THE ENERGY AND RESOURCES INSTITUTE
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Mahindra - TERI
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Sustainable Habitats

Water Sustainability Assessment of Pune

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Message

The Mahindra-TERI Centre of Excellence (MTCoE) is a joint research initiative of Mahindra Lifespace Developers Limited (MLDL) and The Energy and Resources Institute (TERI). MTCoE has been established to develop science-based solutions for India's future built environment with emphasis on enhanced occupant comfort, resource efficiency and sustainable construction. The CoE aims to create a repository of innovative materials and technologies and provide an array of strategies for achieving sustainable habitats.

Overutilization of water resources and contamination of river systems along with lack of water treatment facilities has aggravated the already existing water crisis in India. Climate change impact has led to alteration in rainfall patterns across the country, thus creating an imbalance between water demand and supply. The future of India consists of rapid urbanization and an increasing population which will excessively multiply the water demand across sectors energy, industry, domestic, irrigation etc. Hence, it is crucial to spread awareness and adopt sustainable practices to replenish and conserve water.

The Mahindra-TERI CoE is pleased to present a report on "Water Sustainability Assessment of Pune' as a part of our 3-report series for the cities of Chennai, Gurugram and Pune. This report has been prepared to help building professionals, researchers, real estate developers, policy makers, administrative agencies and end users to generate awareness on the aspects of water sustainability and provide potential solutions to overcome the challenges.

I gratefully acknowledge the support of all those associated with the development of this report and look forward to their continued guidance for its enhancement.

Sanjay Seth
Senior Director- Sustainable Habitat Programme
TERI

Preface

Literature describes urban areas as open systems with porous boundaries and highlights the importance of a systems perspective for understanding ecological sustainability of human settlement. Similarly, a socio-ecological framework helps us to understand the nexus between social equity, environmental sustainability, and economic efficiency. India is urbanizing rapidly with characteristic inequality and conflicts across the social, economic, and locational axes. Following the global pattern, Indian cities use social and natural resources of the rural hinterland and their own resources for survival and growth and, in the process, generate large amount of waste. Water is the most important 'resource flow' in an urban area, driven by a complex set of intersecting socio-economic, political, infrastructural, hydrological, and other factors. These drivers vary a great deal within a city and have a significant impact on the water flow and management and require both micro and macro-level study in order to address it.

In order to enhance the water flow and management in cities, a water sustainability assessment of Chennai, Gurugram, and Pune cities was conducted. The aim was to undertake an assessment of potential risks associated with the water sources and demand & supply at city level and provide recommendations to combat those risks. This report shows the analysis of Pune and Pimpri Chinchwad cities.

Approach

A number of studies have been conducted w.r.t. urban water management across the country. Most of these studies focus on certain aspects of water like stormwater management, wastewater treatment systems, water supply systems, etc. But, in these studies planning for water is oversimplified by governments by conducting assessment in isolated entities. Therefore, drifting from the age-old approach, this report has taken the approach that considers 'One Water', which basically defies the segregation of water in various categories like stormwater, wastewater, etc. Secondly, the approach and the methodology followed for the study is the metabolic approach. It is an emerging field and there have been a number of international studies being carried out since the year 2013. To our assessment, this type of metabolism approach towards water assessment is a new one, which to our understanding has not been attempted yet. Therefore, it makes this water sustainability report different from the existing ones. Also, the past and existing data on water management has been studied, based on which projections for the year 2025 on potential risks has been computed. This has been followed by recommendations for combating these risks for 2025.

Audience

Given the issue of water scarcity, which is being faced in the recent years, and also the growing realization that citizens have to contribute for the efforts towards achieving water sustainability, it is expected that this assessment report will not only help the urban planners but also every stakeholder who is involved with water sector including citizens to have an understanding of the present and the future challenges and means by which these challenges could be addressed. As this study involves the metabolism approach which provides disaggregated understanding about areas where water could be secured without creating negative hydrological footprint to the surrounding regions, it is expected that the output of this approach will help in informing about: (a) the new sources of water, (b) the amount of water that goes out of the system unutilized, which could help in addressing the inefficiency in per capita water storage and availability, (c) the seasonal problems such as flooding and inefficient stormwater management and the required balance for an equitable water distribution over time, (d) the water-related infrastructure, (e) and the water recycling potential.

Challenges

It has to be mentioned at this juncture that data gathering for this report was a challenging exercise. Therefore, the data elements have been fed into the model to calculate the output metrics/ indicators by extrapolations from the available historical data. In this context, the researchers have succeeded in tiding over the obstacles to data access.

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Abbreviations

PMC	Pune Municipal Corporation
PCMC	Pimpri Chinchwad Municipal Corporation
PMRDA	Pune Metropolitan Region Development Authority
PMR	Pune Metropolitan Region
MCM	Million Cubic Metres
GDP	Gross Domestic Product
IT	Information Technology
ITES	Information Technology Enabled Services
BPO	Business Process Outsourcing
MoWR	Ministry of Water Resources
CWC	Central Water Commission
CGWB	Central Ground Water Board
CPCB	Central Pollution Control Board
SPCB	State Pollution Control Board
MoEFCC	Ministry of Environment, Forest and Climate Change
MWRRA	Maharashtra Water Resources Regulatory Authority
MIDC	Maharashtra Industrial Development Corporation
ULB	Urban Local Body
RWH	Rainwater Harvesting
GSDA	Groundwater Survey and Development Agency
GMDA	Groundwater Management and Development Act
GHG	Greenhouse Gas
STP	Sewage Treatment Plant
CETP	Common Effluent Treatment Plant
WTP	Water Treatment Plant
MLD	Million Litres per Day
NRW	Non Revenue Water
lpcd	Litres per Capita per Day
IUWM	Integrated Urban Water Management
KPI	Key Performance Indicator
ICT	Information and Communications Technology
AMC	Annual Maintenance Contract
CPHEEO	Central Public Health and Environmental Engineering Organisation
RWA	Resident Welfare Association

1. INTRODUCTION

This report presents a study of metabolic flow of water within urban system of Pune city for water planning and illustrates the nexus between various urban goals. The central objectives of the study are: (a) to account for inflows and outflows of water (including wastewater) and to construct a well-defined water mass balance; (b) to illustrate how the metabolic flow of water is shaped by economic, policy-related, social, and other variables and how it alters the background water hydrology of city region; and (c) to demonstrate the spatial diversity and variation among the drivers.

Chapter I: City Growth and Environment focuses on the geographic characteristics, city growth and land use, demographics, and social and economic character of the city. These are important drivers for urbanization and has helped in the study of urbanization rate and its impact on water systems of the city.

Chapter II: Water Governance and Administration includes water policies and institutional set-up at central, state, and city level. Water use and management is influenced by the water governance, like who gets what water, when and how and who has the right to water and related services, and their benefits. It determines the equity and efficiency in water resource and services allocation and distribution, and balances water use between socio-economic activities and ecosystems. The study for this chapter has helped in identifying gaps pertaining to water governance in the city.

Chapter III: Water Source Management and Infrastructure covers various water sources available for the city and its related infrastructure—water treatment plants, sewage treatment plants, water meters, and water quality of waterways carrying wastewater. The study helps in the analysis of availability of existing water sources in the city and deficiencies in the existing water-related infrastructure.

Note: Water quality analysis of rivers has not been conducted in detail as it is out of the study scope and would require a separate assessment. Moreover, the objective of this study focuses on the quantity aspect with a brief touch upon on quality.

Chapter IV: Potential Risks in Water Management highlights the possible threats to the urban water cycle and water demand and supply of the city. This chapter is significant as it identifies all the issues interconnected with each other on projections for the year 2025, starting from water availability, its allocation, to capacities of water and sewage treatment plants.

Chapter V: Recommendations on Sustainable Water Management lays down a list of suggestions on combating the identified risks and improving the existing water management. The chapter gives recommendations through an upgraded urban water cycle for the city and it covers all the topics/ drivers discussed in the previous chapters impacting the urban water management. The chapter also has a section on micro-level assessment on water efficiency of audited residential townships in the city. This has helped in analysing the impact of micro- on macro-level systems and forging a link between the two.

System Definitions

The system boundary is defined as the area at Pune City Taluka (PMC area) and Pimpri Chinchwad City Taluka (PCMC area) level under the jurisdiction of Pune Metropolitan Region Development Authority (PMRDA), which includes both urban and rural parts of the cities. For the purpose of water hydrology, water mass balance and for analysing water demand, the study is confined only to urban areas, due to inaccessibility of data for rural areas.

2. CITY GROWTH AND ENVIRONMENT

2.1 Geographic Characteristics

The geographic characteristics section consists of parameters such as location, physiography & landforms, climate, forest, and biodiversity features.

2.1.1 Location

Pune is located in the Indian state of Maharashtra having latitude and longitude coordinates as 18.5204° N and 73.8567° E, respectively. It forms the second largest metropolitan city in the Maharashtra state. Pune is located on the western side of the Deccan plateau at the confluence of the rivers Mula and Mutha. Pune district is bordered by Ahmednagar district in the north, Solapur and Satara districts in the south, Ahmadnagar and Solapur districts on the east, and Raigad and Thane districts on the west.

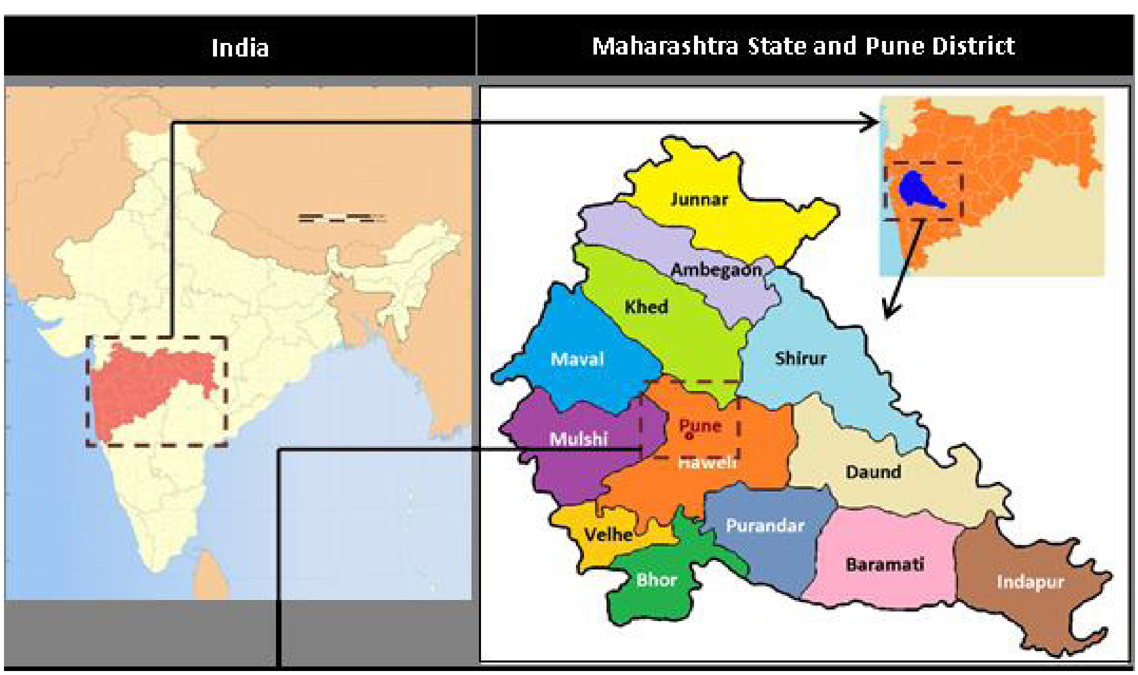
Pune district is one of the 36 districts located in the state of Maharashtra which covers an area of 15,643 km^2, which is further divided into 15 talukas (including 2 city talukas).

The two city talukas are: Pune City Taluka and the Pimpri Chinchwad City Taluka.

Pune city taluka has an area of 331.26 km^2 and is administered by the Pune Municipal Corporation and also has three cantonment boards namely Pune, Dehu Road, and Khadki.

Pimpri-Chinchwad City Taluka covers an area of 181 km^2 and is regulated by Pimpri Chinchwad Municipal Corporation.

For the purpose of the study, we have considered the Pune City Taluka (PMC area) and Pimpri Chinchwad City Taluka (PCMC area) of Pune district only as shown in Figure 1.



