inter-agency coordination**

The policies discussed and the recommendations suggested in this report have identified specific institutional integration requirements for the three sectors (water, sanitation and transport). Past success and failures in such coordination efforts should be carefully examined to arrive at a more effective system for data sharing. The creation of regional-level authorities highlighted in this report is an important step towards achieving the desired intentions of policy mandates.

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# Sustainable Urban Planning Strategies for Cities in Karnataka

## Volume-II

### Annexures

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# Annexure I (A)

Table 1: Data sources for identifying priority regions

| Parameters | | Layers | Units | Source |
|---|---|---|---|---|
| Environment | Elevation | Elevation | State | DEM data form USGS |
| | Slope | Land Slope (in %) | State | NBSS&LUP,R.C.,Bangalore / KSDA, http://raitamitra.kar.nic.in/agri profile/soilclass.htm |
| | Surface Hydrology | River Basins | State | Website of Advanced Centre for Integarted Water Resource Management (ACIWRM) |
| | Groundwater Hydrology | Groundwater depth | Taluk | Karnataka State Natural Disaster Monitoring Centre (KSNDMC), January 2018 data |
| | | Groundwater development status | Taluk | CGWB-Report on Dynamic Groundwater Resources of India (As on March 2013), 2017 |
| | | Categorisation of taluks as safe, critical, semi critical | Taluk | CGWB-Report on Dynamic Groundwater Resources of India (As on March 2013), 2017 |
| | | Net annual GW availability | District | CGWB-Report on Dynamic Groundwater Resources of India (As on March 2013), 2017 |
| | | Total Annual GW Draft | District | CGWB-Report on Dynamic Groundwater Resources of India (As on March 2013), 2017 |
| | | Stage of GW development | District | CGWB-Report on Dynamic Groundwater Resources of India (As on March 2013), 2017 |
| | | Projected water | District | CGWB-Report on Dynamic |

| Parameters | | Layers | Units | Source |
|---|---|---|---|---|
| | | demand for industrial and domestic (2025) | | Groundwater Resources of India (As on March 2013), 2017 |
| | | GW Availability for future use in irrigation (2025) | District | CGWB-Report on Dynamic Groundwater Resources of India (As on March 2013), 2017 |
| | Geology | Soil Typology (red soils, laterite soils, black soils etc.) | State | NBSS&LUP,R.C.,Bangalore / KSDA, http://raitamitra.kar.nic.in/agriprofile/soilclass.htm |
| | | Surface soil texture (Sandy/Loamy/Clayey etc.) | State | NBSS&LUP,R.C.,Bangalore / KSDA, http://raitamitra.kar.nic.in/agriprofile/soilclass.htm |
| | | Available water capacity of soils (in mm) | State | NBSS&LUP,R.C.,Bangalore / KSDA, http://raitamitra.kar.nic.in/agriprofile/soilclass.htm |
| | Rainfall | Rainfall | Taluk | KSNDMC Annual Report 2016 |
| **Ecosystem based services** | Water | Per capita water supply in lpcd (present) | City | SLB Data 2017-18 |
| | | Continuity of water supply in hours | City | SLB Data 2017-19 |
| | Sanitation | Coverage of sewerage network | City | SLB Data 2017-20 |
| | | Extent of sewage treatment capacity | City | SLB Data 2017-21 |
| | | Extent of reuse and recycling of treated sewage | City | SLB Data 2017-22 |
| | Storm water drains | Coverage of storm water drainage network | City | SLB Data 2017-23 |

| Parameters | | Layers | Units | Source |
|---|---|---|---|---|
| Demography | Population | Population | City | Census 2011 |
| | Decadal Growth Rate | Decadal Growth Rate | City | Census 2011 |
| | Population Density | Population Density | City | Census 2011 |
| | | Literacy Rate | District | Census 2011 |
| | Economic Parameters | GDDP | District | Economic Survey 2016-17 |
| | | Growth rate of GDDP | District | Economic Survey 2016-17 |
| | | Per capita income | District | Economic Survey 2016-17 |
| Industrial Development | Existing Industrial Development | Existing Industrial Areas in Karnataka | District | KSSIDC and KIADB |
| | | Bengaluru Mumbai Economic Corridor (BMEC) | State | BMEC Report |
| Transport Infrastructure | Road | Existing Road Network | State | DIVA-GIS web site |
| | Rail | Existing Rail Network | State | DIVA-GIS web site |

## Annexure I (B)

**Description of criteria selected for identifying priority regions**

**Water Stress**

1. Stage of groundwater development

The stage of ground water development is defined by the CGWB as the ratio of Annual Ground Water Draft and Net Annual Ground Water Availability expressed in percentage. The Annual Ground Water Draft is the existing gross amount of groundwater extracted for irrigation, domestic and industrial uses. Net Annual Ground Water Availability is the available groundwater in the area, after deducting the amount of natural discharges from the Annual Replenishable Groundwater Resource[1]. Higher stage of groundwater development indicates higher usage of the resource in the area.

2. Depth to groundwater level

The average depth to groundwater in meters below the ground level is an important criteria that needs consideration to determine the water stress of an area.

3. Categorisation of regions as safe, semi-critical, critical and over-exploited based on stage of groundwater development and long-term pre and post monsoon water levels

The CGWB categorises areas into the above mentioned four categories based on two aspects, (a) stage of groundwater development and (b) long term trend of pre-monsoon and post-monsoon water levels in the area.

4. Future utilisation of groundwater resources (for domestic and industrial uses)

The future utilisation of groundwater resources has been computed by CGWB for 2025 based on the per capita requirement of the projected population for the year and the current dependency on groundwater in the area (CGWB, 2017).

5. Future groundwater availability for irrigation

The future utilisation of groundwater resources has been computed by CGWB for 2025 based on the following formula.

[1] Annual Replenishable Groundwater Resource= Sum of recharge during monsoon and non-monsoon seasons

Water available for future irrigation= Net Annual Ground Water Availability - (Projected demand for Domestic and Industrial use + Existing gross irrigation draft)

6. Drought Vulnerability

Drought vulnerability has been considered as important criteria in deciding whether a region is water stressed. Considering the severity and frequency of droughts that Karnataka has faced over the past years, the KSNDMC has carried out a drought vulnerability assessment of the state at the taluk level. A composite index for drought vulnerability was developed which considers four major parameters (climate based, climate and soil based, climate and crop-cover based and livelihood based) and 28 supporting sub parameters relevant to drought.

Climate based index: This is derived from 7 sub parameters which indicate the vulnerability of the taluk with respect to climate. The average rainfall received and coefficient of variation of the same over a period of 55 years have been considered to calculate the index.

Climate and Soil Based Index: The climate and soil based index is calculated based on the length of growing period (LGP) in the taluks. LGP is arrived at using a water balance approach using rainfall, normal water potential evapotranspiration (PET) and available water capacity (AWC) of soils for the past 34 years.

Climate-Crop cover Based Index: The Climate-Crop cover Based Index is derived from indicators which considers the varying cropping patterns at the taluk level for the state.

Livelihood based index: The Livelihood based index is derived from indicators which considers the vulnerability of the society to droughts.

The detailed list of indicators used under each main parameter can be referred to from table below.

Table 2: List of indicators considered for drought vulnerability assessment

| | | | |
|---|---|---|---|
| Climate Based Index | 1 | South West monsoon rainfall coefficient of variation | The indicators were analysed with data for the past 55 years (1960-2014) to arrive at the climate based index |
| | 2 | North East monsoon rainfall coefficient of variation | |
| | 3 | Pre monsoon average rainy days | |
| | 4 | South West monsoon average rainy days | |
| | 5 | North East monsoon average rainy days | |
| | 6 | Annual average rainy days | |
| | 7 | Aridity Index Anomaly | |
| Climate and Soil Based Index | 1 | Length of growing period (days of moisture availability) | Weekly actual precipitation, normal potential |

| | | | |
|---|---|---|---|
| | | | evapotranspiration (PET), available water capacity (AWC) of soils for the past 34 years (1980-2014) in the taluks were used to calculate the length of growing period. |
| Climate-Crop cover Based Index | 1 | South West Monsoon Integrated Normalized Difference Vegetation Index (NDVI) (SWIN) | The NDVI during the crop season was estimated from 2000 to 2015 to calculate the index. |
| | 2 | Coefficient of variation of SWIN | |
| | 3 | South West Monsoon Maximum Normalized Difference Vegetation Index (SWMN) | |
| | 4 | Coefficient of variation of SWMN | |
| | 5 | August Month's - NDVI | |
| | 6 | Coefficient of variation of August Month's - NDVI | |
| | 7 | North East Monsoon integrated NDVI (NEIN) | |
| | 8 | Coefficient of variation of NEIN | |
| | 9 | North East Monsoon Maximum NDVI (NEM) | |
| | 10 | Coefficient of variation of NEM | |
| | 11 | November Month's NDVI | |
| | 12 | Coefficient of variation of November Month's NDVI | |
| Livelihood Based Index | 1 | Ratio of irrigated to total cultivated area per cent | Literacy for 2001, 2011 and data from 1985 to 2002 has been used for other indicators to calculate the livelihood based index. |
| | 2 | Ratio of Number of marginal to total holdings per cent | |
| | 3 | Ratio of Number of small to total holdings per cent | |
| | 4 | Ratio of Number of semi-medium to total holdings per cent | |
| | 5 | Ratio of Number of medium to total holdings per cent | |
| | 6 | Ratio of Number of big (large) to total holdings per cent | |
| | 7 | Ratio of working to total population per cent | |
| | 8 | Ratio of Number of literates to total population per cent | |

*Source: Report on Drought Vulnerability Assessment in Karnataka, 2017, KSNDMC*

7. Water yield in river basins: The river basin wise water yield is another criteria considered in the analysis. The average annual yield (total run-off plus recharge) Driscoll DG et.al, 2002) of the river basins in Karnataka is as listed in the table below.

Table 3: Water yield in river basins in Karnataka

| River System | Drainage Area (in 1000 sqkm) | Average annual yield in MCM | in TMC |
|---|---|---|---|
| Krishna | 111.74 | 27451 | 969.44 |
| Cauvery | 34.27 | 12034 | 425 |
| Godavari | 4.43 | 1415 | 49.97 |
| North Pennar | 6.94 | 906 | 32 |
| South Pennar | 3.76 | 906 | 32 |
| Palar | 2.97 | | |
| West flowing rivers | 26.39 | 56600 | 1988.83 |
| Total | 190.5 | 98406 | 3475.24 |

*Source: http://www.aciwrm.org/faq/*

8. Average per capita quantum of water supplied

Apart from the criteria indicating water resource availability in different regions, the analysis shall also look at criteria which reflects the status of service delivery in case of water supply. The average per capita quantum of water supplied in urban areas of a district is one such criteria that has been considered. The criteria indicates adequacy of the water supply system of an ULB in sourcing, treating and supplying water to the distribution system. The per capita quantum of water supplied is also one of the indicators listed by the MoUD for service level benchmarking of water supply service in an urban area. The benchmark value for the indicator is set as 135 lpcd for the indicator by MoUD.

9. Continuity of water supply (average)

Another criteria which reflects the status of service delivery in case of water supply is the continuity of water supply (average) in the urban centres of a district. This is also one of the indicators listed by the MoUD for service level benchmarking of water supply service in an urban area. It is defined by MoUD as the average number of hours of pressurised water supply in a day[2] (Ministry of Housing and Urban Affairs, 2008). The benchmark value for the indicator is set as 24 hours for the indicator by MoUD.

[2] Water pressure should be equal to or more than a head of 7 metre (m) at the ferrule point/meter point for the connection (7 m head corresponds to the ability to supply to a single-storey building).

## GROWTH REGIONS

### 1. Total population

The total population has been considered as one of the criteria contributing to the growth of a region.

### 2. Decadal growth rate of total population

Apart from the total population, the trend of population growth also indicates whether the region is a potential area for growth.

### 3. Share of urban population

Urban centres are often considered as the growth poles of a region. Economic activity of the people in the entire region surrounding the city is affected by the existence and progress of the cities. Considering this importance, the share of urban population in a district is considered as one of the determinants of growth.

### 4. Decadal growth rate of urban population

The urban centres act as magnets of growth in a region. The population growth rate of these indicates the growing importance that a centre enjoys in a region. In this purview, the decadal growth rate of urban population is one criteria which is expected to contribute towards growth of a region.

### 5. Gross Domestic Product (GDP)

GDP gives an indication of the state of the economy of an area. It is often one of the prime indicators used to measure and compare the economic status between different areas. In the present analysis, the GDP at the district level (Gross District Domestic Product, GDDP) has been considered.

### 6. Per capita income

The per capita income indicates the prosperity of an area on an average.

### 7. Total industrial area

The industrial area (in acres) has been considered as an indicator of industrial growth of a region.

### 8. Bengaluru Mumbai Economic Corridor (BMEC)

The portion of the BMEC region which falls in Karnataka has been considered in the analysis. The corridor region is expected to promote economic development, planned industrial development and sustainable urbanisation.

### 9. Proximity to national highways

The proximity to road infrastructure, especially national highways, is an added advantage of any area for future growth and development.

### 10. Proximity to railway line

The proximity to rail infrastructure is considered as a criteria contributing to growth of a region.

### 11. Work force participation rate (WPR) at the district level

The rate of workforce participation is an indicator which has a direct correlation to the economic activity of an area. The workforce or labour force being the primary factor of production, plays a prime role in activating other factors of production and thus the overall economy of a region (Kwat, 2016). The WPR is another criteria selected for the analysis.

### 12. Literacy rate at the district level

Literacy rate is considered as an indirect indicator of the sustainability of a suggested intervention in a region. It is an important social determinant of a region's growth.

## Annexure I (C)

### Justification for assigning weightages- Water Stress Criteria

- Among the list of criteria selected, *drought vulnerability* has been considered as the most prominent factor contributing to water stress of a region and hence given the highest weightage. Drought vulnerability is a combination of a number of criteria. These include historical trends of climate (rainfall), cropping patterns, soil water capacity and also social indices like literacy rates, WPR etc. Refer Table 2 in Annexure I (B).
- The *stage of groundwater development* has been given the next highest weightage. It indicates the ratio of current extraction of groundwater to the actual availability of the resource. The higher extraction of groundwater coupled with low availability of the resource can be considered as an important criteria contributing to water stress of a region.
- The criteria *depth to ground water levels* has been given the third highest weightage. It can be assumed that lower the depth to the ground water table, greater has been the extraction. It may also indicate low availability of the resource even naturally.
- The *categorisation of regions as safe, semi-critical, critical and over-exploited* is basically a combination of the stage of ground water development and depth to groundwater level. However it has been considered separately since it not only looks at the current levels but also the long term trend of pre monsoon and post monsoon water levels in the area.
- The *future utilisation of groundwater resources (for domestic, industrial) and future availability for irrigation uses have* been given an equal weightage. They are weighted relatively lower since it indicates a future projected scenario and not the current situation.
- The criteria indicating the service delivery status i.e *per capita water supply and continuity of water* supply has been given a relatively lower rank since it may not directly indicate water stress of a region.
- The *water yield in river basins* has been given the lowest weightage in the list of criteria.

