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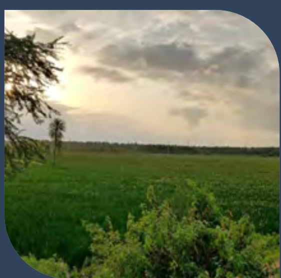
Sanitation Capacity Building Platform

THE PRACTICE OF SUSTAINABLE URBAN SANITATION:

LEARNINGS FROM NINE INDIAN CITIES

RESEARCH REPORT



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Abbreviations

ABD	Area Based Development
AM	Alappuzha Municipality
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APMC	Agricultural Produce Market Committee
ASP	Activated Sludge Process
BBMP	Bruhat Bengaluru Mahanagara Palike
BDA	Bengaluru Development Authority
BEL	Bharat Electronics Limited
BMGF	Bill and Melinda Gates Foundation
BORDA	Bremen Overseas Research and Development Association
BWSSB	Bengaluru Water Supply and Sewerage Board
CCRCP	Chennai City River Conservation Project
CDD	Consortium for DEWATS Dissemination Society
CGWB	Central Ground Water Board
CMA	Chennai Metropolitan Area
CMC	City Municipal Corporation
CMDA	Chennai Metropolitan Development Authority
CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
COVID	Coronavirus Infectious Disease
CPHEEO	Central Public Health and Engineering Environmental Organization
CRZ	Coastal Regulation Zone
CSR	Corporate Social responsibility
DESAL	Desalinized
DMC	Dhanbad Municipal Corporation
DMCA	Dhanbad Municipal Corporation Area
DPR	Detail Project Report
DW&SD	Drinking Water and Sanitation Department
FCI	Fertilizer Corporation of India
FS	Faecal Sludge
FSSM	Faecal Sludge and Septage Management
FSTP	Faecal Sludge Treatment Plant
GCC	Greater Chennai Corporation
GoK	Government of Karnataka
GPCB	Gujarat Pollution Control Board
GWIL	Gujarat Water Infrastructure Limited
HH	Household
HN Valley	Hebbal Nagawara Valley
IIT-ISM	Indian Institute of Technology - Indian School of Mines
JCF	Jharia Coalfield
JMADA	Jharkhand Mineral Development Authority
KC Valley	Koramangala-Challaghatta Valley
KPTCL	Karnataka Power Transmission Corporation Limited
KSDMC	Karnataka State Disaster Management Center
KSPCB	Karnataka State Pollution Control Board
KWA	Kerala Water Authority

LDA	Lake Development Authority
LPCD	Liters Per Capita Per Day
LSGD	Local Self Government Department
MID	Minor Irrigation Department
MLD	Million Liters Per Day
MoHUA	Ministry of Housing and Urban Affairs
MoUs	Memorandum of Understanding
MPA	Megh Pyne Abhiyan
NAC	Notified Area Council
NIUA	National Institute of Urban Affairs
OCCM	Opencast Coal Mines
PHED	Public Health Engineering Department
PiCC	People in Centre Consulting
PMAY	Prime Minister Awas Yojana
POA	Plot Owners Association
RBD	Rainbow Drive
RMC	Rajkot Municipal Corporation
RUDA	Rajkot Urban Development Authority
RWH	Rainwater Harvesting
SAUNI	Saurashtra Narmada Avtaran Irrigation
SBR	Sequential Batch Reactor
SCV	Septage Collection Vehicle
SDG	Sustainable Development Goals
SEZ	Special Economic Zone
SRS	Septage Receiving Station
SSP	Sanitation Safety Protocol
STIFLE	Social-Technical-Institutional-Financial-Legal-Environmental Framework
STP	Sewage Treatment Plant
STPs	Sewage Treatment Plant
SUDA	State Urban Development Authority
SUDA	State Urban Development Authority
SWD	Storm Water Drain
TMC	Devanahalli Town Municipal Council
TPS	Town Planning Scheme
TTROP	Tertiary Treatment Reverse Osmosis Plant
TTUF	Tertiary Treatment Plant using Ultra Filtration
UGD	Underground Drainage
ULB	Urban Local Body
UM	Unjha Municipality
V-Valley	Vrishabhavathi Valley
WHO	World Health Organization
WTP	Water Treatment Plant
WW	Wastewater
WWTP	Wastewater Treatment Plant

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Introduction

The study 'The Practice of Sustainable Urban Sanitation: Learnings from Nine Indian Cities' was undertaken by the BIOME Environmental Solutions Private Limited (Biome) with its consortium partners Megh Pyne Abhiyan (MPA) and People in Centre Consulting (PiCC) as part of the 'Inter-Disciplinary Urban Sanitation Research 2020' programme of the National Institute of Urban Affairs, with the aim of exploring initiatives in urban sanitation, wastewater and faecal sludge management in India, and thereby inform policy and practice in the urban sanitation sector.

The Swachh Bharat Mission (Urban), the flagship programme of the Government of India, in its first phase focused on making India Open-Defecation Free (ODF) through the provision of toilets, and thereafter to ensure their proper use and maintenance (according to the ODF+ protocol). The goal now is for all urban local bodies to attain ODF status through safe collection, conveyance, treatment and disposal of all faecal sludge and sewage, in order to achieve safe and sustainable sanitation for all. This study explores a spectrum of city-specific interventions in order to ascertain gaps, as well as effective interventions in the management of faecal sludge and wastewater. The findings and learnings are collated based on which recommendations are framed which can inform appropriate policy interventions.

Objective and Scope of the Study

The study objective is to capture the diversity of prevalent practices and unique interventions in the urban sanitation planning trajectory with a focus on management of faecal sludge and wastewater in nine cities across five states. This study documents the reuse of faecal sludge and wastewater, and aims to address the knowledge gaps which exist in India's urban sanitation sector.

The study locations have been selected to reflect various geographies, socio-economic conditions, institutional arrangements and scale of progress, of scenarios comprising nine urban local bodies across five states. These are:

1. The municipalities of Devanahalli, Karnataka; Unjha, Gujarat; and Alappuzha, Kerala

2. The municipal corporations of Tumakuru, Karnataka; and Rajkot, Gujarat; Thiruvananthapuram, Kerala; and Dhanbad, Jharkhand, and

3. The metropolitan cities of Bengaluru, Karnataka and Chennai, Tamil Nadu.

Figure i: Study locations

RAJKOT: EXCHANGE OF WASTEWATER FOR FRESHWATER

UNJHA: WASTEWATER AUCTIONING

DHANBAD: WATER CHESTNUT FARMING IN WASTEWATER

BENGALURU: LARGE FORMAL WASTEWATER REUSE FOR AGRICULTURE

DEVANAHALLI: FORMAL AND INFORMAL REUSE OF FAECAL SLUDGE IN AGRICULTURE

TUMAKURU: WASTEWATER REUSE TO GROW A MEDICINAL CROP 'BAJE'

ALAPPUZHA: CANAL REJUVENATION IN THE 'VENICE OF THE EAST'

THIRUVANANTHAPURAM: AN 'UBER MODEL' SEPTAGE MANAGEMENT SYSTEM

CHENNAI: ENERGY RECOVERY AND USE IN WASTEWATER TREATMENT

Research Methodology

The study adopted a three-step approach:

1. Review of existing body of knowledge, including global, national, state and city-level literature, such as legislation, policy, guidelines, toolkits and study reports.

2. Assessment of existing practices, through unstructured interviews with relevant stakeholders, such as State Urban Departments, Water and Sewerage Boards, Municipality, desludging operators(septage and FS conveyance), Farmers/other end users, Technology Providers and NGOs/ Civil Society Organizations, and site visits.[1]

3. Distill learning and formulate recommendations.

Figure ii: Research Methodology

1. Review of Knowledge

Review of legislation, policy, guidelines and other resources

2. Review of Prartice

City specific field studies and STIFLE analysis

3. Learning and Recommendations

Learning and recommendations from the review of knowledge and practice

Analysis was carried out using the **Social-Technological-Institutional-Financial-Legal-Environmental (STIFLE) framework** developed by BIOME to integrate a comprehensive and multidisciplinary understanding incorporating the thematic areas specified. Legal and regulatory frameworks, financial and institutional arrangements, policies, and schemes at the national and state level have been reviewed to contextualize current knowledge and practice. The STIFLE framework is explained in Table i

[1] *Due to the current pandemic situation, field interviews were conducted with extreme caution.*

Table i : Components of the STIFLE Framework

Social	Mapping of key socio-economic and occupational groups, private and informal enterprises including reuse practise by farmers, status of sanitation workers, prevalence of manual scavenging and access to water and environmental sanitation services.
Technical	The nature and sustainability of conveyance, treatment, disposal, and re-use technologies for FS/wastewater management, standards and procedures followed.
Institutional	Policy environment, governance mechanisms and institutional arrangements, and capacities for the provision of urban sanitation and allied services by both public and private sector.
Financial	Financial resources and management, investment in urban sanitation and allied services, capital and operation & maintenance expenditure, contractual arrangements, and business models.
Legal	Master plans, building regulations, codes, and standards of treatment/reuse of FS and wastewater.
Environmental	Environmental costs and benefits.

Therefore, both the learnings from the STIFLE review and identified elements of FS/wastewater management from the cities have informed the study. Local level risk assessment and management for the sanitation service chain - from containment, conveyance, treatment and end use has been analyzed in accordance with the sanitation safety planning framework.[2]

Structure of the Report

Following the introductory sections, the report presents an overview of literature review. City-wise reports are presented from Chapters (1) to Chapters (9) in the following order (1) Rajkot (2) Unjha (3) Dhanbad (4) Bengaluru (5) Devanahalli (6) Tumakuru (7) Alappuzha (8) Thiruvananthapuram and (9) Chennai. The final chapter 10 comprises the Gestalt[3] learning and key recommendations based on the study.

[2] *https://www.who.int/water_sanitation_health/publications/ssp-manual/en/*

[3] *Gestalt theory emphasizes that the whole of anything is greater than its parts. That is, the attributes of the whole are not deducible from analysis of the parts in isolation. The word Gestalt is used in modern German to mean the way a thing has been "placed," or "put together." There is no exact equivalent in English. https://www.britannica.com/science/Gestalt-psychology*

Overview of the Literature Review

A list of documents comprising regulations, policies, guidelines and tools that were reviewed, has been provided in Table ii

Table ii: Documents reviewed

Regulations	
Legislation and Regulation	**Standards/ Codes/ Statutory documents**
• Water (Prevention and Control of Pollution) Act, 1974 • Environment (Protection) Act, 1986 Relevant standards and orders of the Central Pollution Control Board • The National Green Tribunal Act, 2010 • Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013 • State Level Municipal Acts • City Level Regulations	• National Building Code of India, 2016 (codes prepared by BIS) • Municipal Building Regulations • Master Plans • Budget documents • 15th Finance Commission recommendations

Policies, Guidelines and Tools		
Policies	**Guidelines**	**Tools/Plans**
• National Environment Policy, 2006 • National Water Policy, 2012 • National Urban Sanitation Policy, 2008 • National Faecal Sludge and Septage Management Policy, 2017 • Draft National Wastewater Policy, 2017 • State/ City water and environmental sanitation policies	• JNNURM Guidelines, 2005 • Manual on Sewerage and Sewage Treatment, CPHEEO, 2013 • Model Building Bye Laws, 2003 • Land Application of Faecal Septage (MoHUA and CPHEEO), 2020 • Swachh Bharat Mission (Urban) Guidelines, 2015 and 2021 • PMAY (Urban) Guidelines, 2015 • Smart City Mission Guidelines, 2015 City Liveability Index, 2020 • AMRUT Mission Guidelines, 2015 and 2021 • WHO Guidelines on the safe use of wastewater, 2006	• Service level benchmarks, 2010 • Swachh Survekshan, 2019-20 • City Sanitation Plan toolkit, 2009-10 • State FSSM Strategy and City Level Action Plan format Template, 2016 • Smart City • State Annual Action Plan for AMRUT • Other Resources like Performance Assessment System • City and State Level Plans • Detailed Project Reports • Reports of NIUA (SCBP), NITI Aayog, Toilet Board Coalition

The literature review showed that large scale reforms linked urban development flagship programmes like the National Urban Renewal Mission, the Urban Infrastructure Scheme for Small and Medium Towns that explicitly recognized public health and environment outcomes of investments in sanitation, made available multi-million grants only for sewerage projects.

This is in line with the prevailing school of thought wherein monitoring and performance ranking of cities/towns on sanitation outcomes recognized only centralized sewage treatment systems as scientific management. Despite this, focus on sewerage infrastructure, only 25-30% of urban sewage treated and only 7 cities treat more than 50% of their sewage. A key overlooked fact was that 60% of India's 400 million population is connected to onsite sanitation systems, while about 48% of those are connected to septic tanks. (Census of India 2011)[4]. Further, about 65% have access to basic facilities, 7% have none and 5% use unimproved facilities[5].

Table iii: Access to Sanitation in Urban India.

Access to Sanitation	Urban Areas in India (%)
Safely Managed	0
Basic	65
Shared (limited)	23
Unimproved	5
Open defecation	7

Source: WHO-UNICEF JMP 2017

It is being increasingly realized that there is a need to focus on safe management of the full cycle of sanitation, from containment, emptying and transportation, disposal, treatment and/or reuse, especially in the context of onsite sanitation/ non-sewered sanitation systems. This assumes greater significance as the Government of India has recently launched the Swachh Bharat Mission (Urban) 2.0 which will support investments to sustain open defecation free status and safe and scientific disposal of human waste and wastewater, both black and grey.

Following the announcement of the National Policy on Faecal Sludge and Septage Management as well as the SBM (Urban) and AMRUT programmes, states are preparing Detailed Project Reports for support under these schemes and are expecting to avail the support of these national missions and technical assistance from other agencies to develop and operationalize their plans. However, capacity gaps in the non-sewered sanitation sector have been assessed in a recent report by NIUA and it notes that local bodies grapple with limitations in baseline information, understaffing, lack of policy guidelines and protocol for faecal sludge and septage management, public health & environmental engineers, awareness on public health issues connected with sanitation, skills/ knowhow and availability of training institutes, and awareness of the potential and manner of resource recovery from generated waste[6].

The critical link between water, wastewater and environmental sanitation remains largely addressed and it is expected that India is now on a trajectory to do so and fulfil its objectives towards meeting the targets envisaged in Goal 6 of the Sustainable Development Goals 2030.

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[4] *Census of India 2011 - http://censusindia.gov.in/*

[5] *Progress on Drinking Water, Sanitation and Hygiene Update and SDG Baselines 2017 -WHO-UNICEF report- https://washdata.org/reports?reports%5B0%5D=language%3Aenglisht*

[6] *https://smartnet.niua.org/sites/default/files/resources/NIUA%20Capcity%20Needs%20Assessment%20Report%202017.pdf*

City-wise Case Studies

01

Rajkot

Exchange of Wastewater for Freshwater

Abstract

Rajkot city has recognized and promoted wastewater use as a substitute of freshwater and has had this swapping arrangement between the municipality and farmer cooperatives for decades. Due to increased freshwater demand in Rajkot city, farmers are provided wastewater from the city for irrigation in lieu of freshwater from the Lalpari and Randarda Lakes which was used for the city's water supply by the Rajkot Municipal Corporation (RMC).

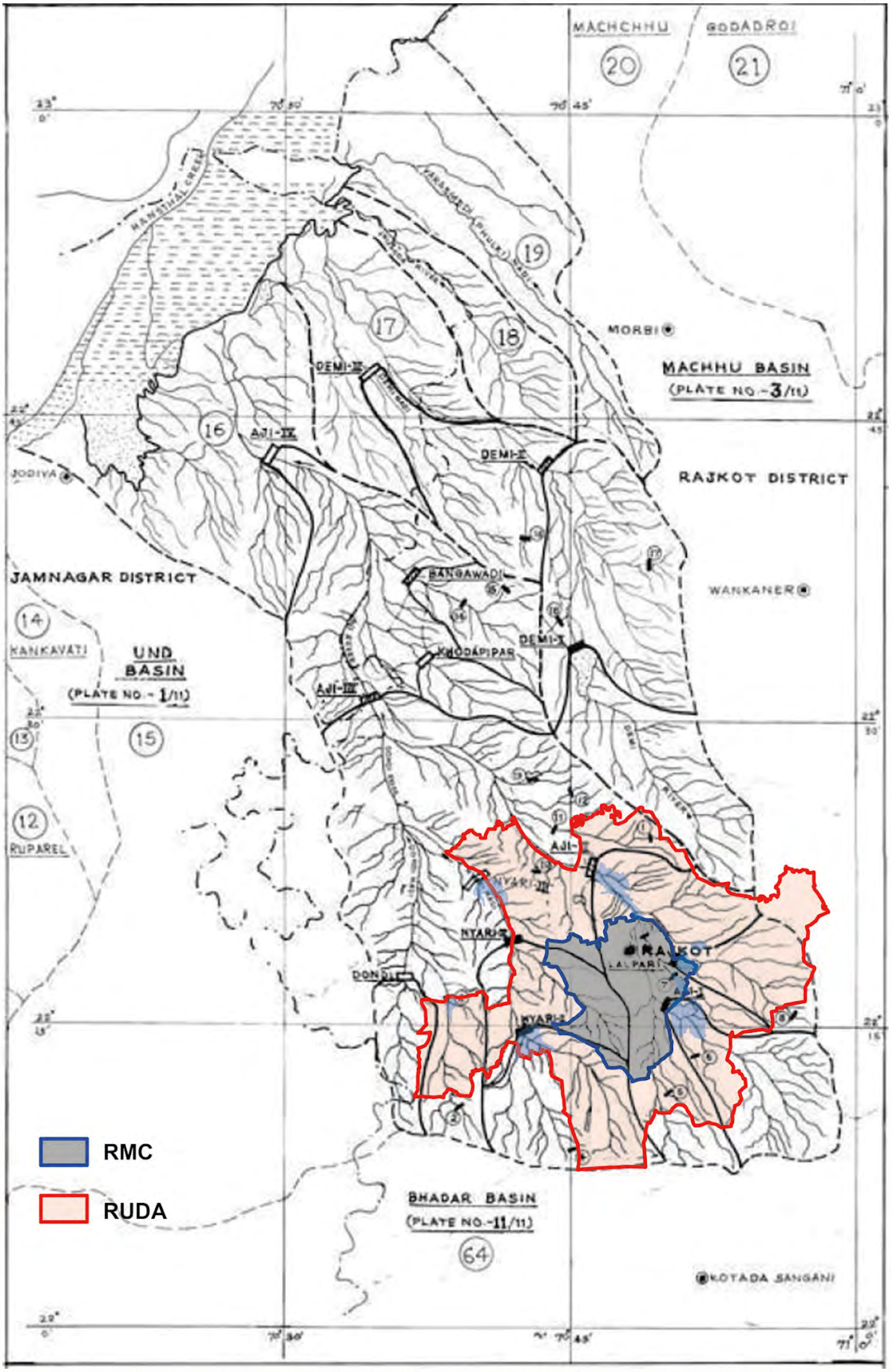
1.1 Physiography

Figure 1.1: Location of Rajkot, India

Rajkot is strategically located in the centre of Saurashtra region in the Aji basin. Rajkot is spread on both banks of Aji River which cuts through the city (Figure 1.2). The terrain surrounding Rajkot is gently sloping. The city has a diverse landscape made up of plateau, hills, linear ridges and alluvial plains. The east-west linear ridge forming upland south of Rajkot forms a water divide for south & south-westerly flowing drainage basins of Bhadar and north & north-easterly flowing drainage basins of Aji, Machhu etc.

Two natural water reservoirs (lakes) are located within the Rajkot city, viz. Lalpari and Randerda. Two major tributaries of Aji are Nyari and Khokhadadi and are within the city along with 19 more tributaries draining the city water (Detail Project Report (DPR) for Drainage Phase-II & Phase - III (Part 1) for Rajkot City, 2006). A series of reservoirs have been built on Aji and Nyari rivers.

Figure 1.2: Aji River Basin and Rajkot City



Source: "Aji Dam under Sauni Yojana," n.d.

Table 1.1: Rajkot at a glance

	Area	104.85 sq. km
	Population	1,390,640 (Census 2011) with population density of 308/ sq. km
	Administration	The Rajkot Municipal Corporation is the key agency providing sanitation and sewerage services. The city of Rajkot is divided into 18 wards.
	Geography & Climate	The city has a diverse landscape made up of plateau, hills, linear ridges and alluvial plains, and has a semi-arid climate.
	Rainfall	The average annual rainfall is 500mm. However, over the last 60 years, it has been below normal for 20 years (Rajkot City Development Plan: 2005-2012, 2016).

1.2 Socio-Economic Conditions

The city has grown in area from 150 ha in 1901 to 1,29,921 ha in 2020, i.e., it has grown approximately 75 times of its initial size. The Rajkot Urban Development Authority (RUDA) was formed and covers an area of 483 sq.km including the area of Rajkot Municipal Corporation (RMC) and 54 villages in the periphery of the RMC.

Rajkot is a strong manufacturing base with a vibrant market. In its early history, Rajkot was organized around the establishment of cloth mills. More recently, the emphasis has shifted to small and medium industries. Manufacturing activities are concentrated in two main industrial estates, namely, Aji industrial estate and Bhaktinagar industrial estate; in addition, many small units are scattered through the city.

Rajkot also serves as a market town for agricultural produce from the surrounding areas. Groundnut and oil seeds are major crops sold and processed in Rajkot.

With increasing industrial, trade and commerce activity, there has been tremendous growth in the population of the town. The city's population has been experiencing an average growth of around 50% since 1961.

1.3 Water Supply

Aji-I, along with the twin lakes of Lalpari and Randarda, was the first water supply scheme serving Rajkot city, constructed by the then Saurashtra Government. After the commissioning of this scheme, treated water was supplied to households. This scheme commenced in 1955 and is still operational. The availability of water from the Aji-I reservoir is 20.43 MLD and from the twin lakes is 6.81 MLD.. Making borewells for groundwater and tanker supply were some more ways for the city to quench its thirst, and construction of Bhadar Dam was completed in a record 135 days so that water for irrigation and drinking could be provided. Recently, Rajkot has shifted to fulfil its water requirements from the Narmada river.

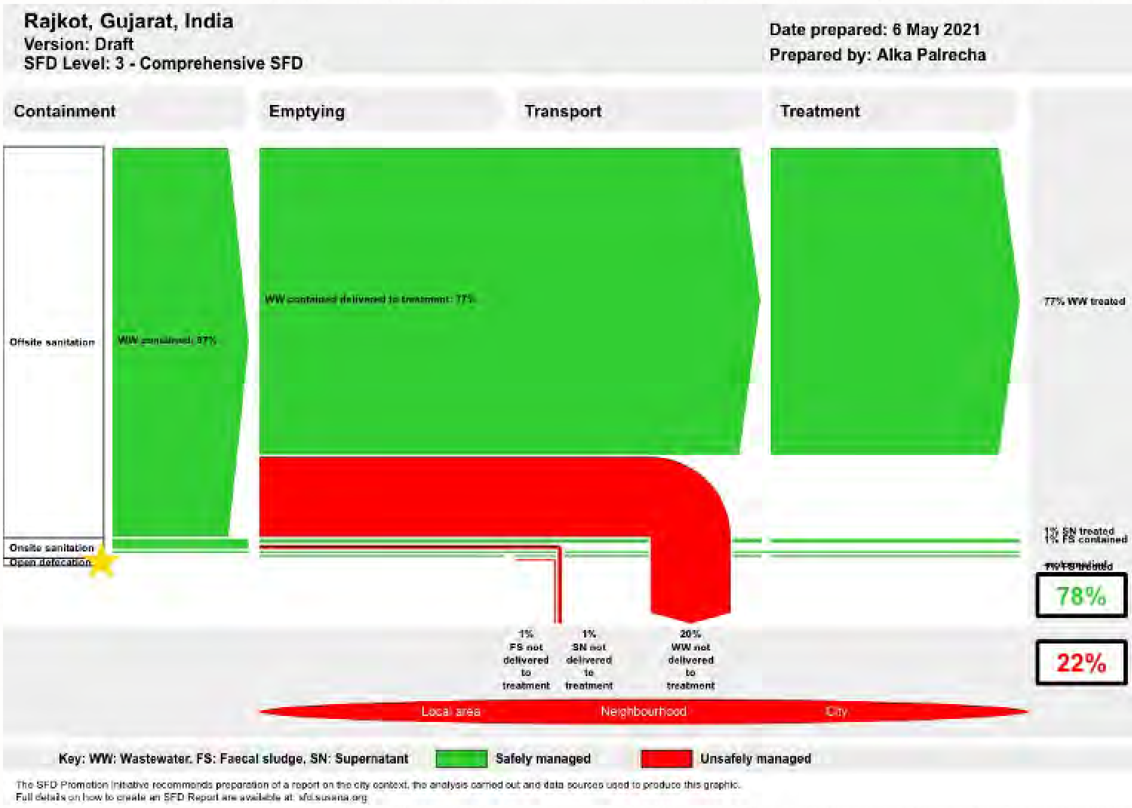
Table 1.2 Water Supply details

Sources of water supply	Aji-I reservoir - 20.43 MLD Lalpari and Randerda - 6.81 MLD Nyari-II - 11.35MLD Nyari-I - 25.9 MLD SAUNI - 140 to 160 MLD Narmada Water Supply - 35 MLD (Based on, Rajkot City Development Plan: 2005-2012 and Draft Comprehensive Development Plan 2031 (Second Revision), Part 1: Existing Conditions, Studies & Analysis)
Total water supply	280 to 300 MLD
Water supply connections coverage	97.56% HHs (PAS 2018-19)
Per capita water supplied	160 lpcd (PAS 2018-19)
Water quality	Potable

1.4 Sanitation Cycle

About 78% of the wastewater generated in RMC is treated, as evident from the Shit-Flow Diagram (SFD) (Figure 1.3).

Figure 1.3: Shit flow diagram of the Rajkot city



1.4.1 Containment, conveyance & treatment

Rajkot has about 97% of its area covered with sewer networks. It is estimated that about 2% of septic tanks are connected to sewer lines through vacuum trucks. Two such trucks are available with RMC and are provided on call, free of cost to remove septage from the septic tanks. This collected septage is emptied in the nearest STP. About 1% septic tanks have impermeable walls but open bottoms to absorb the liquid part of the septage. However, calls for emptying septic tanks are very limited. Although 97% sewer connection exists, not all collected wastewater reaches STPs. About 79% of wastewater collected through sewers reaches STPs and all of it is treated. Broadly, 20% of wastewater is unsafely managed. This shit flow diagram is made considering the population within RMC, i.e., 1,390,640.

Table 1.3: Treatment capacity of Wastewater in Rajkot

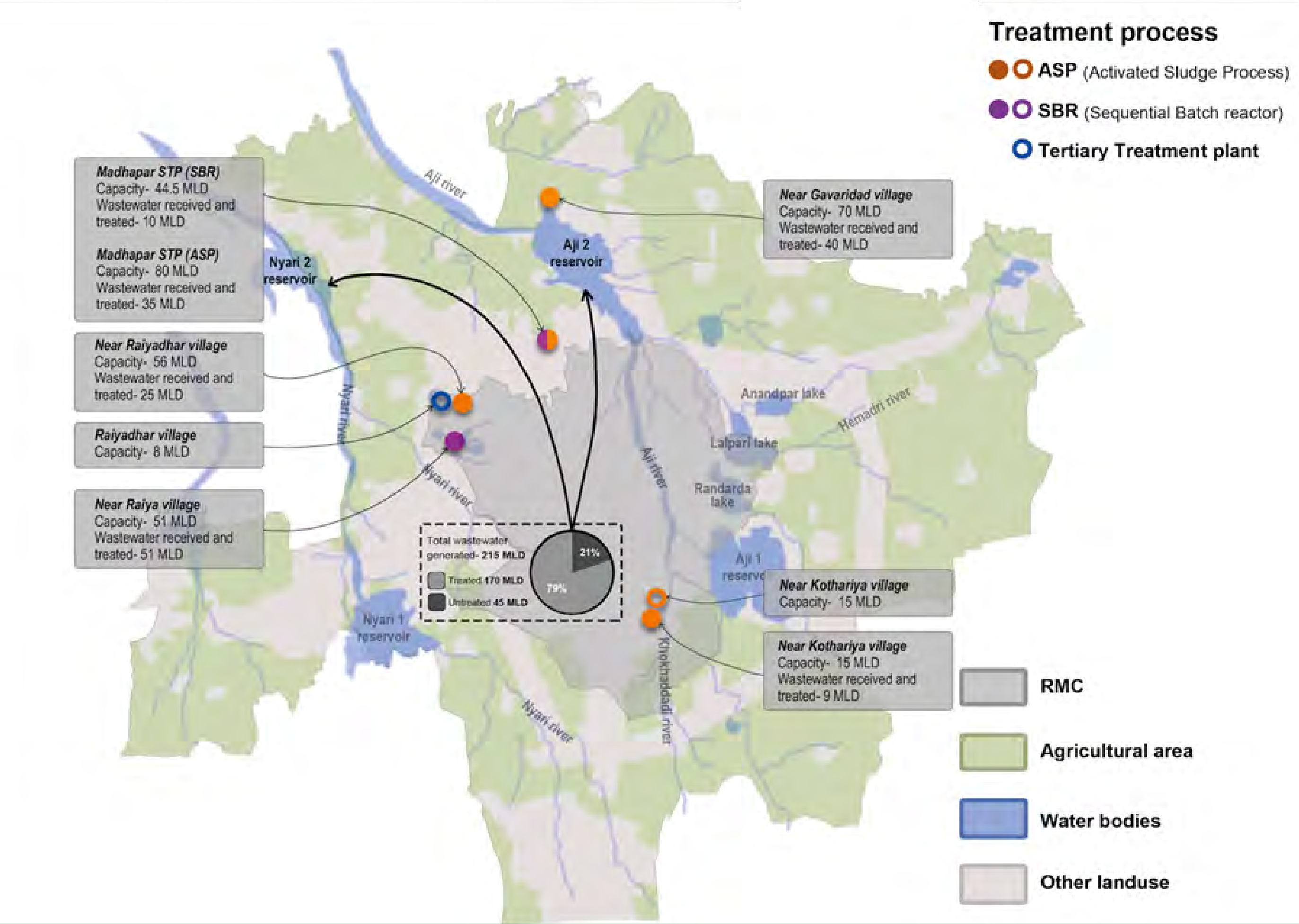
Sr.No.	Particulars	Details
1	Number of STPs	7 existing and 1 under construction
2	Total treatment capacity of STPs (in MLD)	316.5 MLD operational, 23 MLD under construction.
3	Whether all STPs are working	6 operational and 2 under construction
4	Wastewater generated (in MLD)	215
5	Quantity of treated sewage being treated and utilized (in MLD)	170
6	Plan for utilization of treated sewage	As of now treated water is used for irrigation purpose and rest is discharged in Aji-II Dam

Table 1.4: Raw Sewage Characterization

No	Parameters	Value
1	pH	6.5 – 8.0
2	Total suspended solids, mg/L	400
3	Biological Oxygen Demand mg/L	250
4	Chemical Oxygen Demand mg/L	500
5	Total Kjeldahl Nitrogen (TKN)* mg/L	40
6	Phosphorus mg/L	6
7	Faecal coliform, MPN/100ml	$1x10^{6}$
*ammonia-nitrogen plus organically bound nitrogen but does not include nitrate-nitrogen or nitrite-nitrogen		

Source: Detail project Report (DPR) for Drainage Phase-II & Phase - III (Part 1) for Rajkot City, 2006

Figure 1.4: Location of STPs, their capacity, and disposals



1.4.2 Formal and informal use of WW

The city's wastewater finds its way to Aji-II and Nyari-II reservoirs through their tributaries where wastewater is disposed. Both the treated and untreated wastewater are collected in these reservoirs and used formally or informally for irrigation. These reservoirs were storage for supplying drinking water to the Rajkot city. However, as the wastewater is being stored there, its water is no longer usable as drinking water. Gujarat Pollution Control Board (GPCB) had issued notice regarding the dumping of sewage in Nyari-II and Aji-II. The contamination in the river tributaries and eventually in the reservoirs is also due to solid waste dumping in these drainage channels (Detailed Project Report (DPR) for Drainage Phase-II & Phase - III (Part 1) for Rajkot City, 2006)[7].

1.5 Wastewater Reuse: Co-existing Formal and Informal

Wastewater irrigation (treated, untreated and mixed) is widely found in almost every urban centre in Gujarat (municipal corporations like Ahmedabad, Bhavnagar, Vadodara, Surat, and smaller cities like Harij, Visnagar, Patan, Mehsana, etc). In several locations, formal and informal institutions are emerging to manage wastewater irrigation. The first formal wastewater use in Rajkot was initiated in 1960 just after the first water supply scheme from the twin lakes of Lalpari and Randarda was operationalized. The farmers surrounding these two lakes had formed lift irrigation societies, viz. Shri Ramjino Valve Lift Irrigation Society (RAMJI) and Shri Shelej Lift Irrigation Society (SHELAJ), to draw and distribute water from these lakes. With a growing demand for freshwater from Rajkot, an agreement for swapping of freshwater with wastewater was made between the RMC and the farmers who were dependent on the lake for irrigation. The membership of these cooperatives was open to all farmers in the area who had to buy shares depending on the acreage. No dividend was paid on these shares. The management did

[7] *Detail project Report (DPR) for Drainage Phase-II & Phase - III (Part 1) for Rajkot City, 2006.*

not have a concrete structure because of the lack of elected functionaries. No compliance or default tackling mechanism was present. Both RAMJI and SHELAJ had an agreement that they would be allowed to use wastewater in exchange for freshwater without any additional costs. RAMJI still complies with this agreement; they have canals from pumping stations to fields for conveyance of wastewater to fields. The arrangement of SHELAJ has changed. They were offered a new agreement wherein 70% of the treated wastewater from the STP would be given to the farmers free of cost. This did not require any pumping and hence a collective was not required. Farmers started taking treated wastewater independent of the cooperative thus making the cooperative dysfunctional. Now, no pumping is required and a 'kachcha' channel from the STP to the field is laid for procuring wastewater.

The RMC is actively making efforts to formalize wastewater reuse with binding contracts. On the lines of SHELAJ and RAMJI, another lift irrigation society to lift wastewater Shri Iswariya Mahadev Lift Irrigation Society (Madhapur) was established in 2014 with the intention to lift treated wastewater from Madhapar STP. The details of these wastewater cooperatives are given in Table 1.5.

Table 1.5: Institutional arrangement of wastewater cooperatives with RMC

Institution	Number of Members	Payment to RMC	Area Irrigated	Arrangement with municipality
RAMJI, 1962 (Functional)	108	INR 100-1200 per acre for pumping	140 ha	Permission to use untreated WW without costs
SHELAJ, Year 1961 (non-functional)	210	INR 100-1200 per acre for pumping	280 ha	70% treated water to be given to the farmers
Madhapur, 2014	10	INR 6211 per ha treated water cost	18 ha	Treated water will be given by the municipality.

The wastewater cooperatives and the wastewater users prefer to have a formal arrangement with the provider of wastewater as it ensures supply. However, within the co-operative the formalization, terms of membership, and the management of co-operatives remains informal.

An exploration of wastewater being used without any formal agreement was done. The wastewater collected in Aji-II and Nyari-II reservoirs is used by farmers by intercepting the tributaries or from the canals of reservoirs. About 16 villages were using the wastewater, irrigating an area of 5,453 hectares. This water amounts to approximately 60,000 million litres per annum. The calculations are based on crops grown with this water and the irrigation water required by it.