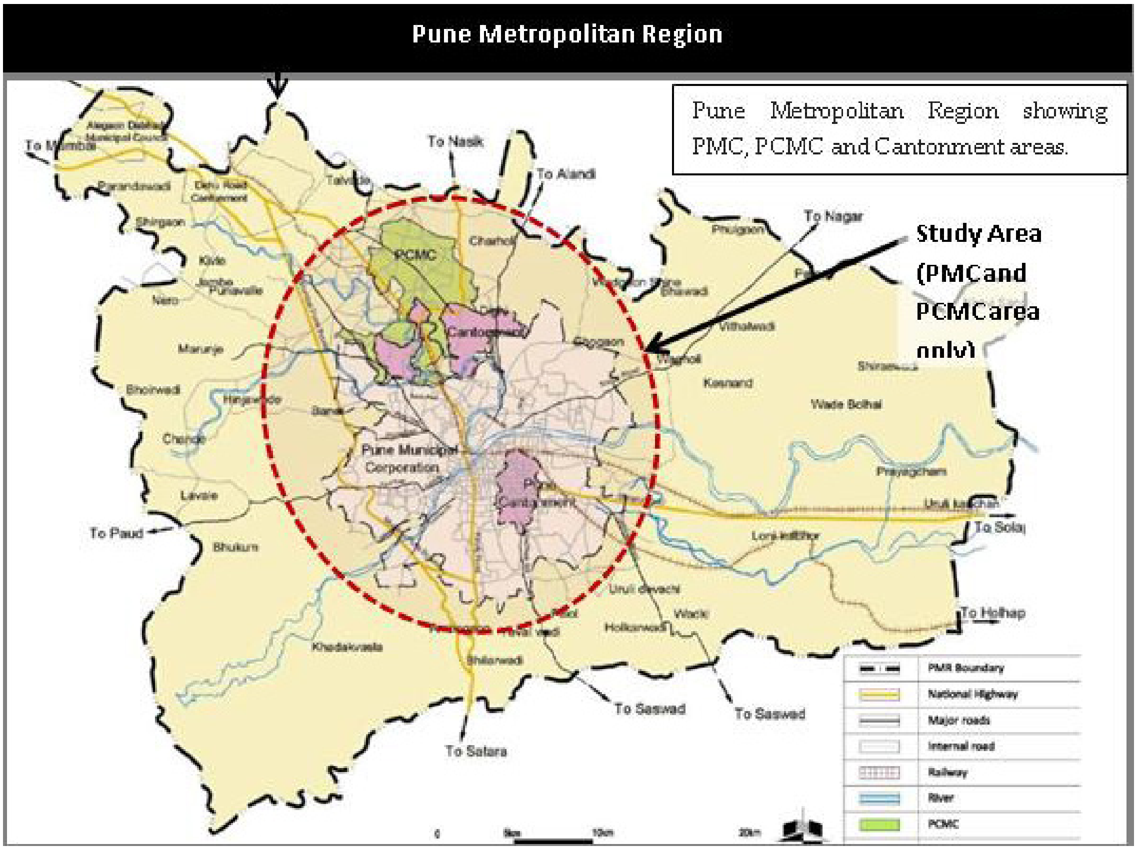


FIGURE 1: Geographical location of Pune City Taluka and Pimpri Chinchwad City Taluka[1]

2.1.2 Physiography and Landform

Pune district lies 560 metres above mean sea level. It forms part of Western Ghats and the Deccan Plateau. Physiographically, the district can be divided into the following three distinct belts:

1. The western belt stretching from 16 to 31 km east of Sahayadri range, which has extremely rugged country cut by deep valleys, divided and crossed by hill ranges.
2. The central belt extending for about 30 km east of the western belt across the tract whose eastern boundary is roughly marked by a line drawn from Pabal in the north, southwards through Pune to Purandhar. In this belt, a series of small hills stretch into valleys and large spurs from Plateaux. Pune and Pimpri Chinchwad City Talukas lie in the central belt.
3. The eastern belt with a rolling topography and the low hills sinking slowly into the plains with relatively broader valleys.

[1] Details available at https://en.wikipedia.org/wiki/List_of_districts_of_Maharashtra#/media/File:India_Maharashtra_locator_map.svg , https://en.wikipedia.org/wiki/List_of_districts_of_Maharashtra#/media/File:Maharashtra_Divisions_Eng.svg , City Development Plan (CDP) of Pune City – 2041under JNNURM, Pune Municipal Corporation, Volume 1- 2012; last accessed on September 14, 2021

Pune district possesses mainly three types of soils namely black-fertile, brown, and mixed type. In western region of the district like in Mulshi, Maval Tahsil talukas, brown soil is found which has low quality while the eastern region is more fertile and plain. The richest alluvial soil is found in the Bhima River valley.

PMC and PCMC areas lie in the north Bhima river basin.

There are two main rivers which serve the Pune city—Mutha and Mula rivers. These rivers originate in the Sahyadri ranges and traverse across Pune. The two rivers further meet and upon their confluence, Mula–Mutha River is formed, which further drains itself into the Bhima River and ultimately into Krishna River. Khadakwasla dam on Mutha River is the major source of water supply to Pune city and the cantonment areas.

PCMC area is served by Pavana River, which originates from south of Lonavala from the Western Ghats, and flows across Dehu, Chinchwad, Pimpri and Dapodi before its confluence with Mula River in Pune city. Pavana dam located 35 km from Pimpri Chinchwad is the sole source of water for the PCMC area.

Three major rivers Mula, Mutha (serving PMC area) and Pavana (serving PCMC area) flowing across the Pune Metropolitan Region are shown in Figure 2.

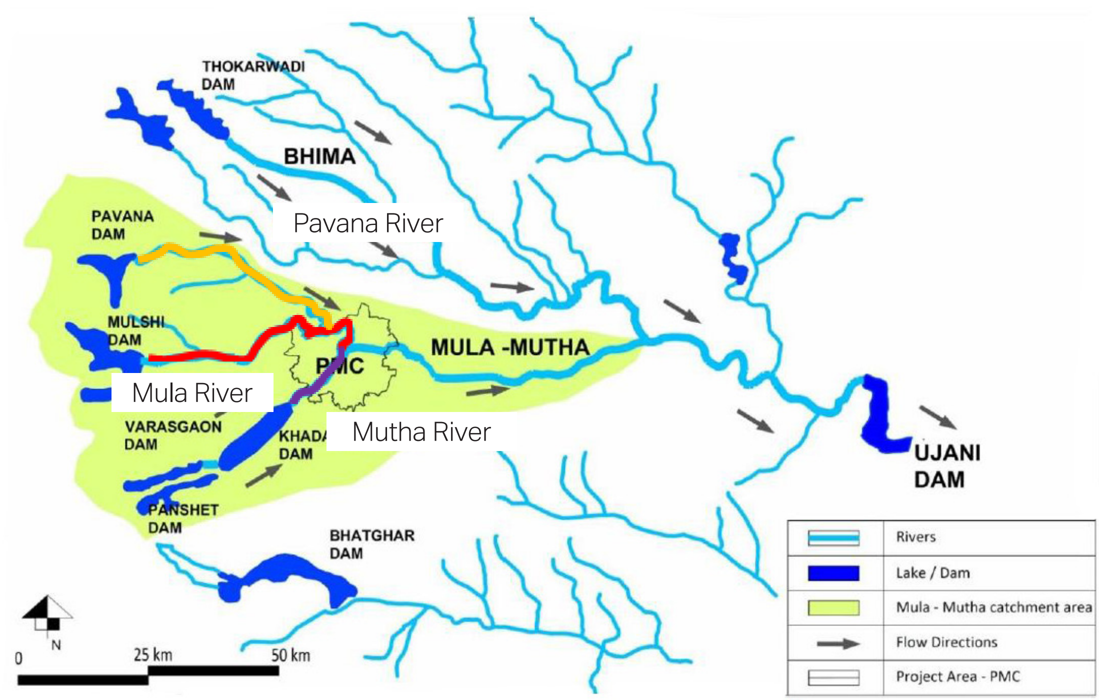


FIGURE 2 : Water bodies in PMR serving Pune and Pimpri Chinchwad City[2]

[2] City Development Plan (CDP) of Pune City – 2041under JNNURM, Pune Municipal Corporation, Volume 1 - 2012

2.1.3 Climate

Pune comprises of hot semi-arid climate. The hottest part of the year is mid-March to mid-June, with average temperatures ranging from 20 to 28 °C. The coolest part of the year is in the months of December and January where average temperature ranges from 26 °C to 9 °C. The highest temperature recorded was 43.3 °C on April 30, 1897 whereas the lowest temperature recorded was 1.7 °C on January 17, 1935. As far as rainfall is concerned, Pune receives rainfall from June to October with July being the wettest month. Average annual rainfall of the city is 722 mm.

2.1.4 Forest and Biodiversity

Green areas in Pune city include the Kamala Nehru Park, Sambhaji Park, Shahu Udyan, Peshwe Park, Saras Baug, Empress Gardens, and Bund Garden. The Pu La Deshpande Udyan is a replica of the Korakuen Garden in Okayama, Japan. The Hanuman hill, Vetal hill, and Taljai hills are protected nature reserves on hills within the city limits. The fauna of Pune city shows diversity and richness in species. Pune city also has a zoo known as Rajiv Gandhi Zoological Park, which is located in Katraj (suburbs of Pune). The 53-hectare zoo is divided into three parts: an animal orphanage, a snake park, and a zoo, and includes the 17-hectare Katraj Lake. Over the years, there has been a change in the native fauna of Pune because of urbanization and introduction of exotic species. Development of the city has resulted in the habitat loss and posed a threat on the faunal community.

Pimpri Chinchwad City Taluka has public parks such as Durga Tekdi park, Bhakti-Shakti park in Nigdi, the Pimpri-Chinchwad Science Park in Chinchwad, and the Boat Club in Thergaon. The city also has a zoo named after Nisargakavi Bahinabai Chaudhari in Chinchwad East. Close to the zoo is a lake garden called the Bird Valley because of the water birds like cranes, which come migrating here. There are a total of 142 public parks in the PCMC area.[3]

2.2 Urban Growth and Land Use

The urban growth and land use consist of sections on spatial growth pattern, land utilization, and land cover.

2.2.1 Spatial Growth Pattern

Pune City (PMC area)

The growth pattern of Pune city has been in concentric rings with town as the nucleus as people tend to stay as near as possible to the core of the city.[4] Pune's cityscape today contains the following four distinct areas:

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3 Details available at https://www.pcmcindia.gov.in/marathi/location.php; last accessed on September 14, 2021

4 Urban Transformation: A Study of Pune City, Published by -Ashish Kelkar Category -Dissertation, Published On -01/08/2018. Details available at https://planningtank.com/dissertation/urban-transformation-a-study-of-pune-city; last accessed on September 14, 2021

1. The old inner city core that is influenced by the historical developments from the late 1700s.
2. The large cantonments that have been designed by the British who made Pune as one of their military bases in the 1800s and which are until today under military-based governance.
3. The new industrial areas, which contribute to Pune's economic prosperity.
4. The urban fringe areas, which are speedily developing with a mixture of housing and informal economy.

From 1973 to 2013, Pune city experienced vast concentric expansion in the built-up area (Figure 3). According to the simulations, it is going to witness continuous expansion inorganically taking over the barren and agricultural land and encroaching vegetation and water bodies within the city limits. Thus, Pune is seen to be growing exponentially in terms of its spatial extent by engulfing the new surrounding villages and bringing it under its ambit, the evolving demography and its rapidly changing economic activities.

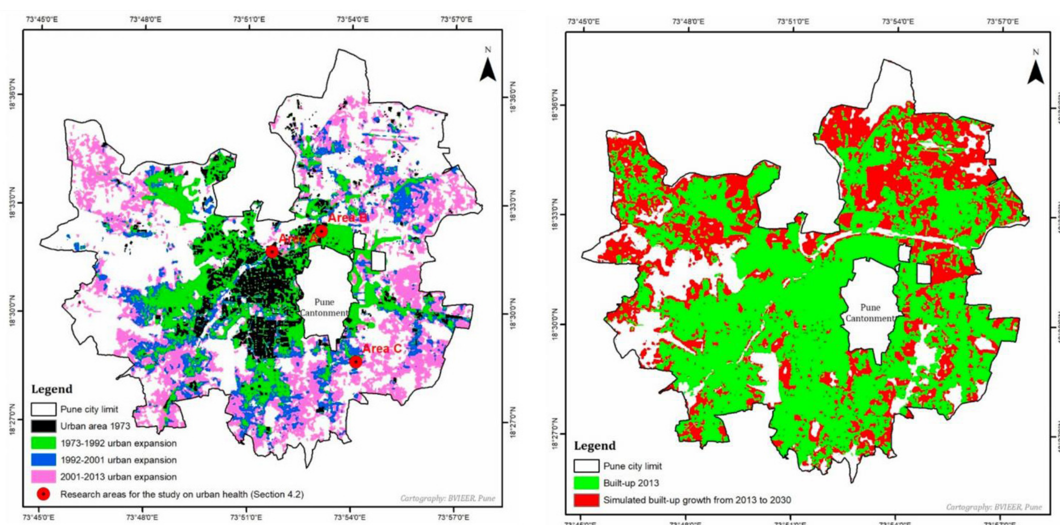

FIGURE 3: Concentric expansion of built-up area in Pune city from 1973–2013 and estimated expansion in 2030[5]

Pimpri Chinchwad (PCMC area)

Pimpri Chinchwad Municipal Council was formed in the year 1970 by merging four villages, namely Pimpri, Chinchwad, Bhosari, and Akurdi. As the years passed by, more and more villages were engulfed taking the area to 86 sq. km, which resulted in the formation of Pimpri Chinchwad Municipal Corporation in 1982. To manage the growing population, the area was further increased and as of 2011 census, the area of PCMC is 181 sq. km. The constant expansion of PCMC limits since its formation was accompanied by concentric expansion of the built-up land in it, with central part of the region having most built-up land (Figure 4). Agricultural settlements have been transforming into fringe settlements, thus reducing its area.

[5] Kantakumar, L N, S Kumar, and K Schneider. 2016. Spatiotemporal urban expansion in Pune metropolis, India using remote sensing. Habitat Int. 51: 11–22

Sizeable portion of the development in Pimpri Chinchwad city in the last decade has grown towards Pune city in the south and Hinjewadi IT Park in the south-western direction.