### Justification for assigning weightages- Growth Criteria

Owing to the importance that urban centres play in a region, the *decadal growth rate of urban population* and the *share of urban population* has been given relatively higher weightages that the rest of the criteria. The *industrial area* and the *area under BMEC region* are given the next highest weightage, considering the growth that industries and economic corridors will drive in the region. The rest of the criteria are given comparatively lower weightages as listed in the following table.

## Annexure I (D)

Table 4: Ranges and respective weightages –water stress criteria

| Sl. No. | Criteria | Range | Weightage | Remarks |
|---|---|---|---|---|
| 1 | Stage of groundwater development (in %) | 25-50% | 1 | The districts with the higher ground water development shall receive higher weightage. |
| | | 50-100% | 2 | |
| | | 100-150% | 3 | |
| | | 150-200% | 4 | |
| 2 | Depth to groundwater level (in meters below ground level) | Less than 10 | 1 | The taluks having ground water at greater depths shall receive higher weightage. |
| | | 10-30 | 2 | |
| | | 30-50 | 3 | |
| | | Above 50 | 4 | |
| 3 | Categorisation of regions as safe, semi-critical, critical and over-exploited | Safe | 1 | The over exploited taluks shall receive highest weightage. |
| | | Semi-critical | 2 | |
| | | Critical | 3 | |
| | | Over exploited | 4 | |
| 4 | Future utilisation of groundwater resources for domestic and industrial uses (in hectare metre, HAM) | 1000-4000 | 1 | The districts with the highest projected water demand shall receive highest weightage. |
| | | 4000-8000 | 2 | |
| | | 8000-10000 | 3 | |
| | | 10000-12000 | 4 | |
| 5 | Future groundwater availability for irrigation (in hectare metre, HAM) | 0 | 4 | The districts with the least water availability in the future for irrigation shall receive highest weightage. |
| | | 1-30000 | 3 | |
| | | 30000-50000 | 2 | |
| | | 50000-70000 | 1 | |
| 6 | Drought Vulnerability | Very Slightly Vulnerable to Slightly Vulnerable | 1 | The taluks with higher vulnerability shall receive a higher weightage. |
| | | Moderately Vulnerable | 2 | |
| | | Highly Vulnerable | 3 | |
| | | Very Highly Vulnerable | 4 | |

| Sl. No. | Criteria | Range | Weightage | Remarks |
|---|---|---|---|---|
| 7 | Water yield in river basins (in TMC) | West flowing rivers (1988) | 1 | Lower the yield of the river basin, higher the weightage it receives. |
| | | Krishna Basin (969) | 2 | |
| | | Cauvery Basin (425) | 3 | |
| | | Godavari, Pennar and Palar (113) | 4 | |
| 8 | Average per capita quantum of water supplied (in lpcd) | Less than 75 | 4 | Lower the average district urban water supply in lpcd, higher the weightage it receives. |
| | | 75- 95 | 3 | |
| | | 95-115 | 2 | |
| | | Above 115 | 1 | |
| 9 | Continuity of water supply (in hours per day) | <5 | 4 | Lesser the number of hours of water supply in a day, higher the weightage the district receives. |
| | | 5 -15 | 3 | |
| | | 15 - 20 | 2 | |
| | | 20< | 1 | |

Table 5: Ranges and respective weightages-growth criteria

| Sl. No. | Criteria | Range | Weightage |
|---|---|---|---|
| 1 | Total population at the district level (in lakhs) | less than 10 | 1 |
| | | 10 to 20 | 2 |
| | | 20 to 50 | 3 |
| | | above 50 | 4 |
| 2 | Decadal growth rate of total population (in %) | Below 0 | 1 |
| | | 1-20 | 2 |
| | | 20-40 | 3 |
| | | Above 40 | 4 |
| 3 | Share of urban population at the district level (in %) | less than 20 | 1 |
| | | 20-40 | 2 |
| | | 40-60 | 3 |
| | | Above 60 | 4 |

| Sl. No. | Criteria | Range | Weightage |
|---|---|---|---|
| 4 | Decadal growth rate of urban population (in %) | Less than 10 | 1 |
| | | 10-20 | 2 |
| | | 20-40 | 3 |
| | | 40-60 | 4 |
| 5 | GDDP (in crore rupees) | Less than 20 | 1 |
| | | 20-40 | 2 |
| | | 40-60 | 3 |
| | | Above 60 | 4 |
| 6 | Per capita income at the district level (in rupees) | 60,000-80,000 | 1 |
| | | 80,000-1,00,000 | 2 |
| | | 1,00,000-1,50,000 | 3 |
| | | Above 1,50,000 | 4 |
| 7 | Total industrial area at the district level (in acres) | Less than 100 | 1 |
| | | 100-500 | 2 |
| | | 500-1500 | 3 |
| | | Above 1500 | 4 |
| 8 | Bengaluru Mumbai Economic Corridor | | 3 |
| 9 | Proximity to national highways | 5 km buffer | 4 |
| | | 10 km buffer | 3 |
| 10 | Proximity to railway line | 10 km buffer | 3 |
| 11 | Work force participation rate (WPR) at the district level (in %) | Less than 42 | 1 |
| | | 42 -46 | 2 |
| | | 46-50 | 3 |
| | | Above 50 | 4 |
| 12 | Literacy rate at the district level | 50 to 60 | 1 |
| | | 60 to 70 | 2 |
| | | 70 to 80 | 3 |
| | | 80 to 90 | 4 |

## Annexure I (E)

Table 6: List of cities lying in very high priority region

| very high priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population |
| 1 | BBMP | I | 8495492 | 28 | Gauribidanur | III | 37947 | 55 | Konnur | IV | 19386 |
| 2 | Hubli-Dharwad | I | 943788 | 29 | Nelamangala | III | 37232 | 56 | Mulgund | IV | 18763 |
| 3 | Bijapur | I | 327427 | 30 | Lakshmeshwar | III | 36754 | 57 | Raybag | IV | 18736 |
| 4 | Tumkur | I | 302143 | 31 | Nargund | III | 36291 | 58 | Kundgol | IV | 18726 |
| 5 | Gadag-Betigeri | I | 172612 | 32 | Vijayapura | III | 34866 | 59 | Jagalur | IV | 17257 |
| 6 | Robertson Pet | I | 162230 | 33 | Hebbagodi | III | 34827 | 60 | Jigani | IV | 17036 |
| 7 | Chitradurga | I | 145853 | 34 | Ramdurg | III | 34800 | 61 | Naregal | IV | 16690 |
| 8 | Kolar | I | 138462 | 35 | Guledgudda | III | 33382 | 62 | Molakalmuru | IV | 15797 |
| 9 | Bagalkot | I | 111933 | 36 | Basavana Bagevadi | III | 33198 | 63 | Koratagere | IV | 15265 |
| 10 | Dod Ballapur | II | 93105 | 37 | Gajendragarh | III | 32359 | 64 | Bommasandra | IV | 15254 |
| 11 | Gokak | II | 79121 | 38 | Badami | III | 30943 | 65 | Chikkabanavara | IV | 14409 |
| 12 | Chintamani | II | 76068 | 39 | Madhugiri | III | 29159 | 66 | Huliyar | IV | 14304 |
| 13 | Chikkaballapura | II | 63652 | 40 | Mudalgi | III | 29128 | 67 | Hunasamaranahalli | IV | 13389 |
| 14 | Nipani | II | 62865 | 41 | Pavagada | III | 28486 | 68 | Dommasandra | IV | 12610 |
| 15 | Tiptur | II | 59543 | 42 | Hosdurga | III | 28370 | 69 | Madanaiyakanahalli | IV | 12563 |
| 16 | Sira | II | 57554 | 43 | Annigeri | III | 28267 | 70 | Sarjapura | IV | 11807 |
| 17 | Mulbagal | II | 57276 | 44 | Devanahalli | III | 28051 | 71 | Chikkabidarakallu | IV | 11554 |

| very high priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Hosakote | II | 56980 | 45 | Bagepalli | III | 27011 | 72 | Arasinakunte | IV | 10567 |
| 19 | Hiriyur | II | 56416 | 46 | Srinivaspur | III | 26793 | 73 | Bethamangala | IV | 10413 |
| 20 | Challakere | II | 55194 | 47 | Mundargi | III | 24919 | 74 | Kumbalagodu | IV | 10178 |
| 21 | Sidlaghatta | II | 51159 | 48 | Navalgund | III | 24613 | 75 | Allipura | V | 9930 |
| 22 | Athni | III | 47842 | 49 | Sadalgi | III | 23790 | 76 | Gudibanda | V | 9441 |
| 23 | Bangarapet | III | 44849 | 50 | Ron | III | 23311 | 77 | Maragondahalli | V | 8824 |
| 24 | Anekal | III | 44260 | 51 | Kudchi | III | 23154 | 78 | Gokak Falls | V | 8080 |
| 25 | Saundatti-Yellamma | III | 41215 | 52 | Konappana Agrahara | III | 20622 | 79 | Kadigenahalli | V | 6587 |
| 26 | Malur | III | 40050 | 53 | Attibele | III | 20532 | 80 | Chelur | V | 5911 |
| 27 | Chikodi | III | 38307 | 54 | Kerur | IV | 19731 | 81 | Matadakurubarahatti | V | 5884 |

Table 7: List of cities lying in high priority region

| High priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population |
| 1 | Belgaum | I | 490045 | 26 | Byadgi | III | 30014 | 51 | Kakati | IV | 13946 |
| 2 | Davanagere | I | 434971 | 27 | Hoovina Hadagalli | III | 27967 | 52 | Hindalgi | IV | 13741 |
| 3 | Bidar | I | 216020 | 28 | Magadi | III | 27605 | 53 | Sambra | IV | 13159 |
| 4 | Hospet | I | 206167 | 29 | Kudligi | III | 26680 | 54 | Gudur | IV | 11969 |
| 5 | Ranibennur | I | 106406 | 30 | Kotturu | III | 26289 | 55 | Yellur | IV | 11850 |
| 6 | Ramanagara | II | 95167 | 31 | Kamalapuram | III | 25552 | 56 | Benakanahalli | IV | 10999 |
| 7 | Channapatna | II | 71942 | 32 | Chitgoppa | III | 25298 | 57 | Kamalnagar | IV | 10252 |

| High priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Koppal | II | 70698 | 33 | Kushtagi | III | 24878 | 58 | Bidadi | V | 9917 |
| 9 | Haveri | II | 67102 | 34 | Chiknayakanhalli | III | 23206 | 59 | Kudur | V | 9114 |
| 10 | Ilkal | II | 60242 | 35 | Hukeri | III | 22988 | 60 | Mouje Nandgad | V | 8837 |
| 11 | Kanakapura | II | 54014 | 36 | Birur | III | 22723 | 61 | Munirabad Project Area | V | 8672 |
| 12 | Arsikere | II | 53216 | 37 | Channagiri | III | 21313 | 62 | Kangrali | V | 8204 |
| 13 | Mudhol | II | 52199 | 38 | Hungund | III | 20877 | 63 | Mutga | V | 7561 |
| 14 | Bail Hongal | III | 49182 | 39 | Aurad | IV | 19849 | 64 | Kodiyal | V | 7061 |
| 15 | Harapanahalli | III | 47039 | 40 | Khanapur | IV | 19309 | 65 | Kawalettu | V | 6265 |
| 16 | Homnabad | III | 44483 | 41 | Gubbi | IV | 18446 | 66 | Chikkajajur | V | 6236 |
| 17 | Bhalki | III | 40333 | 42 | Machche | IV | 18073 | 67 | Londa | V | 5956 |
| 18 | Indi | III | 38217 | 43 | Peeranwadi | IV | 17874 | 68 | Adityapatna | VI | 2623 |
| 19 | Sindgi | III | 37226 | 44 | Bilgi | IV | 17792 | | | | |
| 20 | Mahalingpur | III | 36055 | 45 | Shirhatti | IV | 17610 | | | | |
| 21 | Sankeshwar | III | 34637 | 46 | Kalghatgi | IV | 16917 | | | | |
| 22 | Muddebihal | III | 34217 | 47 | Holalkere | IV | 15783 | | | | |
| 23 | Kunigal | III | 34155 | 48 | Kamatgi | IV | 15620 | | | | |
| 24 | Kadur | III | 34151 | 49 | Aminagad | IV | 15073 | | | | |
| 25 | Talikota | III | 31693 | 50 | Yelbarga | IV | 14814 | | | | |