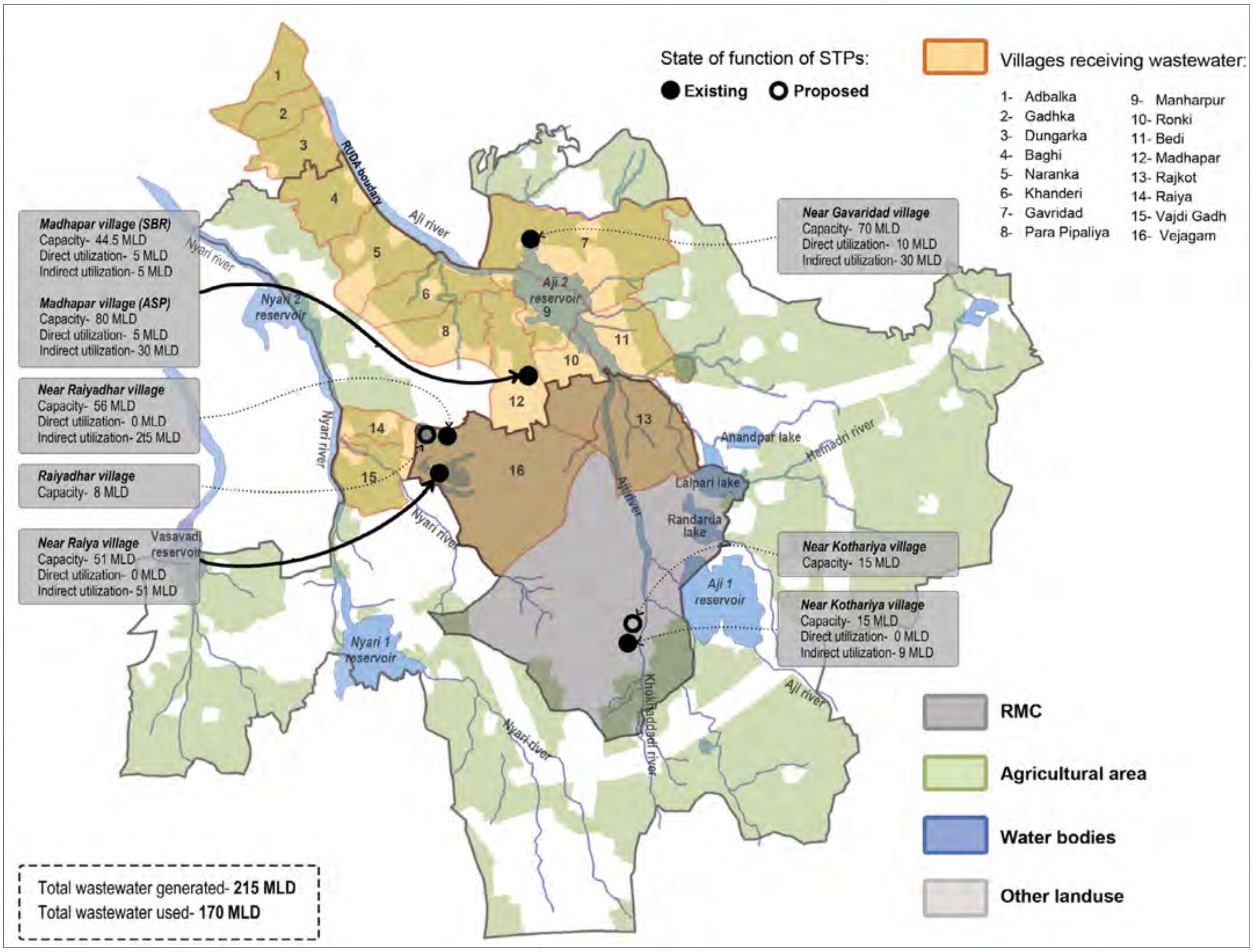
The crops grown through the wastewater irrigation are alfalfa, BT cotton, castor, groundnut, jowar, makai, rose, soyabean, vegetables like okra, cabbage, cauliflower, brinjal, tomatoes and chilli. Wheat is also grown. In Bedi village, it was found that production of wheat crop was 2.5 to 3 times more than the freshwater grown wheat in surrounding villages.

Table 1.6: Crops grown, area irrigated and wastewater used for irrigation

Crop	Area in hectares	Per Hectare Water Requirement (in million litres)	Total water requirement (in million litres /year)
Alfalfa	626	10.6	6,604
BT Cotton	646	10.6	6,815
Castor	313	9.8	3,067
Groundnut	222	6.5	1,449
Juwar	926	6.4	5,950
Makai	302	4.5	1,344
Rose/Flower	101	10.5	1,055
Soyabean	88	3.0	264
Vegetables	1368	23.8	32,490
Wheat	861	3.7	3,186
Total	**5453**	**89.2**	**62,224**

The area irrigated currently with wastewater through a formal mechanism is 158 ha, while the net area irrigated by farmers informally is 3,253 ha, the informal use of wastewater for irrigation is 30 times more.

Figure 1.5: Informal and formal irrigation with Rajkot wastewater



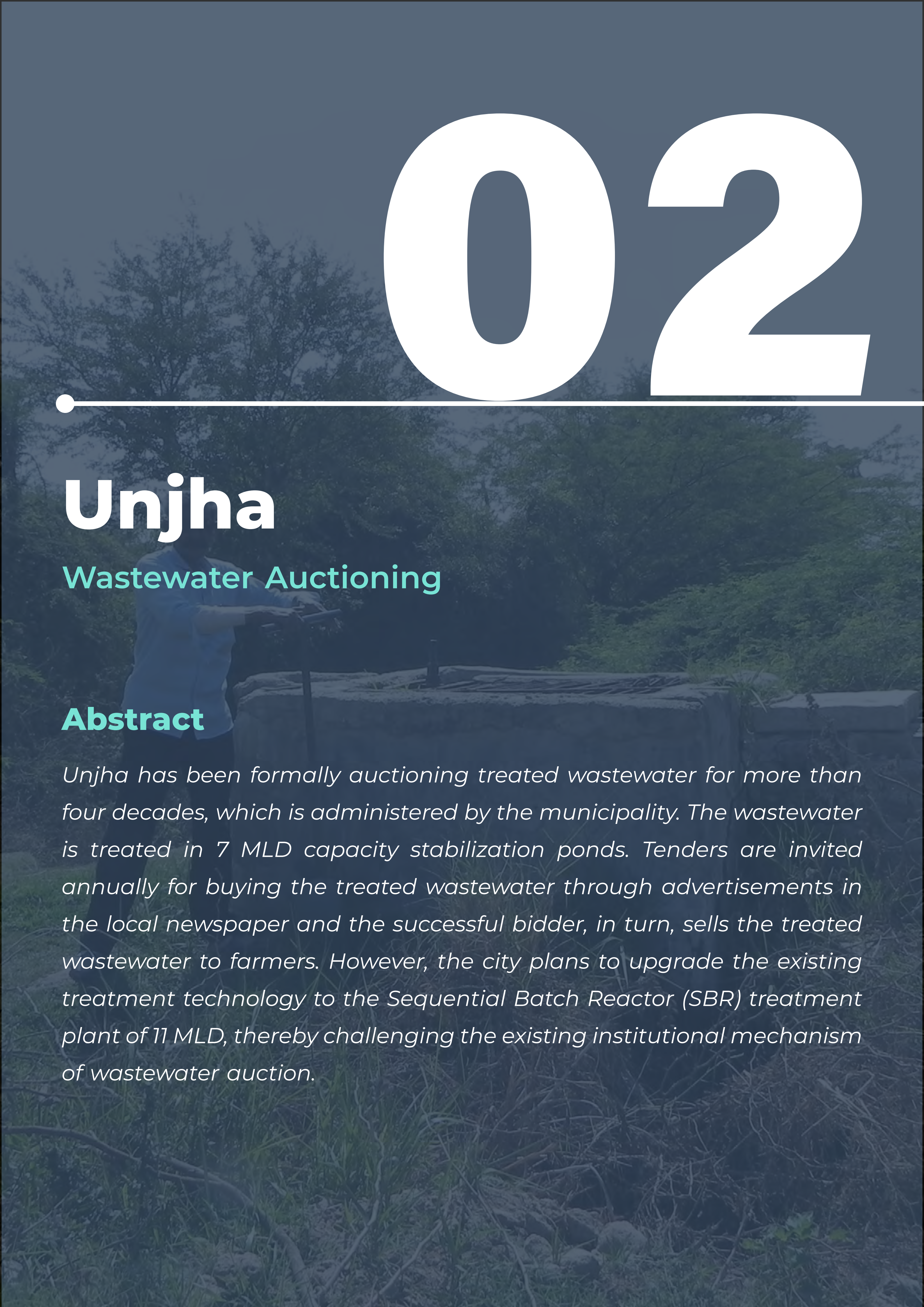
1.6 Key Learnings

The expansion of city limits and population in Rajkot is very rapid. The city will be supplied with more water and more wastewater will be produced. Looking at the current practice and the informal use magnitude, it seems difficult to formally use all the wastewater after treatment within the city. Hence, it is necessary to recognize the informal use in agriculture for promotion of wastewater use as a substitute of freshwater. Rajkot city exemplified it many decades back as a swap for wastewater with freshwater. Learning from this suggests a mechanism of building relations of the city with the people and places out of the city limits through designated wastewater use. Development of institutional mechanisms for such supply of wastewater out of the city limits will be appropriate for using large volumes of wastewater generated by the city.

Aji-II and Nyari-II are now wastewater storage reservoirs. Conveyance of wastewater and storage of wastewater are necessary for efficient use of water and water-like resources (say wastewater). The nature of water use is dynamic and changes. In monsoon the availability of water is more, hence demand of wastewater decreases especially for irrigation use. This is an important pointer as the largest use of wastewater is for irrigation. In the summer and winter months, the requirement of water and wastewater arises. To make it available that time, storage is required. They could be integrated in overall water planning and water budgets.

Rajkot is one of the recipients of allocations under the Smart Cities Mission of the Government of India. The Mission was launched in 2015 and extended to be completed by 2023. For Rajkot, 8 MLD tertiary treatment plant is proposed at Raiyadhar village. This plant will treat 8 MLD out of 56 MLD currently being treated at Raiyadhar through an ultra-filtration system. Secondary treated water will be the input for this plant.

STIFLE Lens	Rajkot Municipal Corporation
Socio-Economic	User groups of farmers are organized into cooperatives and use wastewater for irrigation through formal and informal mechanisms.
Technology	The city has an STP to treat wastewater which converges in two storage reservoirs. Approximately 80% of sewage is treated in the STP.
Institutions	The Rajkot Municipal Corporation is responsible for provision of water supply, wastewater management and solid waste management.
Financial	The RMC and the farmers' cooperatives have a formal agreement whereby the city sells wastewater to the cooperatives and they in turn refrain from using fresh water for irrigation purposes. Farmers' cooperatives pay between 100-1200 per acre to the RMC to pump untreated wastewater which irrigates 140 ha crop area. In addition, a second MoU with another cooperative provides for pumping of treated wastewater to irrigate 18 ha at Rs. 6211 per hectare.
Legal	The state has its own wastewater reuse policy since 2018 and ULBs are responsible for wastewater management.
Environment	Promotion of wastewater reuse for irrigation in lieu of freshwater exemplifies practice of resource recovery and reuse and the 'circular economy'. During the monsoon rain-fed irrigation is prevalent. The storage of wastewater helps optimize its use during summer and winter months alone. It is also observed that the use of untreated wastewater by farmers is a prevalent practice. This is done by intercepting the canals/tributaries of the rivers flowing into the wastewater storage reservoirs. It is estimated that about 60000 million liters per annum is used in 16 villages to treat 5453 hectares. The informal use constitutes 30 times the formal use of wastewater. The intercepted wastewater is used to grow vegetables, wheat, soyabean, flowers, alfalfa, BT cotton, castor, groundnut, Jowar and Makai, thus transforming an arid landscape and enabling food security and incomes.



02

Unjha

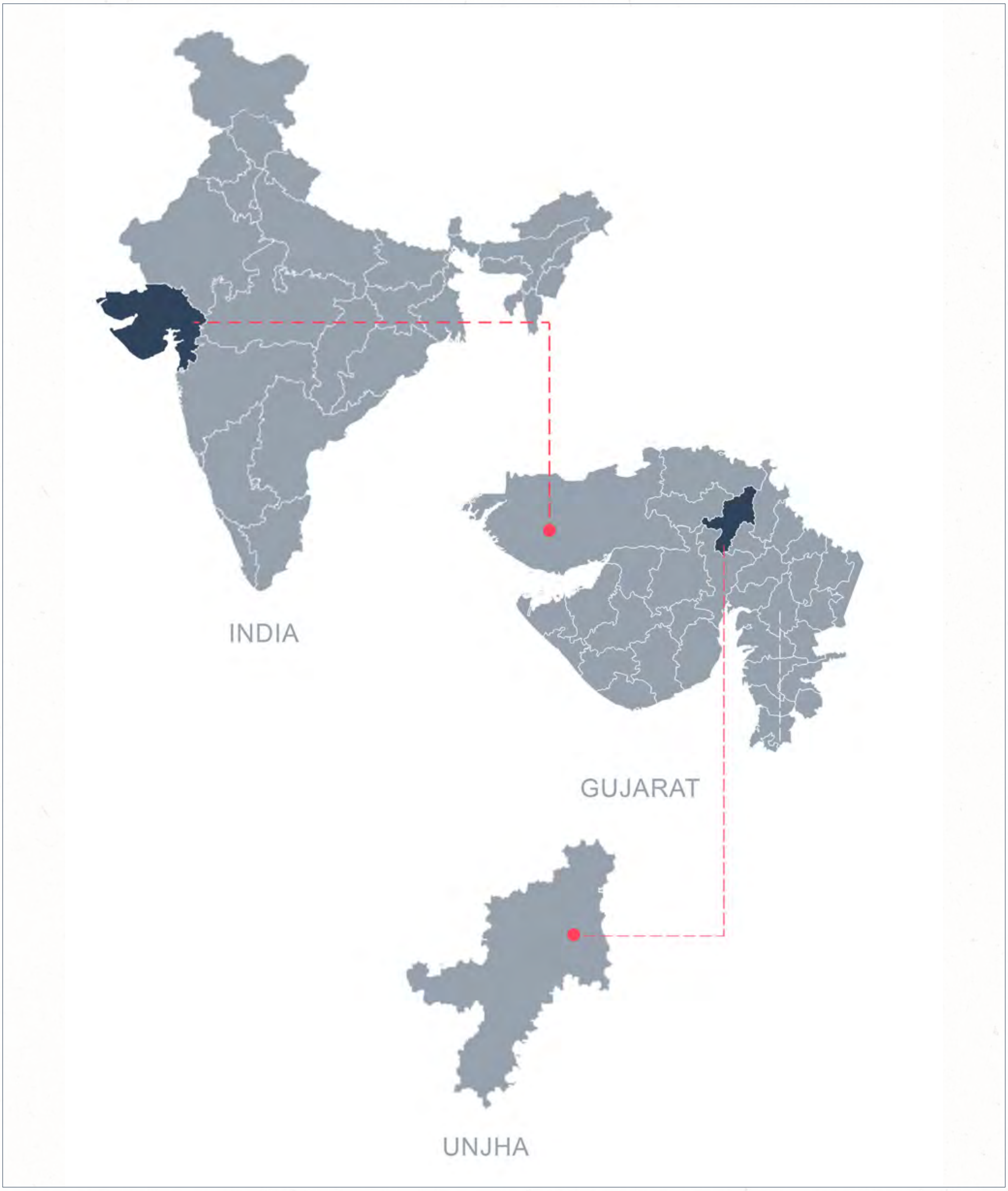
Wastewater Auctioning

Abstract

Unjha has been formally auctioning treated wastewater for more than four decades, which is administered by the municipality. The wastewater is treated in 7 MLD capacity stabilization ponds. Tenders are invited annually for buying the treated wastewater through advertisements in the local newspaper and the successful bidder, in turn, sells the treated wastewater to farmers. However, the city plans to upgrade the existing treatment technology to the Sequential Batch Reactor (SBR) treatment plant of 11 MLD, thereby challenging the existing institutional mechanism of wastewater auction.

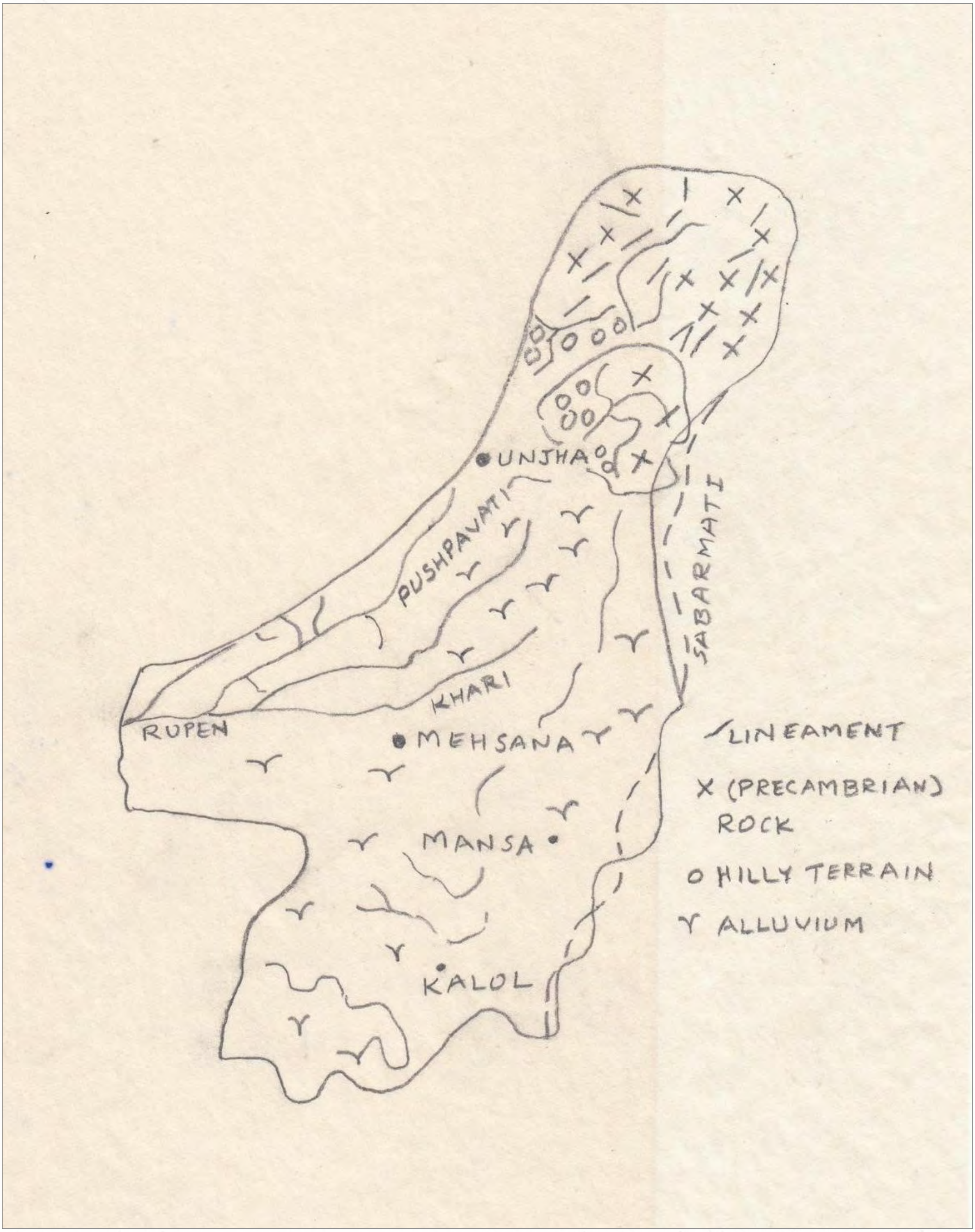
2.1 Physiography

Figure 2.1: Location of Unjha, India



Unjha is a town and a municipality located 102 km north of Ahmedabad in Gujarat. The area of Unjha that lies in the center of the Mehsana district has alluvium soil. The district Mehsana is between two rivers flowing on its boundaries: Sabarmati and Rupen (Figure 2.2). Rupen River has two tributaries: Pushpavati and Khari. Pushpavati flows next to Unjha city and the excess water of the city is drained into it. Rupen drains into the little Rann of Kachchh.

Figure 2.2: Geology and land form of Mehsana District, based on Muley and Nayak, 1983[8]



[8] *Muley, M., Nayak, S., 1983. Hydrogeomorphic studies in Banaskantha and Mehsana districts (Gujarat) using Landsat data. Journal of the Indian Society of Photo-Interpretation and Remote Sensing 11, 47–52.*

Table 2.1: Unjha at a glance

	Area	45.2 sq.km
	Population	62,270 with population density of 1,378/sq. km
	Administration	The Unjha Municipal Council is the key agency providing sanitation and sewerage services. The city has 9 wards.
	Geography & Climate	The topography of Unjha town slopes from north-east to south-west. It is located in the arid region of Gujarat.
	Rainfall	Average rainfall of 600 mm

2.2 Socio-Economic Conditions

The occupation of the households mainly is agriculture, agri-processing, and trading. Politically and economically, the town is dominated by the Patel community. The Kadva Patels are traditionally associated with agriculture and animal husbandry (Singh, 2003, p. 1102)[9]. Though residing in the city of Unjha, most of them own some land and are engaged in agriculture. Traditional caste councils exist for the community to settle conflicts. Women are consigned to household work and agriculture is secondary.

Prominent economic development of the town can be attributed to the Unjha Agricultural Produce Market Committee (APMC) which is Asia's largest hub for trading spices like for cumin seed and fennel seeds (saunf or variyali) with recorded turnover of Rs 2,234 crores in 2013. About 58% of the town's population is directly employed with APMC and other major related factories of spice cleaning. Oil mills and stone factories are also other major employers (APMC website, 2016).

2.3 Water supply

Unjha town is located in an overexploited zone of groundwater resource and depth of borewells varies from 290 to 370 meters (Jadeja, 2011, Dharoi Water Resource Project)[10]. Till 2000, groundwater was the sole source of water supply. Dharoi dam water was introduced to Unjha post 2000.

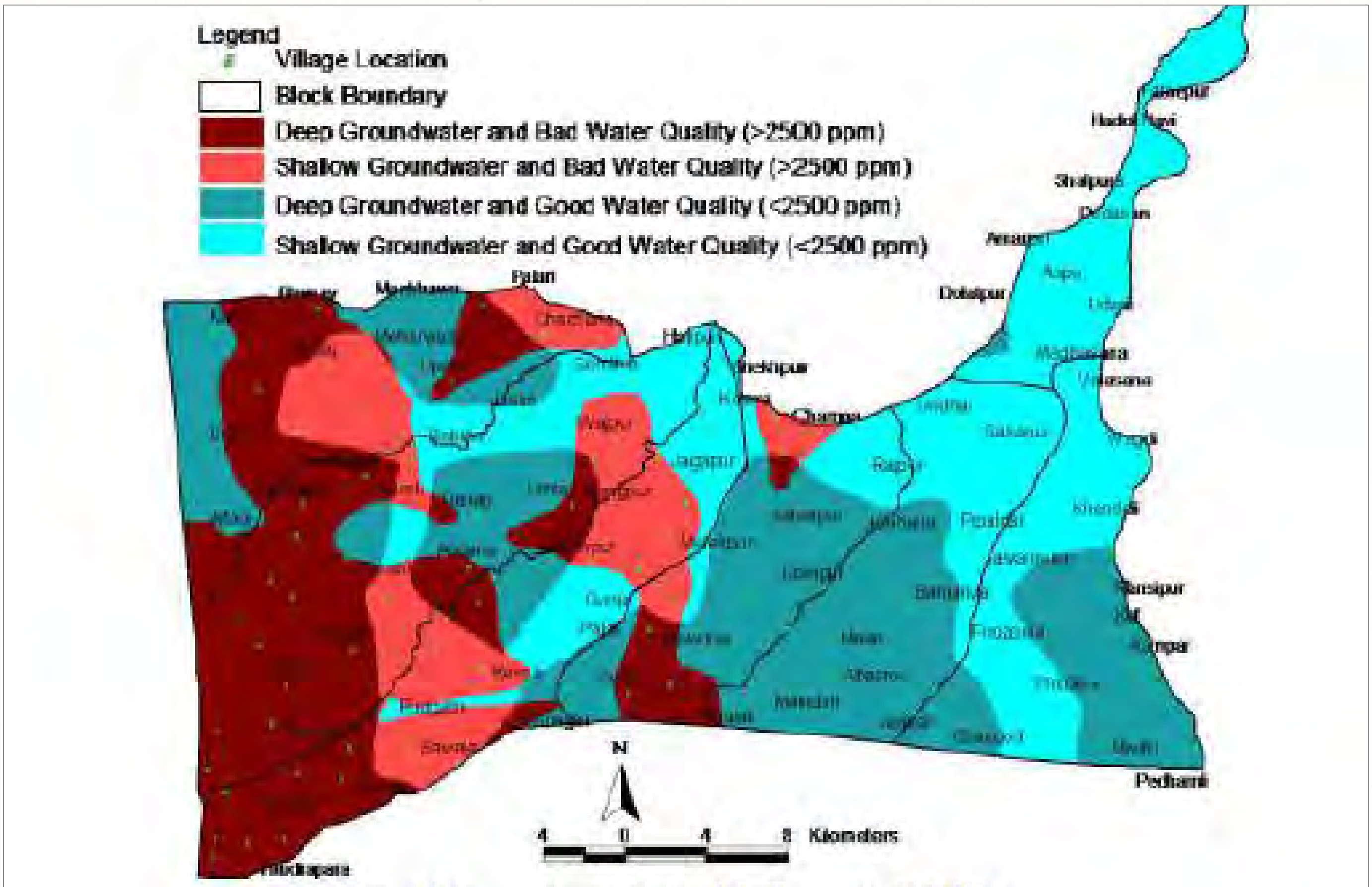
[9] *Singh, K., 2003. People of India, Gujarat: Anthropological survey of India, Part Three. Anthropological Survey of India 23, 1033–1519.*

[10] *Jadeja, Y., 2011. Study on Designed Capacity of the Dharoi Dam vs. Actual Command Area irrigated.*

Table 2.2: Water Supply details

Sources of water supply	Dharoi dam - 7 MLD (87%); Groundwater - 1 MLD (13%)
Total water supply	110.5 MLD
Water supply connections coverage	100% coverage
Per capita water supplied	108 lpcd (PAS 2018-19)
Water quality	Serious problems of increasing fluoride content in groundwater ranging from 1.1 ppm to 14 ppm as against the acceptable limit of 2.5 ppm. The quality of groundwater is not potable.
The efficiency of collection of water supply related charges	94.45%[11]

Figure 2.3: Groundwater situation in Unjha in relation to Dharoi command area



Source: Jadeja, 2011

[11] *Centre for Water and Sanitation, 2019. Performance Assessment System. URL https://www.pas.org.in/web/ceptpas/reportsandpapers?p_p_id=ReportsandPapers_WAR_Portal&p_p_lifecycle=1&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=1&actionVal=Retrieve&SkipAccessChecking=false (accessed 7.13.21).*

2.4 Sanitation Cycle

2.4.1 Containment & conveyance

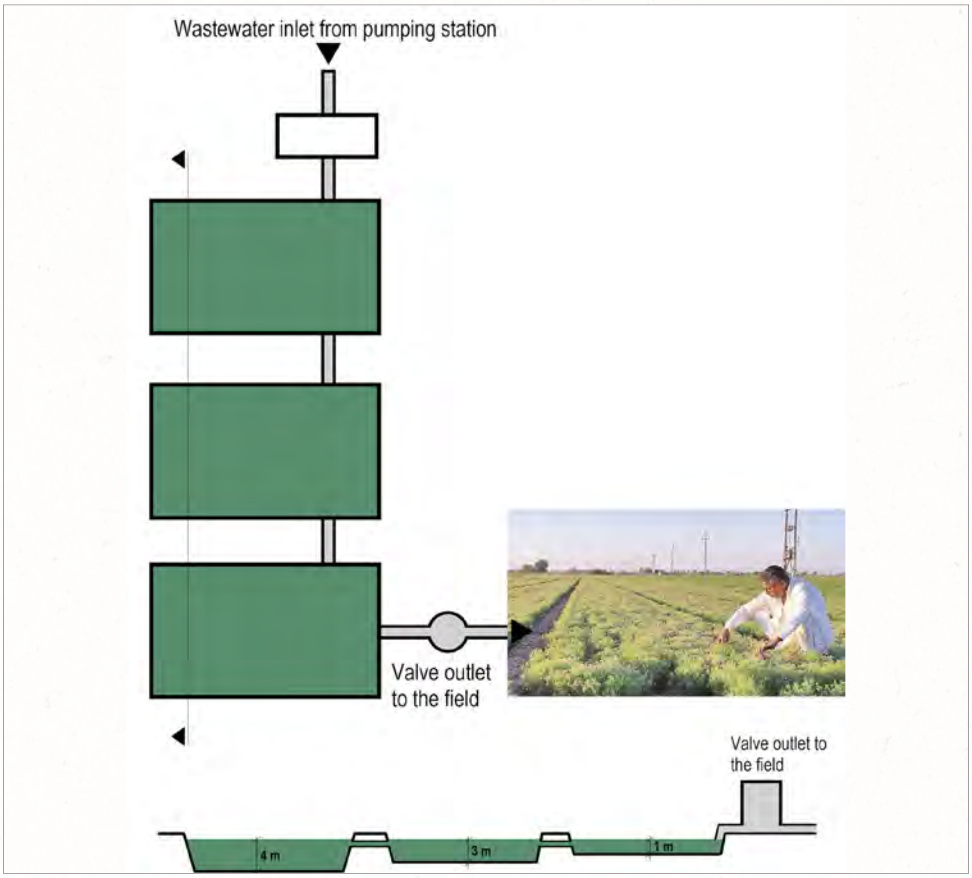
The toilet coverage reported is 100% with a sewerage coverage of 51% in 2018-19 (Centre for Water and Sanitation, 2019). Most of the properties are already connected to the sewer network in 2021 as it was revealed in discussions with municipal officers. The houses that are not connected to sewer networks have soak pits. Thus, the conveyance is mostly formal except in the monsoon. In monsoon as the storm water also reaches the sewer drains, overflow finds its way into Pushpavati River.

Peripheries of the city have poor service provisions. Manual scavenging was not reported as the households interviewed had not emptied the soak pits in recent years.

2.4.2 Formal treatment and reuse

Unjha treats its collected wastewater in a stabilizing pond (not a conventional STP). It has three ponds with a combined capacity of 8 MLD. The detention period is 1-7, 5-20, and 15-20 days in sequence. The sewage generated is about 7 MLD.

Figure 2.4: Schematic plan and section of treatment system in Unjha



2.5 Formal Auctioning of treated wastewater for agricultural reuse

Unjha has been auctioning treated wastewater for more than four decades. It is a formal process administered by the municipality. Tenders are invited annually for buying the treated wastewater through advertisements in the local newspapers (Figure 2.5). A minimum of three bids are required to carry out the process, and the successful bidder gets access to the treated wastewater, who in turn sells it to farmers. Along with the oxidation ponds, outlets are made from which the wastewater is diverted to the fields. These outlets and the pipelines are made by the contractors who have come over the period of time. Thus, the conveyance of treated wastewater from the treatment pond to farmers' fields is the responsibility of the bidders.

There are 40 to 100 farmers who use the wastewater for their agricultural fields and an area of 20 to 50 ha is irrigated using this wastewater. The farmers are charged on an hourly basis on the number of hours they have used the wastewater (number of hours the pumping machines of 10 HP) have worked at the rate of Rs 70 per hour. They pay the amount the next time they use the pump for irrigating their fields. This also ensures that there are no delays in the revenue collection (rarely does any farmer delay payment). The auctioned wastewater is the source of income for the municipalities and the operation and maintenance costs of the system are easily recovered. Rs 2.51 lakhs was the revenue generated from the sale of treated wastewater in 2020.

Figure 2.5: Tender Notice Inviting bid for Treated Wastewater

ઊંઝા નગરપાલિકા

જા.નં.૮૨/૨૦-૨૧

તા.૩-૬-૨૦૨૦

-: ટેન્ડર નોટિસ :-

આથી આ સંસ્થાના ભુ.ગટર યોજનાના ઓક્સીડેશન પોન્ડના તળાવ તેમજ અગીયાર નાળા ફલકું વહેળામાં એકત્ર થતું ગંદુ પાણી ખેતી ઉપયોગ માટે વેચાણથી એક વર્ષથી મુદત માટે કોન્ટ્રાક્ટ આપવાનો છે. તો રસ ધરાવતા ઈસમોને આ સંસ્થા માંથી એક કામના રૂ.૧૦૦૦/- અંકે રૂપિયા એક હજાર પૂરા ટેન્ડર ફી ભરી તા.૧૭/૦૬/૨૦૨૦ સુધીમાં ટેન્ડર કોપી મેળવી લઈ ટેન્ડર સાથે રૂા. ૨૦,૦૦૦/- અંકે વીસ હજાર પૂરા એફ.ડી.આર. થી ભરવાની રહેશે અને ટેન્ડર ભરી તા.૨૪/૦૬/૨૦૨૦ સુધીમાં નગરપાલિકા કચેરીએ સીલબંધ કવરમાં મોકલી આપવા તજવીજ કરવી.

(એમ. એમ. ગઢવી)	(અલ્પેશભાઈ ડી. પટેલ)	(મણીલાલ બી. પટેલ)
મુખ્ય અધિકારી	કારોબારી ચેરમેનશ્રી	પ્રમુખશ્રી
ઊંઝા નગરપાલિકા	ઊંઝા નગરપાલિકા	ઊંઝા નગરપાલિકા

Unjha is upgrading its treatment technology to Sequential Batch Reactor (SBR) treatment plant of 11 MLD. The land allotted for this plant is the same land where the stabilization pond is located. The reuse of treated wastewater from the SBR plant is still to be decided by the municipality.

Wastewater Quality (Treated and Untreated)

The main industries in Unjha are agri-processing, hence, industrial effluents are absent in wastewater. The pond-based treatment system seems to treat the wastewater to an acceptable quality (Figure 1.6).

Figure 2.6: Water quality test report

TEST REPORT

Test Report No. : GL/GR03-Y/95/02/2013
Lab ID No. : 24/2
Sample Described As : **Water**

Page 1 of 1
Date of Receipt : 05/02/2013

Sample submitted by : People In Centre Consulting
701-702, Sakar-IV,
Opp. M.J. Library,
Ashram Road,
Ahmedabad-380006, Gujarat.

Mark : ----
Condition of Sample : Satisfactory
Analysis Date : 05/02/2013 to 11/02/2013

Sr. No.	Characteristic examined	Result	Method of Test
1	pH at 25°C	7.28	IS 3025 (P-11) : 1983, Reaff-2002
2	Turbidity NTU	0.3	IS 3025 (P-10) : 1984,Reaff 2002
3	Total Dissolved Solids mg/L	672	IS 3025 (P-16) : 2002
4	C.O.D. mg/l	179	IS 3025 (P-58) : 2006
5	B.O.D. mg/l	30	IS 3025 (P-44) : 1993
6	Oil & Grease mg/l	1.10	IS 3025 (P-39) : 1991
7	Total Suspended Solids mg/l	238	IS : 3025 (P-17) : 2002
8	Dissolved Oxygen mg/l	5.10	IS : 3025 (P-38) 1989
9	E-Coli per 100 ml	Absent	IS 1622-1981 Reaff. 2003

Agriculture/Cropping pattern

The crops grown are tobacco, jowar, alfalfa, wheat, bajra, castor, and mustard. The profits of these farmers have doubled, i.e., 60 – 70 'man' (1 'man' = 20 kgs) of wheat is grown per bigha. Farmers emphasized the treated wastewater does not contain chemicals and doesn't smell foul, and there are no disadvantages of using this wastewater for irrigation (on site observation shows that there is no foul smell even near the oxidation ponds).