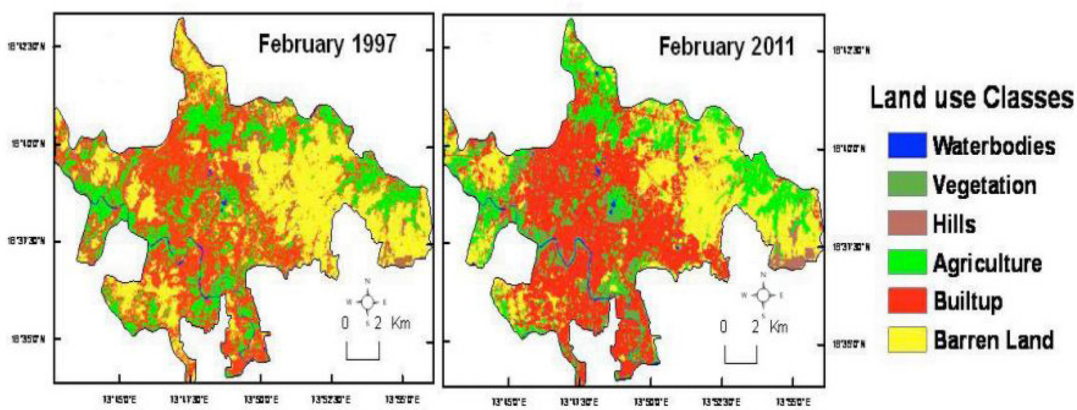

FIGURE 4: Concentric expansion of built-up area in PCMC area from 1997–2011[6]

2.2.2 Land Utilization and Land Cover

Pune City (PMC area)

The study of land use classification for Pune city (excluding cantonment areas) has been shown in Figure 5. Pune city has witnessed significant changes in land use pattern in the period 1973–2011.

	Built Up/Land	Agricultural Land	Vegetation	Fallow Land	Scrub Land	Rivers and Lakes	Canals
1973	28.5	14.4	11.3	9.97	67.6	4.2	2.5
1992	62.1	13.2	11.1	10.5	45.6	1.82	1.53
2001	130	20.1	17.9	17.1	54.2	2.7	1.5
2011	155.9	16.8	15.6	15.8	35.3	2.6	1.5
2019	182.55	14.72	14.07	14.86	26.57	2.52	1.5
2025	205.49	13.32	13.02	14.2	21.48	2.47	1.5

Type of landuse

FIGURE 5: Land use land cover change in Pune city (PMC limits only) (1973–2011)[7] and estimated change in the years 2019 and 2025

[6] Fernandez, R B and A A Dhorde. 2014. Assessment of spatio-temporal variations in land use land cover over Pimpri Chinchwad Municipal Corporation using remote sensing data. International Journal of Geomatics and Geosciences 4(4)

[7] Mundhe, N N and R G Jaybhaye. 2014. Impact of urbanization on land use/land covers change using geo-spatial techniques. International Journal of Geomatics and Geosciences 5(1)

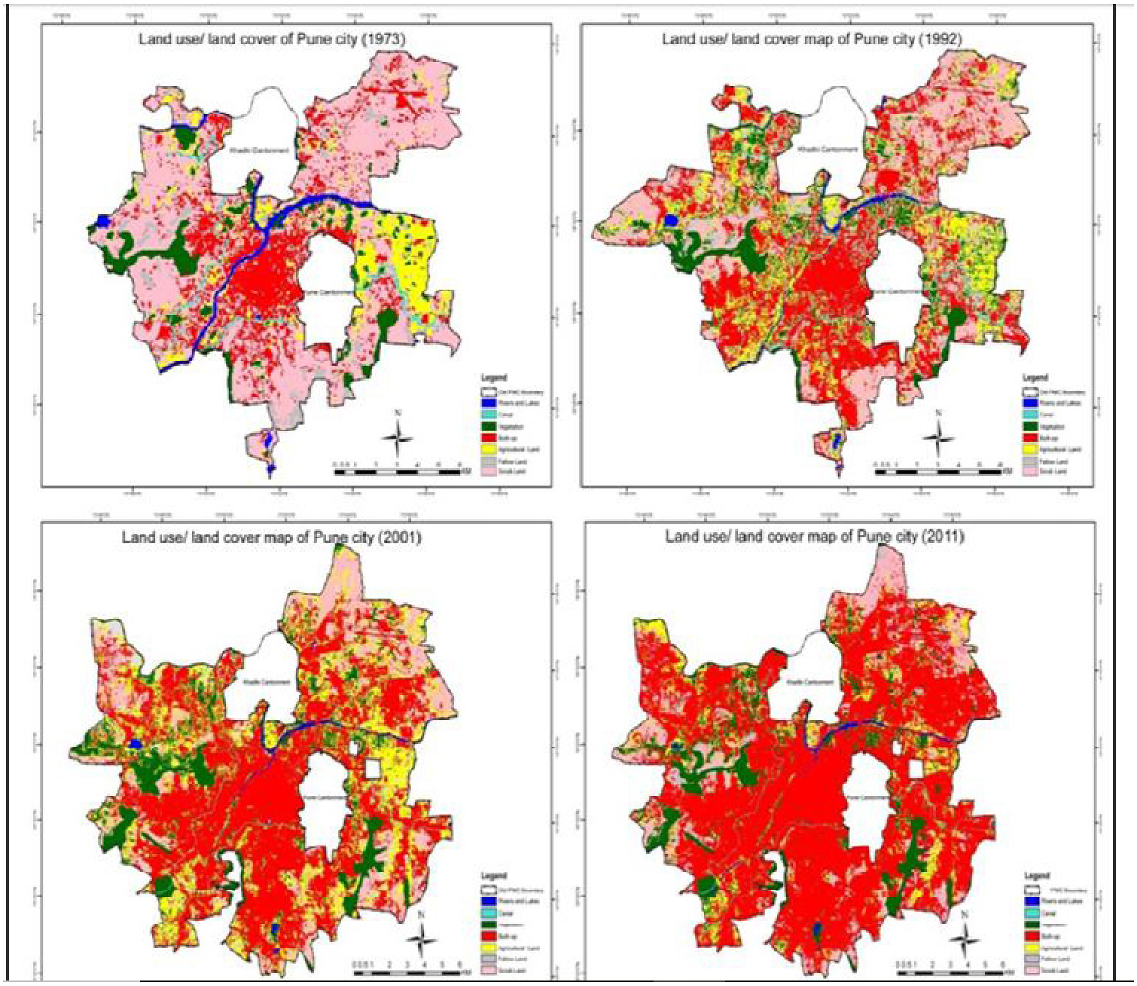

FIGURE 6: Graphical representation of land use land cover change in PMC area with highlighted change in water bodies (1973–2011)[8]

Pune is one of the fastest growing urban regions due to rapid sprawl and population influx. As seen from Figures 5 and 6, the following land use land cover changes have been experienced in Pune city:

» As seen in Figure 5, the built-up area in PMC has grown almost 7 times from 1973 to 2013. Between 1973 and 1992, Pune witnessed only 38.5 km^2 growth in the built-up areas. But due to introduction of foreign direct investment in 1991, this resulted in rapid urbanization and the city witnessed massive growth of about 82.5 km^2 of built-up areas between 1992 and 2013. It is estimated that if this urban growth trend continues, the built-up areas will be increased to reach 205.49 km^2 by the year 2025.

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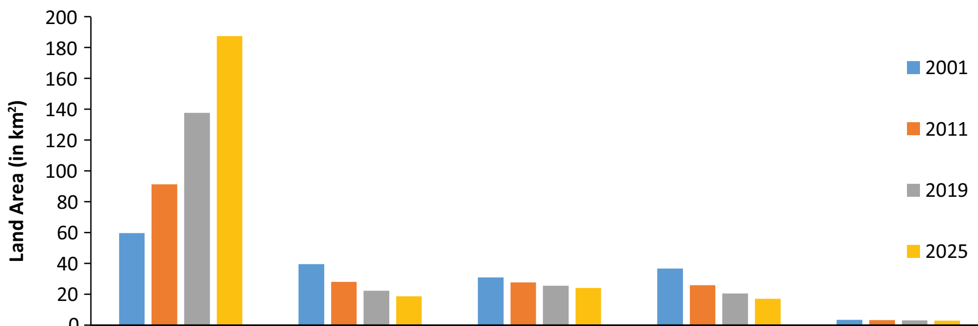
8 Mundhe, N N and R G Jaybhaye. 2014. Impact of urbanization on land use/land covers change using geo-spatial techniques. International Journal of Geomatics and Geosciences 5(1)

- The agricultural land, vegetation, rivers and lakes, canals and scrub land saw a decrease between 1973 and 1992 due to shift to built-up areas.
- Because of merging of 38 fringe villages into PMC limits in 1997, areas of various land typologies were revised. Due to this, the areas of agricultural land, vegetation, fallow land, rivers and lakes, and scrub land reflected more covered area in 2001 as compared to 1992. This increased area of the mentioned typologies was solely due to increased PMC limits and not due to any intervention by the authorities to protect green areas or areas with water bodies.
- And so as the development and expansion of industries and settlements continued, agricultural land, vegetation, fallow land, rivers and lakes, canals and scrub land again saw a decrease in its areas between 2001 and 2011 as it saw in 1973–1992. It is estimated that the areas of these typologies will continue to decrease till 2025, considering the existing declining rate.
- The water body (rivers and lakes) area was quite high in 1973 (4.29 km^2) which got reduced to almost half, that is, 2.66 km^2 in 2011. As can be seen from Figure 6, between 1973 and 1992 the point from which Mutha River enters the PMC limits till its confluence with Mula River saw sharp decrease in its areas due to shift in built-up land. The point of confluence of Mutha and Mula rivers till its exit from the PMC limits also saw decrease in areas due to similar reasons.
- Due to the expansion of PMC limits in 1997 as stated before, the water bodies saw a slight increase from 1.82 km^2 in 1992 to 2.7 km^2 in 2001. But due to continuous built-up expansion and encroachments, the area reduced to 2.6 km^2 in 2011. Necessary interventions will be required from the authorities to conserve the water bodies, which are estimated to continuously shrink in future. The increase in annual monsoon floods in the city are the testament of impact of shrinking water bodies and green cover.
- Canals in the city also saw a decrease between 1973 and 1992 due to increase in built-up land, and the area has been more or less the same since then till 2011.

Pimpri Chinchwad (PCMC area)

The total area under the jurisdiction of PCMC measures 181 km^2. The study of land use classification of Pimpri Chinchwad has been shown in Figure 7.

There has been a constant expansion of PCMC limits since its formation in 1970 till 2011 in order to cater the needs of growing population and industries. Therefore, the change in land use since its formation till 2011 as shown in Figure 7, doesn't give accurate picture of the land use change trend as the PCMC area doesn't remain constant. Although, it does reflect that the built-up area is on a sharp rise due to mass people migration and industrialization, affecting other typologies such as agricultural, vegetation and waste land which are decreasing, but at a slow rate as the built-up expansion has been mostly vertical (high-rise residential apartment) in nature. The water bodies saw a decrease in the area due to unauthorized constructions/encroachment along the river course, especially along the River Pavana. This has resulted in the rising of flood menace in the city due to decrease in catchment areas. Considering the rate of change in land use till 2011, it can be estimated that the built-up areas will continue to expand till 2025 reaching an area almost twice as in 2011. This is going to have an effect on the other typologies, which would experience slight decrease in their areas.



	Built Up/Land	Agricultural land	Vegetation	Waste land	Water bodies
2001	59.82	39.63	30.9	36.72	3.44
2011	91.42	28.12	27.78	25.92	3.18
2019	138	22.21	25.61	20.41	2.99
2025	187.94	18.61	24.1	17.07	2.86

Type of land use

FIGURE 7: Land use land cover change in Pimpri Chinchwad city (PCMC limits only) (2001–2011)[9] and estimated change in the years 2019 and 2025

2.3 Demographic Description

The demographic description discusses about the population growth trend in context of the study area.

2.3.1 Population Growth Trend

Pune City (PMC area)

Pune city was the ninth most populated city in India in 2011 with a population of 3,124,458. There has been a rapid increase in population of Pune city due to industrial and economic growth in the last 20 years. The population growth of Pune City Taluka till 2011 is shown in Figure 8. The population is estimated to increase in future, considering the existing rate of growing population.