Table 8: List of cities lying in medium priority region

| Medium priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population |
| 1 | Mysore | I | 920550 | 36 | Someshwar | III | 24066 | 71 | Sulebhavi | V | 8503 |
| 2 | Gulbarga | I | 543147 | 37 | Hinkal | III | 23162 | 72 | Mudushedde | V | 8155 |
| 3 | Mangalore | I | 499487 | 38 | Mudgal | III | 22731 | 73 | Uppinangady | V | 7813 |
| 4 | Bellary | I | 410445 | 39 | Kurekuppa | III | 22560 | 74 | Narikombu | V | 7800 |
| 5 | Raichur | I | 234073 | 40 | Bankapura | III | 22529 | 75 | Beltangadi | V | 7746 |
| 6 | Hassan | I | 155006 | 41 | Belur | III | 22484 | 76 | Thokur-62 | V | 7433 |
| 7 | Gangawati | I | 114642 | 42 | Gurmatkal | III | 20614 | 77 | Talipady | V | 7237 |
| 8 | Harihar | II | 83219 | 43 | Pandavapura | III | 20399 | 78 | Badagaulipady | V | 7062 |
| 9 | Rabkavi Banhatti | II | 77004 | 44 | Sulya | IV | 19958 | 79 | Kuvettu | V | 7041 |
| 10 | Yadgir | II | 74294 | 45 | Hirekerur | IV | 19191 | 80 | Adyar | V | 7034 |
| 11 | Basavakalyan | II | 69717 | 46 | Hutagalli | IV | 18308 | 81 | Harekala | V | 6814 |
| 12 | Jamkhandi | II | 68938 | 47 | Satyamangala | IV | 18002 | 82 | Donimalai Township | V | 6672 |
| 13 | Kollegal | II | 57149 | 48 | Honnali | IV | 17928 | 83 | Alur | V | 6541 |
| 14 | Ullal | II | 53773 | 49 | Vittal | IV | 17618 | 84 | Shravanabelgola | V | 6485 |
| 15 | Puttur | II | 53061 | 50 | Mulki | IV | 17274 | 85 | Kurgunta | V | 6472 |
| 16 | Siruguppa | II | 52492 | 51 | Alnavar | IV | 17228 | 86 | Belma | V | 6452 |
| 17 | Nanjangud | II | 50598 | 52 | Shaktinagar | IV | 17088 | 87 | Kadakola | V | 6436 |
| 18 | Shahabad | III | 47582 | 53 | Kotekara | IV | 16505 | 88 | Thumbe | V | 6230 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | Savanur | III | 40567 | 54 | Hatti | IV | 16278 | 89 | Bondathila | V | 5858 |
| 20 | Channarayapatna | III | 40417 | 55 | Byrapura | IV | 14276 | 90 | Sajipanadu | V | 5847 |
| 21 | Bantval | III | 40155 | 56 | Turuvekere | IV | 14194 | 91 | Kairangala | V | 5788 |
| 22 | Sedam | III | 39341 | 57 | Shahabad ACC | IV | 13680 | 92 | Muduperar | V | 5686 |
| 23 | Kampli | III | 39307 | 58 | Hatti Gold Mines | IV | 13536 | 93 | Kolambe | V | 5592 |
| 24 | Wadi | III | 37988 | 59 | Pudu | IV | 13533 | 94 | Neermarga | V | 5503 |
| 25 | Sandur | III | 37431 | 60 | Vaddu | IV | 12453 | 95 | Saidapur | V | 5432 |
| 26 | Lingsugur | III | 35411 | 61 | Konaje | IV | 11368 | 96 | Addur | V | 5426 |
| 27 | Chitapur | III | 31299 | 62 | Srirampura | IV | 11234 | 97 | Navoor | V | 5365 |
| 28 | Mudbidri | III | 29431 | 63 | Manjanady | IV | 10401 | 98 | Gargeswari | V | 5343 |
| 29 | Devadurga | III | 28929 | 64 | Tirumakudal Narsipur | V | 9980 | 99 | Kenjar | V | 5338 |
| 30 | Shiggaon | III | 28207 | 65 | Elwala | V | 9826 | 100 | Arkula | V | 5077 |
| 31 | Hangal | III | 28159 | 66 | Bajpe | V | 9701 | 101 | Kariyangala | VI | 4698 |
| 32 | Afzalpur | III | 27088 | 67 | Bhogadi | V | 9041 | 102 | Haralahalli | VI | 4476 |
| 33 | Tekkalakote | III | 26224 | 68 | Munnuru | V | 8864 | 103 | Amaravathi | VI | 2628 |
| 34 | Terdal | III | 26088 | 69 | Yelandur | V | 8779 | | | | |
| 35 | Jevargi | III | 25686 | 70 | Belvata | V | 8605 | | | | |

Table 9: List of cities lying in very low and low priority regions

| Low and very low priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population | Sl No. | Cities | Class | Population |
| 1 | Shimoga | I | 322650 | 38 | Mundgod | IV | 18866 | 75 | Moodabettu | V | 5018 |
| 2 | Bhadravati | I | 151102 | 39 | Nagamangala | IV | 17776 | 76 | Yenagudde | V | 5017 |
| 3 | Udupi | I | 144960 | 40 | Virajpet | IV | 17246 | 77 | Manipura | V | 5001 |
| 4 | Mandya | I | 137358 | 41 | Siralkoppa | IV | 16864 | 78 | Koppa | VI | 4993 |
| 5 | Chikmagalur | I | 118401 | 42 | Arkalgud | IV | 16810 | 79 | Korangrapady | VI | 4944 |
| 6 | Karwar | II | 77139 | 43 | Piriyapatna | IV | 16685 | 80 | 52 Heroor | VI | 4778 |
| 7 | Sindhnur | II | 75837 | 44 | Kushalnagar | IV | 15326 | 81 | Kadwad | VI | 4403 |
| 8 | Chamarajanagar | II | 69875 | 45 | Saligram | IV | 15123 | 82 | Aversa | VI | 4286 |
| 9 | Sirsi | II | 62882 | 46 | Tirthahalli | IV | 14528 | 83 | Sringeri | VI | 3922 |
| 10 | Sagar | II | 54550 | 47 | Heggadadevankote | IV | 14313 | 84 | Tattilli (Mundgod) | VI | 3670 |
| 11 | Shahpur | II | 53366 | 48 | Siddapur | IV | 14204 | 85 | Ambikanagara | VI | 3556 |
| 12 | Dandeli | II | 52069 | 49 | Udyavara | IV | 11854 | 86 | Kudremukh | VI | 2241 |
| 13 | Shorapur | II | 51398 | 50 | Nadsal | IV | 11611 | | | | |
| 14 | Hunsur | II | 50865 | 51 | Saragur | IV | 11425 | | | | |
| 15 | Manvi | III | 46465 | 52 | Sorab | IV | 11332 | | | | |
| 16 | Aland | III | 42371 | 53 | Hanur | IV | 11066 | | | | |
| 17 | Malavalli | III | 37601 | 54 | Jog Kargal | IV | 10847 | | | | |
| 18 | Kumta | III | 36719 | 55 | Jali | IV | 10802 | | | | |
| 19 | Shikarpur | III | 36015 | 56 | Koteshwar | IV | 10229 | | | | |
| 20 | Tarikere | III | 35942 | 57 | Mudigere | V | 9677 | | | | |

| Low and very low priority cities | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Krishnarajanagara | III | 35805 | 58 | Badagabettu (No.80) | V | 9309 | | | | |
| 22 | Madikeri | III | 33381 | 59 | Gonikoppal | V | 8306 | | | | |
| 23 | Bhatkal | III | 32000 | 60 | Bada | V | 8117 | | | | |
| 24 | Kundapura | III | 30444 | 61 | Bhimarayanagudi | V | 8029 | | | | |
| 25 | Hole Narsipur | III | 29974 | 62 | Tonse East | V | 7911 | | | | |
| 26 | Maddur | III | 28754 | 63 | Mallar | V | 7765 | | | | |
| 27 | Gundlupet | III | 28105 | 64 | Gogipeth | V | 7544 | | | | |
| 28 | Krishnarajpet | III | 25946 | 65 | Narasimharajapura | V | 7458 | | | | |
| 29 | Karkal | III | 25800 | 66 | Venkatapura | V | 6928 | | | | |
| 30 | Shrirangapattana | III | 25061 | 67 | Sanoor | V | 6881 | | | | |
| 31 | Haliyal | III | 24238 | 68 | Varamballi | V | 6809 | | | | |
| 32 | Sakleshpur | III | 23352 | 69 | Somvarpet | V | 6729 | | | | |
| 33 | Ankola | III | 22249 | 70 | Mellahalli | V | 6393 | | | | |
| 34 | Bannur | III | 21896 | 71 | Alevoor | V | 6302 | | | | |
| 35 | Chincholi | III | 20897 | 72 | Tenkanidyoor | V | 6188 | | | | |
| 36 | Yellapur | III | 20452 | 73 | Hosanagara | V | 5839 | | | | |
| 37 | Honavar | IV | 19109 | 74 | Bobruwada | V | 5409 | | | | |

# Annexure I (F)

Table 10: Data sources for suggesting sustainable water strategies

| Data | Source |
|---|---|
| • Population<br>• City Class<br>• Civic Status<br>• Area (in sq. km)<br>• Density (persons per sq.km)<br>• Sex Ratio<br>• Literacy Rate<br>• Population Growth Rate (2001-2011) | Census 2001,2011 |
| • Coverage of water supply connections (in %)<br>• Per capita supply of water (in lpcd)<br>• Extent of metering water of connections (in %)<br>• Extent of non-revenue water (in %)<br>• Continuity of water supply (in hours per day)<br>• Quality of water supply (in %)<br>• Coverage of toilets (in %)<br>• Coverage of sewage network services (in %)<br>• Collection efficiency of sewage network (in %)<br>• Adequacy of sewage treatment capacity (in %)<br>• Quality of sewage treatment (in %)<br>• Extent of reuse and recycling of treated sewage (in %) | Report on Service Level Benchmarks, 2017-18, UDD |
| Elevation Range (in m above sea level) | DEM data form USGS |
| Depth to Groundwater table (in m,bgl) | Karnataka State Natural Disaster Monitoring Centre (KSNDMC), January 2018 data |
| Surface Soil Texture | NBSS&LUP,R.C.,Bangalore / KSDA, http://raitamitra.kar.nic.in/agriprofile/soilclass.htm |
| Annual Rainfall | KSNDMC Annual Report 2016 |

| | |
|---|---|
| Average Temperature (in degrees celsius) | KSNDMC |
| Average Relative Humidity (in %) | KSNDMC |

## Annexure I (G)

Table 11: Characteristics of regions in Karnataka

| Regions | North Interior | South Interior | Coastal | Malnad |
|---|---|---|---|---|
| Agro climatic Zones in the region | Northern Dry | Northern Dry | Coastal | Southern Transitional |
| | Northeast Dry | Southern Dry | Hilly | Central Dry |
| | Northern Transitional | Eastern Dry | | Southern Dry |
| | North eastern Transitional | Central Dry | | Hilly |
| | Hilly | Southern Transitional | | |
| Rainfall (in mm) | 508-1960 | 408-967 | 1555-5051 | 641 to 4079 |
| Rainfall (Normal Average of region in mm) | 728 | 1286 | 3451 | 1914 |
| Depth to Groundwater level (in mbgl) | Less than 10m to above 60m | Less than 10m to above 60m | Less than 10m to 20m | Less than 10m to 40m |
| Major Soil Typology | Black Clay | Red Sandy Loam | Coastal laterite and Coastal alluvial | Red Sandy Loam |
| Major Soil Texture | Clayey | | Sandy | |
| Elevation (in m above sea level) | 265 to 1036 | 213 to 1816 | 0 to 1874 | 32 to 1891 |
| Slope characteristic | Level to gently sloping | Level to gently sloping | Very gently to moderately sloping | Gently to steeply sloping |
| Average coverage of water supply network in urban centres (in %) | 70% | 73% | 62% | 84% |
| Average per capita water supply in urban centres (in lpcd) | 93 | 90 | 109 | 113 |

| Regions | North Interior | South Interior | Coastal | Malnad |
|---|---|---|---|---|
| Average extent of metering in urban centres (in %) | 7% | 12% | 65% | 16% |
| Average non- revenue water (NRW) in urban centres (in %) | 27% | 30% | 26% | 28% |
| Average number of hours of water supply per day in urban centres | 2.29 | 2.3 | 6.4 | 2.63 |
| Average quality of water supply in urban centres | 91% | 88% | 96% | 95% |

## Annexure I (H)

### User Guide for Strategy Selection Toolkit

- **Step 1** prompts the user to select the city. The basic information pertaining to the city like population, area, environmental parameters, service level benchmark status etc. can be viewed (refer section 9, annexure 1 for elaborate list). Along with the basic information, the strategy prioritisation guidance relevant to the city, detailed in the previous step can also be viewed once the city selection is made.
- **Step 2** prompts the user to select the priority water cycle component (which the user may select based on the guidance provided or any other component that the user wishes to explore for the city). The available strategy options under the selected water cycle component will be listed below step 2 once the selection is made.
- In **Step 3**, the user can chose the priority strategy option (again based on the guidance provided) based on which the list of strategy /technologies pertinent to the selections made can be viewed.

## Annexure I (I)

### Integrated Urban Water Resources Management

The IUWM approach is based on the fundamental understanding that cities are not only dependent on, but also impact the wider water shed. Activities in the upstream areas like deforestation, over-extraction of groundwater etc. impacting the hydrological regime of the water shed can stress the urban water system located downstream. Similarly discharge of untreated waste water from the cities can impact the water quality for downstream users. The city water use can also lead to reduction in the environmental flows affecting the availability of water for downstream users. This close link of the urban water cycle to the wider water shed necessitates the need for management plans at the water shed scale to consider the urban water system and vice-versa (Jacobsen, Webster, & Vairavamoorthy, 2013).

A similar approach to IUWM is the Integrated Water Resource Management (IWRM), which emerged after the United Nations Agenda 21 and the World Summit on Sustainable Development in 1992 in Rio. The major difference between the two approaches is the spatial scale and the sector of application. While IWRM focuses on the management of the entire river basin which is inclusive of one or many urban centres, the IUWM is specifically for a single urban area. The IUWM can be considered as a subset of the IWRM in this respect. Synergy between IWRM and IUWM plans is critical for the success of each of them (Maheepala, 2010).

The urban water services, urban development and water shed management, (inclusive of their institutions, planning instruments and financing mechanisms), are considered in an integrated manner in the IUWM approach.

## Annexure I (J)

### <u>Best Practices- IUWM</u>

The principles of IUWM which have to be considered depend on the contextual necessities of each city. How an IUWM approach impacted three different cities facing diverse water challenges is described below

<u>Windhoek, Namibia- A water scarce city located in sub-Saharan Africa.</u>

The resource availability constraints pushed the city to adopt an IUWM approach in the early 1960s. The city is, in fact, considered as one of the first to adopt an integrated approach to water management.

Some of the structural and non-structural measures that the city adopted which solve its issues include

- Artificial recharge of aquifers by surface water and recycled water which would act as a storage system to be used during droughts. The underground storage in aquifers also had the benefit of reduced loss due to evaporation. Loss due to evaporation was an issue in case of surface reservoirs due to extreme heat conditions.

- Introduction of a dual pipe system replaced around 6 % of the potable water supply in the city with recycled water to use in landscaping, parks and sports fields.
- Non-structural measures like raising tariff structure, mandatory covering of pools, prescribing water efficient fixtures, limiting water use for irrigation etc.
- Urban planning measures like not promoting water intensive industries and expanding city area to protect its aquifers.
- Awareness campaigns to promote use of recycled water.

The city is an example to demonstrate that targeted and informative campaigns can lead to acceptance among the citizenry for potable use of recycled water even for a developing country.

Melbourne, Australia- A city facing extreme climatic events

Droughts, intense rainfall, heat waves, sea level rise etc. are some of the issues that the city faced which affected its water resources. This prompted the city to adopt IUWM principles to cope with the impacts of the extreme climatic events.

Some of the measures that the city took in IUWM include

- Use of recycled water for tourism industry, irrigation and for municipal and environmental services. Recycled water is also supplied to new residential areas which are mandated to have dual pipe system.
- Desalination plants to supply during extreme water shortage.
- Aquifer recharge with treated storm water and recycled water for environmental benefits as well as for future use. Water is deposited in aquifers usually during winters and maximum extraction takes place during summers.
- Planning amendments where any developer who increases the impervious area in a watershed by 10 sq. m, needs to install onsite systems like rainwater storage tanks, rain gardens etc. and should not allow it directly to flow into storm water drains.
- Demand management measures like promoting water efficient design, pricing, education etc.
- Empowering communities to take ownership of the IUWM measures.