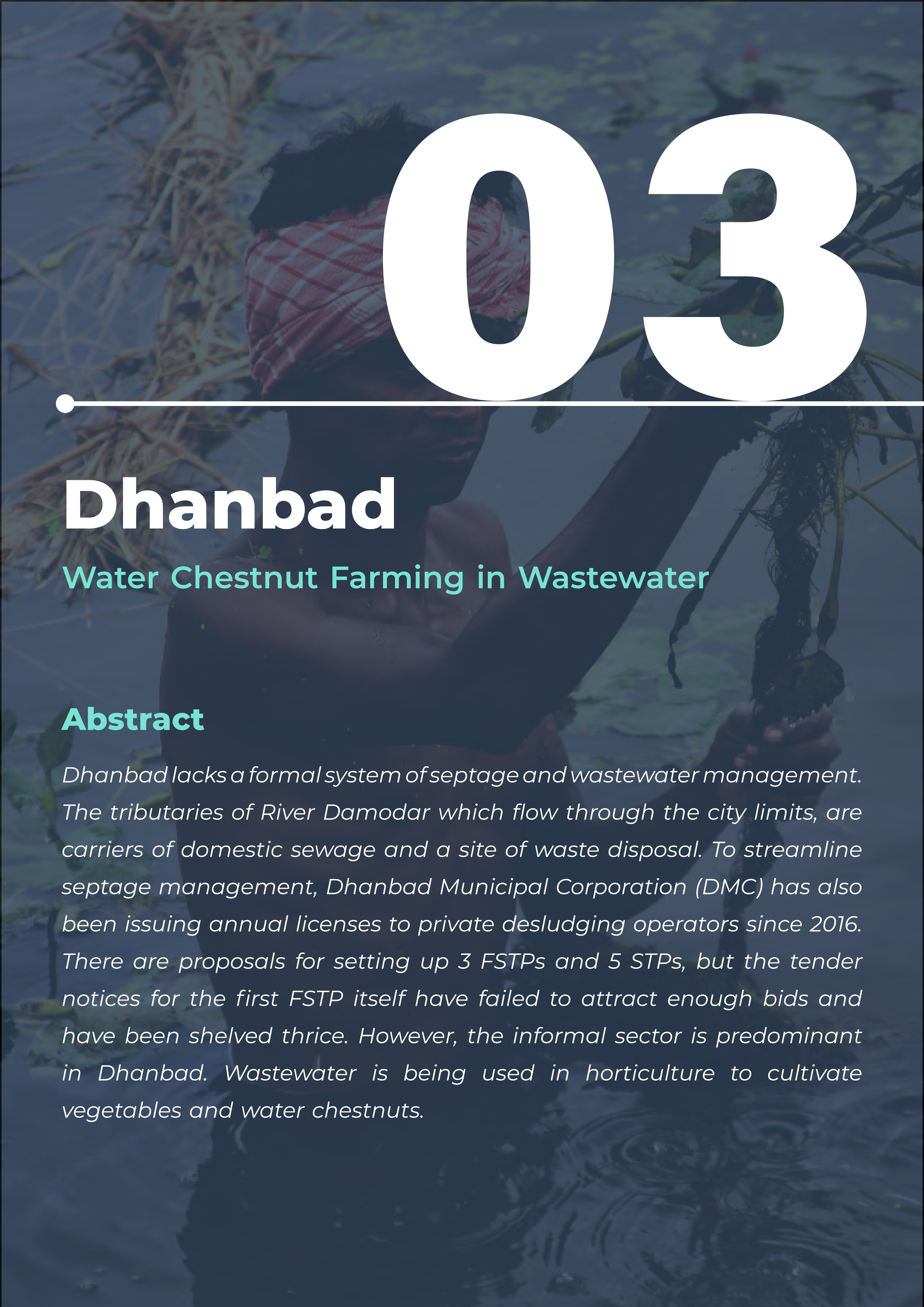
Figure 2.7: Irrigation practices

2.6 Key Learnings

The decision of upgradation of treatment technology seems to have been taken due to overflow of sewage in monsoon giving rise to complaints about stench and filth. The stormwater runoff from the city partly finds its way to oxidation ponds. This exceeds the capacity of the treatment pond and it overflows, eventually going to the Pushpavati River following the gradient. The complaints of citizens regarding this and popularity of membrane-based treatment technology in surrounding towns resulted in the decision of upgradation of the treatment plant. However, the existing stabilization pond treatment seems to be appropriate for treating the wastewater considering it does not have industrial pollutants. Also, the treated wastewater quality test report from the stabilization pond indicates it fits the standard of treatment required for irrigation use. In addition, it seems that in monsoon the overflow will still be flowing towards the river. If the STP remains functional, then this will be treated wastewater flow and on the rainy days, and if STP is not functional then all the stormwater as well as wastewater will overflow, unlike in current times where ponds hold significant quantities of wastewater.

Further, the rights of current wastewater users are to be recognized and integrated in future expansion plans.

STIFLE Lens	Unjha Municipality
Socio-Economic	Around 58% of the population is engaged in agriculture and agri-processing activities. Unjha has the largest Agriculture Produce Marketing Committee which is also Asia's largest trading hub for cumin and fennel.
Technology	A stabilization pond system is used to treat wastewater. It is proposed to set up an SBR based treatment plant with a 11 MLD capacity.
Institutions	The Unjha Municipality is responsible for the water and sanitation supply and maintenance.
Financial	The Municipality follows an annual auctioning system to sell its wastewater to the highest bidder. The Municipality puts out an annual tender and the winning bidder in turn supplies wastewater to the farmers for irrigation purposes. The Municipality received an income of around 2.5 lakhs in the year 2020 from the auctioning process.
Legal	The state has its own wastewater reuse policy since 2018 which mandates ULBs with the task of wastewater management.
Environment	The system of auctioning wastewater results in water conservation and protection in a context of groundwater depletion. It regulates and incentivizes the demand for wastewater through the process of auction facilitating agricultural and livelihood development.



03

Dhanbad

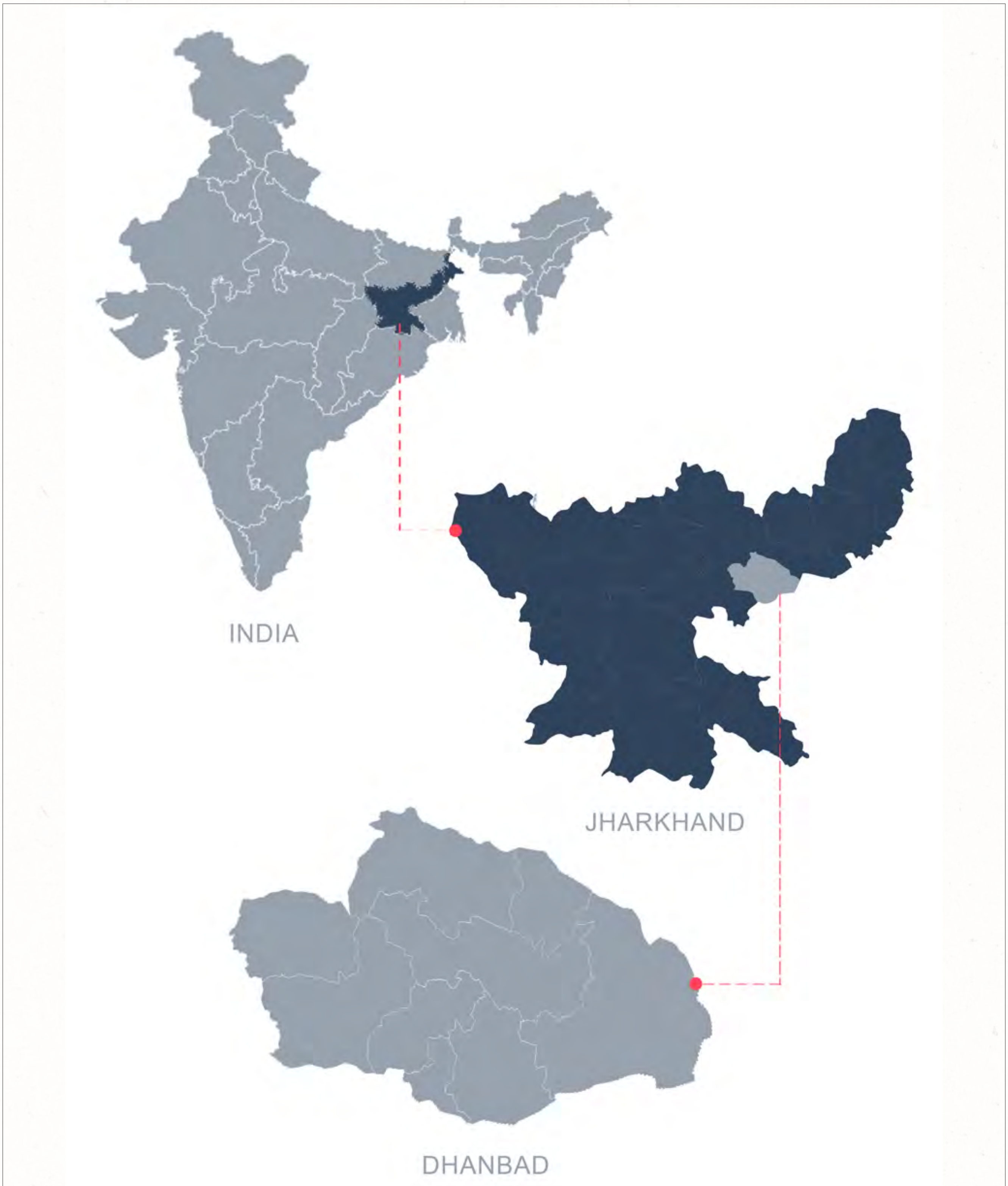
Water Chestnut Farming in Wastewater

Abstract

Dhanbad lacks a formal system of septage and wastewater management. The tributaries of River Damodar which flow through the city limits, are carriers of domestic sewage and a site of waste disposal. To streamline septage management, Dhanbad Municipal Corporation (DMC) has also been issuing annual licenses to private desludging operators since 2016. There are proposals for setting up 3 FSTPs and 5 STPs, but the tender notices for the first FSTP itself have failed to attract enough bids and have been shelved thrice. However, the informal sector is predominant in Dhanbad. Wastewater is being used in horticulture to cultivate vegetables and water chestnuts.

3.1 Physiography

Figure 3.1: Location of Dhanbad, India



As per the Census 2011, Dhanbad district ranks 2nd in terms of population and 20th in terms of area in the state of Jharkhand. Hence, it is the most densely populated district in the state.

Table 3.1: Dhanbad Municipal Corporation Area at a glance

	Area	275 square kilometers (sq. km)
	Population	1.16 million (as of 2011)
	Administration	Dhanbad Municipal Corporation (DMC), spread across five zones and 55 wards
	Geography & Climate	Undulating land, with general slope from west to east. The major river within Dhanbad Municipal Corporation Area is Damodar and its tributaries. It has a warm & temperate climate.
	Rainfall	1,306 mm

3.2 Socio-Economic condition

Dhanbad is known as the coal capital of India. Mining activities are predominant in the south, south-west and eastern part of the district in the region identified as Jharia Coalfield (JCF). JCF is the one single depository of coal spread over an area of about 480 sq.km (approximately 17% of the total district area). There are about 111 coal mines in the district producing around 38 million tons of coal annually (2016-17 estimates). The basic economy of the region is coal mining. Urban centres such as Dhanbad, Jharia, Sindri, Katras, Karkend etc., have developed quite a diverse economic base. Industries of manufacturing, processing, servicing, repairing types and trade and commerce activities have come up in large numbers, and even the supporting and allied service sector contributes to a major extent in providing employment in the region.

There are 526 slums in the DMC with 44,819 HHs, which means that about 17% of the population resides in slums.

3.3 Water Supply

There are multiple agencies supplying drinking water in Dhanbad. Jharkhand Mineral Area Development Authority (JMADA) provides bulk water, while Fertilizer Corporation of India (FCI) and Drinking Water and Sanitation Department (DW&SD) distribute piped water within DMCA. Water supply for the entire mineral areas within the district is done by JSMDA. On the other hand, FCI supplies treated piped water to the erstwhile Sindri Notified Area Council (NAC) area.

Table 3.2: Water supply details

Sources of water supply	Surface water from Topchanchi lake, Damodar River and Maithon reservoir and no factual reports on groundwater use
Total water supply	110.5 MLD
Water supply connections coverage	21.57% (47,622 HHs)
Per capita water supplied	98 lpcd
Water quality	Potable without any issues

According to a DMC official, there are 300 ponds (in use and neglected) within the DMCA, and on an average 50 water bodies of varying capacity across the five zones. However, they are absent in DMC's water mathematics. In fact, the projection of water supply, water consumption, and wastewater generation needs updating. The total water supply is estimated at 110.5 MLD. As per official records approximately 80% of the HHs in DMC do not have water supply connections and are dependent either on public sources or groundwater.

3.4 Sanitation Cycle

According to Brickwork ratings 2017, coverage of toilets was 86%. Under the Swachh Bharat Mission, DMC is focusing on providing more toilet facilities to households. According to Swachh Survekshan 2020, DMCA was 33rd in the category of 47 ULBs with a population of more than 10 lakhs. Dhanbad city lacks a formal wastewater collection, treatment, and disposal system. According to the State Urban Development Authority (SUDA) official, till recently, DMC has been steadfast in ensuring and sustaining the ODF+ status across all the five zones. And now the efforts will be channelized towards ensuring ODF++ status.

To understand the sanitation status of the DMCA, in the absence of credible published resources and reports, a transect walk (along the drains receiving household wastewater) and online questionnaire-based public perception survey (with 74 participants) on different verticals of urban sanitation was conducted.

3.4.1 Containment

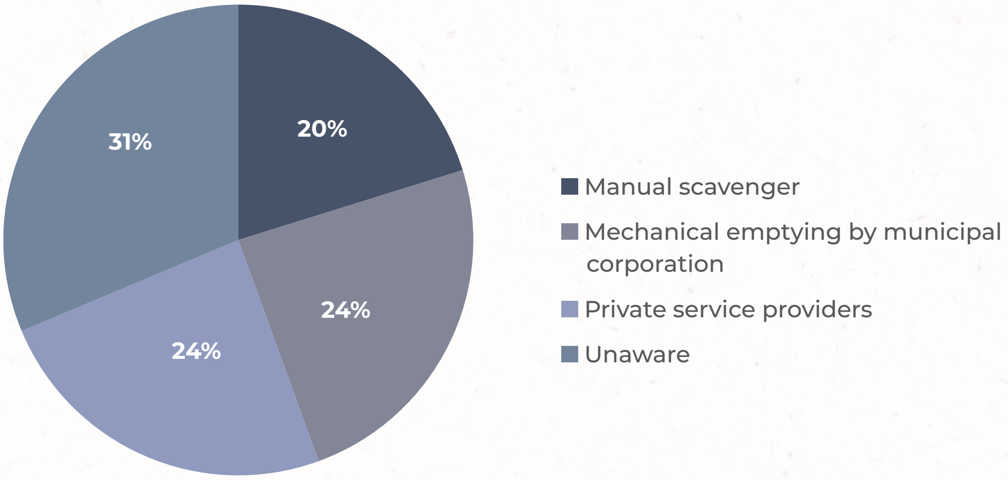
Dhanbad city is completely dependent on an on-site sanitation system. Around 91% of the online survey participants had toilets with septic tanks while the rest 9% either were unaware (5%) or did not have (4%) them. Nearly half of the septic tanks (43.2%) were followed by a soak pit. The participants reported a highly variable trend in the frequency of septic tank emptying ranging from once a year to up to once in 15-20 years. This clearly reflects the lack of scientific design of septic tanks as well as low awareness level amongst the public.

3.4.2 Conveyance

Faecal Sludge Management:
The black water from the households is contained in septic tanks which are emptied by desludging operators. There are both private and public owned desludging operators in Dhanbad.

As per a DMC official, there are 8 desludging vehicles (2021) in Dhanbad for nearly 105,974 HHs with septic tanks (2017), out of which 4 are government owned and 4 others are privately registered. Permits and licenses are given to private players on an annual basis at the cost of Rs 25,000 from 2016. Independent private service providers not registered with DMC are also operating. Variable cost of emptying and conveyance ranging from Rs 500-1500 (DMC official). The capacity is 3,000-5,000 litres.

Figure 3.2: Pit emptying in Dhanbad



As per the online survey, cumulatively 55% of the participants utilized the septic cleaning by DMC and private service providers. And 31% participants were oblivious to who empties the septic tank. 20% reported manual scavenging while only 25% reported mechanical emptying by DMC. A similar percentage of participants stated the private service provider's role in emptying the septic tanks.

The cost of emptying may depend on several factors like level of compaction of sludge, size of septic tank, volume of tanker, difficulty of approach, mechanical or manual cleaning etc. About 69% people expressed their willingness to pay for septic tank emptying, while the remaining were almost equally unwilling and unsure about paying any charges for the same.

Wastewater management:
There is no formal wastewater conveyance system in Dhanbad. The city is not provided with sewer lines. The greywater from the HHs is led into drains. The majority of the drains are either partially covered or open, which increases the chances of solid waste getting into the drains.

Waterborne diseases are often associated with improper sanitation. Even in the lack of a covered wastewater drainage and treatment network, only 24.3% participants from the survey reported the incidences of cholera, diarrhoea, dysentery, hepatitis A or typhoid in their locality. The prevalent practice of boiling drinking water or use of a water purification system, use of mosquito nets, largely dry climate with ample sunshine hours may be a few reasons leading to such observations.

Figure 3.3: Wastewater (mostly grey) led out into nallahs

While walking along one of the streams within DMCA, there were many instances where wastewater (both black and grey) was directly flowing from individual HHs into the drain which is a tributary of Damodar River. A similar process is followed with the on-site containment systems as well. Here the overflow from the septic tank is diverted to the storm water drains.

3.4.3 Treatment

Faecal sludge treatment

According to the online survey, 46% of the participants had some idea about the sewage treatment plant and the sewerage system concept, although the DMCA does not have a well-developed municipal wastewater conveyance system in place yet.

According to few private septic tank cleaning agencies, the septage after being pumped out from the septic tank is either discharged in the open drains or dumped outside the city limits and also in abandoned OCCM in an ad hoc manner. Presently, there are no evolved plans with regard to the septage disposal, and the present system seems to be the accepted normal. At present, five FSTPs are being planned of which the official processes are underway for the one to be established in Sindri.

Wastewater treatment

There is a mention about the use of STP situated at the Indian Institute of Technology - Indian School of Mines (IIT-ISM)[12]. Dhanbad does not have a STP. In 2020, DMC had planned to set up five STPs with a combined capacity of 234 MLD. The treated water is planned to be delivered to the homes through a separate pipeline and for irrigation purposes. Funds on this scheme were being planned to be sourced from the state government, World Bank, Asian Development Bank or District Mineral Fund Trust. However, no such project has yet been formalized. There are on ground challenges like identification of probable sites for five STPs and the six integrated sewage pumping stations and demarcated funding to go beyond the DPR phase despite having plans chalked to build an STP within a year.

Official process to establish DMC's first FSTP at a cost of 40 million rupees is underway; although the tendering process has failed to garner sufficient bids from the contractors thrice. This is partly attributed to the lack of experience among local contractors and reluctance of national players to take up a project in Dhanbad.

3.5 The informal reuse of wastewater to grow water chestnuts

Untreated wastewater (mostly grey) flows in open drains which open up into small streams (tributaries) finally reaching the Damodar river. During the walk along one of such streams, there were two instances where informal use of wastewater was observed. First was pond-based water chestnut farming and the second was concerning vegetable farming along the stream.

Figure 3.4: Jodia talab where water chest-nut cultivation takes place

Water chest-nut farming:

Trapa bispinosa, the scientific name for water chestnut, is an important plant of the Indian Ayurvedic system of medicine, which is used in the problems of stomach, genito-urinary system, liver, kidney, and spleen[13]. The water chestnut farming takes place in Jodia talab. The surface runoff from Bishunpur, Pandarpala, government polytechnic gets drained into this pond through a common unnamed stream. Water in the Jodia talab is largely the surface runoff from ward no 17 and 24 (partial), consisting of domestic water, and rainwater. Thereafter, water from Jodia talab overflows into Rajendra Sarovar.

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[12] *https://www.iitism.ac.in/assets/uploads/news_events/admin/27-06-2020-12:06:36_notices.pdf*

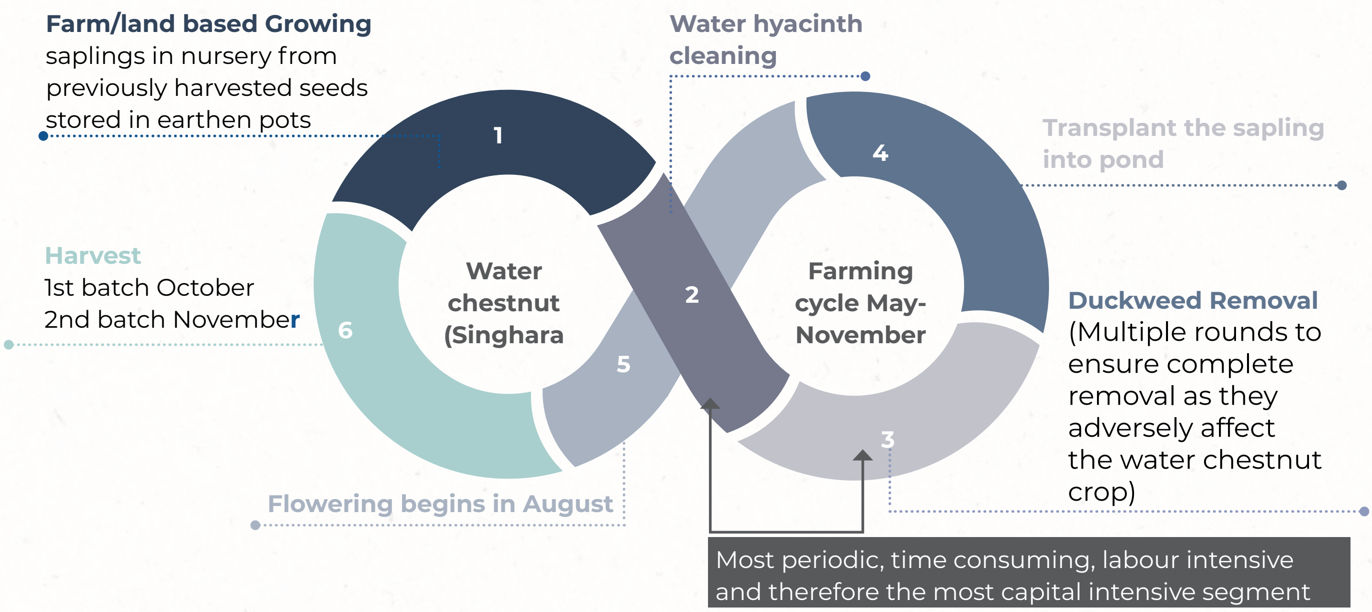
[13] *https://www.researchgate.net/publication/261105900_Trapa_bispinosa_Roxb_A_Review_on_Nutritional_and_Pharmacological_Aspects/ https://www.hindawi.com/journals/aps/2014/959830/*

In Jodia talab water chest-nut farming is being carried out by an individual resident of Pandarpala in Ward 17 of DMC. He belongs to a farmer's family, and the past three generations have been agriculturists. Because of the changing circumstances, the agricultural practice shifted from farm to pond based agriculture. It is for the past 10-15 years that water chestnuts are being cultivated with the help of skilled manual labourers.

Figure 3.5: Water Chestnut cultivation

The cultivation: For water chestnut cultivation, apart from growing saplings in a farm (land)-based nursery, remaining all processes are pond-based, for which multiple cycles of pond cleaning exercise is undertaken. It begins with removal of water hyacinth, followed by multiple rounds of removal of duckweed. The process of annual cleaning of the pond prior to the transplantation of the water chest-nut saplings from the nursery to the pond, instills life and sustenance to the pond. Clearing the pond is the most periodic, time consuming, labour intensive and therefore the most capital-intensive segment of the cultivation. According to the cultivators, pond cleaning is a bonus outcome of the pond-based livelihood. There are many such groups across DMC cultivating water chestnuts.

Figure 3.6: Schematic diagram of water chestnut cultivation



The fruit has rich nutritive value. It contains carbohydrates, proteins, minerals and vitamins. The fruit can be consumed raw, boiled, roasted, or dried to make flour. When the fruit has been dried, it is ground into flour called 'singhare ka atta'. This plant has phytoremediation potential with translocation and accumulation of the metals in non-edible parts like leaves and roots.[14]

The economics: The farmer and 8 daily workers are involved in water chestnut farming. The annual capital investment to grow water chestnuts is approximately Rs.50,000 and there is profit of approximately Rs.50,000 annually. The profits are subject to market changes and vary annually. The minimum price for water chestnut is Rs.20/kg. The daily workers involved in plucking the water chestnut, sell the fruit for Rs.30/kg of which Rs.20 goes to the farmer, and the remaining Rs.10 goes to the workers. The purchase from the pond itself is mostly by a wholesaler/retailer. Subsequently, they sell the fruit for Rs.40/kg to the public. During festivals like Durga Puja, Chhatth and Kali puja, the fruit is in great demand and sold at high prices (Rs.70-80/kg).

[14] *(PDF) Phytoremediation potential of water caltrop (Trapa natans L.) using municipal wastewater of activated sludge pro-cess based municipal wastewater treatment plant*

Vegetable farming

A family since the past three generations has been growing vegetables within the DMCA, adjacent to a prominent nallah which cuts across the municipal area, also known to be an important tributary of River Damodar. The family has been growing vegetables by using the water from the Wasseypur nallah. Vegetables such as sweet gourd, long green beans or cowpea, ladyfinger, maize are grown during monsoon, similarly cauliflower, spinach, radish, and coriander during winters and brinjals during summers. Easy access to water along with no perceived adverse health impact of dealing with wastewater motivated the family to cultivate vegetables throughout the year across three generations.

Figure 3.7: Vegetable farming in DMCA untreated wastewater (Left) and The drain-nallah-tributary (right)

The following observations were reported by the family head and farming lead:

Pros

- The nallah water is the most infallible water source even when deep borewells up to a depth of 500 feet fail during the summers
- The nutrients (described as 'power') in the wastewater reduces the need for additional fertilizers and manure application
- Lower capital investment required due to need of insecticide application only
- The farmer earned around Rs.36,000 from lady finger cultivation in merely 45 days despite lockdown restrictions in 2020 even with limited sales
- However, the quantity of cow dung, septage, hospital waste, domestic and other unknown wastes has increased manifolds in the nallah, changing the quality of water as compared to the composition three decades back
- Despite this change, the family continues to prefer this source due to the consistent and assured vegetable production
- After incessant rains, when the nallah drains the surface flow from the upper catchment area, the quality of water improves
- No difficulty in selling the vegetables in the local market despite people knowing about the irrigation source

Cons

However, there are certain threats that continue to impact the family:

- The fear of municipal authorities getting to know about nallah being the source of irrigation, resulting in a probable disciplinary action
- Land related conflicts
- Increasing threat of localized floods because of the narrowing of the width of the nallah and decreasing carrying capacity of the nallah due to the absence of periodic desilting

These factors have impeded the potential of spreading the productive use of water in the DMCA despite a general acceptance of likewise farmed vegetables among the consumers. This sector holds a promising potential for urban farm-based livelihood opportunity that remains restricted despite the scope to accrue benefits to the urban farming community.

3.6 Key Learnings

Untreated wastewater is being used in agriculture and horticulture in the area, however, these remain unrecognized by the authorities and the users prefer to stay anonymous. This results in a sizable 'opportunity cost' in terms of the unexplored potential of using wastewater as a livelihood support. There are problems stemming from the presence of multiple institutions, parallel departments, multi land-owning units, topography, awareness level, and lack of participation of Dhanbad citizenry, etc. In addition, the inconsistent open access digital record keeping and lack of reliable and up-to-date data availability. Hence, it is important that DMC works on multiple issues across the continuum to ensure sustainable basic civic services and amenities to the residents.

There is a need for promoting decentralized and participatory water and sanitation governance and monitoring by focusing on capacity building of both the DMC officials and peoples' representatives.

Detailed and updated information on basic civic services projects (ongoing and planned) in the public domain is critically required for generating consciousness amidst the citizenry of Dhanbad, thereby creating opportunities for participation resulting in collective accountability of DMC and the people residing within DMCA.

STIFLE Lens	Dhanbad Municipal Corporation
Socio-Economic	Coal mining, manufacturing and service sectors are predominant offering employment for both skilled and unskilled population.
Technology	Currently there is no treatment facility for faecal sludge/septage/sewage.
Institutions	The Dhanbad Municipal Corporation operates septage collection vehicles and has licensed 3 enterprises for this purpose.
Financial	The license fee is Rs 25,000 for the operation of septage collection.
Legal	Around eight private and informal enterprises are engaged in septic tank cleaning operations in addition to the city's licensed operators. Users are charged between Rs 500-1500 per evacuation.
Environment	Wastewater application is seen in pond-based water chestnut farming and vegetable farming activities. Water chestnut is in great demand during festival seasons like the Chhath Puja. It is estimated that there are 300 ponds (in use and neglected) within the DMC, on an average 50 water bodies of varying capacity across the five zones which require cleaning and rejuvenation where treated wastewater can be an input.

04

Bengaluru

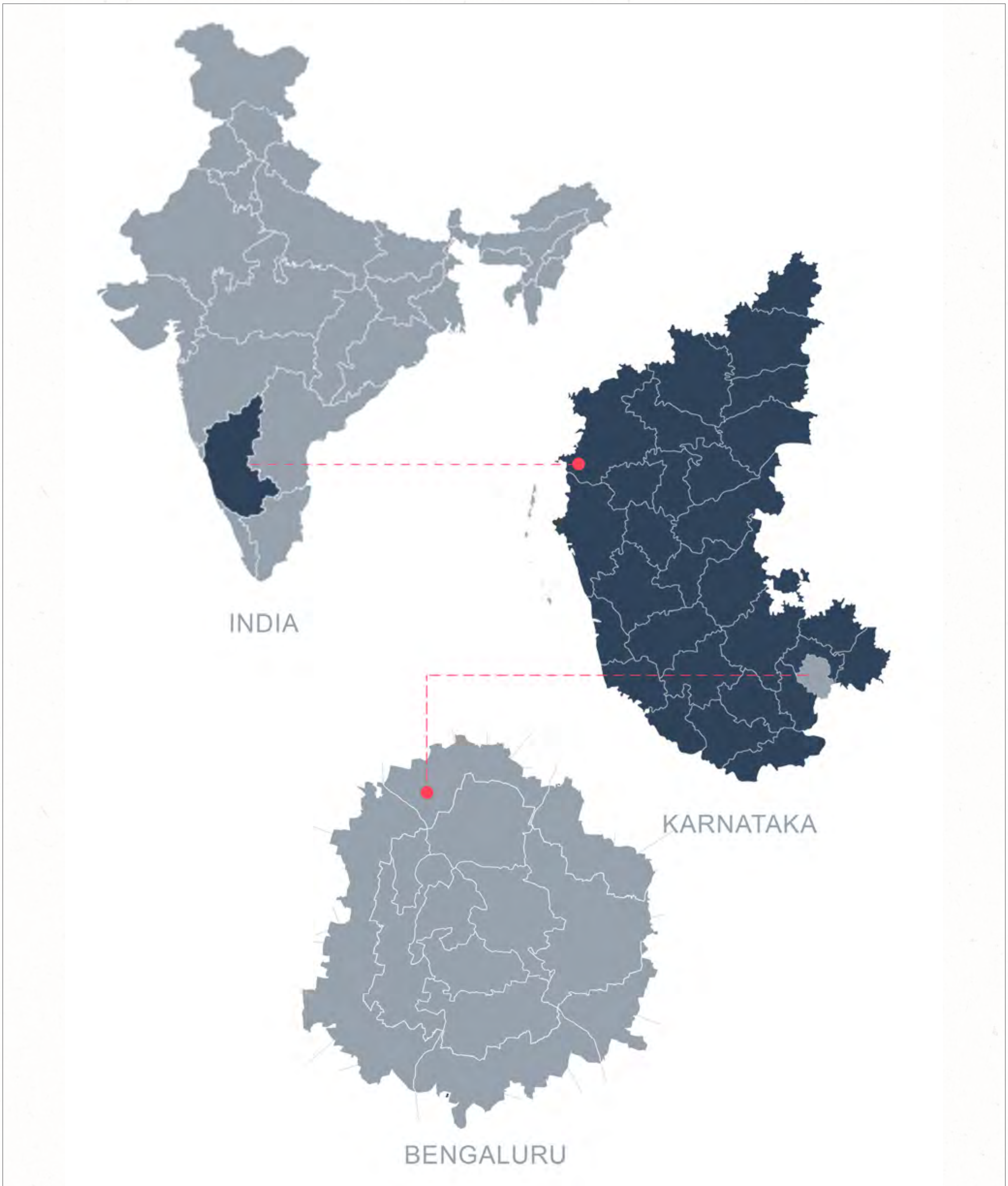
Large Formal Wastewater Reuse for Agriculture

Abstract

At different scales, Bengaluru has lessons for wastewater management, with treated wastewater being formally reused for irrigation, industrial and ecological purposes. Bengaluru also initiates the largest formal wastewater transfer and reuse for agricultural purposes.

4.1 Physiography

Figure 4.1: Location of Bengaluru, India



Located on the South Deccan Plateau, the topography of the city is characterized by a series of valleys delineating three watersheds, viz. Hebbal, Koramangala Challaghatta and Vrishabhavathi. The undulating terrain in the region has facilitated the creation of a large number of tanks providing for the traditional uses of irrigation, drinking, fishing and washing.

Table 4.1: Bengaluru at a glance

	Area	741 sq.km under BBMP
	Population	13 million (as of 2018) and a population density of 10,625 person/sq km
	Administration	BBMP area with 198 wards
	Geography & Climate	Pre-humid to semi-arid climatic conditions
	Rainfall	The mean annual total rainfall is about 970 mm with about 60 rainy days as per Karnataka State Disaster Management Centre (KSNDMC)

4.2 Socio-Economic Conditions

Bengaluru is among the fastest growing major metropolis in India and is referred to as India's Silicon Valley (BBC 21 Oct. 2014; World Economic Forum 5 Oct. 2016). Bengaluru has a population of approximately 13 million as of 2018. The draft revised master plan[15] for the year 2031 prepared by the Bengaluru Development Authority (BDA) estimates that the population of Bengaluru could be as high as 20 million and above by the year 2031.

4.3 Water Supply

Since 1974, Bengaluru has been dependent on Cauvery water stored in the reservoirs of Hemavathy, Harangi, KRS and Kabini. BWSSB sources 1,440 million litres of water per day from the River Cauvery, which is approximately 95 km away and 300 m below the city. However, the water demand of the city is not completely met through Cauvery water and the deficit is met by groundwater. A study[16] estimates that approximately 4 lakh borewells are present in the city supplying about 500-600 MLD of water to the city.

BWSSB states that the city has around 813,346 domestic connections, 58,314 non-domestic connections and around 3,148 industrial connections. Connections are all metered. Tariffs are all volumetric with increasing block tariffs for different domestic (except households in high rises) and non-domestic categories. Domestic category tariffs are highly subsidized (except households in high rises) – especially in relation to the cost incurred by the city to get this water.

To meet the current demand of the newly added 110 villages, BWSSB has taken up the Cauvery 5th phase which will supply an additional 775 MLD of water to the city. The work is under process and expected to start in 2024.

[15] *Bengaluru Revised Master Plan 2031-Information for Preparation | OpenCity.in. (2017, January 11). Open City. https://opencity.in/documents/bengaluru-revised-master-plan-2031*

[16] *https://www.researchgate.net/publication/311068869_EMERGING_GROUND_WATER_CRISIS_IN_URBAN_AREAS_-_A_CASE_STUDY_OF_WARD_No_39_BANGALORE_CITY*

4.4 Formal wastewater treatment and reuse

4.4.1 Conveyance

There are currently 2 million households connected to the sewer network in the city. The sewer lines are connected to the Sewage Treatment Plants located in three valleys, i.e., Koramangala-Challaghatta Valley (KC Valley), Hebbal-Nagawara Valley (HN Valley) and Vrishabhavathi Valley (V-Valley), which are formed in such a manner that the wastewater generated flows down without any major pumping requirements.

As per BWSSB, 1440 MLD wastewater is generated as of 2021 while also acknowledging that the actual amount of sewage generated would be higher as the number of private borewells are not known. Currently 1190 MLD is being treated.