[9] Details available at https://shodhganga.inflibnet.ac.in/bitstream/10603/18669/12/12_chapter%204.pdf; last accessed on October 3, 2021

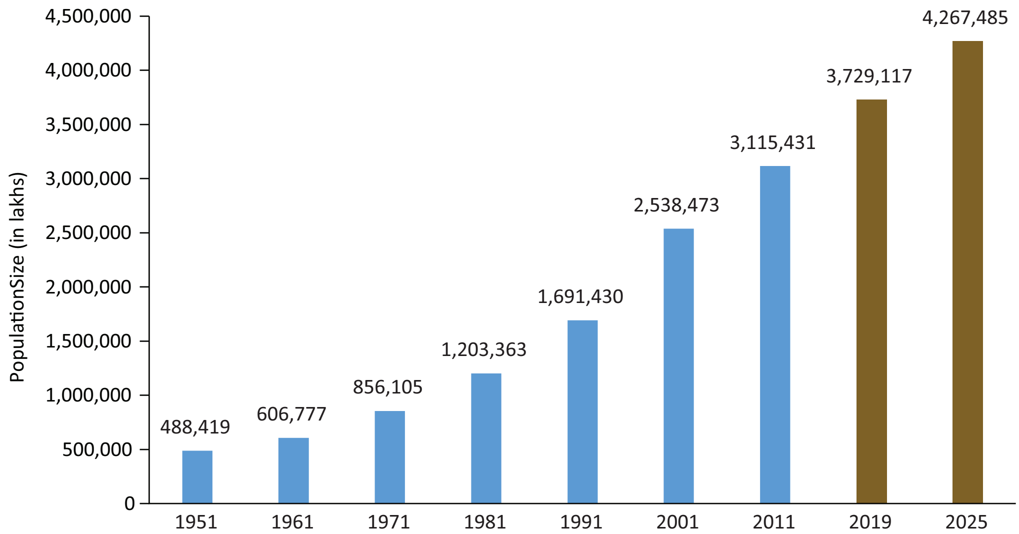


FIGURE 8: Population increase in Pune City Taluka (1951–2011)[10] and estimated population change in the years 2019 and 2025[11]

As far as the decadal variation in population of Pune city is concerned, it saw steep decline from 50.08% decadal growth rate (1991–2001) to 22.73% decadal growth rate (2001–11) due to the development of Pimpri-Chinchwad Municipal Corporation (PCMC) as an industrial centre (Figure 9). Post 2001, though the population continued to increase but the rate of decadal growth decreased in Pune city area due to peri-urbanization in the adjoining areas of Pune City Taluka and creation of Pimpri Chinchwad area.

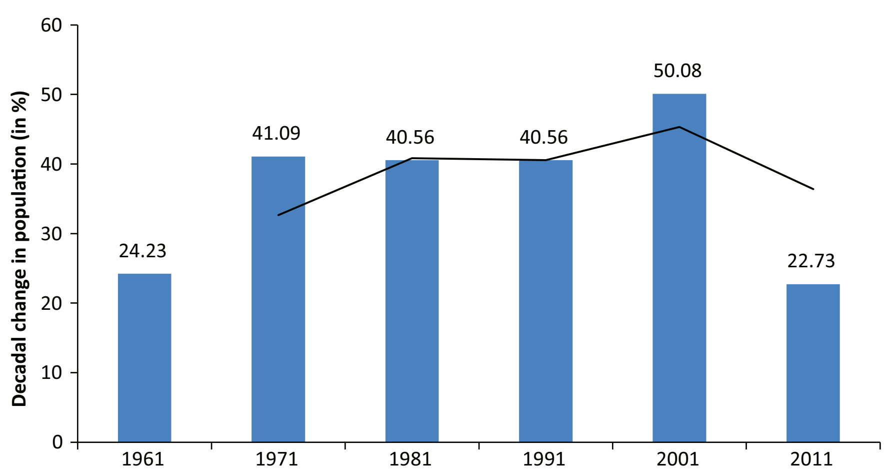


FIGURE 9: Percentage decadal variation in population of Pune city taluka (1961–2011)[12]

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[10] Source: A - 2 DECADAL VARIATION IN POPULATION SINCE 1901, Census of India and Census of India 2001 and Provisional figures of Census India, 2011 and Development Plan of Pune

[11] By author

[12] Source: A - 2 DECADAL VARIATION IN POPULATION SINCE 1901, Census of India and Census of India 2001 and Provisional figures of Census India, 2011 and Development Plan of Pune

The average population density of Pune city is on the lower side of the permissible limits of the UDPFI guidelines for metropolitan cities. It is also the lowest when compared to other mega cities such as Bengaluru, Hyderabad, Ahmedabad, and Chennai.[13] Population density in the Pune city continued to increase from 10,410 persons/km^2 in 2001 to 12,777 persons/km^2 in 2011 due to rapid expansion of IT industry, which generated more employment opportunities resulting in influx of migrant population.

It is evident from Figure 10 that the population density from 1951 to 2011 is gradually increasing except in 2001 which was 10,410 persons/km^2; this was mainly due to the addition of 38 villages within the PMC area in 1997. Considering the rate of change from 2001 to 2011, the population density is expected to further increase to 17,503 persons/km^2 by 2025.

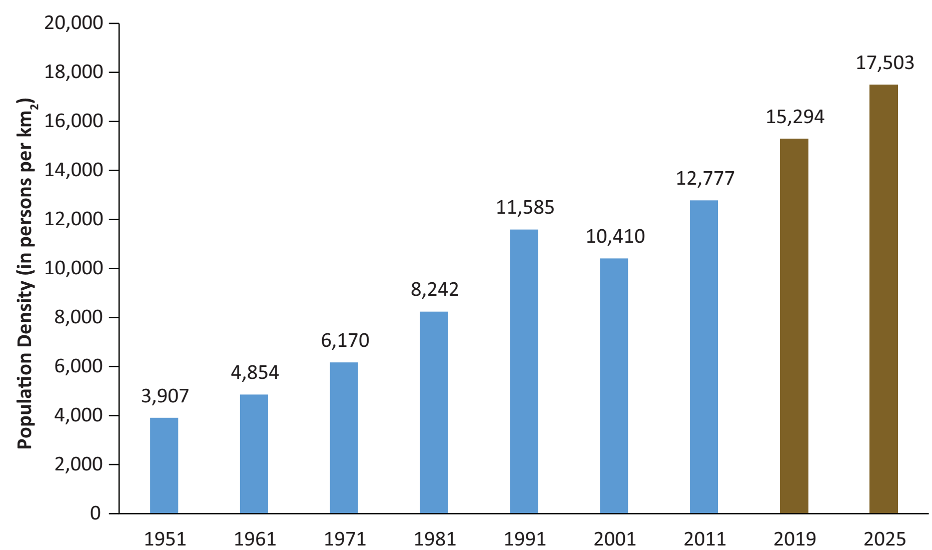

FIGURE 10: Population density change in Pune City Taluka (PMC area) (1951–2011)[14] and estimated change in the years 2019 and 2015

Pimpri Chinchwad (PCMC area)

As far as Pimpri Chinchwad area is concerned, the region saw thrice the increase in population size post 1991 from 520,639 to 1,729,359[15] in 2011. Pimpri Chinchwad was formed as an extension to the Pune city limits due to rapid industrialization, which has over the time intensified the population influx in the city. The population growth of Pimpri Chinchwad City Taluka is shown in Figure 11. Considering the decreasing rate of decadal change in population since 1991 to 2011, the population is estimated to further increase till the year 2025 reaching 3,497,819.

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[13] City Development Plan (CDP) of Pune City – 2041under JNNURM, Pune Municipal Corporation, Volume 1- 2012

[14] Source: A - 2 DECADAL VARIATION IN POPULATION SINCE 1901, Census of India and Census of India 2001 and Provisional figures of Census India, 2011 and Development Plan of Pune

[15] Details available at https://www.pcmcindia.gov.in/location_info.php; last accessed on October 3, 2021

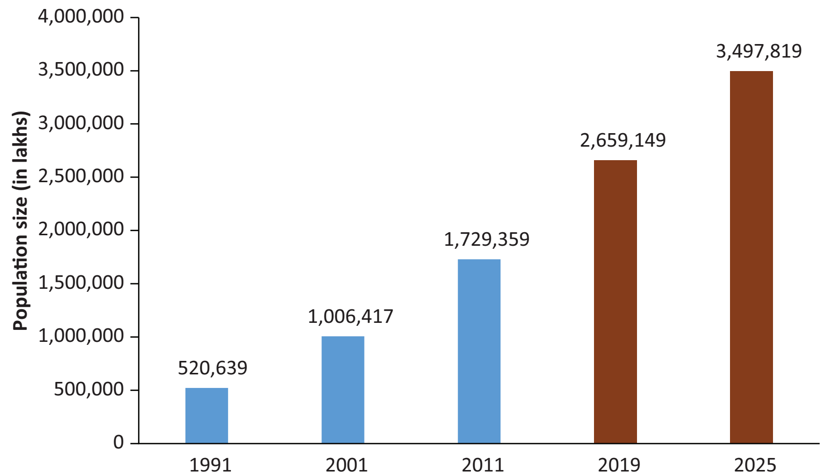

FIGURE 11: Population increase in Pimpri Chinchwad City Taluka (1991–2011)[16] and estimated change in the years 2019 and 2025

Pune's economy. However, in the past few years, the city has emerged as the seat of secondary and tertiary activities while acquiring the status of being one of the major business centres in Maharashtra. Today, Pune city and its region are one of the most attractive investment hubs of the

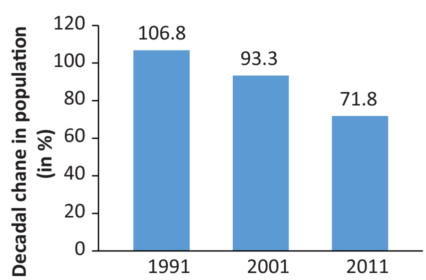

FIGURE 12: Percentage decadal variation in population of Pimpri Chinchwad City Taluka (1991–2011)[17]

The percentage decadal variation in population of Pimpri Chinchwad City Taluka has been shown in Figure 12. The rate of population decadal change is reflected here to be decreasing although the population is increasing. This is due to the constant increase in the PCMC limits till 2011.

2.4 Social and Economic Character

2.4.1 Economy

Traditionally, the city is known for its agriculture and agro businesses. In the beginning, for several years, primary sector activities, predominantly, agriculture has been the mainstay of

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16 Details available at https://www.pcmcindia.gov.in/jnnurm_info/CMP.pdf; last accessed on October 3, 2021

17 Details available at https://www.pcmcindia.gov.in/jnnurm_info/CMP.pdf; last accessed on October 3, 2021

state. This factor is reinforced by its falling under the DMIC project influence area. PMC and PCMC together are serving as base for various large and small units operating in sectors such as auto components, engineering, IT/ITES, BPO, biotechnology, pharmaceuticals, and food processing. These industries along with the agriculture and government sector provide considerable amount of employment to the population in the district as well as in the adjoining districts.

No reliable data on employment and GDP of PCMC is available. Also, the GDP is only available at Pune district level and not at Pune city level. Therefore, for the study of economy, Pune district has been considered and taken as the representative of both Pune City Taluka and Pimpri Chinchwad City Taluka as far as study of GDP is concerned.

The gross domestic product of Pune district had a share of 22.1% in the state income, just below the 22.6% share of Mumbai district.[18] GDP of Pune district increased from 153,429 in 2012–13 and 172,155 in 2013–14.[19]

Majority of the population in Pune city (67.5%) was employed in tertiary sector mostly in IT in the year 2011–12 followed by secondary sector such as automobiles (32.16% employment). The share of people employed in the primary sector like agriculture was the least with only 0.34%.[20] This clearly depicts the shift of employment from primary to secondary and tertiary activities.

2.4.2 Agriculture

Pune City (PMC area)

As can be seen from Figure 5, agriculture area in Pune city has decreased rapidly over the last two decades. The agriculture area decreased from 20.11 km^2 in 2001 to 16.82 km^2 in 2011 and taking this as the declining rate, the agriculture area might be roughly decreased to 14.7 km^2 in 2019. The urban growth of the city has transformed most of the agricultural and barren land of the city into residential, commercial, and institutional area. PMC has been using the surface water tapped by Temghar, Varasgaon, Panshet and Khadakwasla dams for meeting the irrigation water demands for agriculture.

Data on agriculture output is not available at PMC level. Also, as most of the agricultural land has been pushed out of the municipalities limit and considering ten years down the line the remaining agricultural land will be transformed into built up, therefore, agricultural water demand has not been considered in the final calculations for PMC's water demand and supply.

Pimpri Chinchwad (PCMC area)

Similarly, agriculture area in Pimpri Chinchwad has been declining as can be seen from Figure 7 at a steady pace, converting the agricultural land into built-up due to massive industrialization and

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[18] Directorate of Economics and Statistics, Government of Maharashtra, 2009–10

[19] Details available at https://mahades.maharashtra.gov.in/files/publication/esm_2014-15_eng.pdf; last accessed on October 3, 2021

[20] Unit Level Data of National Sample Survey Organization, Employment and Unemployment Situation in India, 68th Round, 2011–12

urbanization. Source of irrigation in the PCMC area is the surface water tapped by Pavana dam.

Data on agriculture output is not available at PCMC level, therefore, agricultural water demand has not been considered in the final calculations for PCMC's water demand and supply.

2.4.3 Industry

Pune City (PMC area)

Since the 1950s, Pune district has housed traditional industries and has seen some spectacular growth in recent years. Pune is known for manufacturing, automobile, government and private sector research institutes and information technology. Pune is one of the most industrially developed districts in India. The efficient transport and communication facilities available here have contributed to the development of industries. Although there are no heavy industries within the PMC area, areas such as Pimpri, Chinchwad, Chakan, Baramati, Jejuri, Daund Ranjangaon have industrial area and Hinjewadi and Talwade have IT park.

Therefore, industrial water demand has not been considered in the final calculations for PMC's water demand and supply.

Pimpri Chinchwad (PCMC area)

Pimpri-Chinchwad is a major industrial hub. It hosts one of the biggest industrial zones in Asia. The city is home to the Indian operations of major automobile companies, several heavy industries, many manufacturing units, and several Software and Information Technology majors. The Pimpri Chinchwad industrial area receives water supply from Pawana dam, which is located in Mawal Tahashil of Pune district.