The city has also realised that even within the city, the approaches will have to be different depending upon the issues and challenges that each area faces.

Rotterdam, Netherlands- A coastal city

Sea levels rise, change in river discharges, intensive rainfall, longer and hotter dry spells etc. were some of the reasons for the city to move towards an integrated approach to water management. Some of the measures that the city adopted are,

- The city is focusing on adopting alternative ways to harvest and store rainwater. Developing water plazas or water squares which will fill up during heavy rainfall preventing the flooding of streets.
- Multi-functional parking garages which are equipped with underground storage facility to be used at the time of heavy rainfall. The stored water would be used at a later time for ecological purposes when there is low river flow. The facility reduces the stress on the sewerage system during a heavy rainfall.
- The city also promotes green roofs for harvesting, treating and storing rainwater.

(World Bank, 2016)

Water Demand Management Strategy - Singapore

Singapore's national water agency has recognised the equal importance that needs to be given to (1) securing an adequate water supply as well as (2) managing demand in overcoming the country's water challenges. For securing adequate water supply, Singapore has adopted the "Four National Taps" strategy, which focuses on diversifying the sources of water available. The "four taps" include –increasing local catchment, imported water, high-quality reclaimed water and water from desalination. For the second aspect, i.e., managing demand, facilitating behaviour change in water use and consumption, and encouraging citizens to take ownership of water resources have been the key. The campaign for the same has been called the "3P approach", which encourages people, public and private to take ownership of water resources. The ABC Waters (Active, Beautiful, Clean Waters) Programme has been central to this approach, which is enhancing Singapore's water infrastructure and bringing people closer to water. The key elements of Singapore’s water demand management strategy include (i) community engagement through water efficient homes and development of ownership through ABC Waters Programme; (ii) water price restructuring, upgrading metering system and legislative measures; and (iii) water efficiency funds to encourage companies to manage demand.

Water conservation programmes have encouraged industries and HHs to use water wisely, and save 10 per cent of their water use, and 10 litres of water a day respectively. Per capita water use has fallen from 165 litres/day in 2003 to 155 litres/day in 2013, and the aim is to achieve 147 litres/day by 2020 (2030 Water Resources Group, 2013)

## Annexure II (A)

### Description of waste streams in sanitation

Faecal Sludge or Septage – is a raw or partially digested slurry or semisolid that results from the collection and storage of excreta or blackwater with or without greywater.

Blackwater - is the combination of faeces, urine and flush water along with anal cleansing water.

Greywater - is the total volume of water generated from washing clothes and dishware, from bathing, but not from toilets.

Excreta - consists of faeces and urine that is not combined with any flush water. Excreta is usually small in volume, but concentrated in both nutrients and pathogens.

Effluent - is a liquid that is output of a technology, typically after blackwater or sludge has undergone solids liquid separation or some other type of treatment.

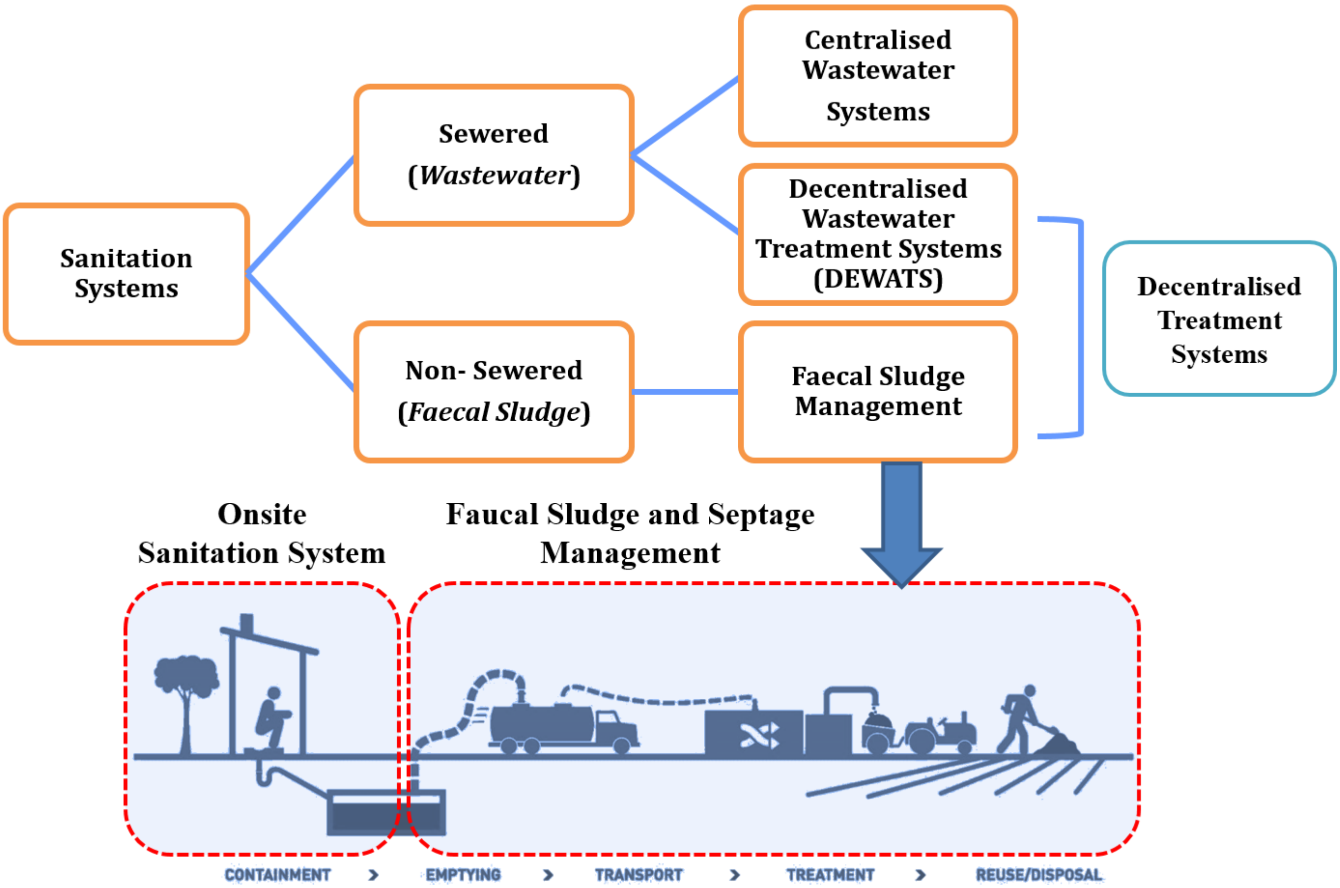
### Description of Types of Sanitation System

A sanitation system is a series of services and technologies for management of resources (wastes) i.e., for their collection, containment, transport, transformation, utilization or disposal (Tilley, Ulrich, Lüthi, Reymond, & Zurbrügg, 2008).

On-site Sanitation System (OSS): An On-site sanitation system typically consists of a user interface and a storage facility. It should ideally be followed by an FSSM system to ensure safe sanitation.Faecal Sludge and Septage Management (FSSM) System: FSSM is the management of faecal sludge that is removed from onsite sanitation systems. FSSM involves collection, transport, treatment and safe disposal of faecal sludge or septage. The sludge can be treated in a separate treatment facility or co treated in a sewage treatment plant.

Sewer-based systems: Also called networked systems generally refer to management of blackwater that is collected through large sewer systems. The blackwater is usually treated in highly mechanised treatment plantsIn case of networked system the blackwater can either be treated in a centralised wastewater treatment facility or in a decentralised wastewater treatment facility (DEWATS).

Figure 1: Sanitation System



# Annexure II (B)

Table 12: Data sources for Sanitation chapter

| Data points | Sources |
|---|---|
| Base Population and area of the city;<br>Share of onsite sanitation system in the cities<br>City Population | Census 2011 |
| City parameter - per capita water supply | Service Level Benchmarks data provided by UDD, Government of Karnataka |
| City parameter – groundwater depth and soil type | Central Ground Water Board Report |
| City parameter – rainfall, temperature, relative humidity | KSMNDC |
| Detail of sanitation technology and their parameters | Existing sanitation compendiums and technology specific literature,<br>expert consultation etc. |
| Individual household toilets built under SBM | SBM dashboard |
| Capital and Operational Cost of technologies | Existing sanitation compendiums and technology specific literature,<br>Expert consultation etc. |
| Removal efficiency of various technologies | |
| Input quality of waste water | CPHEEO manual |
| Detail of sanitation technology and their parameters | Existing sanitation compendiums and technology specific literature,<br>expert consultation etc. |
| Sanitation 21 (S21) planning framework | International Water Association |
| Community-led urban environmental sanitation planning (CLUES) | Eawag |
| Citywide Sanitation Strategy - | Water and Sanitation Program (WSP) |
| Guiding principles for better sanitation planning | SuSanA |
| National Urban Sanitation Policy, 2008 | MoUHA |
| Other Sanitation Planning Process | Asian Institute of Technology (AIT), EWAG, Sustainable Sanitation and Water Management |
| National and State Faecal Sludge and Septage Management Policy,2017 | MoUHA, Government of Karnataka |
| Urban Waste Water Reuse Policy, 2018 | Government of Karnataka |
| Performance Assessment Systems (PAS) for Urban | CEPT (Centre for Environmental Planning |

| Data points | Sources |
|---|---|
| Water Supply and Sanitation | and Technology), India |
| Result and indicators for the Water and Sanitation Sector | European Commission |
| Global City Indicators | Cities Alliance |
| SUSTAINABLE CITIES INDEX 2015 | ARCADIS (Arcadis, 2015) |
| Handbook on Service Level Benchmarking | Ministry of Urban Development (MoUD), Government of India |

## Annexure II (C)

**Detailed Activities and Entry Points for FSSM Inclusive City Sanitation Plan**

Stage1: Exploratory study

*Activities*

- Preliminary assessment of the policy, programmes and strategies at national, state and city level plans.
- Preparation of stakeholder inventory (consultants, NGOs, Other agencies)
- Augment synergy among the stakeholders.

Stage 2: Setting up a City Sanitation Task Force (CSTF)

*Activities*

- Mobilise stakeholders- evaluate perception about sanitation in the minds of different stakeholders
- Constitute a multi-stakeholder CSTF comprising of representation from different segments of the society, agencies responsible for planning and implementation of sanitation, experts and academia groups, practitioners, private firms and consultants, civil society organisations (NGO, CBO (community based organisations), SHGs (self-help groups) etc.), sanitation workers and other significant stakeholders.
- Assign institutional responsibilities to the CSTF. Some of the major responsibilities of the CSTF will comprise of :
    - Generating awareness among the stakeholders

    - Approving progress materials and monitoring progress of the implementing agency
    - Approving the CSP prepared by the implementing agency
    - Providing overall direction to the implementing agency
- Formation of sub- committees to focus on different aspects of the planning and implementation of the plan
- Appointment of one key agency, preferably the ULB, to become the City Sanitation Implementing Agency and assigning city wide responsibilities to them.

*Entry point from state FSSM and UWWR policy*

- The CSTF should be in continuous coordination with the state FSSM task force constituted under the Urban Development Department (UDD), GoK.
- The key responsibilities should reflect the roles and responsibilities defined as per the FSSM policy mentioned in the Table 5.3 of the FSSM policy document.

Stage3: Setting legal, regulatory and institutional responsibilities

*Activities*

- Formal adoption of guidelines by CPHEOO and Environment Acts, SBM guidelines city bylaws
- Laying down monitoring and regulatory responsibilities

*Entry point from state FSSM and UWWR policy*

- The policies suggest that the implementing agency coordinate with the following:
    - FSSM cell/unit in Karnataka Urban Water, Sewerage and Drainage Board formed under the FSSM policy
    - State FSSM task force formed under the FSSM policy
    - Wastewater Reuse Resource Centre formed under the WWR policy
    - Karnataka Industrial Area Development Board
    - Department of forest, ecology and environment
    - Department of energy
    - Department of Agriculture
    - Water Resource Department

- The policy suggests for the adoptions of the state level guidelines and standard operating manual in addition to other guidelines
- The suggests for modification in by-laws to incorporate designs and specifications for FSSM systems

Stage 4: Preliminary (pre-feasibility) Studies

*Activities*

- Base line data collection for
  - Initial preparatory actions, HH survey, questionnaires
  - IEC (Information Education and Campaign, awareness programme, workshops etc.)
  - Planning and implementing institutional changes, social mobilization and up-gradation, improvements and new investments in assets and systems of O&M, M&E, etc.
- Selection of key stakeholders and identification of preliminary characteristics of the stakeholders and their relationships
- Conduct an initial launching workshop, including field visit with all the stakeholders
- Preliminary Assessment of:
  - Existing sanitation practices and needs
  - Existing Government support
  - Existing legal and regulatory framework
  - City structure and heterogeneity of sanitation practices
  - Existing financial flows of the implementing agency
  - Physical constraints, financial constraints, land constraint people's sanitation-related behaviour etc.
  - Existing systems and technologies being used and their potential across sanitation value chain
  - Existing resource availability
- Initial SWOT analysis
- Selection of potential organisational modes

*Entry point from state FSSM and UWWR policy*

Collection of complete data sets for sanitation situation across the sanitation value chain (toilet, onsite storage/treatment, emptying, commence, treatment and reuse/disposal) - sewage network; onsite storage/treatment, IHHL (individual household toilets), PTs (public toilets), CTs (community toilets) FSM truck; private sector or informal sector related data etc. is highly stressed in the policy

- It is imperative that the list of stakeholders include - participation from various FSSM related stakeholders (for example: community, ULB, formal sanitation workers and service providers, informal private service providers for FS emptying, stakeholders with potential reuse of treated sludge etc.).

Stage 5: Feasibility study/ Strategy development exercise

*Activities*

- Detailed evaluation of the following
  - Quantification and characterisation of sludge and waste water generated in the city
  - Institutional setup and capacities, roles & responsibilities and contractual arrangements
  - Technology options including incremental options, up-gradation and retro-fitting options
  - Technologies across the entire sanitation value chain
  - Institutional system for operation and maintenance
  - Reuse of end products from STP and FSTP
  - Capital and operation investment required, financial mechanisms, estimated budget financial viability and sustainability
  - Skills required for running the sanitation system
  - Manpower and human capital adequate safety and remuneration in case hazardous nature of work
  - Environmental impact assessment
  - Social impact assessment
  - Consideration of resource constrains and other areas such as water resources, impact of climate change, use of low energy intensive onsite /decentralised treatment technologies, distributed utilities etc.
- Assessing options through piloting: New ideas and approaches should be tested on a pilot to see if they will work, are affordable and can be managed by the staff that is available.