4.4.2 Formal Treatment

The wastewater generated is collected in 29 existing sewage treatment plants (STPs) located within the three valleys, owned by BWSSB and Bruhat Bengaluru Mahanagara Palike (BBMP) with a current functional treatment capacity estimated to be about 1,200 MLD. There are treatment plants currently under construction to increase volume with an additional 544 MLD, totaling to 1,726.5 MLD (by 2023) (Table 4.2). A range of technologies have been implemented across the facilities ranging from simple activated sludge systems to Moving Bed Biofilm Reactor (MBBR) systems. [17]

Table 4.2: Details of STPs under the three valleys - viz. Koramangala-Challaghatta Valley (KC Valley), Hebbal Nagawara Valley (HN Valley) and Vrishabhavathi Valley (V-Valley)

Sl. No	Name	Existing (MLD)	Under Construction (MLD)	Proposed (MLD)	Total (MLD)
1	K&C valley	536.5	159	29	724.5
2	V. Valley	426	153	58	637
3	Hebbal Valley	220	108	37	365
	Total				**1,726.5**

Souce: BWSSB

Decentralized STPs at gated community level: BWSSB also mandates setting up in-house STPs for residential properties with 20 or more flats or an area more than 2,000 sq.m., whichever is lower. In addition, there are 611 decentralized STPs at the apartment and gated layout scale where wastewater of 109 MLD gets treated.[18]

Karnataka State Pollution Control Board (KSPCB) also mandates zero liquid discharge, encouraging 100% reuse of wastewater generated within institutional campuses. While it is difficult to estimate wastewater treated at a decentralized scale, it can be guesstimated to be 100-150 MLD (Source: Priyanka Jamwal, 2012).

[17] *Bangalore Water Supply and Sewerage Board. (n.d.). Retrieved June 8, 2021, from https://www.bwssb.gov.in/com_content?page=3&info_for=4*

[18] *A Report Of Monitoring Committee On Performance Of Wastewater Treatment Plants In The Apartments And Other Establishments In BBMP Limits Of Bangalore, 2012*

4.4.3 Formal agricultural reuse of treated wastewater

Considering the availability of large volumes of treated wastewater and its potential for agriculture reuse in the drought prone districts of Kolar, Chikkaballapur and Anekal, the Government of Karnataka (GoK) has launched ambitious lift irrigation to transfer secondary treated wastewater from Bengaluru for groundwater recharge in drought affected areas (Table 4.3).

Table 4.3: Details of existing and proposed secondary treated wastewater transfer projects under MID

Name of the scheme	Allocated water (MLD)		Proposed tanks for filling	Tanks filled till date (July 2021)	Water pumped (MLD)
	Irrigation	Industries			
Koramangala & Challaghatta valley (KC Valley) for Kolar	400	40	134	82	310
Hebbar Nagavara Valley (HN Valley)	170	40	65	2	25
Koramangala & Challaghatta valley (KC Valley) for Anekal	120	-	69	Work in progress	
KR Puram project for Hoskote	40	-	30	Tender in process	
Total	**730**	**80**			

The KC valley scheme utilizes 440 MLD of secondary treated wastewater from the STPs located in the KC Valley, viz. 310 MLD from Belur Nagasandra/KC Valley STP, 40 MLD from Kadubeesanahalli Ph-1 STP and another 90 MLD from Bellandur STP, which is pumped in stages and transferred to fill 134 existing tanks in the districts of Kolar and Chikkaballapur, many of which have been dry since the past successive droughts.

Figure 4.2: BWSSB Sewage Treatment Plant in Bellandur

Source: MID

Figure 4.3: Uddapanahalli, Jodikrishnapura and Narsapura lakes filled with treated wastewater from KC valley project

Source: MID

A brief profile of Kolar and treated wastewater transfer:

Kolar is located on the southern plains of Karnataka in the eastern semi-arid zone. The district is located on three basins - Palar, Ponnaiar and Pennar - the tributaries (Palar, Papagani and Markandeya) of which are small and seasonal (CGWB, 2012).[19] A study by Karnataka State Natural Disaster Monitoring Center (KSNDMC) indicates that Kolar is a chronically drought-prone district, having a vulnerability index of 0.68. With the decline of traditional tanks and climate variability, the district has been dependent solely on groundwater for all its irrigation and domestic water demands. As a result of which, groundwater extraction has surpassed natural recharge by 211% in 2017 (CGWB, 2017)[20] and there has been a steep decline in net annual groundwater availability, where all taluks are classified as 'overexploited' (OE) as per the CGWB/MI report.

Figure 4.4: Open wells in the vicinity of Lakshmisagara with full water throughout the year; Agricultural lands nearby Lakshmisagara lake uses water from wells, with drip irrigation

An Instance of Lakshmisagara lake, Kolar:

Lakshmisagara lake is a small lake of about 20-30 acres in area, and about 45km away from the Bellandur STP. Lakshmisagara lake was dry for many years due to drought but has been filled with treated wastewater since the past two years.

Prior to the project, the entire land area here was covered in eucalyptus plantations. Agriculture was not in practice. Only a single crop could be grown during monsoon (Ragi and Maize), which were primarily used only for household consumption. Prior to the transfer of treated wastewater, the existing borewells around the lake have been dug to a depth of more than 800-1000ft, with many stories of failed borewells. The open wells also saw little/no water (had water during the monsoon) and were insufficient for irrigation purposes.

[19] https://www.researchgate.net/profile/Dr-ChikkannaS/publication/344216155_Proceedings_of_REGIONAL_WORKSHOP_on_COMMUNITY_PARTICIPATION_IN_GROUND_WATER_MANAGEMENT_SUCCESS_STORIES_AND_FUTURE_ACTIVITIES

[20] http://cgwb.gov.in/GW-Assessment/GWRA-2017-National-Compilation.pdf

As observed on ground, Lakshmisagara has become a thriving economy after rejuvenation and entry of treated wastewater into the lake. There has been an increase in groundwater table. Most farmers mentioned that their borewell yield has increased and open wells around the lake are brimming with water throughout and even overflow during the monsoon season. Many of the farmers who had left the farms due to drought to look for employment in the city, have now readopted their lands. Farmers have shifted from eucalyptus plantations and are now able to grow 3-4 crops in a year. Farmers have implemented drip irrigation systems and prefer to grow commercially viable crops now, such as tomatoes, beans, cauliflower, chillies, flowers like Marigold and Jasmine and mulberry plants for silkworm rearing. Due to increased agricultural cultivation duration, the employment opportunities for wage labourers - men and women, landless - has increased too.

> *"The KC valley project has benefitted all farmers in Lakshmisagar as they have taken up agriculture again. The groundwater level has increased. Previously, the borewell depth used to go beyond 800-1000ft. Now we find water between 100-300 ft depth. In fact, many farmers prefer not to drill borewells now and instead use water from open wells. I have an open well, which 3 neighbouring farmers also draw water from and yet the open well is always overflowing. There is no problem with water anymore. Previously, all farmers had planted eucalyptus on their lands and were doing labour work in other places. Now they have all come back, removed the eucalyptus plantations and started growing commercial crops again" -*
>
> ***Manju, farmer, Lakshmisagara***

4.5 Informal reuse of untreated wastewater in Agriculture

Bengaluru's wastewater discharges out of the city into the drought prone hinterland, through the Vrishabhavathi valley and the Dakshina Pinakini (DP). Two thirds of Bengaluru falls in KC valley, from which water drains into the Dakshina Pinakini river. From 1995 with the increased use of Cauvery waters in Bengaluru, the stream of urban wastewater from KC valley catchment (estimated to be ~500 MLD)[21] overflows from Bellandur and Varthur lakes (thus the STPs) and drains to Kelvarpalli dam, Krishnagiri dam and thus becomes a main feeder to Dakshina Pinakini river.

Along the banks, some distance away from the city, farmers all along the Dakshina Pinakini have been picking up this treated and untreated wastewater from small wells and pumping it to their lands for irrigation. Farmers cultivate millets, commercially viable crops like vegetables and flowers with this water. This is mostly done informally, through short and long-distance pumping, with individual investments by farmers.

4.5.1 Methods of wastewater use

Farmers both close to the river and many farmers as far as 0-20km away have made investments to use wastewater from the DP river to meet their irrigation needs. Farmers closer to the river are directly utilizing this water to irrigate their lands. The fields are directly irrigated to grow paddy and fodder crops. In some cases, a bund is built and water is channeled directly into the furrows. In other cases, the water is further aerated before use. For all the other commercially grown crops, water is pumped from a well adjacent to the river, which is sent through drip irrigation pipes for all crops, after passing through a sand filter.

Farmers further away have individually invested in a plot of 10ftx10ft next to the river, for building a pump house, which pumps up water from the river via an open well adjacent to the river. They have this water supplied through pipes laid underground passing along roads and neighbouring farmlands, all the way to the farmland. The whole setup involves a pump, 2"-5" dia PVC pipes, electricity connection,

[21] *http://wgbis.ces.iisc.ernet.in/energy/water/paper/ETR116/ETR116.pdf*

farm ponds and filter. The water is pumped whenever there is electricity - about 4-5 hours in a day - to their storage pond. Many have installed double filters, both at the place of pumping and after allowing sedimentation in the storage pond before irrigation.

Figure 4.5: (Left) Water from Dakshina Pinakini being pumped to agricultural lands through a small well close by; (Right) Thousands of pump houses along the Dakshina Pinakini river, which supply water to farmers as far as 10-15km

4.5.1 Investments for pumping wastewater

Pump houses are built on rented land. The annual rent for 10 gunta (0.25 acres) of land was priced at Rs.100,000 in 2007 and the capital cost of set up was at Rs.100,000. These prices have risen steeply over the decade from 1 lakh/km to almost 3 lakhs/km. The cost of the filters is around Rs.50,000-Rs.60,000. There are additional expenses which include farm pond, drip irrigation system etc. Depending on the distance, the total investment varies from 15-22 lakhs, for about 5-10km. Many farmers had earlier invested in borewells that run until a depth of 1,000ft, costing them between 5-10 lakhs each, which have subsequently failed, and then have invested in these wastewater pumping systems which guarantees them 3-4 crops a year. Most of the big farmers who own more than 5 acres of land find it a worthwhile investment as it guarantees three crops a year.

4.5.2 Agriculture / Cropping pattern

Farmers have been able to cultivate their land throughout the year with the majority of the farmers growing three crops a year. Few farmers near Mugalur village are able to grow multiple crops, provided they are growing green leafy

"We have been using water from Dakshina Pinakini since the last 30 years. I have 10 acres of land adjacent to the river, on which we grow paddy, ragi, fodder maize, vegetables (tomatoes and beans), mangoes and sapotas, all using untreated wastewater. I have only one borewell, drilled 5 years ago, up to 850 ft which yields water during the summer. Paddy is irrigated directly. During transplantation, I hire labourers such that all work is finished within the day. They do not use any protective equipment while being in the water and express no safety concern for using the water; a hot water bath after work helps them be clean and to get rid of the smell. Due to the presence of nutrients in the water, they use less or no fertilizers for their crops." -

Anonymous, farmer

"We have been using stream water for the last five decades. We can grow everything using stream water. We grow Ragi, Paddy, Spinach, Rose, Tomatoes and Fodder Maize. We use 50% less manure due to the use of stream water." –

Anonymous, farmer

"I mix and dilute the river water with borewell water (when available) to grow tomatoes, beans, cabbage etc. on 6.5 acres of land. I cultivate throughout the year, due to the perennial availability of water from Dakshina Pinakini. As long as people in Bengaluru have a bath, use the toilet or wash clothes, these waters will flow" -

Anonymous, pumping water to 3-4 km away from river

vegetables. After harvest, the land is left fallow for a month and then put into cultivation for the next crop. Except for ragi, paddy and some green leafy vegetables, most of the vegetables and flowers are irrigated through drip irrigation.

Farmers say they can grow any crop using the wastewater. Ragi and Paddy are grown in all seasons of the year. Fodder maize is also grown for livestock. Through trial and error, farmers are growing various vegetables and greens such as beans, tomatoes, chillies, radish, gourds, cauliflower, spinach, coriander. Flowers like roses, marigold etc. are also a popular choice. Except a few root vegetables such as carrots and potatoes which get damaged due to the acidic nature of water, farmers are growing all crop varieties without any noticeable quality difference for the last 15-20 years.

4.6.4 Perceptions on usage of water from the Dakshina Pinakini and impact of KC valley project on the Dakshina Pinakini:

The farmers have been using this stream water for decades and there have been no concerns about the quality of water as the water gets filtered through its natural channels before use. The farmers also mentioned that they use the same water to grow both commercial crops and for household consumption and observe no negative effects of using this untreated wastewater. Due to the presence of nutrients, and since the water is high in nitrate/urea, the usage of fertilizers is minimized by 10-20%. Even though the pumping setup requires periodic cleaning and the drip pipes last only about 5-6 years due to the acidic nature of water and pipe erosion, the farmers continue to invest to keep this system functional because of the benefits of using the wastewater in absence of any other source of water.

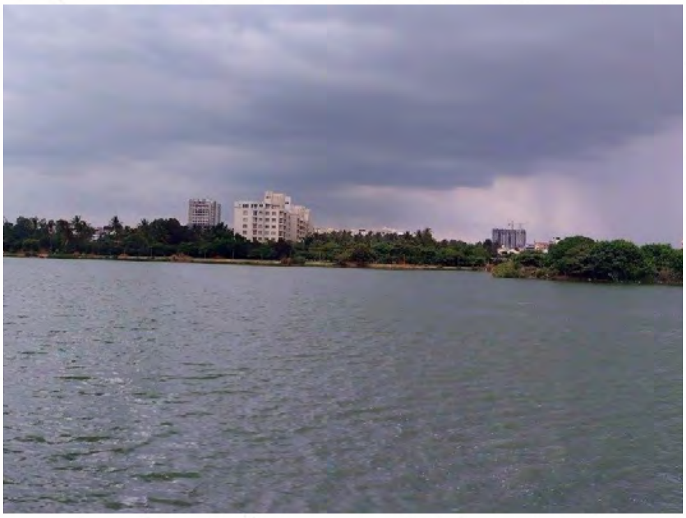
Now as part of the KC valley treated wastewater pumping, the Bellandur-Varthur lake is also planned to undergo rejuvenation, thereby leading to the creation of a direct diversion channel made at Bellandur-Varthur lakes, from which wastewater is being directly sent into Dakshina Pinakini. This has drastically reduced the quality of water in Dakshina Pinakini, which was otherwise treated by the huge wetlands of Bellandur - Varthur lakes. The farmers interviewed opined that both the quality and quantity of wastewater in the stream has come down from the past two years. Some of the big farmers who had made investments in pumping water from Dakshina Pinakini 15+ years ago had recently invested in a new borewell and had entirely shifted to using borewell water for irrigation and are not coming forward to make huge investments in pumping wastewater from Dakshina Pinakini. Many farmers are shifting to other crops such as mulberry, flowers, etc. which can withstand untreated wastewater. However, once all the treatment plants are set up, it is yet to be observed how it will impact the quantity and quality of water flowing down Dakshina Pinakini. With only seasonal monsoon flows contributing to the river, the quantity might be lesser but the water quality would be better.

4.6 The Formal reuse: Ecological and Industrial purposes

4.6.1 Rejuvenation of Jakkur Lake through citizen championship

Jakkur Lake is located in the North east corner of Bengaluru city in Hebbal valley spreading across an area of 160 acres. The lake was rejuvenated with the collaborative efforts by various stakeholders starting from the Lake Development Authority (LDA), Bengaluru Water Supply and Sewerage Board (BWSSB), Bengaluru Development Authority (BDA) and enthusiastic citizen groups. In May 2015 Jalaposhan Trust, a citizen group, signed an MOU with BBMP and officially adopted the lake.

Figure 4.6: Jakkur Lake; constructed wetland in Jakkur lake



Treated wastewater: BWSSB has set up a Sewage Treatment Plant which follows the technology of up flow Anaerobic Sludge Blanket, a secondary level of treatment. The STP was designed to treat 10 MLD of wastewater. Post treatment, wastewater enters a constructed wetland of 8 acres having species of plants such as Typha, Alligator weed, Water Hyacinth which helps remove phosphates and nitrates and further treats the wastewater naturally.

In Jakkur Lake, there is ecological reuse of treated wastewater with multiple benefits:

Water body conservation: Treated wastewater has revived a water body in the city and it is also providing recreation services to the urban folks.

Protection of biodiversity: With treated wastewater filling the lake, Jakkur lake has a perennial source of water. The lake is auctioned for fisheries and availability of fish has made migratory birds like Pelicans and Painted Storks a permanent residence.

Groundwater recharge:
Treated wastewater is used for recharging the groundwater table. Lake is recharging open wells and borewells in approximately 3 km of area around the lake. The open well located closer to the lake is used for drinking water by the fishermen.

The conflict of interests
There is a proposal to sell treated wastewater from Jakkur lake to Yelahanka power plant. Karnataka Power Transmission Corporation Limited (KPTCL) has upgraded the STP from 10MLD to 15MLD. This also upgrades the STP from secondary to tertiary treatment plants. It is orally said that all the 10MLD of treated wastewater goes to the Yelahanka Power Plant and the lake will have 5 MLD. This will result in significant reduction in the water level. Since there is no written proposal, the lake might lose out on its water fully.

4.6.2 Rejuvenation of Doddabommasandra Lake through CSR activity of BEL

Doddabommasandra Lake (50.31 hectares) is located in Nanjappa circle, Vidyaranyapura in the North of Bengaluru. With rainwater being the only source of water for the lake, the lake has been drying for almost a decade. Bharat Electronics Limited (BEL) has rejuvenated Doddabommasandra lake by setting up of a Sewage Treatment Plant and filling the lake with treated wastewater.

Figure 4.7: Doddabommasandra Lake as a wetland having Water Hyacinth, Alligator Weed, Water Cabbage etc.

The first step taken by BEL in the process of rejuvenation was to set up a Sewage Treatment Plant. A 10 MLD capacity Sequential Batch Reactor (SBR) was set up with CSR funding of Rs.13.5cr. BEL signed an MoU with the BBMP for the operation and maintenance of the SBR for the 20 years. Though BEL is water sufficient, it was pumping 1 MLD of treated wastewater from Yelahanka STP at Rs.25 per kiloliter for its horticulture. BEL will be pumping 2 MLD of treated wastewater from Doddabommasandra STP instead of Yelahanka STP cutting down the distance and cost of pumping.

Doddabommasandra lake rejuvenation has proven the capability of CSR to make huge investments in STPs and has the potential to turn out to be a model for the rest of the lakes and the CSR units. The current initiative is to revive the dysfunctional lake ecosystem and enable the benefits of groundwater recharge in the region.

The groundwater table in Vidyaranyapura is shallow and the lake revival has increased the water level in the wells since treated wastewater is feeding the aquifers and recharging the open wells which can also be used for drinking. The lake ecosystem, currently being a wetland, has attracted various species of birds, reptiles and mammals and has become a biodiversity hotspot. The lake also has the potential of generating revenues through fisheries. The lake provides recreational benefits to urban dwellers.

4.6.3 Wastewater Management in TZED Homes

TZED (Zero Energy Development) is a gated layout located at Varthur Village (in Whitefield), Bengaluru. The property is close to the largest lake in Bengaluru, i.e., Varthur lake. TZED is a 5-acre property which has about 75 flats and 15 individual villas, with a daily water demand of 75-90 KL.

Until 2012, the water demand of the campus was met through in-house borewells (40KL-60KL) and tankers (70KL). However, by 2012, all the 4 pre-existing shallower borewells dried up, and the single new borewell dug, which yielded water at 650 feet depth was not sufficient for all of the water needs. However, this community has become self-sufficient in meeting its water demands by taking various initiatives such as implementing rainwater harvesting, groundwater recharge structures and treating and reuse of STP water for potable purposes.

Wastewater management

TZED has invested in a set of filtration systems after treatment at STP plant to make the treated wastewater potable. The wastewater treated through SBR STP, is further treated through sand filter, activated carbon filter and chlorine/ozonizer for disinfection. Water output after disinfection is mixed with borewell water/tanker water and then passed through the RO filtration unit. The output from RO water is supplied to all the households. The RO reject water is used for gardening, car wash and other housekeeping activities.

Other initiatives

- Repair and maintenance of the RWH system and collection of rooftop rainwater in a 4 lakh liter sump that the builder had created for the purpose.
- Investing and implementing 30+ groundwater recharge structures spread across the layout
- Fixing leakages
- Fixing low flow sanitary fixtures, installing timed flushes

4.6.4 Phytoremediation at Rainbow Drive to treat domestic wastewater

The Rainbow Drive (RBD) layout is a 34 acre, 360 housing plot, private gated residential layout that is representative of an increasingly common land-use pattern in growing cities like Bengaluru. The layout is located on Sarjapur Road in Bengaluru, outside of the Municipal area, thus does not receive any formal supply of water or sanitation services from Bengaluru's utility and like most occupied sites here, are dependent on private borewells and/or tanker water markets – most often both sources. RBD layout is completely dependent on 11 in-house borewells. The overall water demand of the layout is 150 KLD and per capita per day water consumption is 138 LPCD.

To achieve an integrated water management system, RBD adapted several strategies including installation of individual metering, charging slab based/block tariff on actual consumption, implementation of Rainwater Harvesting (RWH) at individual household level and groundwater recharge structures at both household and community level and treating and reusing wastewater for landscape purposes, all of which led to the drastic decrease in water demand.

Figure 4.8: Phytorid technology type of wastewater system

Wastewater Management

The Plot Owners Association (POA) realized that wastewater treatment is a very critical component of its overall water management and reusing treated wastewater could greatly contribute to the layouts' self-reliance on water.

The developer had provided two conventional sewage treatment plants (STPs) of 200 KL capacity. Analysis of these STPs by the POA indicated that:

1. Nearly 50% of the production costs of water was contributed to by the operations of the STP at Rainbow Drive.
2. The quality of wastewater treatment was very poor. Expert consultation indicated that the state of affairs was "sewage in sewage out". The treated wastewater did not meet the Karnataka State Pollution Control Board's (KSPCB) discharge norms. The treated water was mostly discharged outside into storm water drains.
3. The STPs had insufficient capacities and insufficient infrastructure to handle the load of the layout, especially at the earlier levels of water consumption.

Thus, the existing system was upgraded to a 250 KL capacity Phytorid technology developed by NEERI, Nagpur. Phytorid technology is a decentralized wastewater system which uses phytoremediation (wetland plant species) for treating the incoming sewage. It is a subsurface flow system designed in a manner that the wastewater flows by gravity from one end to another, over a porous medium of gravel of varied sizes and gets filtered due to the wetland species planted in this gravel bed.

The RBD POA also added an ozonizer after the reed bed treatment system so as to disinfect the wastewater. After ozonation, the wastewater is pumped to an overhead tank where it is further aerated. This is then supplied via a piped network to individual households for landscape water requirements. Each household was charged a one-time fee of Rs 500/- to get a connection to this treated wastewater.

4.7 Prevalence of Manual Scavenging

Manual Scavenging still persists in Bengaluru despite advancements in sanitation infrastructure. Manual scavenging is seen in various forms – in the unclogging of manholes ("dabbe workers") or sewage pipes, in the maintenance of STPs and in the emptying of pits and septic tanks. The BWSSB maintains a fleet of suction, jetting and desilting machines for piped sewage maintenance. BWSSB maintains that nobody on its rolls or no infrastructure under direct BWSSB responsibility utilizes manual scavenging practice as a part of its operations. However large parts of a rapidly growing Bengaluru are not connected to BWSSB sanitation pipes or STPS. Private sewage networks, private STPs and other forms of onsite sanitation exist in many parts of Bengaluru and there is no comprehensive documentation of informal practices of maintenance of such systems.

The evidence of the persistence of these practices comes from the reported deaths during the cleaning of such systems. Bengaluru has reported deaths during pit emptying and in the maintenance of private STPs. Compensation is yet to be processed for all the bereaved families. Legal action is also pending in many cases.

Bengaluru urban district has 344 manual scavengers who have been officially identified under the PEMSR Act 2013 out of whom 232 have received one time cash assistance with around a 100 of them having received training and loans for rehabilitation.

4.8 Key Learnings

As the cities grow, fresh water demand increases and thus the quantity of wastewater generated increases as well. The city is also aiming for a 100% sewerage network, thus increasing the availability of treated wastewater. Bengaluru has one of the largest lift irrigation projects to transfer secondary treated wastewater from the WWTP's of the city to the hinterland to fill lakes for groundwater recharge in drought affected areas. The groundwater in turn is used for agriculture by farmers. The city also mandates decentralized WWTP'S and wastewater management in layouts and apartments for reuse thus reducing the demand for fresh water. The experience from Bengaluru can inform regulatory frameworks for the installation and functioning of decentralized STPs and their monitoring in other metropolises and cities. The city also demonstrates how lakes in the city could be preserved using treated WW thus fulfilling an ecological role for the treated wastewater while indirectly recharging aquifers for further reuse. There are emerging competing demands for agriculture, ecological, industrial and urban reuse, which makes it imperative to have a policy framework to determine a criteria and rationale for distributing the treated wastewater across multiple sectors and streams of reuse. There is a strong need to highlight the coordinated approach where a prioritization of various potential competing reuse is managed.

A city's domestic wastewater is a huge resource for agriculture. More often than not the droughts and water scarcity are experienced by the city's hinterland while the city is safeguarded with piped water supply to meet its water demand. Both (i) provisioning of formal treated wastewater and (ii) informal use of wastewater by farmers in the hinterland who have made investments in primary treatment and storage facilities have ensured food security and livelihoods by mitigating the adverse impacts of drought in the hinterland. Given that the city is dependent on the hinterland for its food security, such provisioning is synergistic and leverages the benefits of the circular economy while simultaneously addressing the deficits in the formal treatment capacity of the city WWTPs.

STIFLE Lens	Bruhat Bengaluru Mahanagara Palike
Socio-Economic	Bengaluru Metropolis is the IT hub of India and is known as its Silicon Valley. The hinterland has a large population dependent on agricultural activities. There are a large number of private enterprises involved in desludging operations within and outside the city limits.
Technology	Wastewater treatment infrastructure comprises 34 STPs of 1510 MLD combined capacity. This is currently being augmented with treatment facilities for an ultimate total of 1726.5 MLD. Further there are decentralized STPs and WW treatment facilities at apartment and layouts. Bengaluru also features one of the largest urban transfers of wastewater to the hinterland areas for irrigation and filling of lakes and waterbodies. Innovative decentralized technologies are also deployed e.g., phytorid technology for treatment of wastewater. Ecological reuse as well as industrial and agricultural reuse of wastewater is practised.
Institutions	The BBMP provides sanitation services and the BWSSB is responsible for water supply and sewerage infrastructure and service provision.
Financial	The BWSSB reports over 98% efficiency in collection of sewerage tariffs and a cost recovery of operation and maintenance cost to the extent of 98%.
Legal	The State Government has a policy for wastewater reuse. The PCB a regulatory body has mandated zero discharge of wastewater and regulates both city wide and layout/ apartment level STPs
Environment	Bengaluru generates more wastewater than it can treat and cleaning and maintenance of water bodies is therefore a priority area. Reuse and transfer of wastewater resources to the hinterland encourages the growth of a circular economy.

05

Devanahalli

Formal and Informal Reuse of Faecal Sludge in Agriculture

Abstract

Devanahalli has an FSTP, which was set up in 2015 and is designed to treat 6000 liters/day of sludge. The sludge is co-composted with biodegradable solid waste and the compost generated is sold to the farmers. However, there are challenges with reference to the financial sustainability of the FSTP necessitating a subsidy in its operations by the municipality. Independently, both greywater/ blackwater flowing in the drains and FS are informally used by farmers for irrigation and as fertilizers for their fields.

5.1 Physiography

Figure 5.1: Location of Devanahalli, India

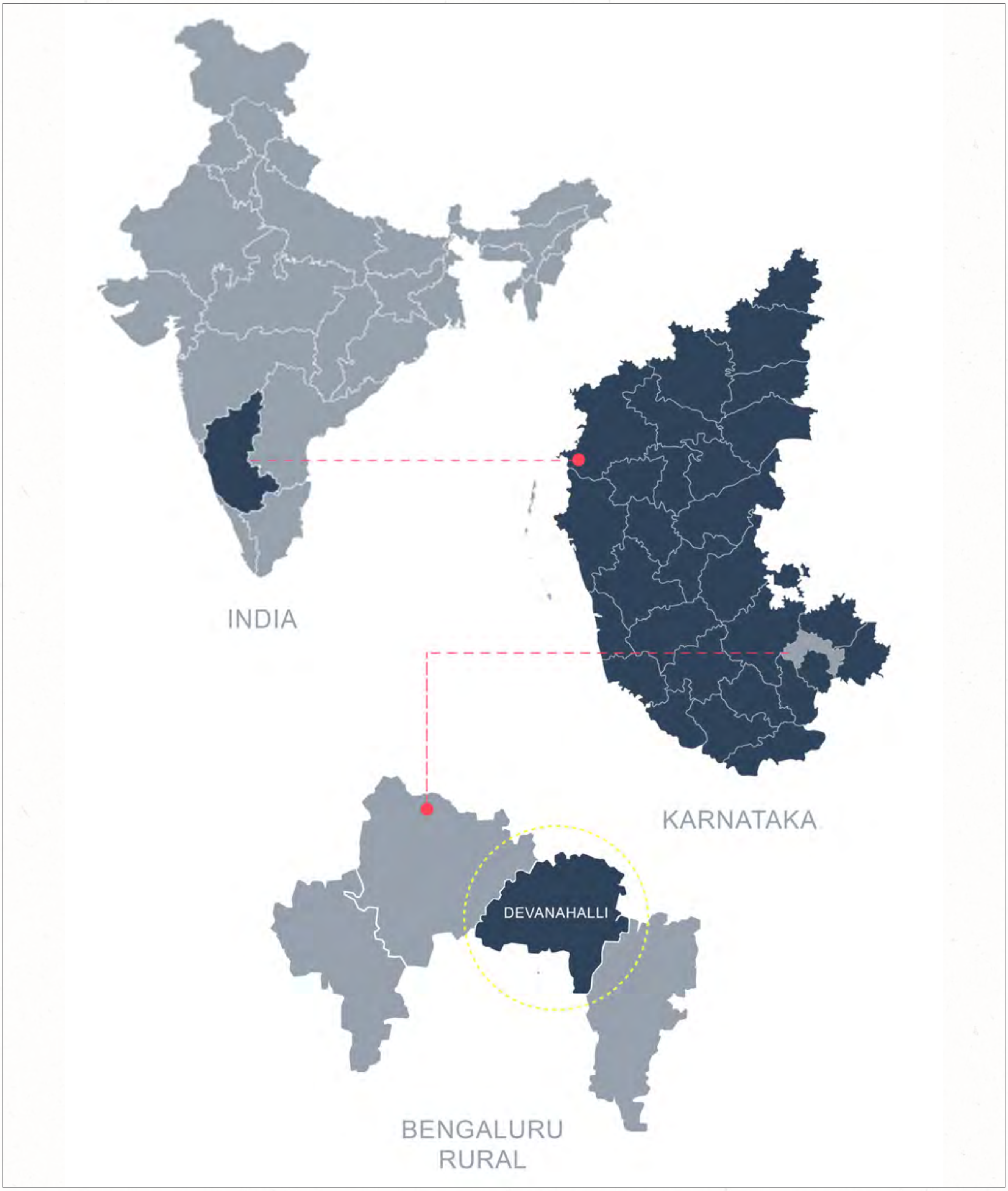


Table 5.1: Devanahalli at a glance

	Area	16 sq km
	Population	28041 (2011 census)
	Administration	Town Municipal Council with 23 wards
	Geography & Climate	Arid to semi-arid zone and is a drought prone region
	Rainfall	The average annual rainfall for the past one decade has been 810mm as per Karnataka State Disaster Management Centre (KSNDMC).

5.2 Socio-Economic condition

Agriculture is the main occupation in Devanahalli. Flowers (roses majorly), spinach, vegetables and grapes are cultivated. The town's proximity to Bengaluru has led people to migrate for employment opportunities. The real estate value in the town has gone up after the setting up of the International Airport. Devanahalli also has a Special Economic Zone encouraging the growth of industries in the area. The literacy rate in Devanahalli town is 86%. The town has 5 slums. Informally, manual scavenging is in practice and there are efforts in giving legal status and economic benefits for them.

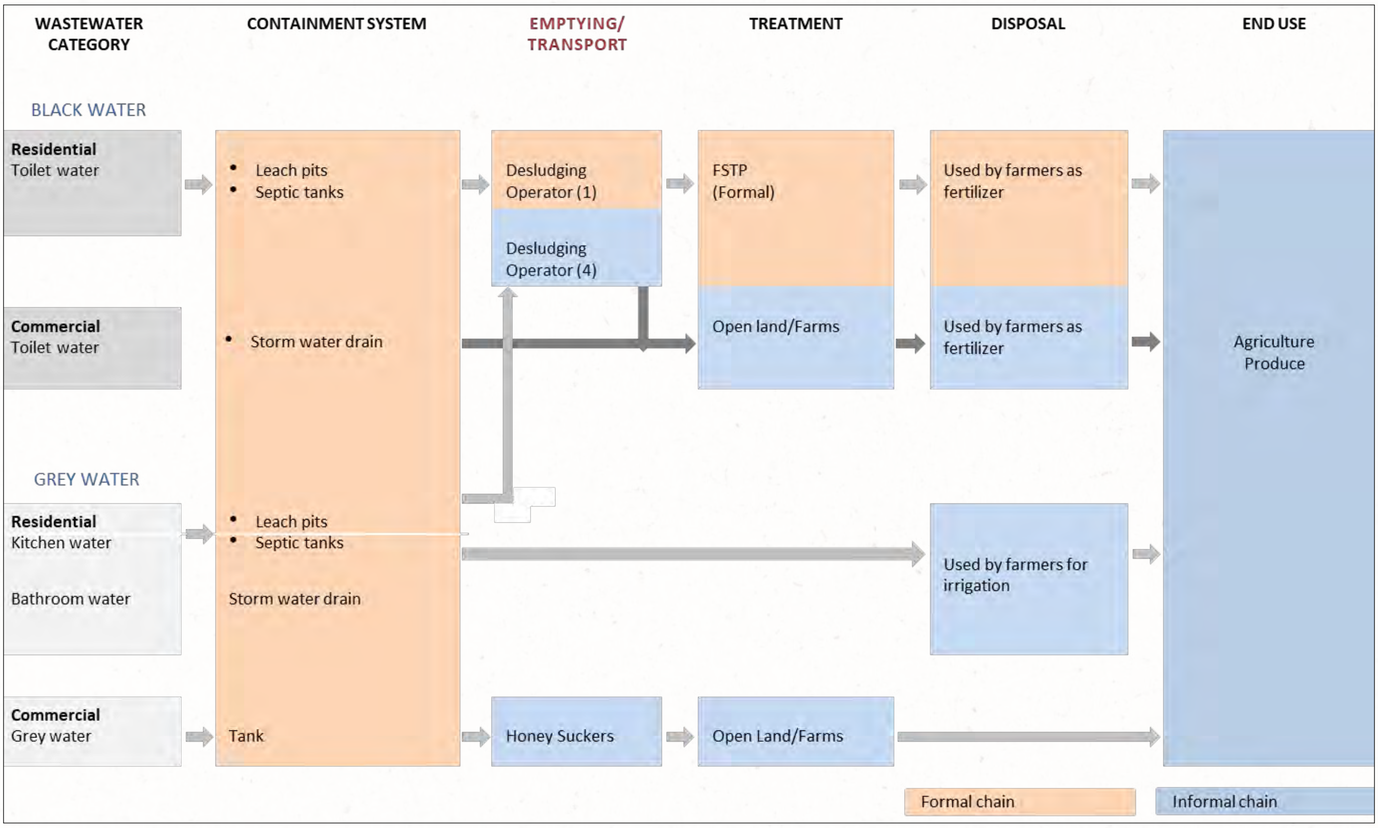
5.3 Water Supply

The water supply to households and commercial units in Devanahalli town is mainly through the public supply system (municipality piped water supply system) and also partly through private (own borewells, open wells and water tankers). The main source of water for Devanahalli TMC is groundwater from borewells, located near Sihineeru Kere which is the only source of drinking water. The total water supplied is 12 lakh litres per day at 55-65 litres per capita per day (lpcd) (Source: TMC).