Data on industrial water consumption is not available at Pimpri Chinchwad level. Therefore, industrial water demand has not been considered in the final calculations for PCMC's water demand and supply.

2.4.4 Housing

Pune City (PMC area)

The PMC had registered 149,359 connections, out of which some 13,992 are classified as non-domestic (commercial, industrial or institutional); 1350 are stand posts; and the remaining 134,017 are classified as domestic (residential housing).[21] Pune city comprises majorly of 5 types of residential housing typologies:

» Apartments buildings

» High-rise buildings

» Individual gunthewari (separate houses), bungalows

» Old city area with close buildings, chawls, wada type structures/ clusters

» Slums

[21] PUNE MUNICIPAL CORPORATION, Pune Water Supply System for Pune city Detailed Project Report, Volume I, Feb 2014

Percentage of households with access to tap water (from treated source) within premises is 99.2% in Pune city (Tables of Houses, Household Amenities and Assets, Census of India, 2011) covering all the housing typologies, partially slums as well. This is way higher than the average standard percentage for any urban centre in India, which is 84.14%.

Pune has witnessed significant growth in slums over the years. It attracts thousands of immigrants due to multiple variants of economic activities and most of them falling in the category of lower strata forming the poor or low-income group, who are forced to live in slums or slum-like conditions due to poor affordability. In 1961, the share of slum population was 15%, which rose to 40% in 2001, reason being inefficiency of local authorities to meet the rising housing demand of the population at affordable price.[22]

Because slums are categorized as substandard housing, they are often believed to have a lack of basic civic amenities such as poor water connection. This doesn't entirely holds true for Pune city. Pune city today has 564 slums, out of which 353 are notified by the government and 211 are not notified.[23] Therefore, 60% of the house units existing in these slum areas are said to be provided with individual connections, whilst the remaining 40% are supplied through the stand posts. The approvals for water connections strongly depends on the legal status of slum (notified or non-notified).

Pimpri Chinchwad (PCMC area)

Housing typology in Pimpri Chinchwad is very similar to that of Pune with high rise, apartment buildings, and slums. It has 71 slums, out of which 34 are undeclared by the government and 37 are declared.[24] Data on households with access to tap water is not available for PCMC area and thus has not been analysed.

2.5 Inferences

Pune City (PMC area) and Pimpri Chinchwad (PCMC area)

» PMC and PCMC areas are going to experience a continuous exponential built-up expansion in the coming years due to the rapid economic development. This shall lead to an unprecedented growth of the city in terms of population, which in turn shall increase the demand for housing and other civic amenities like water supply. A major chunk of the migrated population shall constitute of lower strata group, which would be forced to live in the slums due to demand-supply gap of housing in the city. Providing water connections to growing population of the slums could pose a challenge for the authorities, as it further adds to the burden of water resources already under pressure and an overall urban infrastructure.

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22 City Development Plan (CDP) of Pune City – 2041under JNNURM, Pune Municipal Corporation, Volume 1- 2012

23 Details available at https://pmc.gov.in/en/total-slums; last accessed on October 3, 2021

24 Details available at https://www.99acres.com/articles/pimpri-chinchwad-over-70-slums-to-be-developed-under-smart-city-mission-nid.html; last accessed on October 3, 2021

- Rapid built-up expansion in the coming years could put an enormous pressure on land and water resources, which might change the resource availability and ecology of the area. Water bodies like lakes and rivers could continue to shrink due to encroachments, unauthorized constructions and poor disposal of municipal waste and construction debris into them. The flood intensity during monsoons will keep on increasing in PMC and PCMC region due to reduction in catchment area with shrinking water bodies and green cover and expansion in built-up land.
- Extensive industrialization of Pune district after the 1960s and expansion of IT industry in the last two decades has resulted in rapid increase in population of PMC and PCMC areas. As Pune city nears its urbanization potential, Pimpri Chinchwad is going to experience massive urban growth in the coming years with increase in water demand for residential, commercial, and industrial projects.
- The major sectors of water consumption in the cities over the coming years will be majorly residential housing, commercial, and institutional establishments. Agricultural land area is on a decline due to conversion into built up and would almost become negligible in the near future. As Pimpri Chinchwad is a rapidly developing industrial centre, water demand of the area shall increase manifolds in future. Reclaimed water could provide a strong alternative water source to meet the rising industrial water demand.

3. WATER GOVERNANCE AND ADMINISTRATION

3.1 Water Laws and Policy in India

Legal provisions related to water are available in the constitution, court decisions, central and state laws, and various irrigation acts. However, India does not have any exclusive or comprehensive water law. Water is included in the State List of the 7th Schedule of the Constitution of India and hence all activities related to planning, development, and management of water resources are undertaken by the respective states through their water resources or irrigation departments. In many cases, state governments have established autonomous bodies and corporations for the development and management of water resources.

India does not have any specific law defining the ownership of and rights over water sources. The laws are derived from court rulings and customs. Several court judgments in post-independent India have affirmed that all natural resources – resources that are by nature meant for public use and enjoyment – are held by the state in public trust. For example, the legal position on whether groundwater is a resource meant for public use is fuzzy, and India has no law that explicitly defines groundwater ownership. It is customarily accepted across India that a well on a piece of land belongs to the owner of that land, and others have no right to extract water from the well or to restrict the landowner's right to use the water. This belief and practice is indirectly supported by various laws such as land acts and irrigation acts that list all the things to which the government has a right but groundwater is not mentioned in any such list.

As yet, no law or policy has been formulated asserting that water is a fundamental and inviolable right enjoyed by every citizen of the country. The 'right to water' can therefore be obtained in India on a case-by-case basis, by appealing to the court. At the same time, it has been implicitly accepted that the central and state governments have a primary responsibility to provide drinking water and, subsequently, water for other purposes. Accordingly, a host of programmes and policies have been framed and implemented at the central and state levels including the National Water Policy (National Water Policy, 2002; National Water Policy, 2012).

3.1.1 Institutional Set-up at Central Level

At the central level, the Ministry of Water Resources (MoWR), set up in 1985, has been the nodal ministry responsible for developing, conserving, and managing water as a national resource.

In May 2019, the Ministry of Water Resources, River Development and Ganga Rejuvenation and the Ministry of Drinking Water and Sanitation were merged to form the Ministry of Jal Shakti in order to streamline their functions, i.e., to maintain the quality of drinking water and the natural water bodies, ensure efficient use of water resources to meet the growing demand and sensitization of citizens for water conservation—thus contributing towards the enhancement of sustainable development. The Ministry's remit covers areas as diverse as irrigation, multipurpose groundwater exploitation, command area development, drainage, and flood control. The Ministry also tackles issues related to waterlogging, soil erosion, dam safety, and creation of structures for navigation and hydropower and oversees the development and regulation of interstate rivers.

Three principal technical organizations are part of the ministry: the Central Water Commission (CWC) is responsible for developing and quality measurement of surface water in the basins of major and medium-sized rivers; the Central Ground Water Board (CGWB) monitors, develops, and regulates groundwater resources; and the National Water Development Agency was set up to assess the possibilities of inter-basin water transfers.

The Central Pollution Control Board (CPCB), in collaboration with the State Pollution Control Boards (SPCBs) in several states, has been separately monitoring aquatic resources at selected locations since 1977.

Water quality and environmental matters come largely under the Ministry of Environment, Forest and Climate Change (MoEFCC), which coordinates India's Environmental Action Plan. The Ministry of Housing and Urban Affairs coordinates projects in urban water supply and sanitation. The Rajiv Gandhi National Drinking Water Mission, which is part of the Ministry of Rural Areas and Employment, handles rural water supply and sanitation. The Ministry of Power and the Central Electricity Authority handle water for power generation. Water is also a subject of several other ministries and departments, such as the Ministry of Agriculture (irrigation), the Ministry of Health and Family Welfare, the Ministry of Surface Transport, the Inland Waterways Authority of India, and, for planning and financing, NITI Aayog, the Ministry of Finance, and the Finance Commission.

3.1.2 Institutional Set-up at State Level

Maharashtra Water Resources Regulatory Authority (MWRRA) is a government body responsible for regulation, allocation, management and utilization of limited water resources in the state of Maharashtra. The MWRRA is also authorized to control and set water tariffs. All water regulation projects (irrigation, industrial use, urban and rural use) are abided to have clearance from the MWRRA.

Maharashtra Pollution Control Board (MPCB) implements various environmental legislations in the state of Maharashtra, which includes Water (Prevention and Control of Pollution) Act, 1974; Air (Prevention and Control of Pollution) Act, 1981; Water (Cess) Act, 1977 and some of the provisions under Environmental (Protection) Act, 1986 and the rules framed thereunder like, Biomedical Waste (M&H) Rules, 1998, Hazardous Waste (M&H) Rules, 2000, Municipal Solid Waste Rules, 2000, etc. The MPCB functions under the administrative control of Environment Department of the Government of Maharashtra.

Maharashtra Industrial Development Corporation (MIDC) is one of the corporations of Maharashtra set up to provide infrastructure facilities such as land, roads, water supply, drainage facilities and streetlights to and around the industrial areas.

3.1.3 Administrative Set-up of Pune and Pimpri Chinchwad

The 74th Amendment to the Constitution mandates state government to transfer the responsibility for water supply services to urban local bodies (ULBs). The local bodies in Pune are governed by important pieces of legislation, namely Maharashtra Water Resources Regulatory Authority Act, 2016; Maharashtra Irrigation Act 1976; and Maharashtra Groundwater (Development and Management) Act, 2009.

Pune Metropolitan region has an area of 7,256.46 km^2, which covers 10 talukas (entire talukas of Pune City, Pimpri-Chinchwad city, Haveli, Maval, Mulshi, as well as parts of the Khed, Bhor, Velhe, Purandar, Shirur, and Daund talukas) out of 15 talukas of the Pune district. The Pune metropolitan region is administered by Pune Metropolitan Region Development

Authority (PMRDA), which includes 2 municipal corporations, 3 cantonment boards, 7 municipal councils, 842 villages, and 13 census towns. PMRDA looks at the overall development of Pune metropolitan area which includes provision of potable water and sewerage services.

Various agencies working in the water sector and their functions in Pune city and Pimpri Chinchwad are as follows:

» Water supply, sewerage services and storm water drain management in Pune City Taluka are under Pune Municipal Corporation and in Pimpri Chinchwad City Taluka are under Pimpri Chinchwad Municipal Corporation, respectively. Surface water management such as local ponds, lakes, etc., in these cities is regulated by their respective municipal corporations.

» The water quality monitoring of these water bodies is done by Maharashtra Pollution Control Board (MPCB).

» The enforcement of Development Control Rules (DCR), which includes groundwater recharge through rainwater harvesting lies with Buildings Permission Department of PMC and PCMC. According to the DCR 2007, it is mandated to implement RWH on plots of area more than 300 m2 in non-congested areas of the city. It is a mandatory requirement for issuance of completion certificate. Certification by Architect of the project that RWH has been completed is followed by a visit by 'building supervisor' to verify the implementation. PMC also offers a 2% rebate on property tax as incentive for successful implementation of RWH.

» Groundwater use also forms an important part of non-potable water use in the city. There are primarily three government bodies involved in the groundwater management in the state, PMC/PCMC, Maharashtra Water Resources Regulatory Authority (MWRRA functioning as State Groundwater Authority), and Groundwater Survey and Development Agency (GSDA). In 2009, Maharashtra promulgated the Groundwater (Management and Development) Act (GMDA). Under this Act, the MWRRA, functioning as the State Groundwater Authority, holds the responsibility of protecting and regulating groundwater resource in notified as well as non-notified areas. The State authority ensures protection of recharge areas, take action against groundwater polluters, monitor compulsory registration of rig owners who operate in the state, regulate drilling of deep bore wells by giving specific permissions, etc. Despite setting up the authority in place, the city has seen unregulated drilling of bore wells and decrease in groundwater levels at an alarming rate over the last decade. The implementation of the Act remains a huge roadblock in ensuring the groundwater protection in the Pune and Pimpri Chinchwad city. Also, the focus of this Act has been mostly on the rural groundwater.

» The water supply to industries and the management of effluent water from them in both the areas is done by the MIDC. However time and again, PMC/PCMC have been in a tussle with MIDC over wastewater treatment and its management of the industries.

» Water Resources Department, Government of Maharashtra looks after the irrigation and flood control works in Pune city and Pimpri Chinchwad.