- Characterisation and selection of sites
- Preliminary presentation of the results of feasibility study to the key stakeholders
- Final selection of sanitation system and technology options
- Validation of chosen options by all the stakeholders by conducting a workshop

*Entry point from state FSSM and UWWR policy*

- The policies suggests to assess the technology options in terms of the following
  - Complete and safe systems
  - Technology options for both FSSM and sewage treatment
  - Technology that consumes less power and more dependent on biological processes
  - Technology options based on physical/contextual/ geological constraints
  - Technology options for meeting the require output quality standard
- The infrastructure design and planning should be in line with the state level guidelines and standard operating manual developed under the Karnataka FSSM policy
- The policies suggest to assess the operation and maintenance options in terms of the following
  - Timely and safe collection and transport of sludge and septage
  - Shift towards scheduled de-sludging of onsite storage/treatment systems
  - All stakeholders to be trained and made aware of do's and don’ts while managing FS
  - Incentives and penalties to encourage greater participation and compliance from the service providers
- The policies suggest the following in terms of reuse options
  - Identify reuse potential for treated end products
  - Identification of demand for end products
  - Ensuring supply of sufficient volumes of reuse material
- For financing, the city can take aid from the city sanitation fund in line with the state urban sanitation fund that will be formed under the Karnataka FSSM policy for implementation of projects. It is a dedicated fund for FSSM and sanitation consolidated from various state government schemes/programmes, ULB fund, CSR, Donor/Bilateral/Multilateral grants and loans etc.
- The policy also pushes for funding though public private partnership
- The policy recommends constant capacity building sessions for ULB officials, safai karmacharis and service providers on FSSM

Stage 6: Detailed project development/ Action Plan/City Sanitation plan development

*Activities*

- Development of detailed engineering design
- Defining roles & responsibilities of institutions and private sector
- Development O&M management plan with clear allocation of costs, responsibilities, training needs, tariffs for service provision and O&M systems for new development, O&M protocol for each of the sanitation facilities in the city
- Development of customer complaints and redressal systems
- Development of strategies for control and enforcement
- Defining contracts and bidding processes
- Development of monitoring and evaluation strategy for the implementation phase
- Development of timeline for implementation with distinct phases and an itemised implementation budget
- Defining Collaborations for implementation
- Planning for integration with other sectors and city plans
- Presentation of the Action Plan and Conventions between stakeholders, securing financial and institutional mechanisms
- Validation and finalisation of Action Plan
- Development of detailed project wise Implementation schedule
- Development of pre-procurement management plan

*Entry point from state FSSM and UWWR policy*

- The engineering design must abide by the state level guidelines and standard operating manual
- The roles and responsibilities defined for institutions should be as per the FSSM policy mentioned in the Table 5.3 of the FSSM policy document
- The policy suggested that the cost parity of O&M through reuse of treated end products and ULB funds
- The policy suggests for a robust grievance redressal mechanism linked with IT enabled single window module, with GIS (geographic information system) based MIS (management information system) database
- As a strategy to control and enforce for the service providers, the policy suggests the following

  - Incentives and penalties to encourage greater participation and compliance from the service providers
  - Formalisation of all informal FSSM operations through licensing by ULBs, MIS based reporting of operations, formal training access to formal finance
- Timelines for implementation to be in line with targets set by both policies
- The policy suggests for a digital repository/resource library comprising successful case studies, experiences, projects, papers, training material, etc. from various collaborative partners
- The policy encourages greater private sector participation

Stage 7: Project Appraisal and approval

*Activities*

- Prepare project appraisal document
- Understand the project negotiation process

Stage 8: Implementation

*Activities*

- Acquire project management support to the implementation agency by expert institutions, consultants, NGOs, etc. who were involved in planning,
- Contract preparation and management without delays and as per appropriate quality standards
- Training in contract management for the implementing agency
- Preparation of bidding documents for the projects
- Recruitment of contractors for building sanitation system and operation and maintenance
- Monitoring of construction
- Starting up the system

*Entry point from state FSSM and UWWR policy*

- The policy suggests that while choosing contractors, preference is to be given to the contractors having experience of working on FSSM

Stage 9: Monitoring and Evaluation (M&E)

*Activities*

- Monitoring of the running system (technical stability, cost recovery etc.)
    - Collection of administrative data from implementing agency reports and from the implementing consultants, contractors
    - Memorandum of Understanding (MoU) with relevant local Non-Government Organisations (NGOs) for monitoring
    - Community groups structured feedback
    - Independent third party assessment
    - Development of M&E indicators in terms of output, process and outcome related parameters
- Dissemination of key indicators as a part of awareness campaign to encourage stakeholders to monitor, and devise a simplified mechanism to collect data and report on
- Self-Assessment by the CSTF, which includes implementation agency data, independent assessments, citizens' groups feedback, and crucial field visits
- Generation of report cards from above assessment
- Cross-city monitoring with participation of state level and city level stakeholders
- ULBs to institutionalize the means of monitoring to acquiring new investments
- Regular collection of formal data and informal information and publishing in the public domain
- City Reward Schemes
    - Institution of rewards schemes for cities
    - Rewards could be given on an area basis - city wards; schools and colleges; associations; market and bazaar committees etc.
    - The rewards may be a scroll of honour, nominal amount of money, rating system etc.

*Entry point from state FSSM and UWWR policy*

- The policy suggests the following for the monitoring of FSSM implementation
    - IT enabled single window module, with GIS based MIS database of households, communities and ward level sanitation assets and the sanitation practice by ULB for monitoring
    - The database would assist in scheduling de-sludging services, planning for FSSM and sewage network, regular tariff collection, facilitate appropriate incentives and penalties, maintain records and manifests.

- The sanitation database to be ideally linked with property tax database
- Evaluation through dedicated service level benchmarks suggested in the framework by National FSSM policy
- Development of robust grievance redressal mechanism linked with IT enabled single window module, with GIS based MIS database
- Active participation of residents in implementation and monitoring

Crosscutting and parallel process across all planning stages

Capacity Building

*Activities*

- Carrying out capacity needs assessment in terms of manpower, expertise, equipment, resources, financial management
- Development of training manuals and materials
- Training for orientation, skill building and aptitude for carrying out different types of activities
- Training for working systems in ULBs or service provision agencies to provide the right kind of structural linkages and organizational systems and environments that utilize the skills and perspectives imparted above
- Provision of online capacity building trainings on FSM

*Entry point from state FSSM and WWR policy*

- The policies suggests for the following in terms of capacity building
    - Carrying out assessment of capacities related to FSSM for the ULB/implementing agency
    - Separate initiation and training module for different stakeholders (ULB/ service provider/ planners and engineers/ perspective partners etc.)
    - Engagement of external agency for training of government officials
    - Successful participation to be awarded with certification
    - Planned exposure visits to areas with best practices of FSSM and sewage management

## IEC and Advocacy

*Activities*

- Awareness Generation and Launch Of 100% Sanitation Campaign (city wide)
- Raise awareness amongst all stakeholders about the huge health and environmental costs
- Awareness generation about process, procedure and components of FSSM through interactive resources

## Sanitation for all at all times

*Activities*

- Institute requirements of different user groups who are un-served such as gender, poor, differently abled, ethnic groups etc. As well as look into the intersections among these groups to access vulnerabilities that can be resolved for better
- Develop participatory approaches to consult user groups and involve them in the process of planning and management of sanitation arrangements
- Mobilising user groups and vulnerable communities and initiate a process of collaborative planning and delivery of services- with NGOs and CBO etc.
- Encourage community led O&M for community facilities
- Funds under the sanitation sector to be earmarked for user groups which are un-served

# Annexure II (D)

Table 13: Description of technology groups

| Parameters | Values | Ranges |
|---|---|---|
| Water consumption | Low | < 30 lpcd |
| | Medium | > 30 lpcd. and < 60 lpcd |
| | High | > 60 lpcd |
| Rainfall | Very high | >2000mm |
| | High | 1000mm-2000mm |
| | Medium | 700mm-1000mm |
| | Low | <700mm |
| Require specific soil type | Sandy | |
| | Clayey | |
| | Loamy | |
| | Rocky mountains | |
| | All | |
| Groundwater level | Deep | >10m bgl |
| | Shallow | <10m bgl |
| | All | |
| Slope | High | >1% |
| | Low | <1% |
| Land Requirement at HH level | Low | $<2\ m^2$ |
| | Medium | $2\ m^2$ -20 $m^2$ |

| | | |
|---|---|---|
| | High | >20 $m^2$ |
| Skill Required | High | technically qualified resources |
| | Low | local craftsman (mason) |
| **Type of system** | | **Abbreviation** |
| Decentralised/Centralised networked and FSSM systems | | NS (D/C) + FSSM (D/C) |
| Decentralised/Centralised FSSM systems | | FSSM (D/C) |
| Decentralised/Centralised networked | | NS (D/C) |

| **User interface/ Toilet** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technology name** | **Type of system** | **Parameters of the technology** | | | | |
| | | | **Water consumption** | **Rainfall** | **Land Requirement** | **Groundwater level** | **Soil type** |
| **U1** | Cistern Flush Toilet | NS (D/C) + FSSM (D/C) | high | | medium | shallow/ deep | all |
| **U2** | Pour flush toilet | FSSM (D/C) | medium/ high | | medium | shallow/ deep | all |
| **U3** | Urine Diverting Dry Toilets (UDDT) | | low | Low | medium | deep | all |
| | Dry toilets | | low | Low | medium | deep | all |
| | Composting toilets | | low | Low | medium | deep | all |

| On-site Collection/ Storage | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technology name** | **Type of system** | **Parameters of the technology** | | | | | | | |
| | | | **Water consumption** | **Temperature** | **Work in flood prone areas** | **Land Requirement** | **Ground water level** | **Soil type** | **Energy Requirement** | **Skill Required** |
| **S1** | Single pit | FSSM (D/C) | low | | No | medium | deep | Sandy/ loam y | No | |
| | Single ventilated Improved pit | | low | | No | medium | deep | Sandy/ loam y | No | |
| | Double ventilated Improved pit | | low | | No | medium | deep | Sandy/ loam y | No | |
| **S2** | Fossa Altera / Composting chamber | | low | >25°C | No | medium | all | Sandy/ loam y | No | |
| | Composting chamber + urine tank | | low | >25°C | No | medium | all | Sandy/ loam y | No | |
| | Dehydration | | low | | Yes | medium | all | Sandy/ | No | |

| **On-site Collection/ Storage** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | vaults | | | | | | | loam y | | |
| **S3** | Twin pit for pour flush | | medium | | No | medium | deep | Sandy/ loam y | No | |
| **S4** | Conventional Septic tank with soak pit | | medium/ high | | No | medium | deep | all | No | |
| | Anaerobic baffled reactor (ABR) | | medium/ high | | | medium | deep | all | No | high |
| | Anaerobic filter (AF) | | medium/ high | | No | medium | deep | all | No | high |
| **S5** | Biogas digester/reactor | | medium/ high | >15°C | | high | all | all | no | high |
| | Bio-tank | | medium/ high | 4°C-55°C | | low | all | all | no | |

| Emptying | | | | |
|---|---|---|---|---|
| **Technology groups** | **Technology name** | **Type of system** | **Parameters of the technology** | |
| | | | **Capital Expenditure** | **O&M Expenditure** |
| **ET** | Gulper | FSSM (D/C) | low | low |
| | Manual diaphragm pump | | low | low |
| | Manual pit emptying technology | | low | low |
| | Motorised diaphragm pump | | high | high |
| | Trash pump | | low | low |
| | Motorised pit screw auger | | high | low |
| | Gobbler | | high | low |

| Conveyance | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technology name** | **Type of system** | **Parameters of the technology** | | | | |
| | | | **Water consumption** | **Soil type** | **Slope** | **Skill Required** | **Vehicular accessibility** |
| **C1** | Small Truck | FSSM (D/C) | - | - | - | - | Wide and small lanes |

| Conveyance | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Big Truck | | - | - | - | - | Wide lanes |
| **C2** | Simplified/ shallow sewers/ small bores | NS (D/C) + FSSM (D/C) | high | Sandy/ Clayey/ loamy | > 1% | high | |
| | Conventional gravity sewers | NS (D/C) | high | Sandy/ Clayey/ loamy | > 1% | high | |
| **C3** | Solid free sewers | | medium, high | all | > 1% , <1% | high | |

| Reuse and Disposal | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technique name** | **Type of system** | **Parameters of the technology** | | | | |
| | | | **Rainfall** | **Work in flood prone areas** | **Land Requirement** | **Groundwater level** | **Soil type** |
| **R1** | Fill and Cover / Arborloo | FSSM (D/C) | | | | deep | all |
| | Application of Dehydrated Faeces | | | | | deep | all |
| | Application of Pit Humus and | | | | | deep | all |

| Reuse and Disposal | | | | | | | |
|---|---|---|---|---|---|---|---|
| Technology groups | Technique name | Type of system | Parameters of the technology | | | | |
| | | | Rainfall | Work in flood prone areas | Land Requirement | Groundwater level | Soil type |
| | Compost | | | | | | |
| | Application of Sludge | | | | | deep | all |
| | Irrigation/landscaping | NS (D/C) + FSSM (D/C) | | | | deep | all |
| | Surface Disposal and Storage | | | No | high | deep | all |
| R2 | Fish Pond (Aquaculture) | | very high/ high | | high | deep | all |
| | Floating Plant Pond | | very high/ high | | high | deep | all |
| R3 | Soak Pit | | | No | low | deep | Sandy/ loamy |
| | Leach Field | FSSM (D/C) | | | high | deep | Sandy/ loamy |
| R4 | Biogas Combustion / waste to energy | | | | | | |
| | Fountains, vehicle washing like car, bus and trains, toilet | NS (D/C) + FSSM (D/C) | | | | | |

| **Reuse and Disposal** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technique name** | **Type of system** | **Parameters of the technology** | | | | |
| | | | **Rainfall** | **Work in flood prone areas** | **Land Requirement** | **Groundwater level** | **Soil type** |
| | flushing and Fire protection systems. | | | | | | |
| | Used in Industrial Process | | | | | | |

| **Treatment Technologies** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Technology groups** | Technology name | Type of system | Treatment Type | Parameters of the technology | | | | | | |
| | | | | Land Requirement | Groundwater level | Soil type | Energy Requirement | Skill Required | Capital Expenditure | O&M Expenditure |
| **T0** | Centrifugation | FSSM (D/C) | Primary treatment/ separation | low | all | all | yes | high | high | high |
| | Waste stabilisation ponds (WSPs) | NS (D/C) + FSSM (D/C) | Effluent Treatment | high | all | all | no | low | high | low |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment Technologies** | | | | | | | | | | |
| | Activated sludge process (ASP) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | low |
| | Sequence batch reactor (SBR) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | low |
| | Membrane bioreactors (MBRs) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | low |
| | Moving Bed Bio-Reactor (MBBR) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | low |
| | Up-flow Anaerobic Sludge Blanket (UASB) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | low |
| | Trickling Filter (TF) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | high |
| | BIOFOR Technology (Biological Filtration and Oxygenated | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | low | high | high |