5.4 Faecal Sludge Management

The below diagram captures the sanitation chain of Devanahalli:

Figure 5.2: Sanitation Chain, Devanahalli



The domestic wastewater generated within Devanahalli town can be classified into residential and commercial based on the type of property. Within the residential and commercial, the domestic wastewater is further categorized into black water (from toilets) and greywater (from kitchen, bathroom). As can be seen from the chart, wastewater, significantly greywater flows in stormwater drains perennially.

5.4.1 Containment System

As per baseline survey by CDD in 2015, 78% of the FS is contained in single soak pits, 3% in twin leach pits, 10% in septic tanks and 6% is openly led into storm water drains which are laid to convey rainwater to the downstream lakes or tanks. Overflow from containment is led into stormwater drains. The majority of the containment systems are not accessible and under designed. Commercial settlements in the town do not have stormwater drains and tanks are constructed to store grey water.

5.4.2 Conveyance

Devanahalli town does not have an underground drainage (UGD) system. There is no plan of having sewer lines in the near future as the water supply in the town is less than the 135 lpcd necessary for sewerage services to be provided. Black and greywater from leach pits, septic tanks and small tanks of greywater of commercial properties are drained by vacuum trucks/desludging vehicles.

Pit toilets are emptied once in four to five years. In a day 3-4 residential pit toilets are emptied in the town. On an average each truck is of 3500-4000 litres capacity and can accommodate 2 pit toilets.

Table 5.2: Septage management with desludging operators

The formal	The informal
1 desludging operator	4 desludging operators
Charges Rs.1000 to empty a pit toilet	Charge about Rs.800 to empty a pit toilet
Made a total of 12 trips in 2020 - Source: FSTP Ledger (TMC owned desludging is under repair for a long time)	Made a total of 333 trips in 2020- Source: FSTP Ledger (TMC mentions that the price is kept low to compete with the TMC desludging truck)

5.4.3 Formal treatment and reuse of faecal sludge

The Devanahalli FSTP was originally conceived under the auspices of the Bill and Melinda Gates Foundation (BMGF) granted to Bremen Overseas Research and Development Association (BORDA) in 2013. The Consortium for DEWATS Dissemination Society (CDD) was the implementing agency for this FSTP in the year 2015. The FSTP aimed to put an end to the 'open dumping of faecal sludge' and to bring in 'scientific ways of treating faecal sludge' to mitigate health and environmental hazards.

Factual design as shared by CDD[22] details about the FSTP are in the table below:

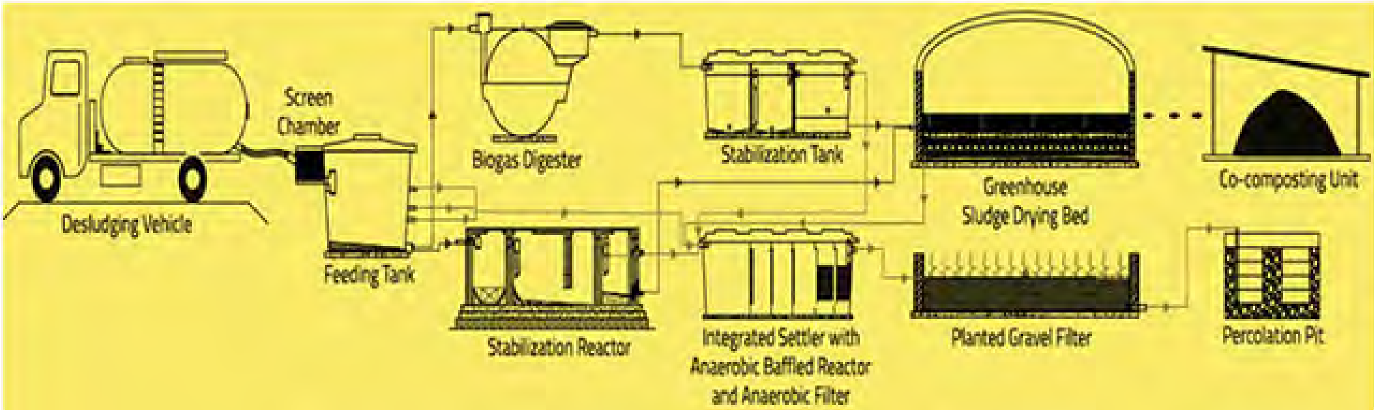
Table 5.3: Details about Devanahalli FTSP

Installed capacity of FSTP	6,000 litres/day
Influent quality	BOD- 30,000 mg/l and COD- 60,000 mg/l
Effluent quality	BOD < 30 mg/l and COD <150 mg/l
Energy Requirement	830 Kwh/month
Human resources	1 Plant Manager, 1 Plant operator, 3 support staff
Resource recovery	Co-compost (faecal sludge and municipal wet waste)
Capital Cost	Rs.80 lakhs (Excluding land cost)
Quantity of co-compost generated per year	Around 10 tons
Selling cost of co-compost per kg	Rs.7/kg
Annual operations cost (Including FSTP, Co-composting and 1 Municipal desludging truck)	Rs.21,41,000
Annual revenue from the sale of co-compost	Rs.80,000

[22] *https://cddindia.org/wp-content/uploads/Insights-from-Devanahalli-December-2020.pdf*

Technical design

Figure 5.3: Technological design process of FSTP



Source: CSE (top) and Sludge stabilization(Bottem)

FSTP capacity was designed based on the number of pit toilets and frequency of emptying in Devanahalli town. There have been conflicting opinions about the operational capacity of the FSTP. However, the CDD's 2020 report mentioned that though the FSTP was operational 1/3rd of its capacity for the majority of the duration since its establishment, since the past 6 months it has been operational at full capacity.

Challenges

- **The capacity of the sludge-liquid separation tank:** The first phase of treatment is the separation of sludge and liquid and the capacity of the sludge-liquid separation tank is very less. It takes about 2 hours to separate solids from the liquids. If there is a desludging truck visiting the FSTP within this 2 hour window, it has to wait till the separation is done. There are instances of desludging operators being asked to unload the trucks in the farm lands outside the TMC boundary. Thus, the operators expect to increase the capacity of the separation tank.

- **Emptying of FS in farm fields:** Desludging operators don't restrict themselves to Devanahalli town and are also engaged in collecting the FS from neighboring towns and villages. If they collect the FS from Devanahalli and the next trip is in neighboring villages, they are emptying the FS in the farm fields in the neighboring villages.

- **Unloading time**: Unloading time to empty FS in the FSTP is around 20 minutes. For the large trucks of capacity 5KL-6KL, it is around 1.5-2 hours. This results in losing business for the desludging operators. Dry faecal sludge takes more time to empty in FSTP.

"I spent Rs.5,000 on co-compost and additional Rs.4,000 to apply. I was told plants would grow well. But I haven't gotten any result from co-compost. I am very disappointed. If it performed well, I was more than happy to recommend it to my friends. I lost the money spent on co-compost. Co-compost just looks good in appearance and one cannot rely on co-compost. Since my plants were already struggling, I couldn't wait and thus applied cattle manure and I also tried artificial fertilizers. It also becomes difficult to just record the performance of co-compost alone. Co-compost should be mixed along with other manures to get good results, co-compost alone fails to give good results".

- Farmer Anonymous

"Co-compost is the cheapest of other manures but it needs to be applied very often, say once in every two months. Whereas in case of cattle manure, we spend about Rs.15,000 per acre per year. Co-compost is like other market manures like urea where it needs to be applied very often. Co-compost can be applied in the rainy season to foster growth."

- Farmer Anonymous

Resource Recovery from the FSTP

During the time of setting up of FSTP, resource recovery was thought to be from biogas, liquid component of the FS for landscaping and dried sludge with addition of wet waste as compost. However, over a period of time the only resource recovery option that worked is compost.

To generate the compost, municipal wet waste is added in the ratio 1:2 to the dried FS. Wet waste from 10 wards is collected and utilized in the FSTP. However, the quantity of wet waste collected is not quantified. According to the TMC, there are around 20 farmers buying the faecal sludge from the FSTP. The interactions with the farmers indicate that there are mixed opinions on the performance of the compost. Few farmers find compost yielding good results and few farmers were disappointed in the purchase and use of compost.

Perceptions of farmers using co-compost

Based on the interaction with 10 farmers who are using or have used co-compost, following narratives about co-compost were noted down:

- All farmers mentioned that co-compost cannot be applied in summers due to excess heat, it demands more water and may also lead to crop burn out.
- There are very a smaller number of farmers who bought co-compost more than once
- Co-compost is mostly applied to grow roses and other flowers. There are very few farmers who apply co-compost to grow vegetables.
- There are instances of co-compost being unsold for longer durations
- Farmers find co-compost expensive as they expect co-compost to be sold at a cheaper price than other farm manures.

Financial sustainability of the FSTP

During the establishment of the FSTP multiple revenue streams were envisaged to recover the financial expenditure on the FSTP. The revenue streams included sanitation tax on households, tipping fee from the desludging vehicles, and sale of co-compost. However, currently the major cost recovery (Rs.80,000) happens from the sale of co-compost.

- The revenue generated from the sale of co-compost is not sufficient to bear the maintenance cost of even a month of the FSTP and honeysucker operations.
- TMC allocates around Rs 12 lakhs annually for the maintenance of FSTP and honeysucker.
- Workers complain of lack of on time salary.

5.4.4 Informal use of faecal sludge in agriculture

Before setting up of FSTP, all the faecal sludge generated in the town was taken up by the farmers. Desludging operators were working in partnership with a few fixed farmers who would take FS on a daily basis. Farmers were cultivating fodder crops, grapes, spinach, coriander and roses. Faecal sludge was converted into an agricultural manure using simple and natural treatment methods of drying and/or mixing with other forms of manure. Farmers were using faecal sludge for many years in the past and gained good results. Their perceptions are listed below:

- FS is the most effective manure.
- FS is highly concentrated. It is ideal to dilute faecal sludge with other farm manures or soil to get best results.
- It is best to apply faecal sludge only after drying. This prevents crop burnouts.
- FS demands more water during summer.

Methods of application:

Several methods of faecal sludge application have been observed. The four important methods are as follows:

1. In one of the methods, faecal sludge from the desludging truck is jetted out directly to crops or trees in the open fields (raw application). There is minimal human contact with the sludge as the liquid faecal sludge flows through furrows.
2. In another method, faecal sludge is jetted out into a composting pit and is left to dry in the sun for two to three months. The cow dung and or sheep dung is added to the FS and allowed to compost. Once this mixture is ready for applying to the crops, a tractor is used to transport this mixture on specific points in the farm. This is further applied to the crops manually by daily wagers and farmers.
3. The faecal sludge is jetted out into a small shallow pit at the corner of the field. Then borewell water pumped out for agriculture is allowed to flow through this pit and then it is channelized to the crops. As the water flows through the shallow pit, it mixes with faecal sludge and flows to the crops through the furrows.
4. Faecal sludge is jetted out directly in an empty farm field set up for the next cultivation. Faecal sludge is allowed to dry in the sun for 3 to 5 days. Post drying, the tiller is used to mix dried faecal sludge with the soil. Then the new cultivation will take place.

Observations from the informal reuse of FS as manure:

In the entire process of FS collection to application, the human contact with raw FS is minimal as the entire collection and disposal system is largely mechanized due to desludging trucks. Farmers have devised ways of handling raw FS through pre-treatment thus ensuring that nutrient balance is maintained.

- Farmers find FS as the cheapest source of manure
- Farmers have also improvised on the crops that can be and cannot be grown with the FS
- The groundwater tables are very deep in Devanahalli. As per farmers, environmental impact in terms of groundwater contamination and soil contamination is negligible.

Farmer V has 9 acres of land. He grows grapes with FS. The FS from the desludging truck is unloaded in a shallow pit located next to the farm. The pit dimensions are 20ft*15ft*3ft deep. After the FS is emptied into the pit, it is covered with soil. Cow dung or sheep dung is also added over it. The entire mixture is allowed to compost for 5-6 months. After the compost is ready, 3-4 baskets of compost twice a year are applied to each grape vine. The farmer has reported increased yield which is not yet quantified.

Perceptions of farmers after setting up of FSTP

The FS which was available either at no cost or minimal cost now has to be purchased from the FSTP as co-compost at a higher price (Rs 7/Kg). The farmers are compelled to purchase co-compost from the FSTP. Furthermore, there are penalties levied if the desludging operator unloads in the farm instead of the FSTP.

Farmers Rajanna and Vijay Kumar are brothers who have been using faecal sludge for the past 3 years. The desludging operators used to unload the FS in an empty land and FS was allowed to dry under the sun for a period of one week. The dried FS is then transported to other farm fields with the help of wage labourers and tractors. Wage labourers were also not hesitant to handle FS since it is dried completely. The farmers use a type of soil locally called Kemmannu, (known for its property of coolness) to reduce the heat. Dried FS is then used to cultivate fodder maize, Ragi, pulses and vegetables. The brothers however are not using FS from the past 6 months due to the strict restrictions imposed by the TMC. They have not tried co-compost from the FSTP in their field and are not planning to buy in the future.

In the words of Babu, Vijayakumar's son, *"FS is the best manure and one should know how to handle it. We dump FS directly to the empty land because it allows it to dry faster when compared to a pond, trench or compost. We grow everything using FS. We have not faced any health hazard so far. Crops thrive in FS. Farmers use other fertilizers like Urea and DAP to have faster growth but with FS we can increase the fertility of the soil and it strengthens the roots."*

5.5 Wastewater management

5.5.1 Informal use of wastewater in irrigation

The main Storm Water Drain (SWD) of the town opposite to Sihineerkere collects all the wastewater from Devanahalli town. The SWD is designed to connect Sihineeru kere to Bettakote Lake so as to allow overflow from Sihineeru kere. However, there are more than 30 farmers along the drain picking up this wastewater for irrigation. Thus, the water generally does not reach downstream Bettakote lake in normal conditions.

Methods of use

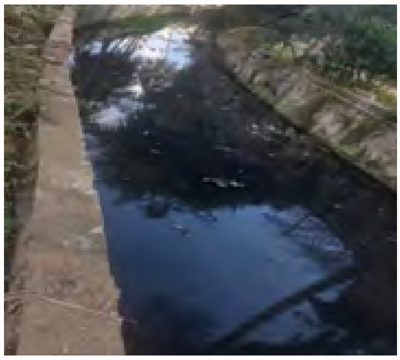
Farmers who do not have a borewell are using wastewater from the SWD. There are some farmers who use borewell water and wastewater together as the borewell yield is sufficient for irrigation. Farmers are using wastewater from the stormwater drains to grow fodder maize, spinach, corn and vegetables. The different methods of use of wastewater from the SWDs in discussed below:

- **Direct use:** Few farmers put a motor and pump directly into the farm as and when required. Farmers use simple net/mesh/basket to avoid solid particles clogging the motors.

- **Shallow ponds:** Few farmers create a shallow pond to hold the diverted SWD water for a while. This pond also has a simple net/mesh to segregate the solid particles in the water. After this pre-treatment of separating large solid particles, the liquid component is allowed to flow into the farm

- **Open wells:** Few farmers allow the water to flow into or pump into open wells. And from the open well, water flows into the field.

Figure 5.4: Main SWD reaching Bettakote lake and SWD carrying grey and black water



Observations from the wastewater use in irrigation in the town:

- The Faecal Sludge Treatment Plant (FSTP) does not consider wastewater flowing in stormwater drains.

- The wastewater reuse has reduced the fertilizer application for the crops

- Farmers are conscious that they are using wastewater and practice health hygiene like bathing and washing hands

- Farmers are reducing the load on already depleting groundwater resources in the town by reusing this water

- However, solid waste is the only issue that the farmers are facing. Hence, they have improvised ways to tackle solid waste flowing in the drains.

"I have been using this water for decades and have not faced any health issues so far. I wash my hands with soap and take a bath with freshwater once back home. This water is rich in nutrients and hence I put less amount of manure to the crops. The motor is kept in a wooden threaded basked - locally called Mankri- and the pipe is covered with a mesh so that the motor is prevented from clogging due to solid waste in the SWD. The land is furrow irrigated to minimize contact with the wastewater. I grow fodder Maize and all leafy vegetables. "

- Farmer Anonymous

“I grow all kinds of spinach and mainly Mint leaves using wastewater from SWD. I also grow fodder maize and sometimes vegetables too. Fodder maize grows much faster and requires less water when compared with fresh water. I sell my produce in the Bengaluru market. I have been working in this wastewater for decades and I have not faced any health hazard so far.”

The structure developed by Farmer K separate Solid particles in the wastewater

Use of commercial greywater in irrigation

The town doesn’t have open drains near the commercial settlements. The black water is contained in pit toilets and greywater is collected in a tank. The greywater tanks are emptied by desludging operators and given to farmers for the use in irrigation. The greywater is used to grow fodder maize and ragi. There are a couple of farmers who are taking greywater regularly from the desludging operators.

Field visits indicated one of the desludging operators K is using the greywater in his own land to grow fodder maize. In his words, “I collect greywater mostly collected from the hotels which don’t have open drains. The greywater contains only kitchen waste which has high nutritive value. We are growing fodder maize in about 6 acres in the outskirts of Devanahalli. We have been cultivating for three years. We have witnessed great results. Fodder maize thrives in grey water. There is also no need to add other manures. Using greywater in irrigation is a good idea. TMC has allowed us to give greywater in farm fields. TMC has checked our truck to know whether we are using greywater or faecal sludge. Since it was greywater they were fine with it.”

- Desludging operator

5.6 Manual Scavenging

Devanahalli town currently has only an on-site sanitation system. Most of the pit emptying is through private vacuum trucks. The Safai Karamchari Kavulu Samithis (SKKS network, an organization of sanitation workers) is also active in the district of Bengaluru Rural of which the Devanahalli town is a part. The network reports that in Devanahalli town unregulated manual scavenging does exist in the form of pit / septic emptying or cleaning of toilet complexes which are overflowing with faecal matter due to blockages. Hotels, marriage halls and hospitals are common places where such problems occur and manual scavenging may be employed to deal with it. Another narrative from the SKKS representatives is that sometimes the “helpers” in vacuum trucks land up undertaking operations during which they come in direct contact with raw faecal matter. These may be during the suction/ disposal operations or during the maintenance of the vacuum truck.

The SKKS, has in its network a total of around 385 members in Bengaluru Rural district. Out of these 75 members have been officially identified as manual scavengers in earlier surveys. 65 of these 75 officially identified members have received one time cash assistance but no further help in rehabilitation. An additional 60 members of the network from this district have applied / “self-declared” as manual scavengers but have not yet received official identification. 250 other members of the network from this district are currently willing to apply for official identification under “self-declaration” and the SKKS network is working to help process the same.

The above numbers include manual scavenger members of the network who report having done manual scavenging work in Devanahalli town. Around 30 members of the network who have applied for official status as "manual scavengers" are from or have reported to have worked in Devanahalli town. 4 of these 30 members have also died of ill-health before being officially identified. The district coordinator of the SKKS Network, estimates that the network has been able to mobilize up to 20% of the actual people engaged in this occupation in the Bengaluru Rural district.

5.7 Filling of lakes with Treated Wastewater

The Minor Irrigation Department (MID) is pumping 210 MLD of TW from Hebbal Valley to fill 65 lakes in Chikkaballapur, Sidlaghatta, Gauribidanur, Gudibande, Yelahanka and Devanahalli. Currently Sihineerkere lake, Doddakere lake and Bettakote lakes are filled with treated wastewater in the town. Sihineerkere lake is the only sweet water source in the town which had gone dry for more than a decades. It received treated wastewater during the mid of 2020 and it has recharged the dried borewells and open wells in the locality. The open wells which have not seen water for the past two-three decades have seen water after the entry of treated wastewater. Farmers are very happy to see the improvement in borewell yield for more than double (from half an inch to 2 inch of water in many cases).

Figure 5.5: Sihineerkere lake(left) and TMC well provided with Safety grill after the rejuvenation(right)

There is an old open well which is 20ft in diameter and 30ft in depth next to Sihineerkere lake which belongs to TMC. The well had not seen water for the past two decades. After the entry of treated wastewater into Sihineer kere, the well had seen water at 10ft from the groundwater. The well has been revived by BIOME Trust in the month of August 2021 with the funding from Say Trees. The pump test conducted during the month of August 2021 indicated the well can yield more than 1.5 lakh litres of water which can meet about 15-20% of Devanahalli's water demand.

5.8 Key Learnings

The farming sector plays a role in recovering and reusing water as well as valuable nutrients from wastewater by applying it to land. While it may not be a conventional wastewater treatment plant or the FSTP treating the sewage and FS, the role that farmlands play is in essence wastewater treatment by segregating solids and breaking down organic matter. By using wastewater for irrigation, farmers are reducing load on the already depleting groundwater in the town. However, there is a need to better understand the health impact on farmers while handling the FS.

The operation and maintenance costs of the FSTP pose a challenge to the Municipality. The only source of revenue from the sale of co-compost does not generate enough revenue to meet all the operational requirements. There are very few takers for the co-compost from the FSTP too. There are mixed opinions on the efficiency of the co-compost and is also perceived to be expensive by some farmers. Vegetables are especially not grown using co-compost as farmers feel that it'll damage the crop.

Institutionalizing the informal: The FSTP has replaced the existing practice of FS reuse instead of integrating it. However, neither the farmers nor the desludging operators are keen on FSTP as the value add from FSTP is unclear. The FS was getting treated and reused prior to FSTP in a 'safe' way contrary to the conventional understanding. Rather the main issue that needs to be addressed is the solid waste management of the town which will help mitigate the risks faced by the farmers and sanitary workers. When land is at a premium in many places in Karnataka, it would be a better option to use the FSTP/municipal land for solid waste management of the town and farmer/s land for faecal and wastewater treatment and reuse.

Further, since the farmer's land will be used for FS treatment and reuse, there is no additional expenditure to the TMC to manage the system. If the TMC can strengthen this desludging operator and farmer partnership by identifying designated sights/farms for FS disposal and register the operators, the trucks can be tracked frequently and so would the disposal and the farms. The involvement of the health team of TMC, public health experts and agriculture university can help in monitoring health and environmental risks associated with this practice. In addition, if the farmers are educated on the Sanitation Safety Planning Protocol (SSP) of the WHO, the risks would be minimized and a better outcome in terms of safe reuse of FS can be expected out of the entire waste management of the town.

STIFLE Lens	Devanahalli Town Municipal Council
Socio-Economic:	The population is dependent largely on agriculture. A Special Economic Zone located in the town is a significant source of employment.
Technology	A Faecal Sludge Treatment Plant, one of the first such plants in India, is located in Devanahalli. The FS is treated at the plant and the co-compost with solid waste biodegradables is sold
Institutions	The Devanahalli TMC is responsible for sanitation services. The KUWSDB constructs and maintains water supply and sanitation infrastructure.
Financial	Proceeds from the sale of compost are Rs. 80,000 per annum. The operation and maintenance costs of the FSTP are about Rs. 22,00,000 per annum.
Legal	Desludging operations are regulated and a fine is imposed on desludging operators who discharge faecal sludge in places other than the FSTP
Environment:	Untreated wastewater/greywater from storm water drains is used to grow vegetables, spinach, maize and fodder. This helps conserve freshwater and groundwater sources. The Minor Irrigation Department (MID) is pumping 210 MLD of treated wastewater from Hebbal Valley, Bengaluru to fill 65 lakes including the Sihineerkere lake which was revived after more than two decades. It received treated wastewater during the mid of 2020 and this has resulted in the revival of dried borewells and open wells in the locality.

06

Tumakuru

Wastewater Reuse to Grow a Medicinal Crop 'Baje'

Abstract

The Sewage Treatment Plant in Tumakuru has an Aerated Oxidation Pond and the treated wastewater is led into Bheemasandra lake. Farmers utilize this water to grow a medicinal crop 'Baje', which is a labor-intensive crop and provides livelihood to 3,000-5,000 workers during the harvesting period. The crop has led to doubling of income for the farmers due to higher crop value.

6.2 Physiography

Figure 6.1: Location of Tumakuru, India

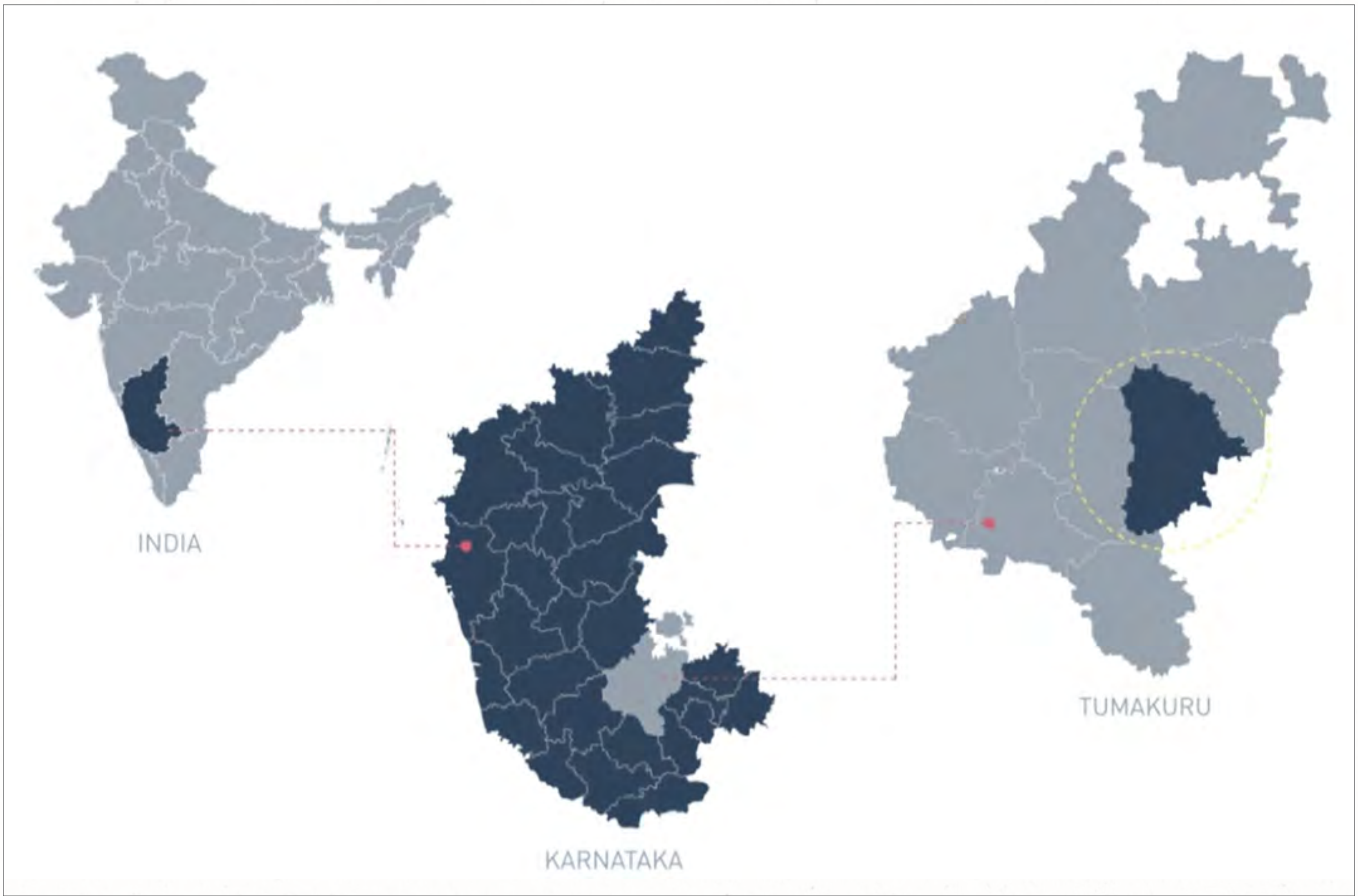


Table 6.1: Tumakuru at a glance

Area	48.6 sq. km
Population	302,143 (2011 Census)
Administration	City Municipal Council with 35 wards
Geography & Climate	Elevation: 822 metres. Arid to semi-arid zone and is a drought prone region
Rainfall	The average annual rainfall of 780mm with 45 rainy days

6.2 Socio-Economic condition

Tumakuru city's proximity to Bengaluru has led to fast urbanization. The city is a 'smart city' receiving huge funding for infrastructural development. The city has an 89% literacy rate and has a combination of working class and agriculture-based occupations. Tumakuru is part of Bengaluru-Chennai industrial corridor and it is expected to contribute to the economy and infrastructural development. It is popular for Sri Siddanganga Mutt, a monastery working on education and social development. There are around 22 declared slums and 17% of the city's population reside in slums. Manual scavenging is practised in the city in spite of technical advancement in pit emptying.

6.3 Water Supply

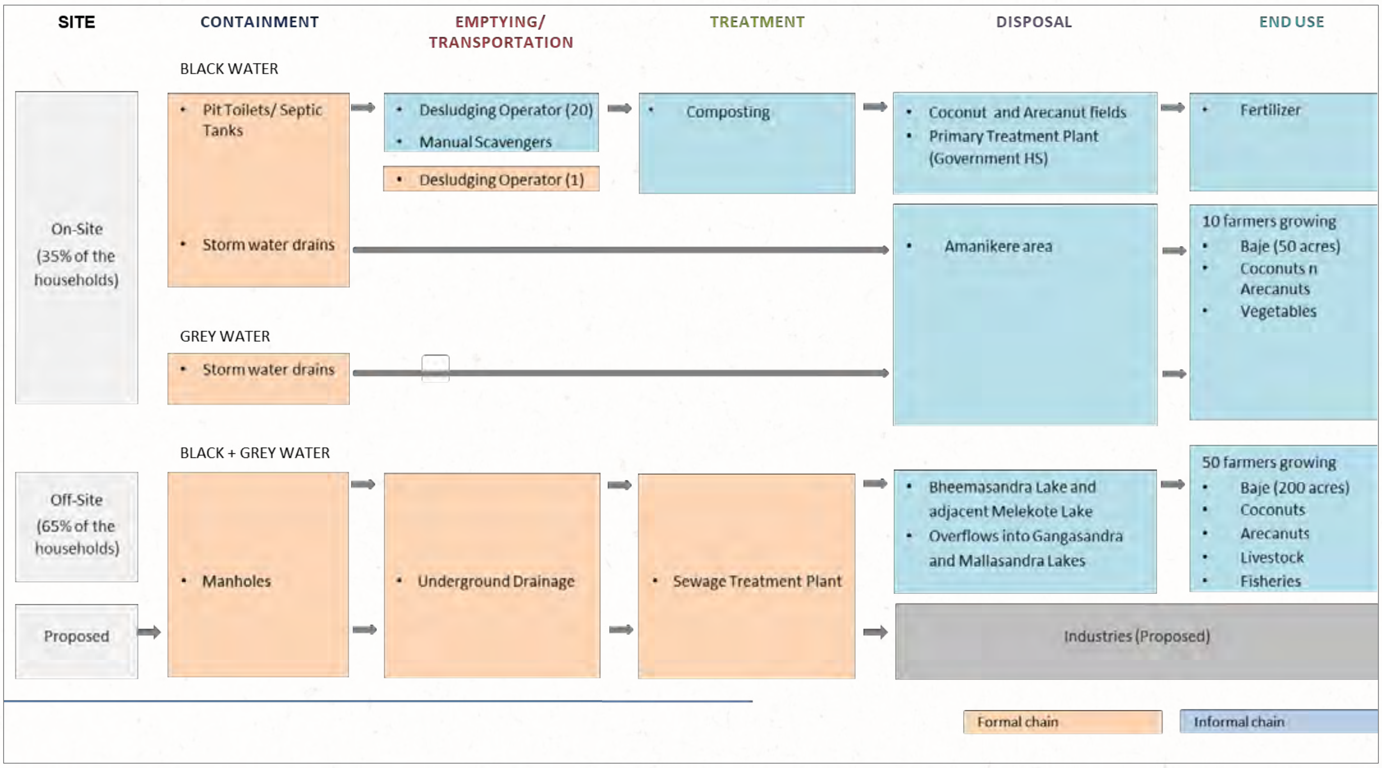
Tumakuru city has no perennial water resources. During British rule, the city's water supply was from a local water body called Mydalakere, but with increasing water demand due to urbanization, in 1996, the city shifted from Mydalakere to Hemavathi reservoir located 170 km away. Tumakuru city has two Water Treatment Plants (WTP), one of 30 MLD capacity and another 50 MLD, to which water is pumped in stages from Hemavathi river. Currently 50 MLD of water is supplied by the CMC at 107 lpcd at a frequency of once in three days for a duration of one hour. In addition, 10 MLD of groundwater is sourced from 450 borewells which are directly connected to the distribution network (TMC, 2020).

Continuous Pressurized water Supply (24/7): Under the Smart City Mission and funded by AMRUT at an estimated cost of INR 258.73 crores, Tumakuru city is moving towards a major milestone in water supply, by implementing 24/7 water supply, to all the households including low income houses. As per the DPR of Karnataka Urban Water Supply and Drainage Board (KUWSDB), the work was started in 2016 and the scheme is expected to be fully operational from 2022. This scheme has the potential of reducing groundwater extraction as it entirely depends on the Hemavathi canal water.

6.4 Wastewater management

The below diagram captures the sanitation chain of Tumakuru city:

Figure 6.2: Sanitation chain, Tumakuru

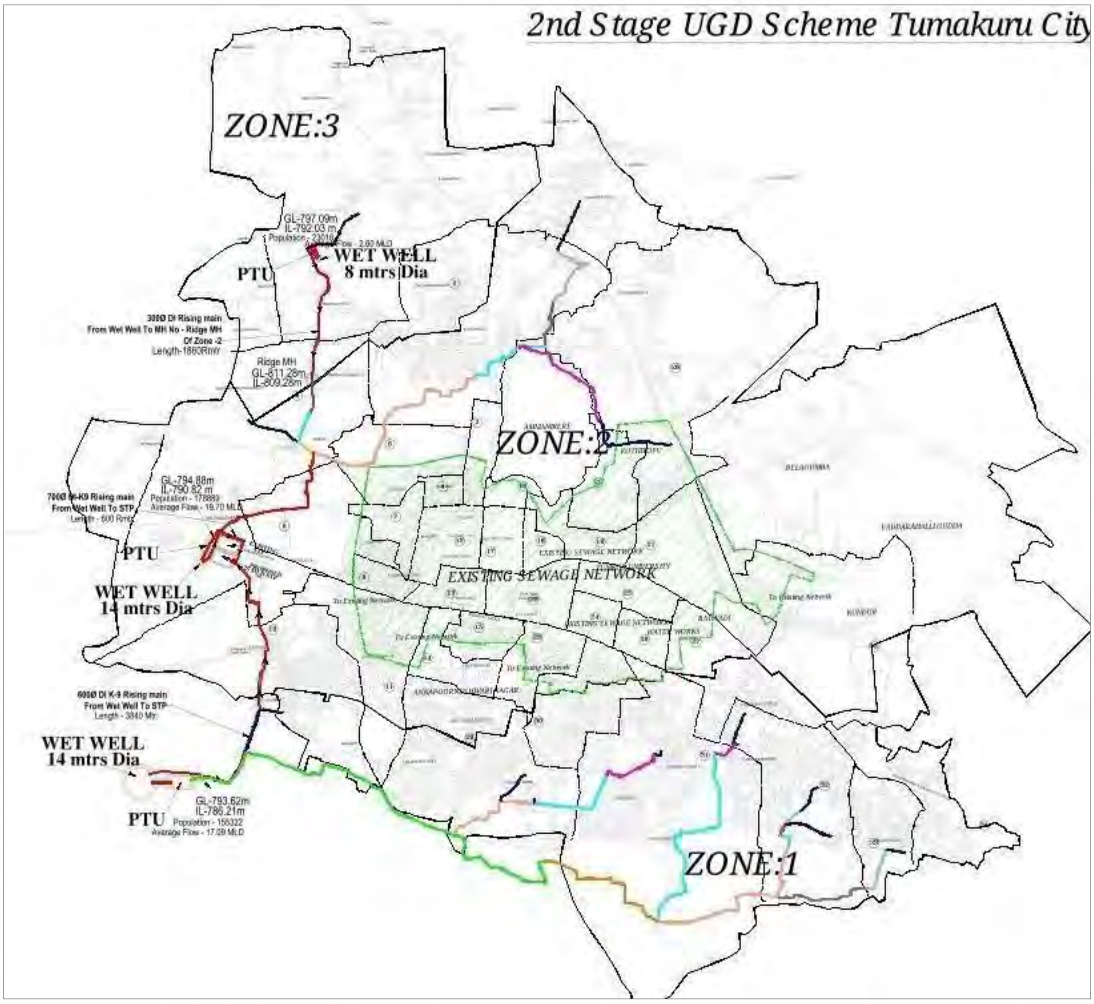


6.4.1 Conveyance: Sewerage network

According to KUWSDB, Tumakuru city has 65% of households connected to the UGD, according to the SLB data. Figure 6.3 indicates sewer lines are connected only to the core areas of the city represented in green colour.