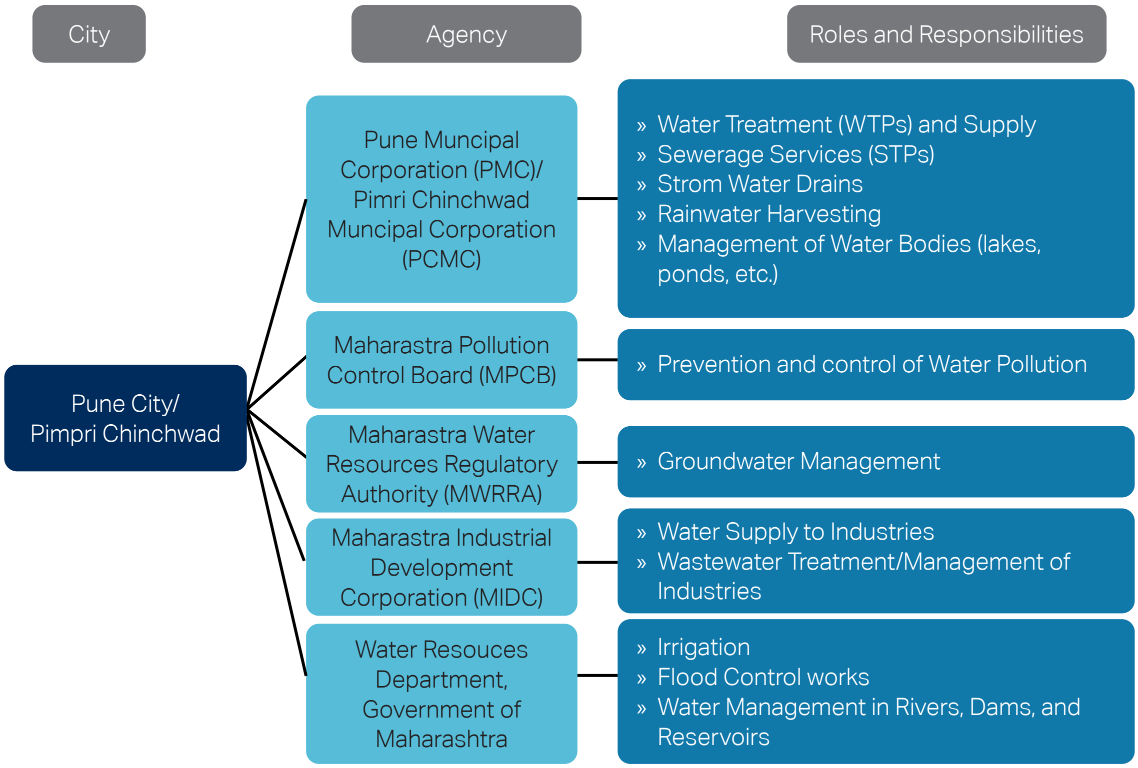

FIGURE 13: Institutional framework for the water sector in Pune city and Pimpri Chinchwad

3.2 Inferences

Pune City (PMC area) and Pimpri Chinchwad (PCMC area)

» Transfer of functions for water supply and services according to the 74th Constitutional Amendment Act is not mandatory and lies under state government's discretion. The idea behind the Act was to strengthen the urban local bodies. Pune city along with Mumbai are the only two cities in India which have devolved maximum functions (14.5, 14 fully and 1 partially)[25] out of 18 to the urban local bodies and that is commendable. However, crucial areas, such as groundwater management, still remain under the state government (MWRRA) control in both Pune city and Pimpri Chinchwad.

» As mentioned in the previous section, Groundwater (Management and Development) Act (GMDA) lays down certain functions for the MWRRA regarding groundwater management that has largely remained unimplemented as the focus of this Act has predominantly been on rural groundwater. Due to this, PMC/PCMC areas have been facing the brunt of this. For example, the Watershed Water Resource Committees (WWRC) to be formed by the

[25] Details available at https://cuts-cart.org/pdf/National_Conference_on_25_Years_of_74th_CAA_RCMLP-2-July10-2018.pdf; last accessed on October 5, 2021

State Authority to work out annual watershed-based or aquifer-based groundwater use in the notified region will include 11 villages from the region and its chairperson will be the Chairperson of the concerned Panchyat Samiti (SANDRP, 2016). It gets unclear about how this will be implemented in urban areas. Therefore, the groundwater management in urban areas (PMC and PCMC) remains poorly attended.

» It has been in fact seen that there are a lot of confusions about permissions to be obtained related to groundwater like bore wells. People are unaware of which authority to be approached and what the binding regulations are. There is a lack of participatory and transparent mechanism for groundwater regulation in these areas.

» This has often been seen that overlapping of functions between government bodies like PMC/PCMC and MWRRA over groundwater management and permissions, between PCMC and MIDC over treatment of industrial waste water, weakens accountability and creates delay in finding and implementing solutions to the problems being addressed.

4. WATER SOURCE MANAGEMENT AND INFRASTRUCTURE

4.1 Water Sources

4.1.1 Historical Background

Pune developed along the river called Mutha, which has been the main source of water supply to the city since the beginning. Pune witnessed rapid increase in population after it became the de facto capital of Maratha Empire under the Peshwas in the 18^{th} century. To fulfil the need of water requirement, the first major water supply system was built in the 1750s. A series of aqueducts were built to transfer water from the lake built by Peshwas in Katraj to the Shaniwar Wada. Later on, more aqueducts and water reservoirs were built in the city.

The first dam was built in Khadakwasla on Mutha River in 1867, which today is the major supply of water to the Pune city and the cantonment areas. The first dam built in Pune after independence was at Panshet in 1961 but it was destroyed due to structural failure, which resulted in massive flood taking thousands of lives. It was rebuilt later in 1972. Two more new dams were built to meet the increasing water requirements—Varasgaon in 1994 and Temghar in 2000.

After the Pimpri Chinchwad became a rapidly developing satellite city to Pune, Pavana dam was built in the year 1990 to meet the water requirements for Pimpri Chinchwad Municipal area.

4.1.2 Current Scenario

To fulfil the increasing demand of water in Pune city and Pimpri Chinchwad area, a number of sources are being tapped to source and distribute water to the region. Both the areas receive their water from three main sources: rainwater, surface water, and groundwater.

Rainwater

No separate rainfall data is available for Pimpri Chinchwad City Taluka. As it is an extended region of Pune city, Pune city has been considered and taken as the representative of both Pune City Taluka and Pimpri Chinchwad City Taluka.

The monsoon period in Pune starts from June and lasts till October. As shown in Table 1, Pune city receives maximum rainfall from June to September with an average annual rainfall of 699.9 mm and with July being the wettest month with lowest evapotranspiration rate. The months between January and May experience negligible rainfall in the city. Water from monsoon rains fills the rivers, reservoirs and replenishes the groundwater periodically. This water is then distributed to meet the requirements of the city.

TABLE 1: Average month-wise rainfall and evapotranspiration statistics of Pune city

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Average rainfall (mm) (1901–2000)[26]	1.6	1.1	2.7	13.6	33.3	120.4	179	106.4	129.1	78.8	28.6	5.3	699.9
Rainy days (1951–1980)[27]	0	0.1	0.6	1.1	2.8	7.5	12.8	10.6	7.4	4.6	2	0.4	49.9
Evapotranspiration (mm/d) (1960–2002)[28]	6.04	6.72	7.29	7.61	7.44	5.94	4.75	4.56	5.13	6.03	6.03	5.8	73.3

TABLE 2: Month-wise rainfall and rainy days statistics of Pune city from year 2015–2020[29]

Months		2015	2016	2017	2018	2019	2020
January	Rain (mm)	1.09	0.02	0.02	0	0	0
	Days	2	1	0	0	0	0
February	Rain (mm)	5.3	1.71	0	0	0	0.2
	Days	1	2	0	0	0	1
March	Rain (mm)	11.53	7.64	1.03	0.48	0	18.7
	Days	11	4	1	2	0	5
April	Rain (mm)	12.08	2.41	0.01	1.23	4.6	0.4
	Days	5	8	0	9	4	2
May	Rain (mm)	18.11	5.85	4.58	3.88	0	12.7
	Days	5	3	3	2	0	6
June	Rain (mm)	132.58	114.73	141.8	155.85	277.2	-
	Days	24	26	28	26	19	-
July	Rain (mm)	44.88	129.4	63.73	119.23	293	-
	Days	20	23	22	26	30	-
August	Rain (mm)	34.08	102.67	69.63	56.16	246.5	-
	Days	23	27	22	24	31	-
September	Rain (mm)	95.14	95.8	141.17	69.89	359.5	-
	Days	20	25	27	24	29	-
October	Rain (mm)	46.23	20.23	97.69	22.1	512.4	-
	Days	15	15	17	10	29	-
November	Rain (mm)	30.26	0.43	2.27	98	90.5	-
	Days	7	1	1	6	12	-
December	Rain (mm)	0.86	0.52	4.4	0	8.5	-
	Days	4	1	4	0	12	-
Total annual rainfall (mm)		432.14	481.41	526.33	526.82	1791.7	-
Total number of rainy days in a year		137	122	125	129	139	-

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26 Details available at http://www.imd.gov.in/pages/services_climate.php?adta=PDF&adtb=&adtc=../section/climate/climateimp; last accessed on October 5, 2021

27 Climatological Table of observations in India, IMD

28 India Water Portal

29 Details available at https://www.worldweatheronline.com/pune-weather-averages/maharashtra/in.aspx; last accessed on October 5, 2021

As seen in Table 2, the rainfall pattern in Pune from 2015 to 2019 shows an extremely undulating pattern.

- It can be seen that in the non-monsoon months, i.e., from January to May the rainfall intensity has decreased from 2015–2019 and saw a drastic increase specifically in the months of March and May in 2020.
- Secondly, in the last 5 years June has become the wettest month in Pune indicating the prepones of heavy spell of rain.
- The peak month rainfall intensity and annual total number of rainy days has increased post 2016. The peak month rainfall intensity shot up in 2019 to three times (512.4 mm) the intensity in 2018 (155.85 mm), which had created havoc across the region with extreme loss of lives and property due to flooding.

The major factor for such an unpredicted rain spell can be attributed to the changing climate across the world due to global warming of which GHG emissions are the most prominent reason. And as it becomes difficult to predict the rain intensity in the coming years, the estimates of water availability in the rivers and reservoirs has become a challenging task for the authorities and prepare accordingly.

Surface Water

Pune City (PMC area)

Mutha River is the major and only source of surface water in the Pune city and is stored in reservoirs built across 4 major dams linked together—Khadakwasla, Panshet, Temghar, and Varasgaon dam, known as Khadakwasla Complex. The combined capacity of all these dams is 818 MCM as shown in Table 3.

TABLE 3: Storage capacity at full reservoir level of surface water sources supplying water to Pune City Taluka

City Taluka	Source of Surface Water	Storage Capacity at Full Reservoir Level (MCM)[30]
Pune	Khadakwasla dam	56
	Panshet dam	294
	Temghar dam	105
	Varasgaon dam	363
Total Combined capacity		818

[30] Details available at http://www.punefloodcontrol.com/bhima_basin_RESERVOIR_WATER_LEVEL_REPORT.aspx; last accessed on October 11, 2021

Pune uses the waters of the Mutha River from the Khadakwasla reservoir. Dams at Panshet, Varasgaon and Temghar supplement the storage capacity of Khadakwasla. Khadakwasla dam has been built on the Mutha River, which begins from the confluence of the rivers Ambi and Mose on which the Panshet and Varasgaon dams are built respectively, and the outflow from Temghar Lake through Temghar dam, which is about 15 km north of Varasgaon dam into Khadakwasla Lake, as shown in Figure 2. All these dams are managed by the Irrigation Department. PMC buys water from the Irrigation Department, treats and supplies it to the city.

The Katraj and Pashan dams are not directly used for water supply by the PMC but have a significant role in the recharge of groundwater, which is used by thousands of residents in the city.

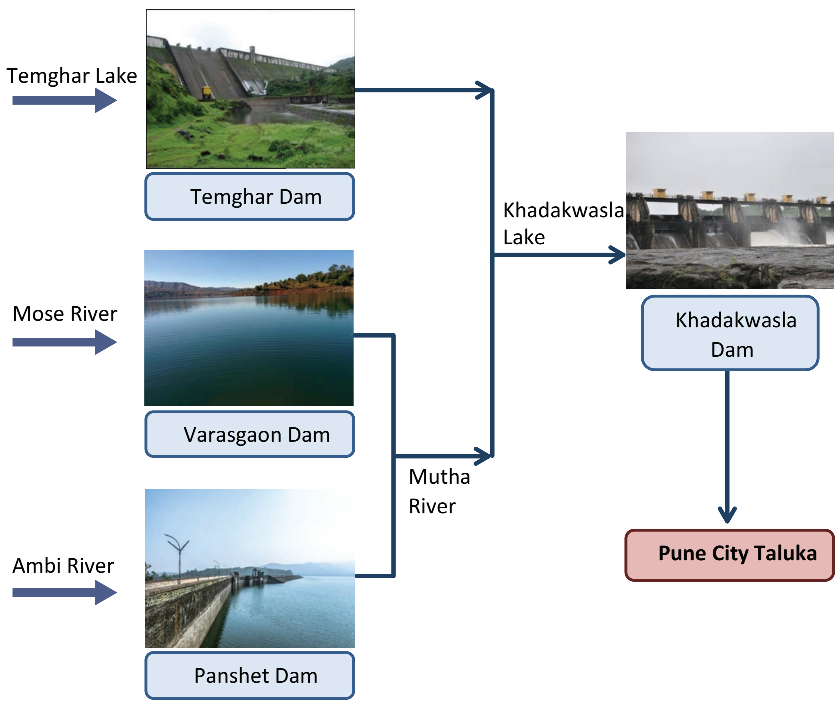

FIGURE 14: Surface water sources for Pune City Taluka[31]

There is one more important source of water in the region, which is Mulshi dam on Mula River, but is currently being used for generating electricity at the Bhira hydroelectric power plant, operated by Tata Power Company Ltd.