| **Treatment Technologies** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Reactor) | | | | | | | | | |
| | High Rate Activated Sludge BIOFOR | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | | high | high |
| | Fluidized Aerated Bed (FAB) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | high |
| | Submerged Aeration Fixed Film (SAFF) Technology | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | high |
| | Cyclic Activated Sludge Process (CASP) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | high |
| | Fixed Bed Biofilm Activated Sludge Process (FBAS) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | high | high | high |
| | Ozonation | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | yes | low | high | low |

| Treatment Technologies | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Chlorine dioxide | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | no | low | high | low |
| | Ultra Violet treatment | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | yes | low | high | low |
| | Microfiltration | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | yes | high | high | high |
| | Anaerobic digester | FSSM (D/C) | Primary treatment/ separation | low | all | all | no | high | low | low |
| | Anaerobic digester | FSSM (D/C) | Primary treatment/ separation | low | all | all | no | high | low | low |
| | Settling & thickening tank - mechanical dewatering | FSSM (D/C) | Primary treatment/ separation | low | all | all | yes | low | low | low |
| | Imhoff tank | FSSM (D/C) | Primary treatment/ separation | low | all | all | no | high | low | low |

| Treatment Technologies | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Belt filter press | FSSM (D/C) | Primary treatment/ separation | low | all | all | yes | high | low | low |
| | Vortex | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | all | all | yes | low | low | low |
| | Chlorination | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | yes | low | low | low |
| | Sono-disinfection | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | yes | high | low | low |
| | Electro-disinfection | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | yes | high | low | low |
| | Solar drying | FSSM (D/C) | Sludge Treatment | high | all | all | yes | low | low | low |
| | Deep row entrenchment | FSSM (D/C) | Sludge Treatment | high | all | all | no | low | low | low |
| | Anaerobic digester | FSSM (D/C) | Primary treatment/ separation | low | all | all | no | high | low | low |

**Treatment Technologies**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Soil Bio Technology | NS (D/C) + FSSM (D/C) | Effluent Treatment | | all | | | | | |
| | Solar photolysis | NS (D/C) + FSSM (D/C) | Disinfection | low | all | all | | | | |

**Treatment Technologies**

| Technology groups | Technology name | Type of system | Treatment Type | Parameters of the technology | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Rainfall | Land Requirement | Groundwater level | Soil type | Energy Requirement | Skill Required | Capital Expenditure | O&M Expenditure |
| T1 | Co-composting | FSSM (D/C) | Sludge Treatment | moderate/ low | high | all | all | no | high | low | low |
| | Vermicomposting | FSSM (D/C) | Sludge Treatment | moderate/ low | high | all | all | no | low | low | low |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lime stabilisation | FSSM (D/C) | Sludge Treatment | moderate/ low | low | all | all | | low | low | low |
| | Sedimentation/ Thickening Ponds | FSSM (D/C) | Sludge Treatment | moderate/ low | high | all | all | no | high | low | low |

| Treatment Technologies | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technology name** | **Type of system** | **Treatment Type** | **Parameters of the technology** | | | | | | |
| | | | | **Land Requirement** | **Groundwater level** | **Soil type** | **Energy Requirement** | **Skill Required** | **Capital Expenditure** | **O&M Expenditure** |
| **T2** | Facultative Aerated Lagoons | NS (D/C) + FSSM (D/C) | Effluent Treatment | high | deep | all | yes | low | high | low |
| | Anaerobic filter (AF) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | deep | all | no | high | low | low |
| | Duckweed Pond System (DPS) | NS (D/C) + FSSM (D/C) | Effluent Treatment | low | deep | all | yes | low | low | low |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sodium Hypochlorite | NS (D/C) + FSSM (D/C) | Disinfection | low | deep | all | no | low | low | low |

| Treatment Technologies | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Technology groups | Technology name | Type of system | Treatment Type | Parameters of the technology | | | | | | |
| | | | | Land Requirement | Groundwater level | Soil type | Energy Requirement | Skill Required | Capital Expenditure | O&M Expenditure |
| T3 | Free Water Surface Constructed wetlands (CW) | NS (D/C) + FSSM (D/C) | Effluent Treatment | high | deep | Sandy / loamy | no | high | high | low |
| | Horizontal Subsurface Flow Constructed wetlands (CW) | NS (D/C) + FSSM (D/C) | Effluent Treatment | high | deep | Sandy / loamy | no | high | high | low |
| | Vertical Flow Constructed wetlands (CW) | NS (D/C) + FSSM (D/C) | Effluent Treatment | high | deep | Sandy / loamy | yes | high | high | low |
| | Detention Lagoons | NS (D/C) + FSSM (D/C) | Disinfectio | high | deep | Sandy / | no | low | high | |

| Treatment Technologies | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | n | | | loamy | | | | |
| | Planted drying bed/ reed bed | FSSM (D/C) | Sludge Treatment | high | deep | Sandy / loamy | no | high | low | low |
| | Shallow trenches | FSSM (D/C) | Sludge Treatment | high | deep | Sandy / loamy | no | low | low | low |
| | Solar sludge oven | FSSM (D/C) | Sludge Treatment | low | deep | Sandy / loamy | no | low | low | low |
| | Geo-bag | FSSM (D/C) | Sludge Treatment | high | deep | Sandy / loamy | no | low | low | low |

| Treatment Technologies | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Technology groups** | **Technology name** | **Type of system** | **Treatment Type** | **Parameters of the technology** | | | | | | | | |
| | | | | **Rainfall** | **Land Requirement** | **Ground water level** | **Soil type** | **Energy Requirement** | **Skill Required** | **Capital Expenditure** | **O&M Expenditure** |
| **T4** | Anaerobic baffled reactor (ABR) | FSSM (D/C) | Primary treatment/ separation | moderate/ low | low | deep | all | no | high | low | low |
| | | NS (D/C) + FSSM (D/C) | Effluent Treatment | | | | | | | | |
| **T5** | Unplanted drying bed | FSSM (D/C) | Sludge Treatment | moderate/ low | high | deep | Sandy/ loamy | no | high | low | low |

## Annexure II (E)

Table 14: Suitable treatment technology groups for specific city groups

| % of HH with onsite sanitation facility | Number of towns | Region | Cities | Preferred Treatment Technology groups |
|---|---|---|---|---|
| **For Small towns (<1 lakh population)** | | | | |
| >75% | 102 | Coastal | 52 Heroor, Addur, Adyar, Arkula, Bada, Badagabettu, Badagaulipady, Bajpe, Bantval, Belma, Beltangadi, Bondathila, Harekala, Honavar, Kairangala, Kariyangala, Kenjar, Kolambe, Konaje, Korangrapady, Kotekara, Kuvettu, Mallar, Manipura, Manjanady, Moodabettu, Mudbidri, Muduperar, Mudushedde, Mulki, Munnuru, Nadsal, Narikombu, Navoor, Neermarga, Pudu, Sajipanadu, Saligram, Someshwar, Sulya, Talipady, Tenkanidyoor, Thokur-62, Thumbe, Tonse East, Udyavara, Ullal, Varamballi, Vittal, Yenagudde | T0,T2,T3,T4 |
| | | | Tattilli (Mundgod) | T0,T1 |
| | | | Ankola, Bobruwada, Jali, Karkal, Koteshwar, Kundapura, Puttur, Sanoor, Sirsi, Uppinangady, Venkatapura | T0 |
| | | Malnad | Satyamangala, Sorab | T0,T1,T2,T3,T4,T5 |
| | | | Kadur | T0,T1,T2,T3,T5 |
| | | | Narasimharajapura | T0,T1 |
| | | | Shikarpur, Siralkoppa, Tarikere | T0,T1,T2,T4 |
| | | | Koppa, Madikeri, Sagar, Tirthahalli, Virajpet, Hosanagara | T0,T2,T4 |

| % of HH with onsite sanitation facility | Number of towns | Region | Cities | Preferred Treatment Technology groups |
|---|---|---|---|---|
| | | | Gonikoppal | T0,T2,T3,T4 |
| | | | Kushalnagar, Mudigere,Sakleshpur, Somvarpet, Sringeri | T0 |
| | | North Interior | Khanapur | T0,T1,T2,T3,T4,T5 |
| | | | Hindalgi, Kakati, Kangrali, Mutga, Peeranwadi, Sambra | T0,T1 |
| | | South Interior | Kudur, Malur, Maragondahalli | T0,T1,T2,T3,T4,T5 |
| | | | Bagepalli | T0,T1,T2,T3,T5 |
| | | | Arasinakunte, Attibele, Chikkabanavara, Hosakote, Madanaiyakanahalli, Mulbagal, Nelamangala, Piriyapatna, Sarjapura, Turuvekere | T0,T1,T2,T4 |
| 50%-75% | 73 | Coastal | Haliyal, Siddapur | T0,T1,T2,T3,T4,T5 |
| | | | Mundgod | T0,T1 |
| | | | Alevoor | T0,T2,T3,T4 |
| | | | Aversa, Bhatkal, Kadwad, Karwar, Kumta, , Yellapur | T0 |
| | | Malnad | Arkalgud, Haralahalli | T0,T1,T2,T3,T4,T5 |
| | | | Birur | T0,T1,T2,T3,T5 |
| | | | Jog Kargal | T0,T2,T4 |
| | | | Alur | T0,T1 |
| | | North Interior | Alnavar, Hirekerur, Shiggaon, Mouje Nandgad | T0,T1,T2,T3,T4,T5 |
| | | | Bankapura, Haveri, Savanur, Hangal, Londa | T0,T1,T2,T4 |

| % of HH with onsite sanitation facility | Number of towns | Region | Cities | Preferred Treatment Technology groups |
|---|---|---|---|---|
| | | | Kotturu, | T0,T1,T2 |
| | | | Benakanahalli, Machche, Yellur, Munirabad Project Area | T0,T1 |
| | | South Interior | Anekal, Bangarapet, Bethamangala, Bidadi, Dommasandra, Gubbi, Gudibanda, Hanur, Jigani, Koratagere, Krishnarajpet, Kunigal, Magadi, Saragur | T0,T1,T2,T3,T4,T5 |
| | | | Byrapura, Chikkaballapura, Devanahalli, Dod Ballapur, Gargeswari, Heggadadevankote, Hunasamaranahalli, Kadigenahalli, Kumbalagodu, Nanjangud | T0,T1,T2,T4 |
| | | | Allipura, Challakere, Gauribidanur, Madhugiri, Mellahalli, Tiptur | T0,T1,T2,T3,T5 |
| | | | Channagiri, Chikkajajur, Holalkere, Huliyar, Jagalur, Molakalmuru, Sira, Chiknayakanhalli | T0,T1,T2 |
| | | | Belvata, Channapatna, Elwala, Honnali, Kadakola, Malavalli | T0,T1 |
| | | Coastal | Dandeli | T0,T1,T2,T3,T4,T5 |
| | | Malnad | Arsikere, Channarayapatna | T0,T1,T2,T3,T5 |
| | | | Belur | T0,T1,T2,T3,T4,T5 |
| | | North Interior | Aurad, Bail Hongal, Basavakalyan, Bhalki, Homnabad, Hukeri, Sankeshwar, Saundatti- Shirhatti | T0,T1,T2,T3,T4,T5 |
| | | | Byadgi, Gajendragarh, Kawalettu, Kushtagi, , Nargund, Navalgund, Ramdurg, Talikota | T0,T1,T2 |
| | | | Chitgoppa, Kalghatgi, Lakshmeshwar | T0,T1,T2,T4, |

| % of HH with onsite sanitation facility | Number of towns | Region | Cities | Preferred Treatment Technology groups |
|---|---|---|---|---|
| 25%-50% | 83 | | Chikodi, Hoovina Hadagalli, Kodiyal, Kudligi, Mundargi, Nipani, Sadalgi, Sandur, Saundatti-Yellamma, Yelbarga | T0,T1,T2,T3,T5 |
| | | | Aland, Aminagad, Athni, Bilgi, Gokak, Gurmatkal, Hungund, Indi, Kampli, Koppal, Kudchi, Kundgol, Lingsugur, Manvi, Mudhol, Raybag, Sedam, Shahabad, Shahpur, Shorapur, Sindgi, Sindhnur, Siruguppa, Sulebhavi, Wadi, Yadgir | T0,T1 |
| | | South Interior | Bannur, Harapanahalli, Hebbagodi, Hunsur, Yelandur | T0,T1,T2,T3,T4,T5 |
| | | | Srinivaspur | T0,T1,T2,T3,T5 |
| | | | Adityapatna, Chamarajanagar, Chikkabidarakallu, Gundlupet, Kanakapura, Sidlaghatta, Tirumakudal Narsipur, Vijayapura | T0,T1,T2,T4 |
| | | | Chelur, Hiriyur, Hosdurga, Matadakurubarahatti, Nagamangala, Pandavapura, Pavagada | T0,T1,T2 |
| | | | Harihar, Krishnarajanagara, Srirampura | T0,T1 |
| | | Coastal | Ambikanagara | T0,T1,T2,T4 |
| | | Malnad | Hole Narsipur | T0,T1,T2,T3,T4,T5 |
| | | | Kudremukh | T0 |
| | | | Shravanabelgola | T0,T1,T2,T3,T5 |
| | | North Interior | Kamalnagar | T0,T1,T2,T3,T4,T5 |
| | | | Badami, Basavana Bagevadi, Donimalai Township, Mulgund, Rabkavi Banhatti | T0,T1,T2,T3,T5 |

| % of HH with onsite sanitation facility | Number of towns | Region | Cities | Preferred Treatment Technology groups |
|---|---|---|---|---|
| <25% | 54 | | Annigeri, Devadurga, Guledgudda, Jamkhandi, Kerur, Kurekuppa, Muddebihal, Naregal, Ron, Terdal, Vaddu | T0,T1,T2 |
| | | | Afzalpur, Bhimarayanagudi, Chincholi, Chitapur, Gogipeth, Gokak Falls, Gudur, Hatti, Hatti Gold Mines, Ilkal, Jevargi, Kamalapuram, Kamatgi, Konnur, Kurgunta, Mahalingpur, Mudalgi, Mudgal, Saidapur, Shahabad ACC, Shaktinagar, Tekkalakote | T0,T1 |
| | | South Interior | Bommasandra, Chintamani, Konappana Agrahara, Ramanagara | T0,T1,T2,T3,T4,T5 |
| | | | Kollegal | T0,T1,T2,T4 |
| | | | Amaravathi, Bhogadi, Hinkal, Hutagalli, Maddur, Shrirangapattana | T0,T1 |
| **For Medium towns (1-5 lakh population)** | | | | |
| >75% | 1 | Coastal | Udupi | T0,T2,T3,T4 |
| 50%-75% | 2 | Coastal | Mangalore | T0,T2,T3,T4 |
| | | Malnad | Chikmagalur | T0,T1,T2,T4 |
| 25%-50% | 12 | Malnad | Hassan, Shimoga | T0,T1,T2,T3,T4,T5 |
| | | | Bhadravati | T0,T1,T2,T4 |
| | | North Interior | Bidar | T0,T1,T2,T4 |
| | | | Bagalkot, Gadag-Betigeri, Gangawati, Ranibennur | T0,T1,T2 |
| | | | Belgaum | T0,T1 |
| | | South Interior | Robertson Pet, Tumkur | T0,T1,T2,T3,T4,T5 |

| % of HH with onsite sanitation facility | Number of towns | Region | Cities | Preferred Treatment Technology groups |
|---|---|---|---|---|
| | | | Chitradurga | T0,T1,T2 |
| <25% | 7 | North Interior | Bijapur | T0,T1,T2,T3,T5 |
| | | | Bellary, Hospet, Raichur | T0,T1 |
| | | South Interior | Davanagere | T0,T1,T2 |
| | | | Kolar | T0,T1,T2,T3,T4,T5 |
| | | | Mandya | T0,T1 |
| **For Large towns (>5 lakh population)** | | | | |
| <25% | 4 | North Interior | Gulbarga | T0,T1 |
| | | | Hubli-Dharwad | T0,T1,T2,T4 |
| | | South Interior | BBMP | T0,T1,T2,T4 |
| | | | Mysore | T0,T1 |