Initiated under Tumakuru Smart City Mission in 2017, KUWSDB is aiming for a 100% UGD network, to connect every single household in the city to the sewerage system. The works are undertaken by AMRUT with KUWSDB as the implementation agency.

Figure 6.3: UGD network of Tumakuru

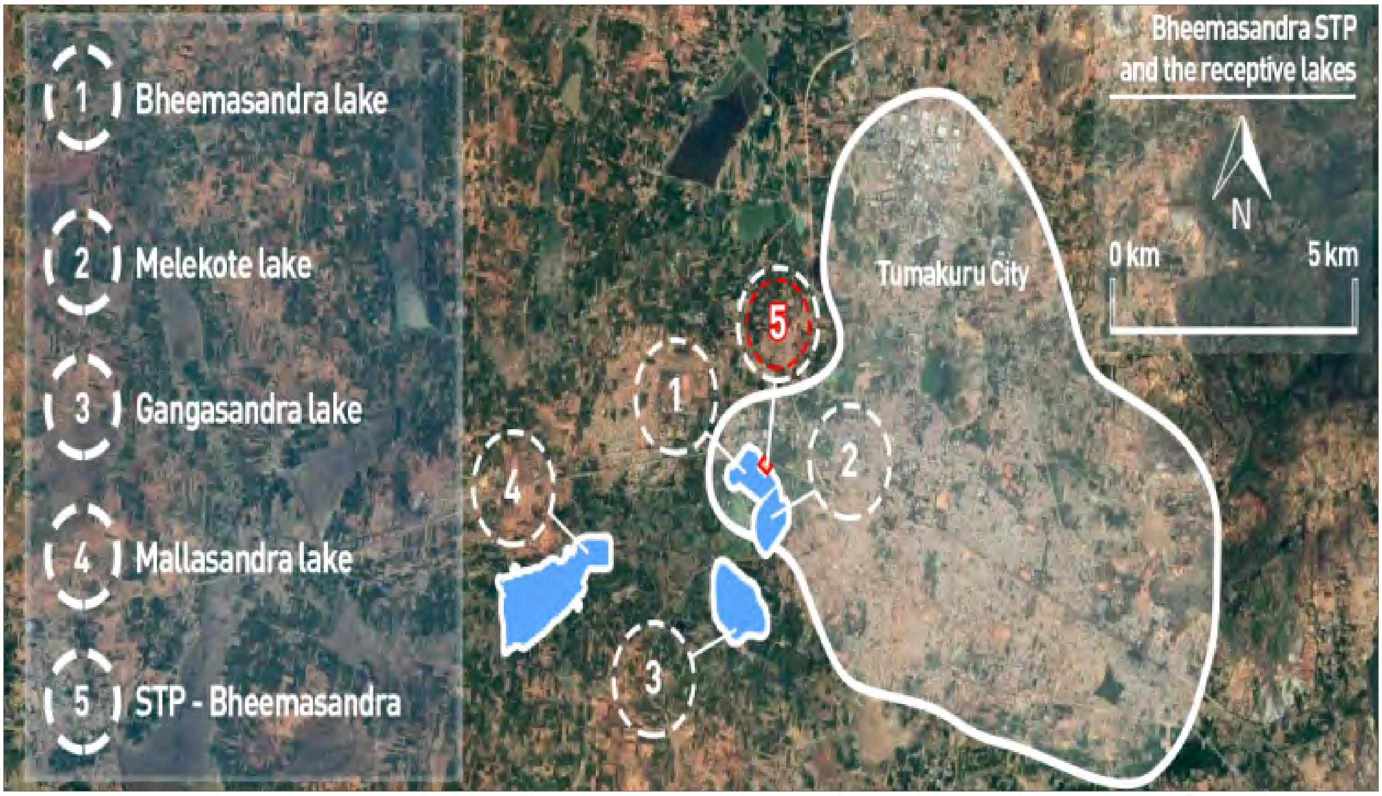


Source: KUWSDB

6.4.2 Formal Treatment

The wastewater generated from households that are connected to the UGD network is connected to a Sewage Treatment Plant. The STP was constructed by KUWSDB and is maintained by the municipality. It has been operational since 2004, is of 24.75 MLD capacity and is an Aerated Oxidation Pond. Additionally, bio-enzymes are added to activate the bacterial growth to increase the oxygen level in the wastewater. After aeration, the wastewater is led into the polishing pond where the wastewater is held for 3 days. This treated wastewater is let into Bheemasandra lake (50 acres) which overflows into an adjacent lake called Melekote lake (90 acres). This treated wastewater from Bheemasandra and Melekote lakes further overflows into Mallasandra and Gangasandra lakes respectively.

Figure 6.4: Lakes receiving treated wastewater

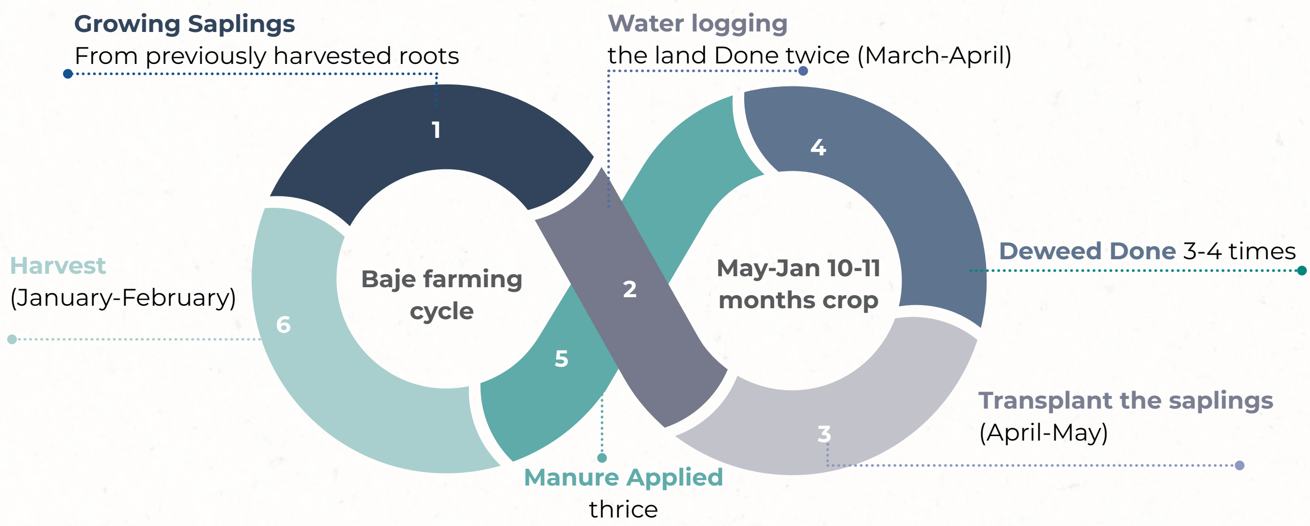


6.4.3 Informal reuse of treated wastewater in Baje cultivation

Farmers from the command area of both Bheemasandra and Melekote lakes are using treated wastewater in irrigation informally, to cultivate a wetland crop locally called Baje (Sweet Flag, (scientifically referred to as Acorus Calamus or also known as Vacha and Vasambu in local Indian languages). It is a rhizome which is used widely in pharmaceutical industries and is a part of indigenous and Ayurveda for treating various health problems such as digestive disorders, stimulating brain functioning, asthma, speech impediments, hair care, sedative, cold etc. Countries like Germany, Austria, Holland, Hungary, Italy, Russia, Sweden and Switzerland have recognized the health benefits of Baje and are using it in their pharmaceutical industries.[23]

Technique of Baje cultivation

Figure 6.5: Schematic diagram of Baje cultivation



[23] https://www.tandfonline.com/doi/full/10.1080/13880200701538724

Treated wastewater is used both directly (by installing submersible pumps in the lakes and through sluice gates) and indirectly through groundwater recharge. Baje is grown in wetlands, as a 11 month crop (Jan-Nov). It is grown from saplings harvested from the previous year. Before planting the saplings, land is ploughed thoroughly for two to four times and water is allowed to flow. Baje saplings are planted leaving about two inches of gap between each sapling, which multiplies through rhizomes. Baje follows flood irrigation. Treated wastewater from the lake is allowed to flow continuously through sluice gates and is channeled until the last plot of agricultural land using bunds.

After two months of planting, two bags of urea and DAP 16, 18 and 20 are applied 4-5 times. De-weeding is done two to four times. Baje is ready for harvest after 10 months. Watering is stopped a month prior and once the land is dry, harvest begins. The grass is burnt in the land itself. In an acre a minimum of 35-40quintals of Baje is harvested. Now the task of the farmers is to remove the rhizomes, clean the Baje and cut into small pieces of three to four inches. In recent years machines are being used to clean Baje. Finally once Baje is packed in gunny bags it is ready to be sold. Traders buy Baje from the fields directly and farmers also sell them in APMC yards (Baje is not a listed commodity).

Figure 6.6: Baje cultivation in the command area of Bheemasandra lake (top) and Baje stems (bottom)

Change in cropping pattern:

Farmers of Bheemasandra and Melekote were cultivating paddy in the command areas before the entry of treated wastewater, since paddy failed to survive in wastewater. During water scarcity, a farmer successfully experimented by allowing wastewater from the open drain to his Baje field. The market for Baje was also high and the income from Baje was more than double of paddy. Thus, the availability of wastewater and a stable market motivated all the farmers of Bheemasandra to shift from paddy to Baje cultivation.

Livelihood for wage labourers

Baje is labour intensive; an acre of Baje requires 18-10 labourers for planting and 20 labourers for harvest. Approx. 4000 labourers are employed during harvest, with labourers coming from as far as 30km and migrants from Raichur and North Karnataka regions. Baje fields are mostly dominated by female workforce because of the nature of the work with Rs.300-350/day wages. Baje is seen as a most reliable source of livelihood during the non-agricultural season of the year. Thus, Baje has made a massive impact on the wage labourers.

Figure 6.7: Baje cultivation

6.4.4 Impact of treated wastewater

Ecological impacts

Positive impacts

- After the entry of treated wastewater, the biodiversity of both lakes in terms of birds, reptiles and mammals has increased and are considered as biodiversity hotspots by ebird[24].
- Treated WW enabled groundwater recharge where the majority of open wells have water throughout the year at less than 5ft from the ground level.
- Post the entry of treated WW, none of the farmers have drilled a borewell.
- Based on farmers' experiences, they require 30-50% less of artificial fertilizers as the treated WW is rich in nutrients.

[24] *https://ebird.org/hotspots?hs=L6798113&yr=all&m=*

"I grow Baje in about 10 acres using treated wastewater. We have not faced any health issues so far. There are no issues in growing Baje. I am not convinced with the quality of STP treatment. I don't see the Aerators functioning. As we have noticed that the plant operators will let untreated wastewater directly into Bheemasandra lake mostly during the rain. The groundwater has turned saline after the entry of treated wastewater. As I think most of the issues would be solved if STP operates well."

Farmer Anonymous

"I own no land and depend completely on agriculture for my livelihood. Baje is non seasonal and the harvest begins in December and goes on till February-March. Just after the harvest the new planting begins. Baje gives livelihood to thousands of wage labourers like me when we don't get any work in the season. I travel for 10kms to work in the Baje field. I have been working in the Baje fields for a decade now. Skin allergies are mostly seen for the newcomers and they gradually get used to it. The tenants complain of smell and mosquitos are nothing in front of our livelihoods. One should arrive at a conclusion where all of us can co-exist. Increasing the quality of treatment might be of help in reducing the smell and mosquito breeding".

Wage labourer

Negative impacts

Salinity of groundwater: Farmers have observed that due to seepage of treated wastewater, borewell water has become tasteless. Drinking water from RO plants if kept for more than a day turns tasteless.

Threat to native species of fish: African Carp is an invasive species of fish which preys on native species of fishes. Therefore, native species of fish cannot survive in the lake.

Economic impact

- Treated WW from Bheemasandra and Melekote lakes have provided perennial source of water for irrigation.
- Baje has contributed to the increase in income of the farmers.
- Baje is seen as a most reliable source of livelihood by thousands of farmers during the harvest.
- Formal fishing in the lakes tendered by the government (using coracle) is generating huge revenues to the contractor whereas informal fishing (folks fishing in small quantities without the coracle) is generating livelihood for the fishermen.
- Treated wastewater has also provided livelihood for grass cutters like Typha cutters who travel from more than 50kms distance.

6.4.5 Challenges: Proposal of selling treated wastewater to industries

Tumakuru is home to 9,000 industries including small, micro and major units of production. The major industrial hubs in the city are Vasanthanarasapura, Anthrasthanahalli (as well as Sathyamangala), Hirehalli and Dobbaspet. Vasanthanarasapura lies on Chennai-Mumbai corridor, it is also home to a 520-acre Japanese Industrial Township that is attracting startups and new manufacturing units. The growth of industrial hubs translates to a drastic increase in water demand.

Tumakuru CMC acknowledges the lack of financial resources and technical expertise for maintenance of the STP and is currently treating only 40% of the wastewater. In the words of an Executive Engineer from CMC, "CMC has various responsibilities and provided the time and resource constraints we cannot pay much attention to STP. We neither have finances nor the technical expertise to handle the STP. We are seeing STP as a burden. On the other hand, there are industries demanding water in huge quantities. We are concerned about the health of Baje farmers and groundwater contamination around Bheemasandra lake. Thus, we perceive selling of treated wastewater to industries as a business model where CMC can also generate revenue. KIADB will ensure better treatment and the plant itself will be handed over to them. Once the treated wastewater is taken out from the Bheemasandra lake it will be filled with Hemavathi water to benefit the farmers of Bheemasandra and Melekote."

As per the proposal there is a provision of pumping 35 MLD of treated wastewater to the industries. KIADB is creating an infrastructure to pump 10 MLD of treated wastewater as against their requirement of 5MLD.

6.4.6 Farmer’s perception on treated wastewater

Farmers of Bheemasandra perceive treated wastewater as a resource. Farmers are very happy about the fact that treated wastewater is generating huge revenues and providing livelihood for thousands of wage labourers. Farmers have become extremely reliant on treated wastewater and it is very difficult for them to accept the proposal of selling treated wastewater to industries. Farmers reject the CMC’s perception that treated WW is causing health and environmental hazards.

Majority of the people who are against treated wastewater entering Bheemasandra and Melekote lakes are found to be the tenants or the ones who don’t have landholding. It can be rightly said that beneficiaries of treated WW are in favour and non-beneficiaries of treated wastewater are against treated wastewater who mention increase in mosquito breeding and foul smell as the major reasons.

6.5 Faecal sludge management

6.5.1 Containment

In the majority of the households in the city black water is contained in pit toilets. In the words of desludging operators, septic tanks are rarely seen in Tumakuru. The greywater is openly led into storm water drains.

6.5.2 Emptying and Transport

The Formal: Emptying and Transport

City Municipal Corporation bought the first desludging truck in 2008, which is the only government owned truck operating in the city. In about 2 years private desludging operators started to operate in the city. Government owned desludging truck makes about 10-15 trips a day.

- CMC charges Rs.500 to empty a pit toilet
- FS is disposed in nearest manholes and in the treatment plant
- It has a capacity of 4000 litres

Figure 6.8: Government owned truck and one of the private owned truck

The informal: Conveyance

- As the city expanded, the number of desludging operators in the sector also witnessed a rise. There are 20 privately owned desludging trucks operating in Tumakuru city.
- Private owned HS makes a minimum of 2 trips and a maximum of 7 trips a day
- They charge Rs.1000-Rs.1700 (based on the distance travelled) to empty a pit toilet
- There is no formal designated faecal sludge emptying site in Tumakuru. Desludging operators are working in partnership with farmers, who take the faecal sludge free of cost and apply to areca nuts and coconuts fields as manure.
- Some of the FS is disposed in nearest manholes and in Primary Treatment Plant

6.5.3 Treatment

There is no formal Faecal Sludge Treatment Plant (FSTP) in Tumakuru city and informal on-farm treatment of FS is practiced.

Farmers mostly apply the FS directly to the farm without any treatment. FS is applied row wise (furrows) to areca nut and coconut farms. There are few farmers who compost the faecal sludge in ponds and trenches. These ponds and trenches are around 5 ft deep. The FS is allowed to compost for about 5 months before it is applied on the field.

6.5.4 Reuse

Farmers use faecal sludge as manure to grow coconuts and areca nuts. In a day 50 truckloads of FS are generated in Tumakuru city. FS has the potential to fertilize 1800 acres annually.

6.5.5 Economics of farmers and desludging operators' partnership

Livelihood: Desludging operators are locally owned by eight people who each own more than one truck. There are about twenty drivers and 30 helpers making their livelihood out of this business. The drivers are paid the sum of Rs.15,000 and helpers Rs. 10,000 a month.

No social barriers: It is found that desludging operators (drivers and cleaners) and owners are from all social groups, including Muslims and different social castes like Lingayath, Vokkaliga, Gowda etc. are working in this business.

Profits for desludging operators: The owners in the business are consistent and none of the owners have incurred loss or sold their business from the past twelve years. The workers in the business are assured of job security and have been working consistently for more than five years.

Table 6.2: Financial analysis for desludging operators

Cost of trucks	Rs.800,000 (Used) Rs.1,800,000(New)
Average no. of trips per day	4
Average charges per trip	Rs.1200
Revenue per day	Rs.4,800
Expenditure per trip	Rs.500
Salaries for operators (on average 2)	Rs.20,000
Monthly profit	Rs.64,000
Annual profit	Rs.7,68,000
Simple Return on Investment	~One year (Used) 3.5 years(new)

Desludging operators are found to be not threatened by the 100% UGD coverage as they perceive the city will be expanding and CMC will not be able to provide UGD fully. They are prepared to move to the outskirts as the city expands.

Cost savings for the farmers: Areca nut and coconut farmers use farm manure of cattle, hen and sheep every year. Farm manure would cost Rs. 50,000 to 60,000, requiring about 20 tractor loads per acre. In the partnership of desludging operators and farmers, due to the need of a safe space to dispose of the faecal sludge, this happens for free for the farmers. This results in the cost saving of about Rs. 45,000 to Rs. 55,000 per year for farmers.

6.5.6 Perception of faecal sludge management and use

Perception of desludging truck owners

Desludging Truck owner M: Mr. M entered the business a couple of years ago. He works as an operator in the WTP pump house. As the government owned desludging truck was hugely inadequate to meet demands, Mr. M invested in a desludging truck, anticipating the business as a profitable venture. He has two trucks and has five people working for him. In the words of M, "City will keep on expanding and the municipality cannot provide UGD coverage to all the households."

Septic Tank Cleaners D: He started his journey as a laborer, became a driver and he owns a couple of vacuum trucks. He has been working in the field for 10 years. He also drives the truck himself. He has employed five people.

6.6 Prevalence of Manual Scavenging

Manual scavenging is very active in Tumakuru city. They reside in slums and are from the Madiga community. An interview of 10 manual scavengers was conducted to understand the prevalence and process of manual scavenging. Manual scavengers are engaged mostly in emptying private pit toilets in suburbs. There are few manual scavengers who get inside the public manholes which are smaller in size. Manual scavengers are not dependent on pit emptying alone and they are working as municipal workers, toilet cleaners in hostels and convention halls, painters and as domestic maids. It was observed that manual scavengers call the desludging trucks to empty the pit toilets if the FS is watery. The operator fails to empty the pit toilets if the FS is dry and manual scavengers get into the action. They will be intoxicated (to get over the foul smell) and finish the pit emptying work within two to three hours. The FS is taken in buckets and disposed of in empty land. If emptied in villages FS is given to farmers which is used as manure. They generally charge a minimum of Rs.3000 and up to Rs.7000 and they will be a team of 3-5 people. In a week they engage in a minimum 2-3 pit emptying works. A lady manual scavenger (50 years old) was also interviewed who is very active in pit emptying. Manual scavenging is seen as a profitable activity.

Mr. K is a farmer from Gulur village of Tumakuru taluk which is around 10 kilometers from the city. Krishnegowda owns eight acres of Areca nut and Coconut farm. He has been using faecal sludge for the past five years. Every day the desludging operators dump a minimum of two to five truckloads in his field.

Farmer K

"My farm was depleting in quality. The yield was less and trees were lost. Once the desludging operator approached me and asked if they could empty the faecal sludge in my land. I saw faecal sludge as rich manure and asked them to dump it directly. In just two years, I found my farm thriving. There is an increase in quantity and quality of the yield and trees are growing very well".

6.7 Key Learnings

Both wastewater and FS generated in the city have been informally used for agriculture for decades. There are social, environmental and economic impacts from these informal partnerships; the combination of desludging operators and farmers are filling the gaps in Tumakuru's sanitation treatment and reuse system. Tumakuru generates about 30 MLD of wastewater. The transfer of wastewater from the core areas of the city (with UGD connection) to the villages like Bheemasandra, Melekote, Gangasandra and Mallasandra ensures a rich nutrient exchange between an urban area and its rural hinterland

The oxidation pond treatment is 'fit for purpose' as it meets the needs of nutrients in the treated wastewater for the farmers requirements. Lakes in Tumakuru city could be filled with treated wastewater formally for irrigational and ecological reuse. National Green Tribunal's (NGT) stringent treated WW standards are costly to achieve and thus CMC finds it more convenient to sell the treated WW to industries than for irrigation. Industries can pick treated WW from oxidation ponds and further treat it for their reuse, thus saving cost burden for the CMC.

Desludging operators and farmers could be seen as solution providers. In the interim, where Tumakuru city is yet to cover all the households with sewer lines, formalizing the desludging operators and farmers partnership by ensuring Sanitation Safety Plan protocols will increase the safety and efficiency of the system. With 100% UGD in place, Tumakuru city can aim for filling up more lakes in the city with treated wastewater where thousands of farmers can benefit indirectly from groundwater recharge. Attention will then need to be paid to minimize health and environmental risks using the SSP manual of WHO.

STIFLE Lens	Tumakuru City Municipal Corporation
Socio-Economic	In the operation of desludging trucks, social class barriers are ignored when there are better livelihood opportunities.
Technology	The city is currently implementing a project for city wide sewerage network coverage. A new STP is also proposed with a capacity of 25 MLD
Institutions	The Tumakuru CMC provides sanitation services and is supported by the KUWSDB for its sewerage network and treatment infrastructure.
Financial	The cultivation of Baje, a medicinal crop, provides a reliable income for 3000-5000 people during the harvest season. Arecanut and coconut cultivation make use of FS. There are around 20 private desludging operators estimated to be earning a profit of around 10 lakhs per annum.
Legal	Standards for wastewater treatment for agricultural and other reuse may be developed based on ‘fit for purpose’
Environment	Treated wastewater is let into Bheemasandra lake (50 acres) which overflows into an adjacent lake called Melekote lake (90 acres). This treated wastewater from Bheemasandra and Melekote lakes further overflows into Mallasandra and Gangasandra lakes respectively.

07

Alappuzha

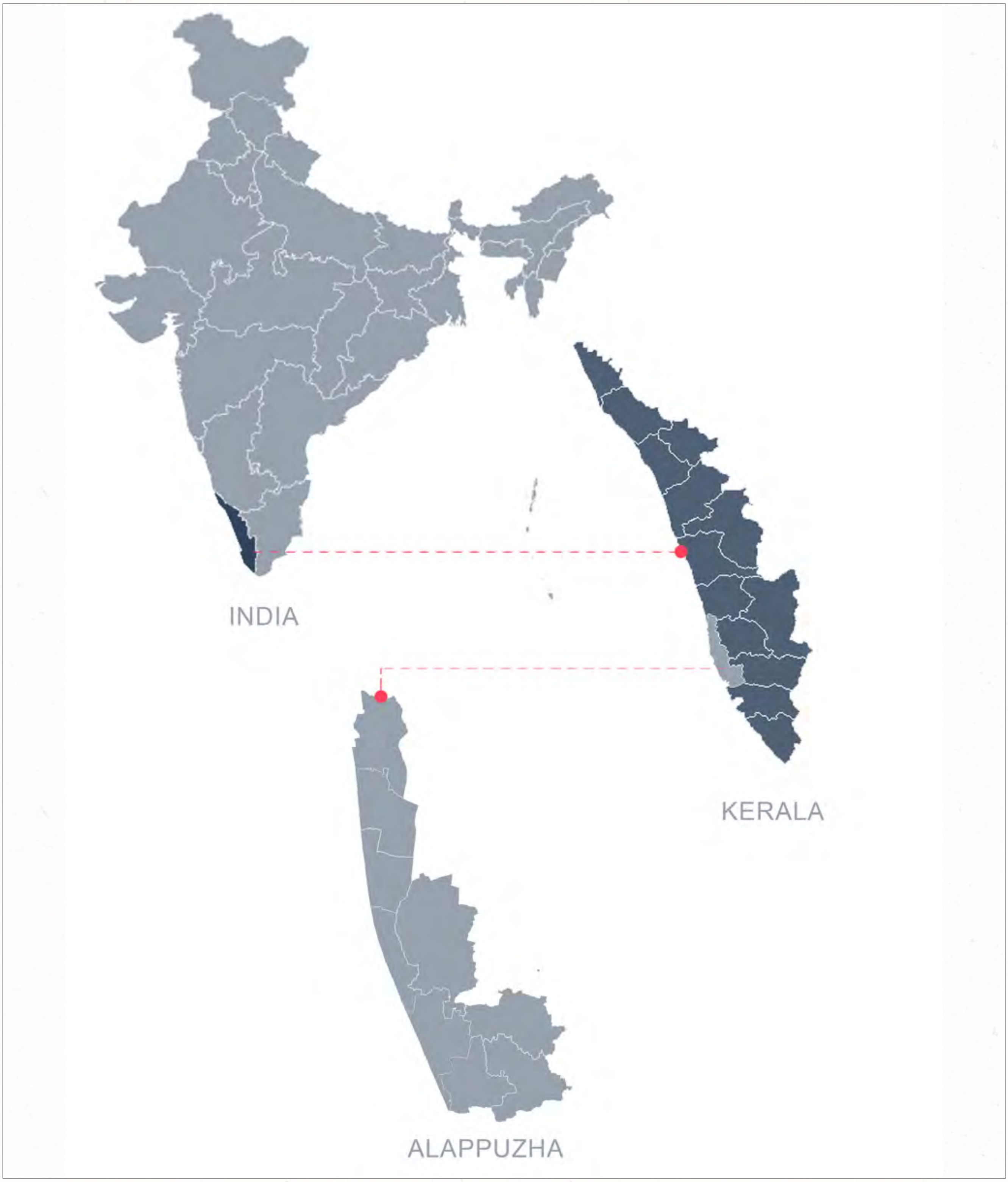
Canal Rejuvenation in the 'Venice of the East'

Abstract

Alappuzha town is known as the 'Venice of the East' due its extensive network of canals and backwaters and is a popular tourist hub. However, due to the lack of a sewerage system, wastewater and septage/faecal sludge from houses, establishments and houseboats have polluted the canals, triggering several sanitation interventions.

7.1 Physiography

Figure 7.1 Location of Alappuzha in Kerala, India



Alappuzha town is situated in Kerala and is a picturesque coastal town with backwaters, beaches and lagoons and a canal network. It lies between the Vembanad Lake and wetland system and the Arabian sea. The Vembanad Lake is the largest brackish wetlands ecosystem in Asia and a Ramsar site. Alappuzha is known as the 'Venice of the East' as it is crisscrossed with canals. Apart from road and rail connectivity, inland waterways link the town to adjoining and nearby cities. Parts of the town are below sea level and prone to water-logging. The water table is 3m below the ground. The town is part of the Kuttanad region, a deltaic formation of four rivers joining Vembanad Lake and known as the 'rice bowl' of Kerala.

Table 7.1: Alappuzha at a glance

	Area	65.57 sq.km.
	Population	174146
	Administration	Alappuzha Municipal Corporation has 52 wards
	Geography & Climate	Alappuzha is on a peninsular landmass between the Arabian Sea and the Vembanad Lake. It has a temperate and humid climate.
	Rainfall	The average rainfall received by the region is 2763 mm.

7.2 Socio-Economic Context

Alappuzha has a mixed working population of government employees, workers in private sector establishments, agricultural workers and employees in various industrial and manufacturing segments of the town. Tourism, fisheries, coir industry and agriculture comprise the mainstay of the economy.

7.3 Water Supply

The first water supply scheme for Alappuzha was the Maharani Parvati Bai water works, situated in Punnapra and commissioned in 1941. Tube wells are the main source of water supply in Alappuzha provided by the Kerala Water Authority. As the area is water logged and the groundwater table is high, open wells in this area are highly polluted and contaminated. In view of the quality issue, KWA and the Department of Tourism has set up 6 reverse osmosis (RO) plants across the town. Over 50 tube wells in 38 locations cater to water supply in Alappuzha municipality and adjoining 8 panchayats, with a total yield of 25 MLD. The per capita supply is estimated to be 80 lpcd. All the connections except stand posts are metered connections and are billed according to actual water consumption. People also depend on private wells for water requirements. The quality of groundwater is poor in Alappuzha with high concentration of chlorides, fluorides and iron. Because of high fluoride content, Alappuzha has been declared as an endemic area with reference to fluoride (CGWB, 2013).[25]

17.4 Sanitation Cycle

The Alappuzha Municipality was constituted in the year 1896. The Municipality covers an area of 65.57 sq. km. and is divided into 52 wards. The Alappuzha Municipal Corporation provides sanitation services and partly looks after septage/faecal sludge management. The Kerala Water Authority, a state level agency under the Department of Water Resources, provides water supply, sewerage and wastewater treatment and disposal services. The State Sanitation Mission (Suchitwa Mission) under the Department of Local Self Government is the technical agency for sanitation, solid and liquid waste management. The State Pollution Control Board plays the regulatory role.

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25 *http://cgwb.gov.in/District_Profile/Kerala/Alappuzha%20.pdf*

7.4.1 Conveyance

The network of canals is the backbone of the drainage system. There are 8 main canals, 7 secondary canals and 23 connecting sub-canals, which constitute the main surface water drainage system in Alappuzha. The most important canals are Vadai canal and commercial canal running east–west, on either side of the central area of the town. Other canals run north south. The A.S. canal and Ambalapuzha canal is on the northern side; Rani Thodu and Vada Pozhithodu are on the southern side of the central core of the town.

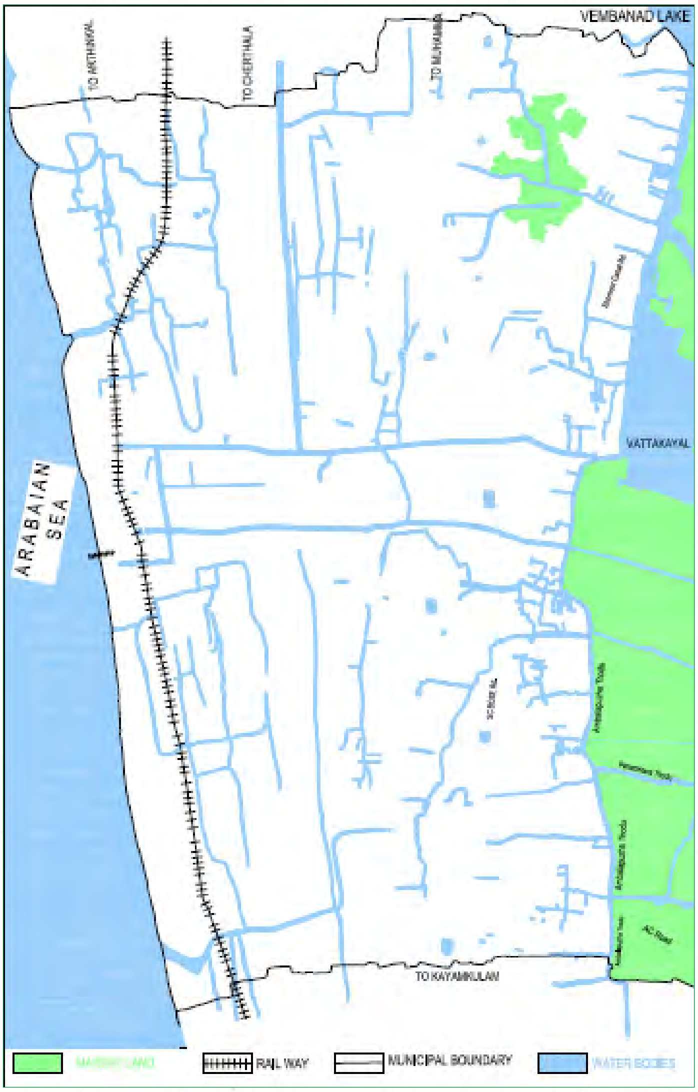
Table 7.2: Details of Canals

Name of the Canal	Length (m)
Commercial canal	3500
Vadai canal	3950
East junction canal	640
West junction canal	880
Murinjapuzha canal	600
Uppotti canal	250
AS canal	2800
Ambalapuzha canal	5000

Source: City Development Plan, 2009 Alappuzha

The town faces severe water logging problems, especially during monsoon. The drains along the roadsides and the connecting streams comprise the tertiary drains. Only 2% of the road side drains are pucca and are mostly open. The road side drains have a length of about 250 km., i.e., about 80% of the city road network length. The canals are polluted due to sewage disposal. Only about 30% HHs have sanitary toilets with septic tanks, and another 30% have leach pits. The remaining rely on other means including open defecation in public areas. Outlets from septic tanks are often opened into drains or canals (City Development Plan, 2009 Alappuzha).

Figure 7.2: Water Bodies in Alappuzha Town



7.4.2 Treatment

Alappuzha does not have a sewerage system. Septage/faecal sludge sullage and solid waste from households and from commercial establishments finds their way into drains, streams, canals and lakes. The leachate percolates into groundwater polluting the entire water bodies in the town as the subsoil water table is high. About one third of the households in the town have provision of septic tanks for sewage disposal. Effluent water from the septic tanks is let out through perforated/ disjointed pipes laid below the ground level for absorption into the soil causing water pollution. The Municipality maintains a desludging vehicle which evacuates sewage from the septic tanks. But the Municipality does not have a sewage treatment plant for disposal of such removed sewage. Private septage collection vehicles are active, although illegal. There is a lack of a centralized treatment/designated disposal area. The sanitation problem in Alappuzha is unique due to the peculiarity of its land, sandy soil, waterlogged situation, presence of canals in all wards and the backwaters.

Figure 7.3: Discharge of Blackwater into Open Drains

7.5 Initiatives in Focus – the formal and the informal

The town is characterized by the (i) dependence on ground water sources for potable uses (ii) fluoride contamination in ground water sources (iii) E coli prevalence in wells (iv) unscientific septic tanks that discharge into the soil (v) high water table and water logging (vi) prevalence of water borne and vector borne diseases and (vii) canals that have turned into cesspools due to the discharge of grey and black water from households, houseboats and other establishments. This situation was not only impeding the public and environment health of Alappuzha and potentially adversely impacting domestic and international tourism as well.