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[31] Details available at https://alchetron.com/Temghar-Dam , https://media-cdn.tripadvisor.com/media/photo-s/09/c0/2f/80/varasgaon-and-panshet.jpg, https://www.hindustantimes.com/pune-news/irrigation-department-shuts-down-pumps-at-khadakwasla-dam-cuts-pune-s-water-supply/story-9oV6JuTXHvvDiFeBduzpOK.html, https://www.justdial.com/Pune/Panshet-Dam-Near-Tanaji-Sagar-Panshet/020PXX20-XX20-141211114515-W7X5_BZDET, https://www.hindustantimes.com/pune-news/water-level-in-pune-s-pavana-dam-depletes-to-39-per-cent/story-PgWp2hXj5HTdsVVIWV9G3I.html

As seen from Table 4, the current live storage of water in Khadakwasla reservoir is highest during monsoon months (July to November) almost near to the live storage capacity at FRL at times, but reduces during the months from January to May.

The variations in current live water storage each year can be attributed to the undulating pattern of rainfall from 2015–2019 (Table 2). It can be seen here that the total annual rainfall is increasing since 2015, but the average live water storage capacity shows a decreasing trend post 2017. This less collection of rainwater could be due to the mismanagement of rainwater.

TABLE 4: Current live storage of water in Khadakwasla reservoir 2015–2020 (MCM)[32]

Months	2015		2016	2017	2018	2019	2020
January	-		24.3	34	39.8	33	45.4
February	-		29.8	35.3	32.8	31.8	35.8
March	-		24.6	43.4	42.4	34	35
April	44		22.3	49	42.3	26.8	31
May	39.8		31.5	27	33.6	18.2	24.3
June	27		16.4	14.3	14.3	14.5	-
July	19.8		43	29.5	40.5	39	-
August	14		53.3	53	56	54.6	-
September	14.4		53.4	54.3	50	56	-
October	25.3		51	54.3	41.3	46.8	-
November	25.5		43.3	46	38.2	50.5	-
December	30		35.8	38.5	30	45	-
Average	26.6		35.7	39.9	38.4	37.5	-

The current live storage of each month has been computed by taking average of readings of 4 to 5 days of that month.

Pimpri Chinchwad (PCMC area)

Pimpri Chinchwad area receives its water from the Pavana dam built on Pavana River which has a storage capacity of 240.97 MCM.

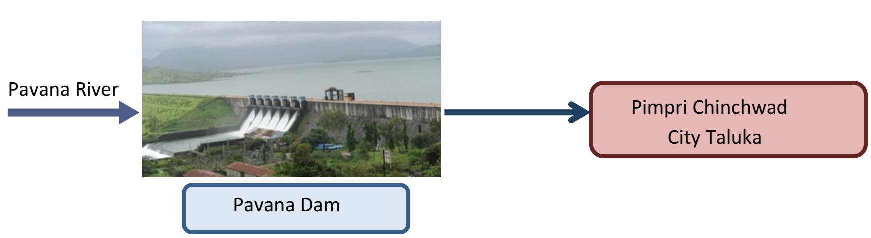

FIGURE 15: Surface water sources for Pimpri Chinchwad City Taluka

32 Central Water Commission, Water Information, Reservoir Level and Storage Bulletin

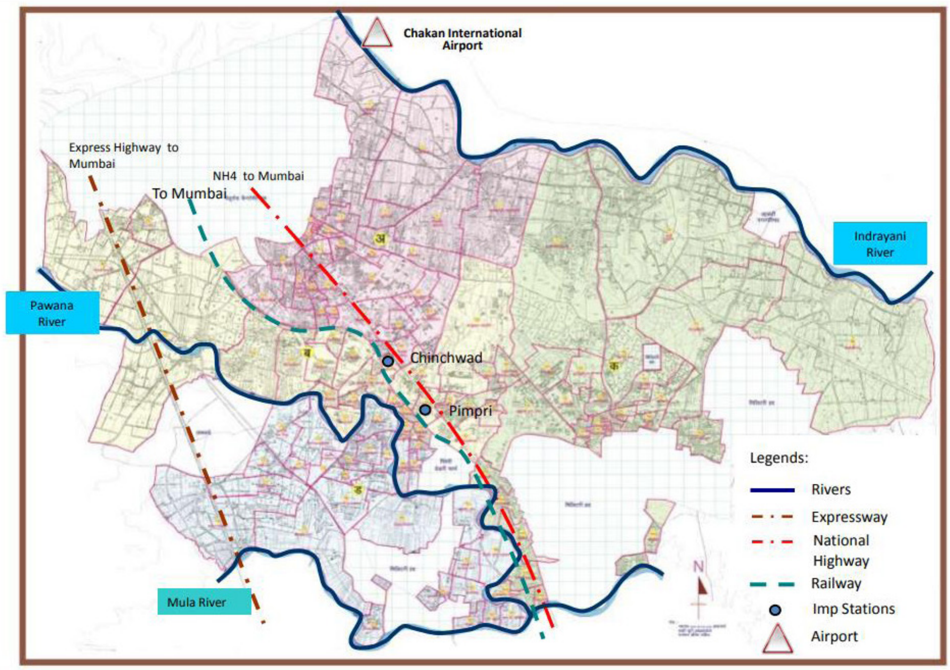

FIGURE 16: Pimpri Chinchwad City Taluka map showing rivers layout[33]

Pimpri Chinchwad is fed by three rivers. Pavana River, which flows across the city, is the only source being used by the city among the three rivers. The remaining two rivers are Mula and Indrayani rivers which flow along the periphery of the city taluka. Indrayani River flows on the northern boundary, which later meets the Bhim River. Mula River flows along the southern boundary, which later enters the Pune City Taluka and gets merged with Pavana River. This Mula River then merges with Mutha River in Pune city to form Mua-Mutha River.

Water from Mula River is being used for generating electricity, as mentioned in the last section. Both Indrayani and Mula rivers are found to be highly polluted due to discharge of untreated wastewater into these rivers.

The current live storage of water in Pavana reservoir is not available, hence could not be analysed.

Groundwater

Groundwater forms an important component of water use in the Pune city, although there is no system in place to measure the actual volume of groundwater extracted**.** It is not known how much share of the total city's water use is groundwater. As mentioned in the previous chapter under 'Administrative Set-up of Pune city and Pimpri Chinchwad', groundwater management in both the talukas is poor and unregulated, therefore resulting in unavailability of reliable data on it.

There are 399 dug wells and 4,820 bore wells in the city. [34] According to *Ground Water Information Report 2013,* depth of groundwater level within Pune city varies between 5 and 10 m. The

[33] Details available at http://mohua.gov.in/upload/uploadfiles/files/PCMC_Water_PPT_0.pdf; last accessed on October 11, 2021

[34] Details available at https://pmc.gov.in/informpdf/CDP/2_CDP_Physical_Social_infra.pdf; last accessed on October 11, 2021

chemical quality of groundwater in city was good and suitable for drinking and irrigation purposes. However, localized nitrate contamination was observed. In 17% water samples collected from CGWB Ground Water Monitoring Wells, excessive nitrate content (> 45 mg/L) was recorded during the year 2011.

In a recently published report *Pune's Aquifers: Early insights from a strategic hydrogeological appraisal* in 2019 by Acwadam in collaboration with the Centre for Environment and Education and Mission Groundwater (Bhujal Abhiyan) shows that Pune's groundwater is depleting at an alarming rate due to rapid expansion of the city. The hilly terrain of the region has started to face the brunt of it due to which the water recharge capability is getting disturbed due to the impact of hill cutting specifically for carrying out activities such as quarrying and mining. The Lonavala–Khandala belt of the Western Ghats being ecologically fragile is experiencing the depleting carrying capacity due to these activities, leading to further environmental deterioration.[35]

As the groundwater description/data by CGWB is only available for 13 talukas of Pune district and not for Pune city and Pimpri Chinchwad city talukas, therefore, the numbers for groundwater extraction for Pune city has been taken from the report mentioned before for computation of water demand and supply in the subsequent chapters. Also, PCMC is currently in the process of conducting the groundwater assessment. Therefore, analysis of groundwater for Pimpri Chinchwad has been excluded due to unavailability of data.

4.2 Water and Wastewater Treatment Infrastructure

In order to meet the various types of city's water demand, the water stored in the reservoirs requires infrastructure for a safe and continuous supply to the end user.

To meet the minimum water quality standards, Water Treatment Plants are installed where the water tapped from the reservoirs is treated and further supplied to the city.

The wastewater from cities is further collected and treated in Waste Water Treatment Plants in order to remove as much of the suspended solids as possible before the remaining water is discharged back to the rivers.

4.2.1 Water Treatment Plants

Historical Background

In 1750, Peshwas built the Katraj Lake to arrange for water supply to the Pune city. Later in 1790, the well water was directed by means of an earthen duct, which was said to be of very good quality and was collected in a tank at Sadashiv Peth area in Pune city.

In 1755, Ambil Odha River was dammed at Katraj, creating two lakes. The upper one was for settling silt and the lower one for providing water. The reservoir created by the damming of Ambil is the Katraj Lake, which is located 10 km south of Pune city. This historic water supply

[35] Details available at https://indianexpress.com/article/cities/pune/lonavala-hill-cutting-will-lead-to-environment-degradation/; last accessed on October 11, 2021

system comprises huge ducts and underground tunnels originating from Katraj Lake of the city to the historic Shaniwarwada Fort, the ancient seat of the Peshwas. This Katraj water supply scheme played an important role as Pune was flooded when Panshet tumbled down in 1961. Today however, water from the Katraj reservoir is found to be not potable and cannot be used as drinking water.

In 1876, Britishers built a small canal running parallel to the Mutha River bringing the water to Pune city. Some of the pipelines laid about 150 years ago still exist. Two canals Mutha Right Bank Canal and the Mutha Left Bank Canal were drawn. Water in the Mutha Right Bank Canal was directed towards Swargate Water Purification Plant, and after purification it was being supplied to Pune city. Up to the year 1968, the Swargate Water Purification plant played the main role in water supply in Pune.

Current Scenario

The water extracted from the surface and subsurface sources such as intake wells, infiltration wells and bore wells is treated in the Water Treatment Plants (WTPs), which is managed by PMC for Pune city and PCMC for Pimpri Chinchwad city. It is then distributed to different parts of the city and supplied for different end uses for domestic, industrial, and irrigation purposes.

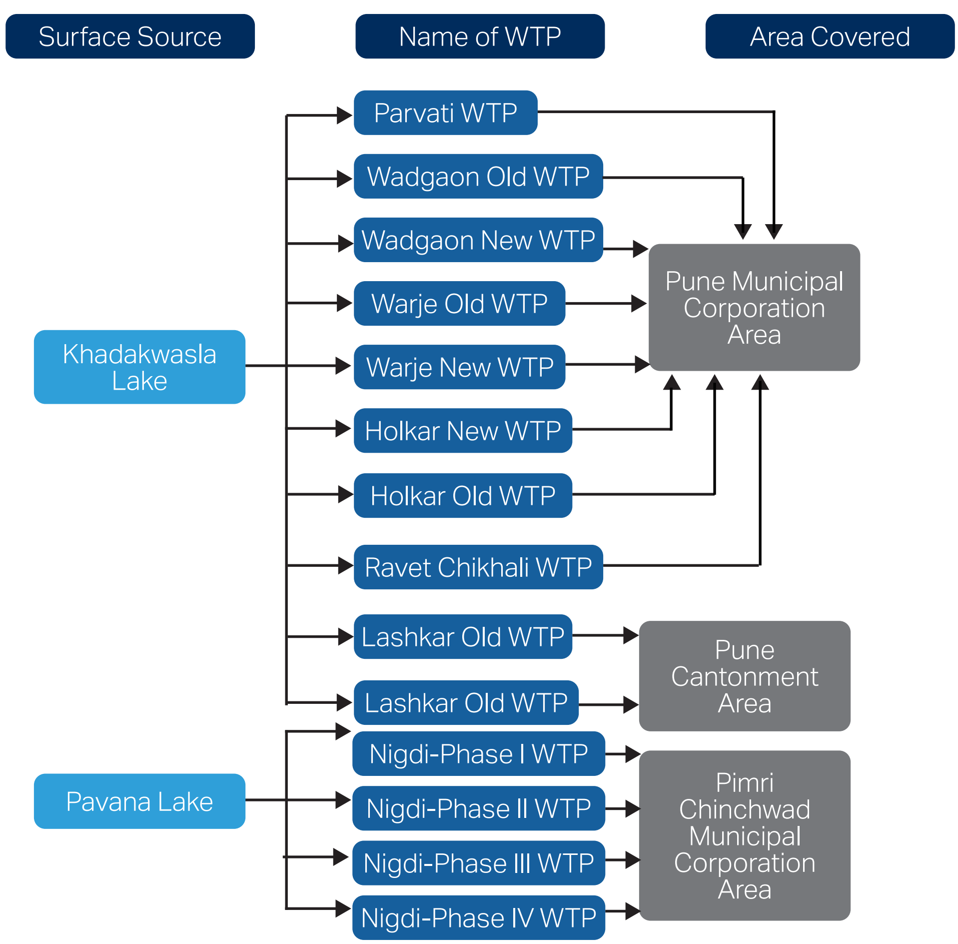

FIGURE 17: Water treatment plants in Pune and Pimpri Chinchwad City Talukas

At treatment plant, the raw water is made potable up to the standards of safe drinking water by pre-chlorination, primary treatment, and filtration. Quality control is assured through laboratory testing at the WTPs.

Today, a number of water treatment plants have been constructed across the Pune city to treat the water from Khadakwasla reservoir. Currently, there are 8 water treatment plants in Pune city, which have a combined treatment capacity of 1034.5 MLD.