# Annexure II (F)

Table 15: Calculations used in the Sanitation model

| Calculation | Assumptions |
|---|---|
| **FSSM Scenario** | |
| Design flow of your septage treatment facility for existing system=Number of HH* Percentage of HH having toilets and storage* Average volume of existing storage units* Percentage of the storage units that will be desludged/ Target desludging frequency/ No. of working days in a year<br><br>Design flow of your septage treatment facility for new system= Number of HH*(Percentage of HH having toilets (but no storage/collection)+Percentage of HH having no toilets)* Average volume of new storage units*Percentage of the new storage units that will be desludged / Target desludging frequency/ No. of working days in a year<br><br>No. of working days in a year = (Days of week the program will operate* (12* No. of weeks in a month )- No of days for maintenance of plant<br><br>**Plant capacity - design flow**=((Design flow of your septage treatment facility for existing system+ Design flow of your septage treatment facility for new system)/1000)*(1+Growth rate) | Target desludging frequency – 2 years<br><br>Percentage of the storage units that will be desludged – 50%<br><br>Percentage of the new storage units that will be desludged – 100%<br><br>No. of days for maintenance of plant -15 days<br><br>No. of weeks in a month – 4.5<br><br>Average volume of existing storage units – 3m3 |
| Number of loads per day per truck= Hours of operation per day(Estimated drive time to the home or business+ Estimated time to pump the tank+ Estimated drive time from collection site to treatment plant+ Estimated unloading time at the treatment facility+ Estimated drive time to the next home or business)<br><br>Adjusted loads per day per truck = Number of loads per day per truck* Efficiency of trucking operation<br><br>Number of tank volumes accommodated in the truck= Capacity of the truck/( Average volume of existing storage units+ Average volume of new storage units)<br><br>**No. of trucks**=(Plant capacity*1000)/ Average volume of new storage units/ Number of tank volumes accommodated in the truck/ Adjusted loads per day | Estimated drive time to the home or business -0.5 hour<br><br>Estimated time to pump the tank-0.5 hour<br><br>Estimated drive time from collection site to treatment plant-0.5 hour<br><br>Estimated unloading time at the treatment facility-0.5 hour |

| | |
|---|---|
| per truck | Estimated drive time to the next home or business-0.5 hour<br>Hours of operation per day-10 hours<br>Efficiency of trucking operation= 0.85<br>Capacity of the truck- 10m3 |
| **Capital cost**<br>**UI =** Number of HH* Percentage of HH having no toilets*toilet CAPEX<br>**Storage=** Number of HH*( Percentage of HH having no toilets+ Percentage of HH having toilets but no storage/collection)*storage CAPEX<br>**Conveyance=** Number of trucks*(truck CAPEX+ emptying equipment CAPEX)<br>**Treatment**=(Primary treatment CAPEX +60%*(Effluent treatment CAPEX + Disinfection CAPEX)+40%*sludge treatment CAPEX)*Plant capacity<br>**Contingency**= CAPEX-Contingency*(UI + Storage + Conveyance +Treatment)<br>Total = UI + Storage + Conveyance +Treatment+ Contingency | CAPEX-Contingency - 2% |
| **O&M Costs**<br>**Storage=** Number of HH*( Percentage of HH having no toilets+ Percentage of HH having toilets but no storage/collection)*storage OPEX<br>**Conveyance=** Number of trucks*(truck OPEX+ emptying equipment OPEX)<br>**Treatment**=(Primary treatment OPEX +60%*(Effluent treatment OPEX + Disinfection OPEX)+40%*sludge treatment OPEX)*Plant capacity<br>Total =Storage + Conveyance +Treatment | |
| **Revenue**<br>**Quantity of treated sludge generated =** ((Plant capacity*1000)* Sludge converted to manure for land application*Density of sludge*No of days in a | Sludge converted to manure for land application – 30% |

| | |
|---|---|
| year)/1000<br>**Quantity of treated wastewater generated=**(Plant capacity*1000)*Water sent for irrigation* No of days in a year<br>**Revenue from sale of treated sludge**= Quantity of treated sludge generated* Rate at which treated sludge is sold<br>**Revenue from sale of treated wastewater=** Quantity of treated wastewater generated* Rate at which treated water is sold<br>**Revenue from reuse=** Revenue from sale of treated sludge+ Revenue from sale of treated wastewater<br>Number of storage units that is emptied by ULB= Number of HH* (Percentage of HH having toilets and storage+ Percentage of HH having no toilets+ Percentage of HH having toilets but no storage/collection) * Percentage of the storage units that will be desludged<br>**Revenue from user charges=** Percentage of the user charges that is revenue*( Number of storage units that is emptied by ULB* User charges for collection of FS by ULB)<br>**Total Revenue**= Revenue from reuse+ Revenue from user charges | Density of sludge – 1.5kg/l<br>No. of days in a year- 365<br>Water sent for irrigation – 40%<br>Percentage of the storage units that will be desludged – 50% |
| **Operating ratio**= Total revenue/ Total O&M cost | |
| **Land requirement** =(Primary treatment (land req) +60%*(Effluent treatment (land req) + Disinfection (land req))+40%*sludge treatment (land req))*Plant capacity | |
| **Networked Scenario** | |
| Design flow of your septage treatment facility= Number of HH* (Percentage of HH having toilets and storage+ Percentage of HH having no toilets+ Percentage of HH having toilets but no storage/collection+ Percentage of HH connected to decentralised systems)* HH size*(0.8* Per capita water supply<br>**Plant capacity - design flow**= Design flow of your septage treatment facility/1000 | HH size- 5<br>Waste water generated is assumed to be 80% of water supply |
| **Capital cost**<br>**UI =** Number of HH* Percentage of HH having no toilets*toilet CAPEX<br>**Conveyance=**Number of HH* (Percentage of HH having toilets and storage+ | CAPEX-Contingency - 2% |

| | |
|---|---|
| Percentage of HH having no toilets+ Percentage of HH having toilets but no storage/collection+ Percentage of HH connected to decentralised systems)* HH size*Sewer CAPEX/capita<br><br>**Treatment**=(Effluent treatment CAPEX + Disinfection CAPEX)*Plant capacity<br><br>**Contingency**= CAPEX-Contingency*(UI + Storage + Conveyance +Treatment)<br><br>Total = UI + Conveyance +Treatment+ Contingency | |
| **O&M Costs**<br><br>**Conveyance=**Number of HH* (Percentage of HH having toilets and storage+ Percentage of HH having no toilets+ Percentage of HH having toilets but no storage/collection+ Percentage of HH connected to decentralised systems)* HH size*Sewer OPEX/capita/year<br><br>**Treatment**=(Effluent treatment OPEX + Disinfection OPEX)*Plant capacity<br><br>Total =Conveyance +Treatment | |
| **Revenue**<br><br>**Quantity of treated sludge generated =** ((Plant capacity*1000)* Sludge converted to manure for land application*Density of sludge*No of days in a year)/1000<br><br>**Quantity of treated wastewater generated=**(Plant capacity*1000)*Water sent for irrigation* No of days in a year<br><br>**Revenue from sale of treated sludge**= Quantity of treated sludge generated* Rate at which treated sludge is sold<br><br>**Revenue from sale of treated wastewater=** Quantity of treated wastewater generated* Rate at which treated water is sold<br><br>**Revenue from reuse=** Revenue from sale of treated sludge+ Revenue from sale of treated wastewater<br><br>Number of sewage connections= Number of HH<br><br>**Revenue from user charges=** Percentage of the user charges that is revenue*( Number of sewage connections * User charges collection by ULB)<br><br>**Total Revenue**= Revenue from reuse+ Revenue from user charges | Sludge converted to manure for land application – 0.1%<br><br>Density of sludge – 1.5kg/l<br><br>No. of days in a year- 365<br><br>Water sent for irrigation – 80% |

| | |
|---|---|
| **Operating ratio**= Total revenue/ Total O&M cost | |
| **Land requirement** Effluent treatment (land req) + Disinfection (land req))*Plant capacity | |

## Annexure II (G)

Table 16: Standards prescribed in UWWR policy, CPHEOO manual and CPCB

| Use | BOD (mg/l) | COD (mg/l) | TSS (mg/l) | TDS (mg/l) | DP (mg/l) | TN (mg/l) | Cl (mg/l) | SiO2 (mg/l) | Hardness CaCO3 (mg/l) | Alkalinenity CaCO3 (mg/l) | ph |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Discharge into public sewers | 350 | | 600 | 2100 | | | | | | | 5.5 - 9 |
| Disposed onto land for irrigation | 100 | | 200 | | | | | | | | 5.5 - 9 |
| Marine coastal areas | 100 | 250 | 100 | 2100 | | | 1 | | | | 5.5 - 9 |
| Inland Surface water | 30 | 250 | 100 | 2100 | 5 | | 1 | | | | 5.5 - 10 |
| (a) Landscape irrigation such as parks and golf courses, (b) Recreational impoundments such as fishing and boating, (c)Fountains, (d) Vehicle washing like car, bus and trains, (e) Toilet flushing and (f) Fire protection systems. | 30 | 250 | 100 | 2100 | 5 | | 1 | | | 50 | 5.5 - 9 |
| Use in the construction industry like soil compaction, dust control, washing aggregate | 30 | 250 | 100 | 3000 | 5 | | 500 | | | | |
| Discharge into water bodies | 10 | | 5 | | 1 | | | | | | 6.5 - |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 8.3 |
| Cooling water quality for industries | 5 | | | | 0.6 | 3 | 100 | 20 | 200 | | |
| Boiler feed | | | | 700 | | 0.1 | 0.4 | 30 | 350 | 350 | 8.5 - 9.5 |
| Pulp and paper | | | | | | | 1000 | 50 | 100 | 100 | |
| Textile | | | | 100 | | | | | 25 | | |
| Petroleum and coal | | | | 1000 | | | 300 | | 350 | 125 | |
| Agriculture | | | | | | | | | | | 6.0 - 9.0 |

Table 17: Standards met by the scenario

| Use | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BOD** | **COD** | **TSS** | **TDS** | **DP** | **TN** | **Cl** | **SiO2** | **Hardness CaCO3** | **Alkalinity CaCO3** | **ph** |
| Discharge into public sewers | KF, KN, RF, RN, CF, CN, UF, UN | | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |

| Use | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BOD** | **COD** | **TSS** | **TDS** | **DP** | **TN** | **Cl** | **SiO2** | **Hardness CaCO3** | **Alkalinity CaCO3** | **ph** |
| Disposed onto land for irrigation | KF, KN, RF, RN, CF, CN, UF, UN | | KF, KN, RF, RN, CF, CN, UF, UN | | | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |
| Marine coastal areas | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |
| Inland Surface water | KF, KN, RF, RN, CF, CN, UF | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, CF, CN, UF | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |
| (a) Landscape irrigation such as parks and golf courses, (b) Recreational impoundments such as fishing and boating, (c)Fountains, (d) | KF, KN, RF, RN, CF, CN, UF | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |

| Use | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BOD** | **COD** | **TSS** | **TDS** | **DP** | **TN** | **Cl** | **SiO2** | **Hardness CaCO3** | **Alkalinity CaCO3** | **ph** |
| Vehicle washing like car, bus and trains, (e) Toilet flushing and (f) Fire protection systems. | | | | | | | | | | | |
| Use in the construction industry like soil compaction, dust control, washing aggregate | KF, RF, RN, CF, CN, UF | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF | | KF, KN, RF, RN, CF, CN, UF, UN | | | | |
| Discharge into water bodies | KF, RF, RN, CF, CN, UF | | RF, CF | | KF, RF, CF, UF | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |
| Cooling water quality for industries | KF, RF, CF, UF | | | | KF, CF, UF | KF, RF, UF | | | KF, KN, RF, RN, CF, CN, UF, UN | | |
| Boiler feed | | | | KF, KN, | | | | KF, KN, | KF, KN, | KF, KN, | KF, KN, |

| Use | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BOD** | **COD** | **TSS** | **TDS** | **DP** | **TN** | **Cl** | **SiO2** | **Hardness CaCO3** | **Alkalinity CaCO3** | **ph** |
| | | | | RF, RN, CF, CN, UF, UN | | | | RF, RN, CF, CN, UF, UN | RF, RN, CF, CN, UF, UN | RF, RN, CF, CN, UF, UN | RF, RN, CF, CN, UF, UN |
| Pulp and paper | | | | | | | KF, KN, RF, RN, CF, CN, UF, UN | KF, KN, RF, RN, CF, CN, UF, UN | | | |
| Textile | | | | | | | | | | | |
| Petroleum and coal | | | | KF, KN, RF, RN, CF, CN, UF, UN | | | KF, KN, RF, RN, CF, CN, UF, UN | | KF, KN, RF, RN, CF, CN, UF, UN | | |
| Agriculture | | | | | | | | | | | KF, KN, RF, RN, CF, CN, UF, UN |
| | Parameters that affect the use | | | | | | | | | | |
| KF | Standards met by Kolar FSSM Scenario | | | | | | | | | | |

| **Use** | Parameters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **BOD** | **COD** | **TSS** | **TDS** | **DP** | **TN** | **Cl** | **SiO2** | **Hardness CaCO3** | **Alkalinity CaCO3** | **ph** |
| KN | Standards met by Kolar Networked Scenario | | | | | | | | | | |
| RF | Standards met by Raichur FSSM Scenario | | | | | | | | | | |
| RN | Standards met by Raichur Networked Scenario | | | | | | | | | | |
| CF | Standards met by Chitradurga FSSM Scenario | | | | | | | | | | |
| CN | Standards met by Chitradurga Networked Scenario | | | | | | | | | | |
| UF | Standards met by Udupi FSSM Scenario | | | | | | | | | | |
| UN | Standards met by Udupi Networked Scenario | | | | | | | | | | |