It was therefore decided to initiate a programme for the rejuvenation of the canals.

7.5.1 Rejuvenation of Canals and the Canalpy Campaign

Canal rejuvenation mainly involved desiltation, preventing the dumping of solid waste and human waste, along with an education and awareness campaign to disseminate the message and get citizens to actively participate in cleaning and maintenance of canals. The MLA of the area, Dr Thomas Isaac played a galvanizing role in setting the agenda and organizing its implementation from 2011-12 onwards.

Figure 7.4: DEWATS Facility in Chathanad Colony

One-off Cleaning Drives

Sanitation committees comprising political leaders and civil society representatives were formed to kick off campaign mode, one-off cleaning drives on holidays. Posters were displayed, songs were sung and pledges made committing the city and citizens to waste management.

Decentralized Solid Waste Management

Further, a campaign was started to promote decentralized management of waste with segregated treatment practised at the household level/source level. As part of the 'Nirmala Bhavanam Nirmala Nagaram' (Clean Homes Clean City) initiative as it was named, the biggest waste-dump in the city was transformed into a WATSAN (water & sanitation) park. It is now popularly known as the 'Thumboormuzhi aerobic composting model' which can convert two tons of wet waste into compost in 90 days.

Faecal Sludge and Septage Management - DEWATS

Attention was also given to black water/septage/faecal sludge contamination. In order to address the need to convert unsafe toilets that discharge waste into the open, into canals and drains, a DEWATS model was set up at the Chathanad Colony. The NEERI, Consortium for DEWATS Dissemination Society, Bengaluru, and Inspiration, Cochin, along with IRTC, ANERT, KSSP, local MLA and Councillors, local NGO/CBOs were partners and collaborators.

The Canalpy Campaign

A canal-restoration project, Canalpy, is taking shape in the backwaters of Alappuzha. Funded by the Kerala Institute of Local Administration (KILA), the effort is supported by Cochin University College of Engineering Kuttanad, IIT-Bombay, National Environmental Engineering Research Institute (NEERI), Consortium for DEWATS Dissemination Society, Bengaluru and Inspiration, Cochin. The campaign itself is an outreach programme to involve and educate the public to adopt a decentralized method of disposing waste, at source treatment of the pollution and facilitate community ownership and participation to rejuvenate, restore and maintain the canal networks in the Alappuzha town.

Figure 7.5: The Canalpy Campaign 'Canals are not Drains'

7.5.2 Faecal Sludge and Septage Management

Given that over two-thirds of citizens use septic tanks which are unscientifically constructed, frequent emptying is required. The town does not have a designated dumpsite and hence the collection and disposal of septage is largely informal and 'illegal.' Septic tank waste includes oil, grease, kitchen waste, slaughterhouse waste and thickened flour-paste from bakeries. The desludging operators charge between Rs 3,000-5,000 from households, commercial establishments and houseboats. It is then disposed of in water bodies, the highway and the outskirts of the town.

The operators are often embroiled in legal battles with law enforcement authorities and end up paying fines. They have recently organized into an Association of Septic tank Cleaners (ACSA) and are now exploring options to set up a private treatment plant as an enterprise.

"We clean the septic tanks of police officers, judges and Municipal authorities, yet have to pay bribes and fines alternately"

- Desludging operator

7.5.3 The Floods of 2018 – A Flashpoint

Alappuzha town mostly falls under the category II of the CRZ Act. Prone to the vagaries of the sea and backwaters, it is also flood-prone. The heavy rains and floods in the year 2018 caused extensive damage in Alappuzha to lives, livelihoods and infrastructure including the water and sanitation infrastructure. Over 350,000 individuals were evacuated from their homes during the floods and shifted to relief camps which were often school buildings. Septage overflow issues in the camps prompted the authorities to provide temporary recognition of septage collection vehicles and it was arranged for the faecal sludge and septage waste to be treated at facilities set up within campuses of PSUs and companies around Alappuzha town, as an interim emergency measure.

The WASH Institute, Kodaikanal pitched in with an onsite mobile treatment unit (MTU) technology in the peak of the floods, comprising a hosepipe to extract septage from the septic tank with a motor outlet connected to the MTU for in-situ treatment. The unit was operational for a two-month period.

7.5.4 Closing the Gap

A City Development Plan for Alappuzha town recommended three options for city wide sanitation.

Option 1 – Establishment of centralized sewerage scheme with a STP located at some convenient location in the periphery of the town and extending services to cover the whole town area.

Option 2 – Establishment of community septic tanks for a group of persons/HHs and providing a secondary treatment facility for every septic tank. Such partially treated water can be let off safely into drains or canals. A large number of such community septic tanks may be required in the town. Such facilities may be partially charged to the beneficiaries.

Option 3 - Considering difficulty in providing adequate gradient for the sewer lines for a centralized sewage system, it may be possible to divide the town area into 4-6 divisions (taking consideration of geographical features, natural divisions etc.] and provide zonal level mini sewage treatment plant of about 5 MLD and linking residential and other building within zones by sewer lines to STP.

Currently under the AMRUT project, procurement and establishment of sewer lines and treatment infrastructure is under way in accordance with option 3.

Table 7.3: Septage and Sewerage Infrastructure Projects under AMRUT

Treatment Infrastructure	Capacity	Technology	Cost (Rs)
Sewage Treatment Plant at General Hospital	240 KLD-Phase I &II	Electro Coagulation	3.45 Cr
50 KLD Sewage Treatment Plant with the associated network at Thottumudi Colony	50 KLD	Biological-RMBR	2.24 Cr
Sewage Treatment Plant at Shatabdhi Mandiram, Alissery ward	15 KLD	Biological-RMBR	0.44 Cr
Two 10 KLD Mobile Septage Treatment Units	10 KLD	Electro Coagulation	0.8 Cr

7.6 Key Learnings

Robust containment systems suitable for water-logged areas exacerbated by dense settlements are a prerequisite for safe management of sanitation. Innovative and resilient sanitation technologies for flood prone areas should be the subject of research and development.

Adequate treatment facility for septage/faecal sludge is an imperative and it is envisaged that the city is actively provisioning for treatment infrastructure and formalizing collection of septic tank waste. Dedicated treatment systems for houseboats are required.

Rejuvenation of canals through the CANALPY programme was driven by a former minister. The momentum needs to be sustained on such programmes through an 'institutional owner', ideally the Municipality.

STIFLE Lens	Alappuzha Municipality
Socio-Economic	Tourism, fisheries, coir industry and agriculture comprise the mainstay of the economy.
Technology	A DEWATS treatment system is operational to prevent discharge of faecal sludge and other waste into open areas. The construction of decentralized STPs and FSTPs worth 6.93 crore rupees is underway. Appropriate technology for toilets(containment) for this waterlogged and flood prone area remains a challenge.
Institutions	The Alappuzha Municipality is responsible for sanitation provision and septage management. The Kerala Water Authority a parastatal is mandated to provide water supply and sewerage services
Financial	Informal septic tank cleaning services are operational with Rs 3000-5000 charged per evacuation from households, other establishments and houseboats
Legal	Hon'ble Supreme court directions 22.02.2017 and NGT orders dated 3.08.2018, 19.2.2019,28.8.2019, 21.5.2020 and 20.9.2020 etc., makes sewage management mandatory for all ULBs in the country. Efforts are underway to ensure compliance.
Environment	The 'Canalpy' campaign to rejuvenate canals that crisscross the town is underway and it is envisaged that the campaign will positively impact environmental sanitation and public health outcomes

08

Thiruvananthapuram

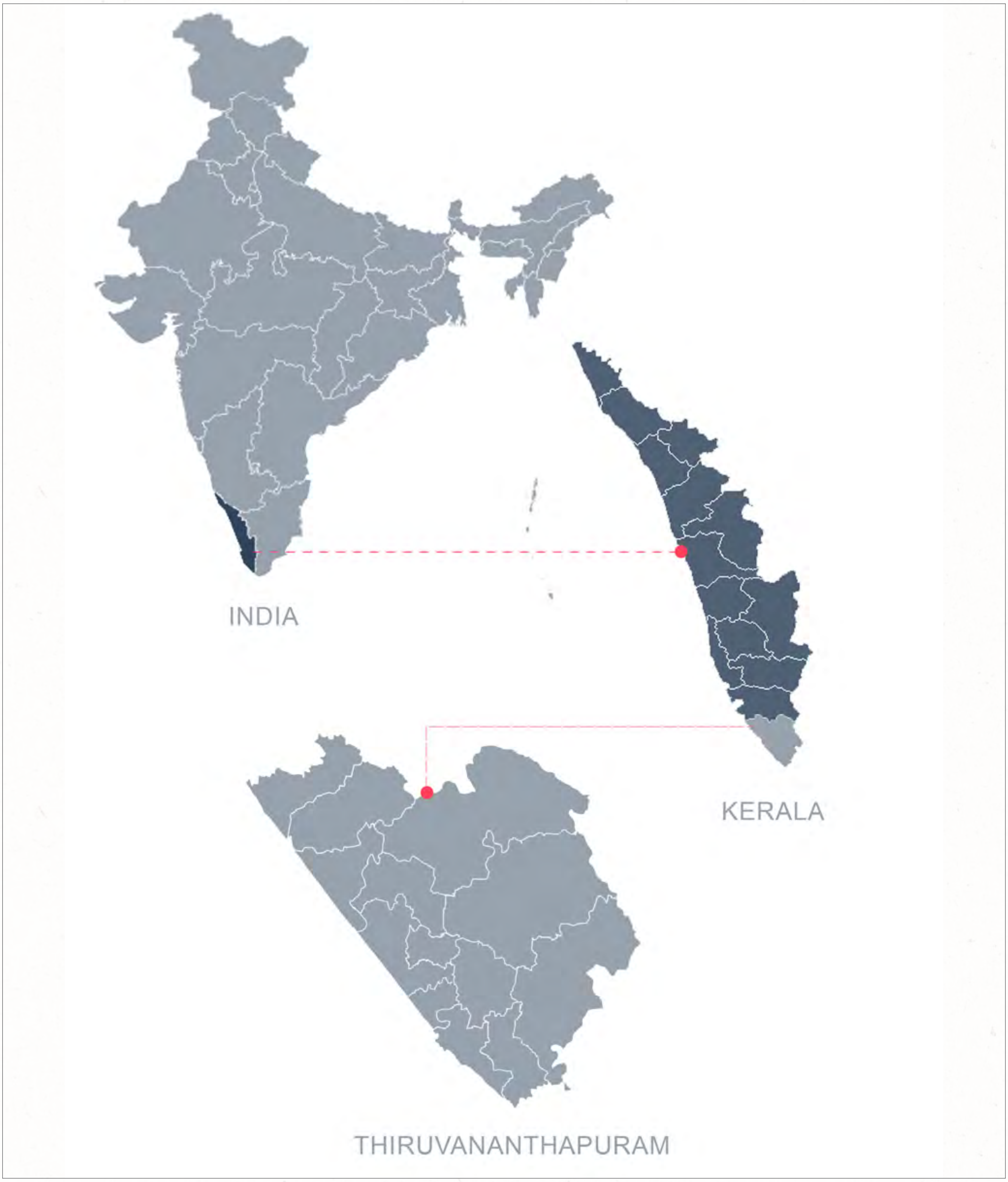
An 'Uber Model' Septage Management System

Abstract

The Thiruvananthapuram Municipal Corporation introduced its 'septage management byelaws' to regulate septage collection, treatment and disposal in 2019. Septage/faecal sludge has since been co-treated at a Sewage Treatment Plant. The septage management is akin to an 'uber model' system with the Municipal Corporation acting as the aggregator.

8.1 Physiography

Figure 8.1: Location of Thiruvananthapuram, Kerala, India



Thiruvananthapuram, the capital of the state of Kerala is a coastal city built on seven hills and is located between the Western Ghats and the Arabian sea to the west, near the southern tip of the mainland. The city is characterized by its undulating terrain and has coastal, midland and highland zones. The Karamana and Killiyar are the two major rivers.

Table 8.1: Thiruvananthapuram at a glance

	Area	214.86 sq. km.
	Population	955,494 with 3,549/sq. km
	Administration	Thiruvananthapuram Municipal Corporation with 100 wards
	Geography & Climate	A coastal city built on seven hills and located between the Western Ghats and the Arabian sea to the west
	Rainfall	Average rainfall of 2,000 mm

8.2 Socio-Economic Context

Thiruvananthapuram Municipal Corporation constituted in 1940 is the oldest Municipal Corporation and currently serves the most populous city in Kerala. The density of population in the core city area is estimated to be over 7,000/sq.km. The city is advanced in terms of human development indices, i.e., sex ratio, literacy and health. The economy is based on tourism, information technology and related services.

8.3 Water Supply

The water supply system in Thiruvananthapuram was commissioned in 1933 and comprises one of the oldest piped water supply schemes in the country. The Karamana river is the main source of piped water supply schemes via the Aruvikkara and Peppara reservoirs. The network covers around 202 sq.km. benefitting about 372,387 households and additionally provisions non-domestic/commercial/industrial uses as well. It is estimated that around 335 MLD water is supplied daily. The residents also depend on private wells and borewells for water requirements. There is a progressive slab based tariff system for water supply connections and services for various categories of users and metering is universal.

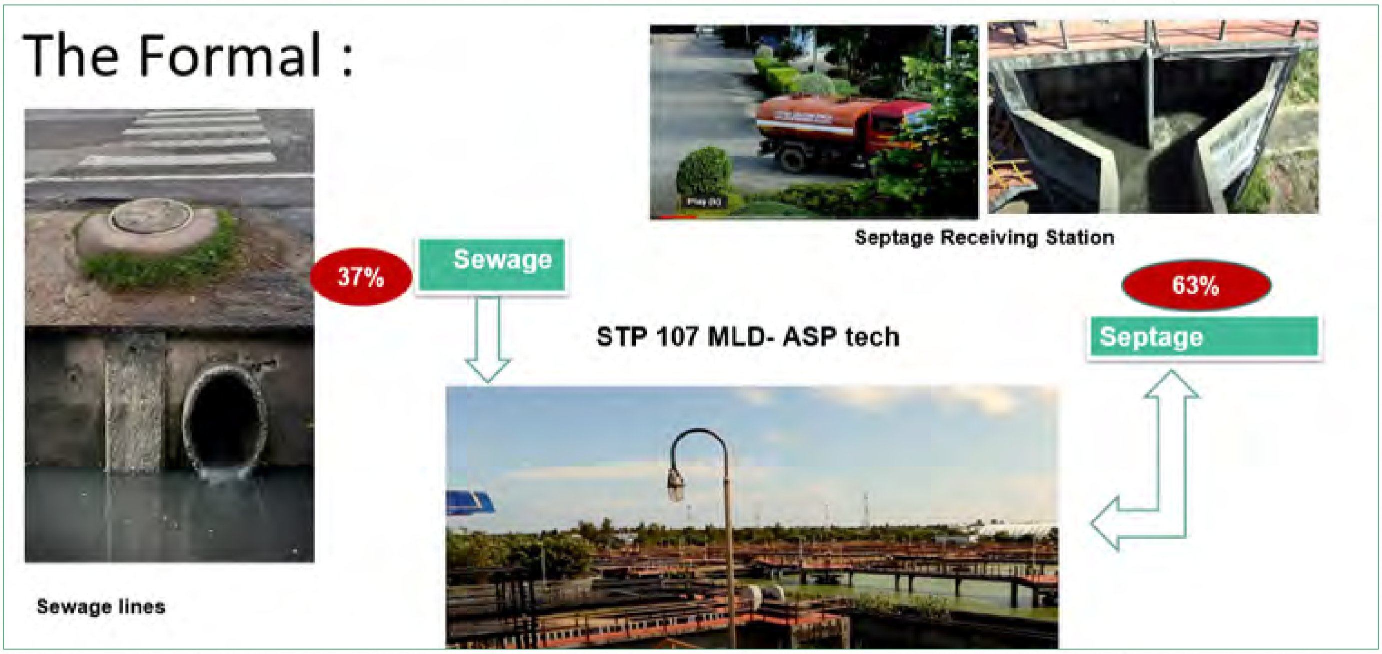
8.4 Sanitation Cycle

The Thiruvananthapuram Municipal Corporation is responsible for providing sanitation and septage/faecal sludge management services. The Kerala Water Authority, a state level agency under the Department of Water Resources, provides water supply, sewerage and wastewater treatment and disposal services. The State Sanitation Mission (Suchitwa Mission) under the Department of Local Self Government is the technical agency for sanitation, solid waste and wastewater management. The State Pollution Control Board plays the regulatory role.

While there is near universal coverage and access to toilets, it is to be noted that there is a predominance of on-site sanitation systems such as septic tanks (153,488) and leach pits. It is estimated that there are around 1,998 households that do not have a proper outlet for the toilet waste resulting in discharge into open drains (the drainage network covers only about 60% of the city) and canals. The sewerage network was first laid in 1945 covering the core areas of the city. Currently only around 37% of the city

(75 sq. km. of network) and 43 of 100 wards in the city corporation area have access to a sewerage connection. Around 10% households in the networked area have not yet been able to avail sewerage connections. Augmentation of the sewerage network was taken up with limited success under various completed and ongoing schemes like the JnNURM, KSUDP and AMRUT, the key challenges being land acquisition.

Figure 8.2: Offsite and Onsite Sanitation Facilities in Thiruvananthapuram Municipal Corporation



The sewage treatment facility with 107 MLD capacity is located at Muttathara and treats around 44 MLD of wastewater daily. It was commissioned under an ADB supported project, the Kerala Sustainable Urban Development Project, and has been functional since 2013. The remaining wastewater and FS produced from on-site sanitation infrastructure are evacuated by septage collection vehicles and co-treated with sewage at the STP. Wastewater and greywater from households and establishments is also discharged directly into open spaces/canals/drains.

8.5 Towards City Wide Sanitation - Initiatives in Focus

8.5.1 Action Plan for the Abatement of Pollution of the Karamana River

The main source of water for the city, the river Karamana, has been polluted, especially in its downstream where it is joined by Killiyar river as it passes through the city area and becomes the receptacle of FS/septage, greywater and municipal solid waste.

The Edayar Residents Association filed OA No.302/13 before the National Green Tribunal, Chennai to control the pollution of the Karamana river, the main source of water in the city. As per the order dated 15-11-2017, the Tribunal directed the Chief Secretary to hold a meeting with the stakeholders to chalk out an action plan for stopping pollution of the Karamana river.

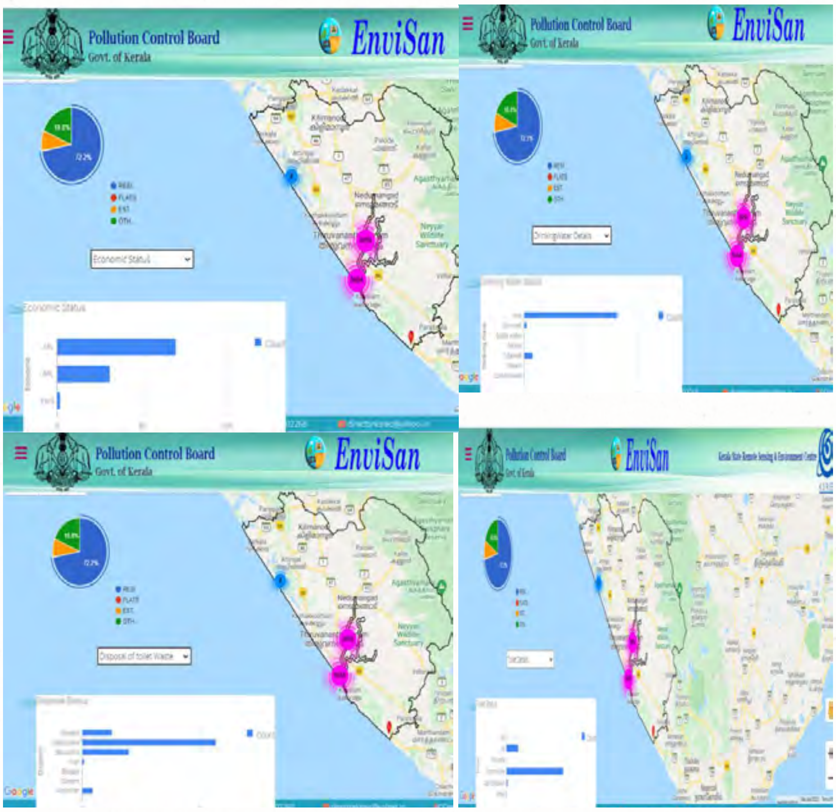
Accordingly, as a first step, the Government of Kerala requested the preparation of a concept plan jointly by the Kerala State Pollution Control Board, Irrigation Department, Kerala Water Authority and Thiruvananthapuram Municipal Corporation. It was decided to conduct a detailed sanitation survey around the river banks to determine sources of pollution and measures to abate pollution in order to restore and rejuvenate the river. The survey

Figure 8.3: The Survey Report of Abatement of Pollution of the Karamana River

was initiated by the Kerala State Pollution Control Board. The Socio-Economic Unit Foundation, an NGO was deployed to conduct the survey with the help of a mobile application 'Envisan'[26] developed by the Kerala State Remote Sensing and Environment Centre. The Central Pollution Control Board has recognized this initiative as a 'best practice in environment management.'[27]

The survey captured, photographed and uploaded the septage disposal mechanisms household-wise/ apartment-wise and geo-tagged the households that discharged septage/faecal sludge into water bodies resulting in pollution of the river. The households were segregated by BPL/APL categories, area-wise, and by the type of residence. Other institutions and commercial establishments were also surveyed and mapped. The prevalence of water and vector borne diseases was also documented. The survey results were available on a real time dashboard.

Figure 8.4: Screenshots of the Envisan Dashboard and Mobile Application



The Municipal Corporation decided that households under the BPL category with unsafe toilets would be provided with subsidies for their conversion and upgradation. APL households would be served notices requiring them to upgrade their toilet facilities per Section 340 of the Kerala Municipalities Act. Accordingly, notices were issued to such households and they were directed to build soak pits to contain the faecal sludge and leachate. Further, details of sewers and manhole locations were also collected. The availability of this information made it easier to deal with overflows and chokages. The survey resulted in the identification of over 3,000 houses and 50 commercial establishments and institutions including central and state government-run institutions which were discharging faecal sludge/ septage and other waste into water bodies. A waste management plan with a 10 crore budget was prepared to address the violations and provide facilities for safe disposal of septage and solid waste covering around 25,000 population. The plan comprised (i) short term measures like maintenance and debottlenecking of the sewerage network to enable more sewage to flow into the STPs, river quality and storm water monitoring, scientific facilities for slaughterhouse and market waste management and (ii) desilting and development, rehabilitation of 8,150 families from the banks of the river and preparation of DPR and full coverage of sewerage network.

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[26] *http://117.232.111.146/envisan/*

[27] *Restoration of Karamana river-Initiatives of Kerala State Pollution Control Board https://cpcb.nic.in/success-stories/*

However due to the COVID-19 pandemic and subsequent lockdown and elections to the Legislative Assembly the plan has not been executed as envisaged.

8.5.2 Establishing facilities for co-treatment of septage in the STP and a regulated septage management system

Based on public interest litigation, the High Court of Kerala in 2011 based on PIL WP(C) No.34496 of 2009 directed the State Government to ensure that the State/Municipal or Panchayat authorities provide space and facilities for treatment and disposal of sewage and toilet waste. The State Government was required to file a detailed report on its action plan to ensure such facilities. In response, various steps were initiated across the state including in Thiruvananthapuram city. With reference to the action plan for Thiruvananthapuram, the Government stated that the newly commissioned STP would not only treat sewage but also that it could co-treat septage collected from non-sewered areas of the city and district. Steps were taken to construct a septage receiving station in the Muttathara STP premises. The next step was to regulate the collection of septage such that illegal dumping of septage waste/faecal sludge could be prevented and septage aggregated to be treated at the STP.

The Thiruvananthapuram City Corporation with the support of the Kerala Water Authority operationalized a septage receiving station. It also sought to regulate the collection and disposal of septage/faecal sludge and promulgated septage management byelaws in 2019 for a demand based collection system and subsequent disposal. The byelaws are meant to regulate the operation of septage collection vehicles within the authority of the Thiruvananthapuram Municipal Corporation covering both individuals or agencies/enterprises involved in septage collection and realize the objectives of scientific handling of septage and prevent dumping of septage in water bodies and public places.

This following section provides a description of the septage management system, based on an IT enabled model similar to the 'Uber' and 'Ola' model with the Municipal Corporation (MC) functioning as the aggregator, as defined in the byelaws.

Functioning and Management of the Septage Receiving Station

The Kerala Water Authority is responsible for the day-to-day maintenance of the septage receiving station with the Municipal Corporation facilitating the collection system and covering the expenditure on maintenance/repairs in the septage receiving station (SRS). The SRS is equipped with basic amenities like electricity, water supply and toilets and functions from 7 a.m. to 7 p.m. daily. The SRS has appropriate signage including night glow signage with the contact information of the health officer and health enforcement squads displayed prominently. The byelaws also specify that additional personnel can be allotted for septage management activities should it be required, and funds can be set apart for the purpose. The MC and the KWA are expected to deploy adequate personnel.

Figure 8.5: Septage Collection Vehicle Operators at the Septage Receiving Station

Licensing procedures for septage collection vehicle

Application for septage collection vehicle licence are routed through the Health Officer and Charge Officer. Each application is processed within 30 days. Within 7 days of approval, the applicant receives a notification of approval. Upon remittance of the license fee, a licence and a sticker are issued within 7 days of fee receipt. The license is provided for a one year period. The fee rate is specified as follows:

Table 8.2: License Fee for Registration of SCVs

Vehicle Type (Capacity of the Tank in Litres)	Fee (Rs)	Late Fee before expiry of licence (Rs)	Late Fee after expiry of license (Rs)
5000	2500	1000	50
50001-7500	3500	1500	75
>7500	5000	2000	100

Currently there are around 30 empanelled SCVs. They make an average of 50-60 trips a day. The licensees are organized and registered as the 'All Kerala Septic Tank Cleaners Owners and Workers Association.'

Terms of License

The vehicles should be colour coded and painted brown with 'Septage Collection vehicle' to be painted in white lettering on either side of the tank. License number and contact information for the health enforcement squad is to be painted in fluorescent white at the back of the vehicle. The SCV (septage collection vehicle) should be equipped with GPS facilities which are then connected to the call centre network. User fee will be collected online by the MC and licensee is not expected to have any monetary transactions with the customer. The licensee's share of the user fee is transferred monthly to their bank account based on the recommendation of the Charge Officer. SCV operators/workers are expected to wear a blue uniform as prescribed. The Licensee is to ensure personal protection equipment for the workers. Violation of terms can result in a fine of Rs. 10,000 and/or cancellation of license. Action is taken against unlicensed vehicles involved in the collection and disposal of sewage/septage waste and fines can range from Rs. 25,000-50,000.

User Fee

Users' Fees are collected per the tariff structure in Table 8.3 A share of the user fee is allocated to the MC for the maintenance of the SRS.

Table 8.3: User Fee for Septage Collection Services

Vehicle Type (Capacity of the Tank in Litres)	User Fee	SRS Service charge	Amount to be paid to the Licensee
5000	3000	750	2250
50001-7500	4000	1000	3000
>7500	6000	1500	4500

Request for cancellation will cost the customer Rs 1000. Of this 750 will be paid to the licensee and 250 to the MC. The customer/user is to make appropriate arrangements for electricity connection to operate the motor. For bulk generators requiring daily collection Rs 3000 is charged per trip.

Web Application

Users/customers will be registered via the application and service requests and user fees are also accepted and updated only in the online application. The service requests/bookings are processed at the call centre via the application and allotted to the licensee prioritized on location. The application tracks and updates collection of septage and its disposal at the SRS. Any complaint or grievance is also resolved by the call centre. The application comprises the following modules:

Table 8.4: Modules in the Web Based Application

<table>
<tr><td>Septage Dashboard</td><td rowspan="11">Septage Master Data Sub Module
• Checklist management
• Vehicle capacity group
• Dynamic settings
• Feedback capacity management
• Time slot management
• Hose length management
• Template Management
• Status Transition Control
• Booking Type</td></tr>
<tr><td>Booking Management</td></tr>
<tr><td>GPS Management</td></tr>
<tr><td>Vehicle Empanelment</td></tr>
<tr><td>License Renewal</td></tr>
<tr><td>Designation Hierarchy</td></tr>
<tr><td>Septage Reports</td></tr>
<tr><td>Septage Plant Operator</td></tr>
<tr><td>Septage Master Data</td></tr>
<tr><td>Payment Module</td></tr>
<tr><td>Septage Call Centre</td></tr>
</table>

8.5.3 Decentralized Treatment Facility

The State is also committed to the need for decentralized treatment plants to bridge the gap. Accordingly, a 5 MLD STP has been commissioned in the Medical College area under the AMRUT scheme, in addition to the existing STP.

8.5.4 Reuse and Recovery Potential

In compliance with the directions of the NGT in the matter of OA no. 148 of 2015 titled Mahesh Chander Saxena Vs South Delhi Municipal Corporation, all the States/UTs have prepared action plans on utilization of treated sewage. The State of Kerala has yet to prepare its larger plan however the State Annual Action Plan for AMRUT has stated that while power generation is not feasible due to the type of processing technology used, the (i) dried sludge is used as manure for gardening purposes at STP campus and (ii) the treated water of 42 MLD, of which 3% is used for irrigation purposes in the STP campus. Further it is planned to sell around 5% of treated effluent to the adjoining former sewage farm under the dairy department.

8.6 Key Learnings

The adverse environmental impact of faecal sludge/sewage being dumped in water bodies has been mitigated to a considerable extent due to the initiatives taken by the MC and state level agencies.

Simultaneously, steps are being taken to expand the sewerage network and the septage collection services. The STP facilities are subsidized by the Government. Further, the Kerala Water Authority receives a sewage cess as a one-time connection fee to the sewerage network. However, there is no tariff on sewerage. The MC is to bear the cost of gap funding operation and maintenance at the STP and the SRS.

With reference to the sophisticated and IT enabled 'Uber' model, septage treatment services operate on a user-fee sharing model between the MC and the licensee. Currently around 30 licensees operate septage collection services. Any increase in numbers of licensees means an erosion of profit margins as the users/customers are fairly static. Expansion of septage collection services outside the city limits may be a useful step both for environment health and economic feasibility.

From the citizen perspective, the user fees for septage collection services are fairly steep for those who have on-site sanitation facilities. However, those who are connected to sewerage are residents of the more affluent core city area who do not pay any fee at all. These two models exacerbate existing inequities. They represent two ends of a spectrum and need to be rationalized.

Currently the reuse and recovery of resources from water and wastewater/faecal sludge/septage is yet to receive priority.

STIFLE Lens	Thiruvananthapuram Municipal Corporation
Socio-Economic	The city is advanced in terms of human development indices i.e., sex ratio, literacy and health. The economy is based on tourism, Information Technology and related services.
Technology	Co-treatment of septage/faecal sludge is carried out at the STP which has a 106 MLD capacity. Septage receiving station in the premises decant the faecal sludge waste from where it is conveyed and treated at the STP. An IT enabled septage collection system has been instituted to enable this process.
Institutions	The Thiruvananthapuram Municipal Corporation provides sanitation and septage management services. The Kerala Water Authority, a parastatal is mandated to construct operate and maintain water supply and sewerage services
Financial	The septage collection system operates on a user fee model shared between the licensee of the septage collection vehicle and the Thiruvananthapuram Municipal Corporation. The revenues amount to around Rs 8 crore annually for the MC which is used to maintain the Septage Receiving Station.

09

Chennai

Energy Recovery and Use in Wastewater Treatment

Abstract

The Greater Chennai Municipal Corporation has initiated a series of wastewater reuse and recovery measures like co-treatment of septage, energy recovery from STPs, ecological, industrial reuse and tertiary treatment of wastewater.

9.1 Physiography

Figure 9.1: Location of Chennai, India

Chennai is located on the southeastern coast of India and is bounded on the east by the Bay of Bengal and on the remaining three sides by Kanchipuram, Chenglepet, and Thiruvallur Districts. It stretches nearly 25.6 km along the Bay of Bengal – Coromandel Coast. The topography of the region is a flat coastal plain and is a low-lying area with an average elevation of 6.7m. Most of the localities are at sea level and therefore drainage in such areas remains a serious problem.

Chennai has a tropical wet and dry climate. The average annual rainfall of the city is 1400 mm. Sometimes cyclones in the Bay of Bengal hit the region. Chennai is dependent on the monsoon which fills the water reservoirs.

There are three main rivers flowing in Chennai. The first one is the Cooum River which runs through the center of the CMA and the second one is the Adyar River which flows in the southern part of the CMA region. The third and most important river in terms of both its domestic and non-domestic use is known as the Kosasthalaiyar River, which flows in the northern part of the region. An 8 km long stretch of Buckingham Canal which runs parallel to the coastline links Cooum and Adyar rivers and is the main channel carrying wastewater of the city. These two rivers Adyar and Cooum which are found in the city are heavily polluted due to the discharge of untreated waste from unauthorized sewage discharges and solid waste dumping from domestic, commercial, and industrial areas.

Table 9.1: Chennai at a glance

Area	426 sq.km
Population	6.73million
Administration	Greater Chennai Corporation (GCC)
Geography & Climate	Topography: Flat and Humidity: 65-80%
Rainfall	1400mm

9.2 Socio-Economic condition - Industrial growth

CMA and Chennai city have been among the fastest-growing regions in industrial development. The manufacturing sector has been the front runner in CMA's industrial growth, with a large contribution to employment. In the recent past, Chennai has witnessed massive infrastructure development which has resulted in an industrial sector boom, especially medium and large scale industries in the peripheral areas and extended Chennai Metropolitan Region. Major industries in CMA are automobile and transport equipment manufacture and their ancillary industries, railway coach building, shipbuilding, petrochemicals and fertilizers, automotive tyres, bicycles, electrical and other machinery, and leather products.

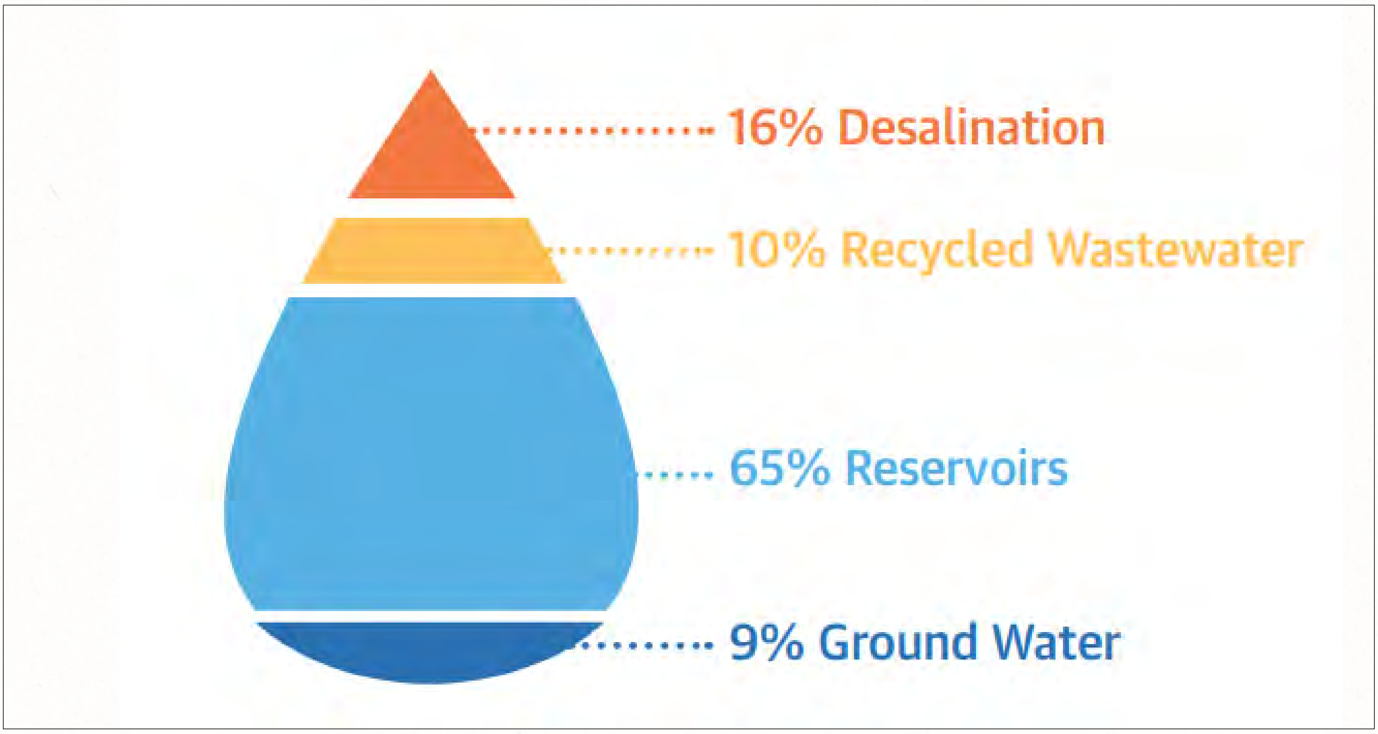
As of today, the industries in CMA receive water from both surface and groundwater sources. To reduce the municipal freshwater supply to these industries, sewage treatment plants have been planned in the CMA which shall work on reverse osmosis treatment methods. By this method, sewage that is usually let into the city's river after secondary treatment will now be diverted to new tertiary treatment plants, which makes the water fit enough for industrial use.