## Annexure III (A)

Table 18: List of Karnataka cities having CTTPs and CMPs

| Comprehensive Traffic and Transport Plan (CTTP) | City Mobility Plan (CMP) |
|---|---|
| 1. Belgaum | 8. Bidar |
| 2. Bellary | 9. Bijapur |
| 3. Bengaluru | 10. Chitradurga |
| 4. Mangalore | 11. Davanagere |
| 5. Mysore | 12. Shimoga |
| 6. Gulbarga | 13. Tumkur |
| 7. Hubli-Dharward | 14. Udupi |

*Source: CSTEP analysis based on CTTPs and CMPs*

## Annexure III (B)

Table 19: Calculations and assumptions for travel pattern factors

| S. No. | Input parameter | Calculation or assumption |
|---|---|---|
| 1 | Population | The CTTPs and CMPs reports for selected Karnataka cities were prepared in different base and horizon years. The base year considered in the model is 2011 and the horizon year is 2031. The populations considered in the model are for the study area (i.e., the local plan area). For CTTPs/ CMPs that have different base and horizon years, the populations were calculated considering the city's compound annual growth rate (CAGR). |
| 2 | Motorised per capita trip rate (MPCTR) | Certain CTTPs/CMPs state that the MPCTR will increase by 1% in real terms. This assumption is validated by considering the trips assigned in the four-stage model, for the base and horizon years. Hence, it was established that the MPCTR will increase at 1% annually. |
| 3 | Trip length | The trip lengths considered in the model are for the following motorised modes, namely: a) two-wheelers; b) four-wheelers, exclusive of taxis; c) buses (PT); and d) auto rickshaws (IPT). |

| | | |
|---|---|---|
| | | Wherever the trip lengths for the base year were not given in the respective CTTPs/ CMPs, values from similar size class cites were considered from the study titled 'Review of Urban Transport in India', by CTSEP and IUT. |

*Source: CSTEP*

Table 20: Population of study area (LPA)

| Cities | Population base year (2011) in Million | Population horizon year (2031) in Million |
|---|---|---|
| Bidar | 0.25 | 0.43 |
| Bijapur | 0.33 | 0.71 |
| Chitradurga | 0.15 | 0.29 |
| Shimoga | 0.36 | 0.68 |
| Tumkur | 0.45 | 0.95 |
| Udupi | 0.23 | 0.35 |
| Bellary | 0.45 | 0.92 |
| Belgaum | 0.55 | 1.14 |
| Davanagere | 0.62 | 1.26 |
| Mangalore | 0.84 | 1.36 |
| Gulbarga | 0.60 | 0.94 |
| Hubli-Dharward | 0.95 | 1.64 |
| Mysore | 0.97 | 2.06 |

*Source: CSTEP*

Table 21: Motorised per capita trip rate (2011 and 2031)

| Cities | MPCTR base year (2011) | MPCTR horizon year (2031) |
|---|---|---|
| Bidar | 0.58 | 0.696 |
| Bijapur | 0.69 | 0.828 |
| Chitradurga | 0.73 | 0.876 |
| Shimoga | 0.67 | 0.804 |
| Tumkur | 0.78 | 0.936 |
| Udupi | 0.68 | 0.816 |
| Bellary | 0.5 | 0.6 |
| Belgaum | 0.97 | 1.164 |
| Davanagere | 0.7 | 0.84 |
| Mangalore | 0.94 | 1.128 |
| Gulbarga | 0.5 | 0.6 |

| | | |
|---|---|---|
| Hubli-Dharward | 0.95 | 1.14 |
| Mysore | 0.66 | 0.792 |

*Source: CSTEP*

Table 22: Trip lengths (2011)

| Cities | 2W | 4W | PT (Bus) | IPT (Auto rickshaw) |
|---|---|---|---|---|
| Bidar | 2.37 | 2.47 | 3.67 | 3.6 |
| Bijapur | 3.1 | 2.9 | 3.5 | 3.3 |
| Chitradurga | 4.05 | 4.28 | 2.53 | 3.64 |
| Shimoga | 3.5 | 5.03 | 5.77 | 3.7 |
| Tumkur | 4.83 | 4.95 | 4.7 | 4.02 |
| Udupi | 4.45 | 4.95 | 5.7 | 4.2 |
| Bellary | 3.66 | 4.3 | 3.3 | 2.23 |
| Belgaum | 3.5 | 4.6 | 6.1 | 4.7 |
| Davanagere | 4.08 | 7.2 | 6.86 | 3.58 |
| Mangalore | 4.08 | 5.18 | 6.63 | 3.15 |
| Gulbarga | 4.68 | 5.66 | 6.6 | 4.15 |
| Hubli-Dharward | 5.57 | 5.81 | 8.01 | 6.05 |
| Mysore | 7.62 | 8.6 | 8.07 | 7.56 |

*Source: CSTEP*

Table 23: Motorised mode share (2011)

| Cities | Estimates for 2011 mode share (in percentage) | | | |
|---|---|---|---|---|
| | 2W | 4W | PT | IPT (Auto rickshaw) |
| Bidar | 49 | 17 | 4 | 30 |
| Bijapur | 37 | 11 | 11 | 41 |
| Chitradurga | 49 | 12 | 0 | 39 |
| Shimoga | 51 | 14 | 8 | 27 |
| Tumkur | 76 | 4 | 12 | 8 |
| Udupi | 71 | 10 | 9 | 10 |
| Bellary | 52 | 12 | 11 | 25 |
| Belgaum | 48 | 9 | 17 | 26 |
| Davanagere | 57 | 7 | 12 | 24 |
| Mangalore | 15 | 8 | 51 | 26 |
| Gulbarga | 51 | 7 | 15 | 27 |
| Hubli-Dharward | 33 | 19 | 22 | 26 |

| Cities | Estimates for 2011 mode share (in percentage) | | | |
|---|---|---|---|---|
| | 2W | 4W | PT | IPT (Auto rickshaw) |
| Mysore | 46 | 11 | 17 | 26 |

*Source: CSTEP*

## Annexure III (C)

### Arriving at EV penetration (percentages) for low, medium and high- effort scenario

Two- wheelers (2Ws)

In Karnataka, two-wheelers account for about 70% of all registered vehicles (2017). NEMMP's consumer research on adoption of EVs indicates that two-wheelers have high acceptance value. The projected global and Indian penetration percentage of two-wheeler EVs stands at 35.5% and 15%, respectively. The global percentage of 35% has been considered for the high-effort scenario, followed by a penetration rate of 15% for the medium-effort scenario. Since the existing penetration of EVs is low in the country, and keeping in mind consumer acceptance, the low-effort scenario rate for two-wheeler EVs was set at 5%.

Four- wheelers (4Ws)

The passenger car vehicle segment is predicted to dominate the EV market in India (Persistence Market Research, 2017) . Automobile companies like Mahindra, Tata, REVA, etc. have already tuned their production to suit the market. The global and Indian penetration range for four-wheeler EVs lie between 17.8% and 19%. Thus, 20% has been considered for the high-effort scenario, followed by 15% for medium-effort scenario, and a practical projection of 5% for low-effort scenario.

Public Transport (Bus)

India presently has about 1.7 lakh registered public bus operators (UIPT India, n.d.), amongst which the Bengaluru Metropolitan Transport Corporation (BMTC) ranks first in terms of the total fleet size (Shakti Sustainable Energy Foundation & Center for Study of Science, Technology and Policy, 2018). With a wide realisation of shifting diesel-run public transport to electric-run public transport, nationally, efforts have been undertaken to procure/ upgrade buses and develop charging infrastructure. The Government of India recently agreed to sanction a subsidy to BMTC for procuring 80 e-buses ((‘Centre gives nod to subsidy for e-buses in Bengaluru’, 2018). The projected global penetration of e-buses stands at 20%, which has been considered for the high-effort scenario. Considering the existing fleet size of State Road Transport Undertakings (SRTUs), nationally and Karnataka State Road Transport Corporation (KSRTC) fleet, the medium and low-effort penetration scenarios were set at 5% and 1%

respectively.

Intermediate Public Transport (Auto rickshaws)

Many Indian cities (more specifically medium size cities) depend on IPT for commute. NEMMP states that the ease of implementing EVs in the auto rickshaw segment will be moderate. Kolkata has an existing fleet size of more than 10,000 e-rickshaws (commonly known as TOTOs), and it is suggested in the near term (i.e. within 3 to 5 years) the existing fleet convert from lead-acid batteries to lithium ion batteries. In Kolkata, the proposed deployment of e-rickshaws in the future is estimated to reach about 50% (Shakti Sustainable Energy Foundation & India Smart Grid Forum, 2017). Thus, the medium-effort scenario EV intervention rate is considered to be 50%, while the high-effort scenario (i.e. aggressive scenario) rate is considered to be 100%, and the low-effort scenario rate is 25%.

# Annexure III (D)

**Annexure 1: Learning from best case practices (case studies)**

Globally and nationally several policies and strategies are adopted to promote the growth of EVs. It is important for cities in Karnataka to learn from such best practices, contextualise and address challenges pertaining to the adoption of EVs in the state. Secondary literature has been studied to derive learnings for uptake of EVs in Karnataka's cities.

Case study 1: Kolkata is transitioning to a low-carbon city, by promoting the adoption of EVs in prominent modes (buses, three-wheelers, ferries), apart from PVs. An integral mode in the transport system of the city is the e-rickshaws (commonly known as TOTOs) that run in the periphery of the city. These vehicles are fit with lead-acid batteries and a DC motor and in 2015 were considered in the Motor Vehicle Act. Kolkata also has a well-established public bus system operating on multiple routes. A study has reviewed literature on up-gradation of EV technology to cut the initial costs and achieve better performance. In the e-rickshaw segment, a leasing model for the use of batteries and conversion of lead-acid batteries to lithium ion batteries, for better environmental sustainability is being explored. With respect to e-buses, the aim is to assess the range of the battery size by altering the standard of 300 kwh batteries used in imported buses to 100 kwh to 200 kwh batteries, more contextual to Kolkata's needs. The transition in battery technology and leasing mechanism will help Kolkata adopt better performing EVs in the public transport segment, along with responsible battery recycling, with the aim to reduce the (transport sector's) carbon footprint of the city (Shakti Sustainable Energy Foundation & India

Smart Grid Forum, 2017)

Case study 2: China is one of the forerunners in the adoption of EVs. The country's New Energy Vehicle (NEV) programme, mandated in 2009, promotes the adoption of electric/ hybrid vehicles with the aim to curb air pollution. China deployed about 1,70,000 e-buses across major cities. In Shenzen till date, about 16,359 e-buses have been launched under this pilot scheme. The successful operation of e-buses is attributed primarily to the charging station infrastructure. Across the city, a total of 8,000 charging points and 510 charging stations help recharge the e-buses in less than two hours, due to which e-buses can travel higher distances (Bhavnani, Shekhar, & Sharma, 2018) . Additionally, a fast charging infrastructure network, of about 1,800 piles, has been established for all types of commercial NEVs (Lauer & Dickhaut, 2016). In the two-wheeler segment, China has explored the option of up-grading technology through improvements in battery lifespan, motor efficiency and energy densities, which has helped reduce the initial price of the vehicle. China's electric two-wheeler market saw an average price drop of about 30% from its initial vehicle price (Asian Development Bank, 2009).

Case study 3: Norway is recognised as the highest battery electric vehicle (BEV) shareholder and is a pioneer in EV adoption. A likely reason can be attributed to its strong incentive mechanism, covering both fiscal and non-fiscal measures. Norway's incentive mechanism cuts across the purchase and manufacturing markets. The incentive packages feature no value added tax (VAT), an 80% reduction in annual fees, no road tolls, etc. Apart from direct fiscal incentives, the package covers additional attractive incentives such as free parking, free access to ferries, and access to bus lanes. A survey stated that access to bus lanes was a decisive factor for promoting the adoption of EVs among consumers (Bjerkan, Nørbech, & Nordtømme, 2016).

## Annexure IV (A)

Table 24: Data Sources for Indicators

| Sl. No. | Data | Source |
|---|---|---|
| 1 | Performance Indicators for Water Supply Services | International Water Association (Alegre et al., 2000) |
| 2 | Performance Assessment Systems (PAS) for Urban Water Supply and Sanitation | CEPT (Centre for Environmental Planning and Technology), India<br>(Mehta, Mehta, & Mansuri, n.d.) |
| 3 | Result and indicators for the Water and Sanitation Sector | European Commission |
| 4 | The California Water Sustainability Indicators Framework | California Water Plan Update, 2013<br>(Davis, 2014) |
| 5 | Global City Indicators | Cities Alliance |
| 6 | Sustainable Cities Index 2015 | ARCADIS (Arcadis, 2015) |
| 7 | Handbook on Service Level Benchmarking | Ministry of Urban Development (MoUD), Government of India<br>(HANDBOOK OF SERVICE LEVEL BENCHMARKING, n.d.) |
| 8 | Composite Water Management Index | NITI Ayog, Government of India |

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| | | (NITI Ayog, GoI, 2017) |
| 9 | Proposal for a Sustainable Urban Transport Index (SUTI) for cities in the Asia- Pacific region | CONCITO<br><br>(Gudmundsson, 2016) |
| 10 | Sustainable Cities Mobility Index 2017 | (ARCADIS, 2017) |
| 11 | Service Level Benchmark for Urban Transport at a Glance | Ministry of Urban Development (MoUD, n.d.),<br><br>Government of India |
| 12 | Smart Cities Preliminary Report 2014 | (IS0/ IEC JTC 1, 2014) |
| 13 | Developing Indicators for Comprehensive and<br><br>Sustainable Transport Planning | Victoria Transport Policy Institute, 2011<br><br>(Litman, 2011) |
| 14 | Sustainable Urban Transport in Asia: Making the Vision a Reality - Main Report. A CAI-Asia Program | Asian Development Bank, 2006<br><br>(CAI-Asia Program) |

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