9.3 Water Supply

Table 9.2: Water supply details

Sources of water supply	River water, groundwater and DESAL water
Distant water sources	• Krishna water from Somasheela river in Andhra: 12 TMC • Veeranam: 180 MLD (285kms away)
Surface water	5 lakes: 12.5 TMC (depending on the monsoon)
Groundwater (Borewell water)	100 MLD (supplied during water scarcity)
Desal Plants	• Two Desalination plants at Minjur and Nemmeli, each 100 MLD capacity • There is a proposal for a 150 MLD DESAL plant at Nemmeli and another 400 MLD at Perur is in the DPR stage. CMWSSB targets to supply 750 MLD of DESAL water by 2025[1].
Water Treatment Plants	• 5 Water Treatment Plants (WTP) • Total combined treating capacity of 1294 MLD. Currently, 830 MLD of water is supplied to the Citizens at 135 LPCD.

Figure 9.2: Water supply from various sources



Source: CMWSSB

Figure 9.3: Desalination plants

Source: CMWSSB

Chennai city's water supply and sewerage is handled by CMWSS Board. Chennai drinking water requirement is dependent on monsoons. During the 2017 drought, CMWSSB has taken up the initiative of using an abandoned quarry as a drinking water storing unit28. After the success of this pilot quarry, 22 queries are used to store drinking water requirements. The quarries have a total capacity of 1500 million cft of drinking water. These quarries are at a distance of about 45 kms from the city and combined storage is about 0.5 TMC of water.

Chennai's water supplies are dependent on the monsoon, hence failure of monsoon results in curtailed supplies. Due to limited supplies, the scarce resources are unevenly distributed raising the inequality in access to water. To tackle this CMWSSB's 2050 Master Plan has proposed augmentation of water supply. The funds for this are leveraged from internal finances, Government of India funds, and external funds.

9.4 Sanitation Cycle

9.4.1 Conveyance

Chennai city had 100% sewage connectivity in the core areas in the year 2010. The city expanded in the year 2010 when 42 new ULBs were added to the city which reduced the percentage of sewage connection. Thus, Greater Chennai has partial underground sewer networks and the remaining are having onsite Septic Tank arrangements.

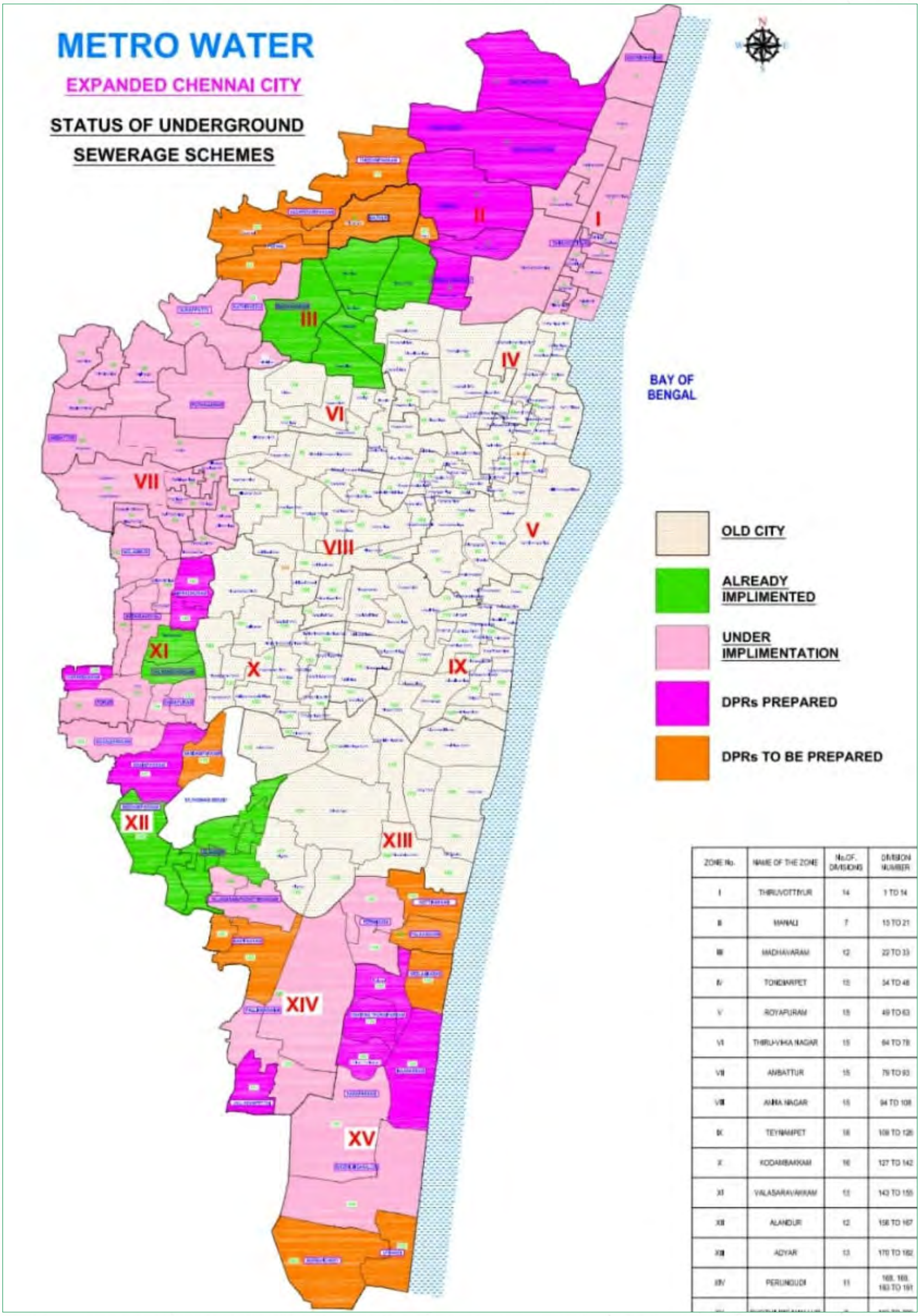
The current status of sewerage system in added 42 ULB s in GCC are:

- Already existing sewer network: 2 ULBs.
- Woks under execution: 16 ULBs.

[28] *file:///C:/Users/ADMIN/Downloads/Nemmeli-Desal%20(3).pdf*

- DPR proposals in planning & design: 24 ULBs.
- According to CMWSSB, at present, 5.32 lakh households have sewer connections (50% according to 2015-16 SLB data) The plans for implementations of the sewerage systems to all added ULBs are contemplated in CMWSSB 2050 Master Plan.

Figure 9.4: Chennai city's sewer network map[29]



[29] *https://chennaimetrowater.tn.gov.in/pdf/NEW-CITY-UGSS.pdf*

9.4.2 Treatment:

Currently there are 12 Sewage Treatment Plants in the city located in 5 zones. The STPs were commissioned from 1991 onwards with the funding from Chennai City River Conservation Project (CCRCP). The STPs are located at Kodungaiyur, Koyambedu, Nesapakkam and Perungudi and Alandur. The installed capacity of STPs is 727MLD and the operating capacity is 530MLD.[30]

Figure 9.5: Koyambedu Sewage Treatment Plant

In addition to 12 STPs, two new STPs at Sholinganallur (72MLD) and Thiruvottriyur (31MLD) are operating from 2021 and 2019 respectively.

Table 9.3: STP details, Chennai

Location	Capacity (MLD)	Technology*
Existing STPs		
Kodungaiyur	270	Activated Sludge Process (ASP)
Koyambedu	214	ASP
Nesapakkam	117	ASP
Perungudi	126	ASP
New STPs		
Sholinganallur	72	Sequential Batch Reactor (SBR)
Thiruvottriyur	31	ASP

30 *https://chennaimetrowater.tn.gov.in/seweragesystem.html*

9.4.3 Resource recovery and reuse

CMWSSB is emphasizing the re-use of treated wastewater since the 1980s. The 12 STPs generate about 530MLD of treated wastewater. Out of which 146MLD (27%) is being reused. The remaining 384MLD of treated wastewater is released into Chennai waterways (the channels reaching the sea) following CPCB norms.

Reuse of secondary treated wastewater for non-potable use to industries:
From the year 1993 onwards, CMWSSB has been selling treated wastewater to industries:

- 36MLD of secondary treated wastewater is sold for non-potable use to Chennai Petrochemical Corporation (23 MLD), Madras Fertilizer (11.5 MLD) and Manali Petrochemicals (1.5 MLD) at the rate of Rs.8.75/KL. This generates revenue of Rs.10 crores annually.

- Further, 3 lakh litres per day of secondary treated sewage is supplied to the Chennai Municipal Corporation for watering of plants and lawns at public parks and traffic islands, at no cost.

Generation of biogas:
Chennai is the first Indian city to initiate biogas power generation as early as 2005. The 7 STPs in 4 locations are generating power using the methane content of the biogas and are self-supporting without any need for additional power from the electricity grid. The total power generated is 134,534 KWH which has resulted in the cost saving of Rs 61.84 crores on energy. Thus, biogas generation has become a sustainable solution to confront the ever-rising energy costs and to combat the environmentally damaging greenhouse gases.

Table 9.4: STPs generating biogas (Source: CMWSSB)[31]

Location of STP	Capacity (MLD)	Capacity Of Gas Engine (KW)	Power production per month (KWh)	Cost savings / month @ Rs.3.50 / KWh
Kodungaiyur (Zone - I&II)	110	1064	4,50,000	15.75 Lakhs
Koyambedu (Zone - III)	60	625	2,25,000	7.90 Lakhs
Nesapakkam (Zone – IV)	40	469	1,50,000	5.25 Lakhs
Perungudi (Zone – V)	54	1064	3,60,000	12.60 Lakhs
Total	**264**	**3222**	**11,85,000**	**41.50 Lakhs**

Tertiary treatment of reverse osmosis plants wastewater for non-potable use to industries:
To meet the non-potable water demands of the development of Special Economic Zones (SEZ) and expansion of industries around Chennai and to control the groundwater exploitation/ depletions, need for installing two Tertiary Treatment Reverse Osmosis plants (TTROs) from the existing STPs arose in

[31] *https://chennaimetrowater.tn.gov.in/pdf/stp.pdf*

the late 2010s. Accordingly, two such plants of 45 MLD capacity each at Kodungaiyur and Koyambedu were constructed and commissioned in 2019-20. The plants have a combined feed capacity of 127MLD and the have the efficiency to produce 90MLD per day of water from secondary sewage treatment plants.32 The tertiary treated water is of potable quality and is distributed to industries for non-potable purposes. This initiative is helping to decrease the burden on groundwater.

Figure 9.6: 45 MLD tertiary Treatment Reverse Osmosis Plant

Reusing tertiary treated wastewater for recharging of lakes and indirect use:

To do this it is required to construct tertiary treatment wastewater plants to produce water that is of reusable quality. Tertiary treatment includes additional nutrient removal, UF membrane filtration, and ozone disinfection to get the water to the required quality. A detailed study based on the STP at IIT Madras was presented for consideration to the special initiatives water group constituted by the Government of Tamil Nadu. After careful consideration, the Government issued an approval in 2018 for two proposals of each 10 MLD capacity for recycling and recharge of tertiary treated water with ultra- filtration (TTUF) from the Nesapakkam STP and Perungudi STP to fill Porur and Perungudi lakes, and the works are in progress, expected to be commissioned at the end of 2021. The plants are expected to operate by early 2022. The aim of this project is to have groundwater recharge (which in turn revives a lake ecosystem) as well as surface water augmentations and to set up Water Treatment Plants next to the lakes and integrate the water into the city's drinking water supply. CMWSSB's vision through TTUF plants is to reduce the dependency on DESAL water and groundwater and to create a circular economy of resource transfers.

Figure 9.7: The Nesapakkam Plant to treat 10 MLD of wastewater

32 *file:///C:/Users/ADMIN/Downloads/Chennai%20 MWSSB%20 Innovation%20State.pdf*

9.5 Septage management

Chennai city is not fully covered with sewer lines. Households in the non-core area still contain FS/ septage in septic tanks. Desludging operators are engaged in emptying the septic tanks. CMWSSB has provided a decanting facility in the STPs to desludging operators formally.

Presently, Chennai Metropolitan city has four sewer lorry decanting stations at Kodungaiyur, Koyambedu, Nesapakkam and Perungudi STPs. This is envisioned to end the practice of unauthorized dumping of septage into the city's waterways. Clusters have been identified and grouped in such a way that all focal collection points are situated approximately at a radius of 18 to 20 km from the designated Sewage Treatment Plants (STP). Private owned desludging operators are provided a one-time registration license by the CMWSSB and collection of registration fee is Rs. 2000 per truck and the decanting fee is Rs. 100 per truck per trip.

Figure 9.8: Decanting facility at the STPs

Chennai city is managing its FS/septage formally by providing licenses to the desludging operators. Yet there are desludging operators who engage in illegal operations who function without license and dump the FS/septage in open fields, rivers and in the sea.

9.6 Key Learnings

Water scarcity has driven Chennai to move towards sustainable water management practices. Chennai has created a circular economy in managing its wastewater and septage/FS. Following are the best practices from Chennai:

- Green energy initiative: Chennai was the first Indian city to generate biogas from the STPs and in turn use the power to run the plant.
- Industrial reuse of treated wastewater: Chennai is meeting rising industrial water demand through its secondary treated wastewater. The plans of treating wastewater to tertiary level with RO (TTRO) will further meet the industrial water demand. This reduces the dependency on groundwater and also generates revenue to CMWSSB.
- Co-treatment: Co-treatment of septage/FS in the STPs optimizes use of treatment infrastructure and reduces the dumping of septage/FS in water bodies and thus helps in reducing pollution.
- Integrated Urban Water Management: Chennai city's plan of recharging the groundwater by filling up of lakes in the city with treated WW (TTUF) will revive the lake ecosystems. The plan of setting up of Tertiary Treated Ultra Filtration (TTUF) Plants and water treatment plants and extracting groundwater (from indirect recharge) and incorporating it into the city's water supply is the first of its kind in the country. This is aimed to reduce the dependency on desal water and to have secured water supply during monsoon failure. This also shows how lakes act as buffer systems in this sustainable source augmentation and in creating a circular economy.

STIFLE Lens	Greater Chennai Municipal Corporation
Socio-Economic	Major industries in CMA are Automobile and Transport Equipment Manufacture and their ancillary industries, Railway Coach Building, Shipbuilding, Petro Chemicals and Fertilizers, Automotive Tyres, Bicycles, electrical and other machinery, and leather products.
Technology	CMWSSB has provided 100% sewer lines to the core area of the city. There are 12 Sewage Treatment Plants in the city, currently generating 530 MLD of treated wastewater. Out of which, 146 MLD of treated wastewater is reused for energy recovery and also sold to industries. There are ambitious projects of treating the wastewater to tertiary level with RO and ultrafiltration to sell to industries and to recharge the lakes and for potable purposes. Desal water is also available.
Institutions	The Greater Chennai Municipal Corporation is responsible for sanitation and septage management services and the Chennai Metropolitan Water Supply and Sewerage Board operates water supply and sewerage infrastructure and services.
Financial	Treated Wastewater is a good revenue source for the CMWSSB. Biogas powered STPs enable carbon Trading. CMWSS Board has adopted Clean Development Mechanism (CDM) which leads to savings in energy cost to the tune of Rs.45.46 lakhs per month.
Legal	The annual policy note defines the agenda and sets priorities for sectors.
Environment	An integrated urban water management approach is taken. Biogas generation in all the STPs is first of its kind in the country which supplies power to run the STPs. A chronic challenges it to prevent sewage outfalls into River Adyar, River Cooum and Buckingham canal and their associated drains through short term interception and diversion arrangements. The CMWSSB is currently preparing a city aquifer management plan

10.
Gestalt Learning

10.1 Summary of city-wise service levels, institutional arrangements, key stakeholders, sanitation service chain for each city and key initiatives

Table 10.1: Overview of Service Levels

City	Water Supply Coverage	Toilet Coverage	Sewerage Connections
Rajkot MC	98%	100%	60%
Unjha M	86%	100%	51%
Dhanbad MC	12%	100%	--
BBMP	72%	100%	72%
Devanahalli TMC	80%	50%	--
Tumakuru CMC	76%	95%	65%
Alappuzha M	85%	100%	--
Thiruvananthapuram MC	78%	99.50%	37%
Greater Chennai MC	84%	95%	50%

Source: SLB data 2016-17

Table 10.2: Overview of Wastewater and Faecal Sludge Treatment and Reuse

City	Wastewater Treatment	Faecal Sludge Treatment	Co-Treatment	Formal WW and FS Reuse	Informal WW and FS Reuse*
Rajkot MC	Yes	No	No	Yes	Yes
Unjha M	Yes	No	No	Yes	Yes
Dhanbad MC	No	No	No	No	Yes
BBMP	Yes	No	Yes	Yes	Yes
Devanahalli TMC	No	Yes	No	Yes	Yes
Tumakuru CMC	Yes	No	No	Yes	Yes
Alappuzha M	No	No	No	No	No
Thiruvananthapuram MC	Yes	No	Yes	No	No
Greater Chennai MC	Yes	No	Yes	Yes	No

Six cities namely, Rajkot, Bengaluru, Tumakuru, Thiruvananthapuram, Chennai and Unjha have a formal wastewater treatment system

Table 10.3: Government and Other Institutions - City Wise

City Government	Key Institutions and Role-Government	Key Institutions-Others
Rajkot MC	• Rajkot Municipal Corporation • Rajkot Urban Development Authority • Gujarat Water Supply & Sewerage Board • Dept of Urban Development and Housing • State Pollution Control Board	• Farmer cooperatives • Industries • Private cesspool operators
Unjha Municipality	• Unjha Municipality • Gujarat Water Supply & Sewerage Board • Dept of Urban Development and Housing • State Pollution Control Board	• Farmers • Contractors • Private cesspool operators
Dhanbad MC	• Dhanbad Municipal Corporation • Jharkhand Mineral Development Authority • Drinking Water and Sanitation Department • Urban Development and Housing Department • State Pollution Control Board	• Farmers • Private cesspool operators
BBMP- Bruhat Bengaluru Nagara Palike	• Bruhat Bengaluru Mahanagara Palike • Bengaluru Water Supply Sewerage and Drainage Board • Urban Development Department • Bengaluru Development Authority • Department of Irrigation • State Pollution Control Board	• Corporates • Civil Society Organizations • Residents' Welfare Associations • Plot Owners' Associations • Desludging Operators • Farmers • Industries
Devanahalli TMC	• Devanahalli Town Municipal Council • Karnataka Urban Water Supply Sewerage and Drainage Board • Urban Development Department • State Pollution Control Board	• NGOs • Farmers • Desludging Operators
Tumakuru CMC	• Tumakuru City Municipal Corporation • Karnataka Urban Water Supply Sewerage and Drainage Board • Urban Development Department • State Pollution Control Board	• Farmers • Desludging Operators • NGOs
Alappuzha M	• Alappuzha Municipality • Dept of LSGD and Sanitation Mission • Kerala Water Authority • District Tourism Promotion Council • State Pollution Control Board	• Association of Septic Tank Cleaners, Alappuzha • Academic and Technical Institutes • Houseboat Operators

Thiruvananthapuram MC	• Thiruvananthapuram Municipal Corporation • Dept of LSGD and Sanitation Mission • Kerala Water Authority • District Tourism Promotion Council • State Pollution Control Board	• All Kerala Septic Tank Cleaners Owners and Workers Association • • Technology provider for Call Centre and Web App
Greater Chennai MC	• Greater Chennai Municipal Corporation • Chennai Metropolitan Water Supply and Sewerage Board	• Private Cesspool Operators • Residents Welfare Associations • Civil Society Organizations

10.2 Drivers in the Practice of Sustainable Urban Sanitation

It can be seen that the diverse practices and approaches to wastewater and faecal sludge management and the trajectory of sanitation service provision in the cities under study are driven by a range of factors.

In Rajkot and Unjha, the prevalence of farming and water requirements for both potable and irrigation purposes in a semi-arid area have given rise to a unique arrangement between authorities and user groups. This is also true for the cities of Tumakuru and Devanahalli where despite the prevalence of formal treatment systems for wastewater and/or faecal sludge, there is considerable demand for untreated wastewater and faecal sludge mostly by informal users.

Informal use of treated wastewater in Dhanbad for water chestnut farming is tied to cultural practices and demand for them in the festival season. Proposed commitments for wastewater treatment have been jump started due to legal and regulatory requirements, directed by the NGT and the Supreme Court.

Centrally sponsored schemes have given a fillip to wastewater and faecal sludge treatment initiatives in Thiruvananthapuram and Alappuzha in the absence of any local/state level programme and schemes. Further, judicial interventions have accelerated the pace of interventions that have had positive impacts in a limited area. Further, in Alappuzha, the need to sustain backwater tourism has motivated the city to undertake the cleaning of its canal network and this has become the entry point for city wide sanitation interventions led by a Former Minister, who mobilized R&D and academic institutes to provide a solution to its peculiar sanitation challenges due to its high water table, coastal erosion and ecological fragility. The devastating impact of the floods of 2018 proved the flashpoint to galvanize the ‘Canalpy’ campaign.

Chennai metropolis showcases a range of initiatives focused on the reuse and recovery of resources from wastewater and faecal sludge and arises from the water scarcity problem plaguing the area. Energy recovery from STPs, co-treatment of septage with sewage, desal plants, rainwater harvesting system, initiatives to fill lakes with treated wastewater and tertiary treatment for potable water all represent an integrated urban water management approach, even as long-standing threats to water bodies like the Cooum river and Buckingham canal remain.

Bengaluru, which supplies the largest transfer of treated wastewater to the adjoining towns and the hinterland also had a ‘change champion’, an elected leader with a commitment to find solutions for the water scarce areas in his constituency and its surroundings. The KC Valley project implemented by the Minor Irrigation Department helps convey treated wastewater that the city is unable to process to the water starved hinterlands resulting in recharging and rejuvenation of lakes and water bodies as well as providing sufficient quantities of water for a flourishing agricultural economy in the hinterland. The engagement of civil society organizations in the wastewater management practices in Bengaluru, corporate involvement and inter-sectoral collaboration facilitated the successful implementation of various wastewater treatment and reuse practices in the metropolis. It is also noteworthy that metropolitan cities have started to treat sewage for potable purposes indirectly.

The geography and settlement patterns, nature of containment systems, availability of water and land, financial and technical capacities, cultural attitudes towards reuse of wastewater and faecal sludge, the 'Not In My Backyard' syndrome are all influencing factors impeding or accelerating the move towards universal safe sanitation.

Formal sanitation arrangements are currently under-equipped to process and treat the wastewater and faecal sludge generated in the cities. The presence of a large informal sector, i.e., user groups of farmers, farm workers, desludging operators and their unrecognized efforts and investments to process and access wastewater, supports and complements the role of the formal system. It also results in more efficient recovery and utilization of wastewater and faecal sludge resources.

10.3 A Dialectical Approach to Understanding Urban Sanitation Interventions

Discourses around sanitation are often organized around dichotomies that compel an either/or position in assessments, analysis and solutions. There is the formal and the informal, onsite and offsite, treated and untreated, the rural-urban, private vs public and so on. In this section we re-examine such polarities in the light of the findings from the practice of sustainable urban sanitation in nine cities in India. The cities range from small and medium towns to bustling metropolises.

Informal-Formal: The sanitation system is predominantly informal/private. Private investments in toilets and septic tanks to arrangements made for reuse and recovery from wastewater and faecal sludge prevail even as formal standardized infrastructure for conveyance and treatment are provided. Rajkot as a case in point, has a formal arrangement for the swap of wastewater to obviate the use of freshwater. In addition, private and informal investments are made to dig canals and construct storage to tap wastewater for use in irrigation. Devanahalli has an FSTP that produces compost and yet there is demand for faecal sludge as a soil fertilizer. The formal and the informal co-exist and converge.

Rural-Urban: Conventionally the transactions between rural and urban areas disproportionately benefit the urban areas. However, it is also seen that the rural and the urban are mutually dependent. Bengaluru transfers its treated wastewater to the towns and the hinterland for irrigation and filling up of lakes and the hinterland provides employment for farmers and farm workers as also produces food and fodder and other essential primary produce.

Onsite solutions-Offsite solutions: All sewered cities continue to have onsite facilities or in-house facilities. This is prevalent not only in low-income areas but also in new townships/corridors. Solutions like the DEWATS, Co-treatment of faecal sludge with septage, sewage treatment in constructed wetlands, respond to this reality. Most cities and towns have a combination of on-site and off-site facilities that require imaginative combinations of solutions.

Small & Medium Towns-Metropolises: While there is greater pressure on metropolises to perform and the magnitude of technical and financial resources that metropolises have enables them to execute high investment infrastructure and reap the benefits of scale, chronic problems remain, just as they do in small and medium towns, including the pollution of water bodies and groundwater and vector borne diseases, sub-optimal basic amenities in unserved/low income/slum areas.

Centralized-Decentralized Facilities: All cities with centralized facilities continue to have blackspots and unserved areas. Neither will decentralized solutions alone suffice. Therefore, multiple solutions that are context-specific and context-sensitive need to be developed.

Rights-Business model approach: Sanitation and water supply are viewed as basic human rights. An equity perspective needs to inform all interventions in sanitation planning and implementation. Current practices often exacerbate existing inequities. The user charges for septage collection services in Thiruvananthapuram ranging between 3500-7000 INR in the unsewered areas of the city are a contrast to the lack of a sewerage tariff in the relatively more affluent sewered core areas of the city. The 'polluter pays' principle must differentiate between those belonging to different economic strata.

However, in the absence of a cost recovery/ business approach services will likely turn sub-optimal adversely affecting the urban poor.

Public-Private: The existence of the private sector is necessary for the public sector. The sanitation economy includes contractors, workers, enterprises, technology providers, users, buyers and generators.

Treated-Untreated: The "labelling" of informal application of septage and wastewater as "illegal dumping" may be reviewed in the light of the study findings. In the majority of the cities studied, such "dumping" is used gainfully following a modicum of primary treatment. It is necessary to differentiate between pollutants and resources. Stringent standards result in the "best being the enemy of good."

Innovations/Pilots-City Wide Approach: "Pilots never fail, pilots never scale." The city-wide approach is a gradual process that requires demonstrated effective solutions to be replicated and adapted. It also requires building on the strengths and influencing factors in each city while simultaneously learning from other city experiences.

A dialectical approach to recognize and factor in the transactions, coordination, co-existence and convergence of various dichotomies is fundamental to sustainable practices in urban sanitation.

10.4 Recommendations

Urban India is set for a turnaround in sanitation interventions as the policy focus shifts to achieving outcomes like ODF++, Water+ and Zero Discharge of untreated wastewater. This section provides a set of recommendations that can inform flagship programmes on Swachh Bharat Mission (Urban) 2.0 and the AMRUT 2.0 and related initiatives, while recognizing the diversity and uniqueness of each urban area and calling for adaptive solutions taking into consideration this uniqueness.

1. Socio-Economic Interventions

Integration of Informal Sector and Livelihoods in the City Sanitation Plan: Forthcoming city sanitation plans prepared as part of the Swachh Bharat Mission (Urban) guidelines should include the integration of livelihoods and be accommodative of the existing sanitation economy. Agricultural reuse of wastewater and faecal sludge supports farmers, farm workers; rejuvenation of lakes and integration of wetlands supports fisher-people. A mapping and database creation of existing reuse practices, both within and outside city administrative limits, will help develop an inclusive city-wide sanitation plan.

Rehabilitation of Sanitation Workers Engaged in Manual Scavenging: The process of identification and rehabilitation of those engaged in manual scavenging has been moving at a tardy pace. There is a need for civil society organizations to mobilize the workers and provide forms of intermediation with various state & non-state actors so they can be helped in their pathway towards rehabilitation out of this practice into more dignified forms of sanitation work or alternate work. The need for such civil society players is under-recognized in the implementation of the PEMSR 2013 Act.

2. Technical Interventions

'Fit for Purpose' standards: Technology norms and standards for the circular economy may be layered and 'fit for purpose' standards may be evolved including for aquaculture. Informal reuse and nature-based solutions may be particularly encouraged. Current standards for treated waste-water for example is a 'one size fits all' independent of the proposed reuse of the treated wastewaters. Agricultural reuse may not require Phosphate and Nitrogen stripping and may only require biological control. Recipient space of the treated wastewater such as agricultural land, wetlands or water bodies should determine its appropriate treatment standards.

Integrated Guidelines: Sanitation improvements are inextricably linked with solid waste management and storm water drainage. Therefore, integrated planning guidelines can be provided.

Clearinghouse Support: Cities will need clearinghouse support to identify and apply technological solutions, particularly with reference to new and emerging technologies and nature-based solutions.

3. Governance and Institutional Interventions

Inter-Departmental and Inter-Sectoral Coordination Mechanisms: It is important to establish formal mechanisms to enable coordination between sectors and departments for matters beyond territorial and sectoral jurisdiction. As a case in point a coordination committee comprising representatives of the BBMP, BMWSSB, Department of Minor Irrigation and the Rural Districts may be set up to review and monitor wastewater transfer activities from the city to the hinterland. Agriculture and Public Health to evolve joint solutions and to address administrative jurisdictional issues and put in place monitoring systems for areas outside jurisdiction of cities/towns.

Management of Multiple End Uses of Wastewater: A fair and equitable system of managing multiple and competing demands for wastewater should be in place. Projects on wastewater reuse should decide on the norms for allocation to further equity and reuse goals in order to manage competing demands. There is for example a potential for wastewater reuse for agricultural, ecological, urban and industrial reuse and there may be a potential conflict between each of these demands as in the case of the Jakkur lake in Bengaluru where treated wastewater currently used for ecological purpose of filling the lake is sought to be diverted to a power plant for industrial reuse.

Scale as Replication: Rather than a monolithic centralized solution, the endeavour of the sanitation plan should be to find a million solutions and a million solution finders/problem solvers" such that key stakeholders such as farmers, truck operators etc. are included in the quest to find solutions. The solutions need to be context specific and based on local conditions.

Institutionalize consultation process: Where informal use is prevalent, it is important create institutional capacities and protocol to engage with the respective stakeholders and integrate their concerns

Adaptive Management Framework: Adopting an adaptive management framework facilitates flexible decision making in an uncertain environment. In other words, it is an iterative process of 'learning by doing'.33 Drawing from Heifetz and Linsky,[34] the model can be illustrated as follows:

Kind of Challenge	Problem Definition	Solution	Locus of Work
Technical	Clear	Clear	Authorities
Technical and Adaptive	Clear	Requires Learning	Authorities and Stakeholders
Adaptive	Requires Learning	Requires Learning	Stakeholders

City governments must adopt a flexible strategy for decision making in an inclusive manner with particular reference to 'tough choices.'

4. Financial Resources and Technical Capacities

Valuation of Benefits of Resource Recovery and Reuse: Currently there are no mechanisms to capture and compute the economic and non-economic benefits of resource recovery and reuse. A framework and toolkit to capture these would be useful for project development and resource mobilization.

Database and Knowledge Management: It is recommended that a database on good practices in reuse and recovery be prepared for dissemination. A web portal / knowledge management system to learn from and exchange solutions and ideas on sustainable practices may be established. One such platform is www.urbanwaters.in

33 *https://www.doi.gov/sites/doi.gov/files/migrated/ppa/upload/Chapter1.pdf*

34 *http://www.uapa533.com/uploads/8/4/4/9/8449980/leadership_on_the_line-_staying_alive_through_the_dangers_of_leading.pdf*

5. Regulatory and Legal Interventions

Regulation: The current regulations come under the Air and Water Pollution Act with the State Pollution Control Boards as the institution responsible. A form of light regulation will need to be worked out to regulate each one of the actors in the sector from the generator of faecal sludge / wastewater to the end users such as farmers and fishers.

Risk mitigation strategy: Where informal use is predominant, measures to put risk barriers in place must be considered as part of the 'light regulation' process.

Graded Approach: Small and medium towns that require greenfield planning may be supported and capacitated to manage a graduated 'sanitation ladder' approach. [35]

Mainstreaming sanitation safety planning: These include de-risking informal practices, periodic surveillance and monitoring of water bodies, crops produced and research and development to develop resilient technology for containment, conveyance, treatment and reuse can be prioritized.

6. Environmental and Ecological Interventions

Managing the Commons: A key aspect to ecological and environmental interventions is the management of the commons. It is proposed that Elinor Ostrom's 'Eight Principles' on the Governance of the Commons' (cited below)[36] may be suitably adapted.

- Boundaries of users and resources are clear.
- Congruence between benefits and costs.
- Users had procedures for making their own rules.
- Regular monitoring of users and resource conditions.
- Graduated sanctions
- Conflict resolution mechanisms.
- Minimal recognition of rights by the government.
- Nested enterprises.

[35] *Sanitation Ladder-https://washdata.org/monitoring/sanitation*

[36] *https://www.actu-environnement.com/media/pdf/ostrom_1990.pdf*

Notes:

Notes:

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NIUA is a premier national institute for research, capacity building and dissemination of knowledge in the urban sector, including sanitation. Established in 1976, it is the apex research body for the Ministry of Housing and Urban Affairs (MoHUA), Government of India. NIUA is also the strategic partner of the MoHUA in capacity building for providing single window services to the MoHUA/ states/ULBs.

About SCBP

The Sanitation Capacity Building Platform (SCBP) is an initiative of the National Institute of Urban Affairs (NIUA) to address urban sanitation challenges in India. SCBP, supported by Bill & Melinda Gates Foundation (BMGF) is an organic and growing collaboration of credible national and international organisations, universities, training centres, resource centres, non-governmental organisations, academia, consultants and experts. SCBP supports national urban sanitation missions, states and ULBs, by developing and sourcing the best capacity building, policy guidance, technological, institutional, financial and behaviour change advise for FSSM. SCBP provides a unique opportunity for:

- Sharing and cross learning among the partner organisations, to pool in their knowledge resources on all aspects of urban sanitation capacity building;
- Developing training modules, learning and advocacy material including key messages and content, assessment reports and collating knowledge products on FSSM. Through its website (scbp.niua.org), SCBP is striving to create a resource centre on learning and advocacy materials, relevant government reports, policy documents and case studies;
- Dissemination of FSSM research, advocacy and outreach to State governments and ULBs.

Its strength is its ability to bring together partners to contribute towards developing state sanitation policy, training of trainers and training content development, technical and social assessments, training programme delivery, research and documentation.

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