Pimpri Chinchwad has 4 WTPs treatment plants. Water is lifted from Ravet bund which is then pumped into these WTPs at Nigdi from where it is then later distributed to the entire PCMC area. These WTPs have been developed in different phases as seen in Table 5, which has a combined capacity of 428 MLD.

TABLE 5: Water treatment plants with their treatment capacities in Pune city and Pimpri Chinchwad City Taluka

City Taluka	Name of WTP	Capacity (MLD)
Pune Cantonment Board[36]	Lashkar Old	325
	Lashkar New	100
Total Capacity		425
Pune city (PMC)[37]	Parvati	455
	Wadgaon Old	125
	Wadgaon New	125
	Warje Old	150
	Warje New	100
	Holkar Old	12.5
	Holkar New	40
	Ravet Chikhali	27
Total Capacity		1034.5
Pimpri Chinchwad[38]	Nigdi - Phase I (1989)	114
	Nigdi - Phase II (1999)	114
	Nigdi - Phase III (2006)	100
	Nigdi - Phase IV (2010)	100
Total Capacity		428

[36] Details available at https://pmc.gov.in/en/water-treatment-plants-0; last accessed on October 11, 2021

[37] Details available at https://pmc.gov.in/en/water-treatment-plants-0; last accessed on October 11, 2021

[38] Details available at http://mohua.gov.in/upload/uploadfiles/files/PCMC_Water_PPT_0.pdf; last accessed on October 11, 2021

4.2.2 Sewage Treatment Plants

Historical Background

Sewerage system in Pune was laid in the late 1915, which covered core central areas of Pune. Later from 1928, the collected sewage was given preliminary treatment such as screening and grit removal at Bhairoba Nala, and it was used for irrigation purpose. This system was designed for 31.8 MLD to cater to the ultimate design capacity for population of 2,60,000 in the year 1951

In the year 1981, a complete collection and disposal system was planned taking into account the adjoining areas where population was expected to increase. A 90 MLD sewage treatment plant was constructed at Dr Naidu I D Hospital. The treated sewage is let off into the Mula-Mutha River. There is an intermediate pumping station at Kasba Peth of 90 MLD capacity from where sewage is pumped into the sewage treatment plant at Dr Naidu Hospital.

Up to the year 1997, the total main sewer length in all the zones was approximately 146.83 km, in old Pune city limit. Dr Naidu Sewage Treatment Plant with full-fledged primary and secondary sewage treatment facility was treating 90 MLD sewage, and Bhairoba Nala sewage treatment plant with primary sewage treatment facility was treating 32 MLD sewage.

Considering the increase in the area under the jurisdiction of PMC and a rapid rise in population, the project plan for water supply and sewerage services was revised and more STPs were added over the years.

Current Scenario

Pune City (PMC area)

There are a total of 10 sewage treatment plants in Pune city as can be seen in Table 6. But instances of discharging untreated sewage directly into waterways is rampant. Due to insufficient capacity of sewage treatment plants and not enough sewage carrying infrastructure covering every household, this is resulting in discharge of untreated waste directly into Mula-Mutha River. The polluted Mula-Mutha rivers combine to form Bhima River, which further meets Krishna River and ultimately flows into the Bay of Bengal.

Pune City (PMC limits) covers 92% of sewerage network of 2,200 km. Six intermediate pump stations (IPS) have been installed for pumping the sewage.

As per the agreement between the Pune Municipal Corporation and the Water Resources Department (WRD) of the Government of Maharashtra, Pune receives 11.5 TMC of water annually and it is supposed to give back 6.5 TMC of water back to the WRD. This 6.5 TMC of treated water from STPs is used either in agriculture or directly discharged in Mula-Mutha River.

TABLE 6: Sewage treatment plants in Pune City Taluka as of 2019[39]

S. No.	Sewage Treatment Plant	Designed Capacity (MLD)	Main Treatment Process
1	Naidu (New)	115	Activated sludge process
2	Bhairoba	130	Activated sludge process
3	Tanajiwadi	17	Biotech with extended aeration
4	Erandwane	50	Modified activated sludge process
5	Bopodi	18	Extended aeration process
6	Baner	30	Sequential batch reactor process
7	Mundhwa	45	Sequential batch reactor process
8	Kharadi	40	Activated sludge process
9	Naidu (Old)	90	Activated sludge process
10	Vitthalwadi	32	Activated sludge process
Total		**567**	

Pimpri Chinchwad (PCMC area)

There are 13 STPS in PCMC area, which have a combined capacity of 317 MLD.[40]

Discharge of untreated wastewater is also seen in Pimpri Chinchwad, despite having STPs in place. Reasons such as underutilization of existing STPs and absence of sewage-carrying infrastructure covering every household can be attributed to this.

There are 16 pumping stations in the city to send the sewage to these STPs. There is a network of 1187-km long drainage pipelines to transport the sewage to the pumping stations.

4.2.3 Water Meters

Water metering is the process of measuring the water use. It helps in cutting losses due to theft and ageing infrastructure and also makes the end user to use the water judiciously. More the coverage of metered water connections, more efficient is the revenue collection by the municipality. Due to its numerous benefits, water meter installation is seen to be increasing in Indian cities both by municipalities and private entities.

Pune City (PMC area)

As of year 2010, the coverage of metered connection for water was only 29.71%[41] as compared to the Service Level Benchmark (SLB) indicator of 100%. Due to the inadequacy in metered connections, this resulted in low revenue collection for the water supply department. High number of unmetered water connections further led to non-judicious use of water. Almost all the metered

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39 Details available at http://icrier.org/pdf/pune_6feb13_new.pdf; last accessed on October 11, 2021

40 Details available at https://www.pcmcindia.gov.in/location_info.php; last accessed on October 12, 2021

41 Details available at https://pmc.gov.in/informpdf/CDP/2_CDP_Physical_Social_infra.pdf; last accessed on October 12, 2021

connections covered the commercial establishments. No updated data on installed metered connections in the city post 2010 is available.

Recently in 2019 in order to overcome the shortage of water meters in the city, PMC invested in over 275,000[42] smart water meters to monitor, measure and manage activity across its network covering both commercial and residential sites. The objective was to encourage customers to reduce consumption levels and ensure continuous water supply. Although no official statistics over its implementation is available.

Pimpri Chinchwad (PCMC area)

Coverage of metered connection in Pimpri Chinchwad from 2004–10 is given below. The rate of installation of water meters in PCMC has been in alignment with the increase in water connections as the city urbanized post 2000. The ratio of metered connection to total number of connections increased rapidly from 7.8% in 2006–07 to 96.4% in 2009–10. This ensured fair revenue collection and judicious water use.

TABLE 7: Water meter connections in PCMC from 2004–10[43]

S. No.	Year	No. of connections	No. of metered connections	No. of unmetered connections	Ratio of metered to total no. of connections (in %)
1	2004-05	-	-	-	-
2	2005-06	77,191	0	77,191	0
3	2006-07	89,747	7082	82,665	7.8
4	2007-08	98,554	70,159	28,395	71.1
5	2008-09	109,695	87,505	22,190	79.7
6	2009-10	117,019	112,831	4188	96.4

Data on metered connections post 2010 is not available, hence couldn't be analysed.

4.2.4 Water Quality of Waterways Carrying Wastewater

Mula-Mutha River crossing through the Pune city is among the 35 most polluted river stretches in the country. It has been classified as Priority 1 (the highest risk category) by the Central Pollution Control Board. The major factors for its pollution are untreated domestic wastewater discharge into the river due to inadequate sewerage system (including pumping stations) and sewage treatment capacity.[44]

Similarly, rivers flowing across Pimpri Chinchwad are also found to be polluted.[45] Pavana River is the most polluted as it flows across the city and is found to have a heavy industrial wastewater discharge into it. The remaining two rivers Indrayani and Mula that flow at the periphery of the city taluka are less polluted than Pavana.

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42 Details available at https://www.sify.com/finance/pune-city-to-use-275000-digital-water-meters-news-technology-tctordbdebcfc.html; last accessed on October 12, 2021

43 Details available at http://mohua.gov.in/upload/uploadfiles/files/PCMC_Water_PPT_0.pdf; last accessed on October 12, 2021

44 Details available at https://pib.gov.in/PressReleasePage.aspx?PRID=1573749; last accessed on October 12, 2021

45 Details available at https://www.hindustantimes.com/cities/pcmc-readies-action-plan-to-contain-pollution-of-rivers/story-urALV7e7xLU5bE4LiRzd7H.html; last accessed on October 12, 2021

As it can be seen, that the water quality of rivers in the cities has degraded and is in need of immediate interventions. This would require a detailed study analysing the data to fill in the gaps and generate solutions to improve the quality of these water bodies.

4.3 Inferences

Pune City (PMC area) and Pimpri Chinchwad (PCMC area)

Surface source

» The region is going to experience a staggered pattern of rainfall over the coming years due to rapidly changing climate, thus making it difficult to predict the rainfall intensity and period. This would affect the water storage capacity in the reservoirs as well, which would fluctuate throughout the year. Therefore, the authorities would have to emphasize on tapping alternative sources of water like treated STP water and adoption of water-efficient technologies to cope up with the challenges of water scarcity that could be faced in the future. Adaptation strategies would also be required to put in place to avert the rising flood risk due to excessive rainfall.

Groundwater Source

» Unavailability of data on groundwater recharge potential and extraction creates information gap for the planning bodies. Due to no reliable record of groundwater availability and extraction data, the natural resource continues to get exploited without any municipality control. This is a huge roadblock to understand and analyse the water use by the city from various sources. Groundwater information for Pune district is available but there is a need to carry out study on groundwater management at the taluka level (Pune city and Pimpri Chinchwad city) as city level understanding of groundwater would require city-level study.

  Although few privately conducted studies show that if the built-up expansion is not controlled and water flow is not properly managed, the groundwater levels and quality will keep on decreasing in near future as well.

Sewage Treatment Plants

» The existing STP infrastructure in both talukas is proving insufficient in treating the total waste generation and is underutilized, as a significant amount of sewage is found to be getting discharged into the water bodies without getting treated.

Water Metering

» Unavailability of latest data on water metering in both talukas poses a challenge in computing water use and losses. Extrapolating the ten years-old available data on water meter connections of both talukas suggests that inadequate metering connection is still persistent today.

Water Quality of Waterways Carrying Wastewater

» The quality of rivers (Pavana, Indrayani, Mula and Muth-Mula) flowing across both the talukas are deteriorating due to discharge of untreated domestic sewage (both PMC and PCMC area) and industrial wastewater (PCMC area only) into it.

5. POTENTIAL RISKS IN WATER MANAGEMENT

5.1 Urban Water Cycle

Water is continuously cycling around, through and above the Earth in a natural water cycle that has existed for billions of years. As water moves between the land, ocean, rivers and atmosphere it changes from solid to liquid to gas. This natural water cycle is our planet's way of recycling water, and is essential for life on Earth. The stages of natural water cycle include environmental evaporation, condensation, precipitation, infiltration, run-off, and transpiration.

The urban water cycle is different from the hydrological cycle. People have changed the natural water cycle by building pipes, taking water for drinking, and removing sewage and stormwater. This is known as the urban water cycle, which uses engineered methods that bring clean water to each of us.

5.1.1 Pune City Taluka

The main steps of urban water cycle for Pune city are:

1. **Source:** The major source of water supply in Pune city taluka is surface water, which is used to meet the domestic and non-domestic water requirements of residential, commercial, industrial, agricultural, and vegetation spaces. Major source of water supply remains the Khadakwasla dam on Mutha River along with Panshet, Varasgaon, and Temghar dams.

   Groundwater is also another important source for meeting the water supply demand of Pune but is unregulated, resulting in exploitation of the groundwater resource. The groundwater extraction is found to be carried out by private individual households. Tankers are also found to be used during months of water scarcity.

   In addition to this, rainwater harvesting in buildings is also found for meeting mostly non-domestic water requirements. The untapped rainwater is discharged into the waterways as untreated run-off.

   There is one more important source of water in the region which is Mulshi dam on Mula River, but is only currently being used for generating electricity.

   There are two lakes Katraj and Pashan also in the city but are found to be heavily polluted due to waste discharge. During British era, these lakes were a major source of drinking water to the nearby villages.

2. **Treatment, Storage and Distribution:** Water tapped from the Khadakwasla dam is transferred to various WTPs built across the city for treatment. The treated water is then distributed and stored in several large water storage tanks. There are 67 water supply zones[46] in the Pune city having a total of 56 water service reservoirs[47] with a total storage capacity of 400 ml, i.e., 30% of the daily demand. This treated water is then supplied

[46] Details available at https://pmc.gov.in/sites/default/files/project-glimpses/24x7_water_brochure.pdf; last accessed on October 12, 2021

[47] Details available at http://icrier.org/pdf/pune_6feb13_new.pdf; last accessed on October 12, 2021

from these water service reservoirs to the respective zones through a network of pipes consisting of different diameters to the respective city. The lowest diameter size of pipe is 80 mm and highest diameter is 1600 mm. Total coverage of water connections in Pune city is 94%, which indicates 6% of the households do not have water supply connections.

3. **Use:** The supplied treated water from water service reservoirs is then used by residential, commercial, public, agriculture, and landscape spaces in the city. There are no heavy automobile industries inside the Pune City Taluka, therefore industrial wastewater has not been included in the water cycle of the city.

4. **Collection:** The wastewater from residential, commercial and public spaces is then collected and conveyed by sewer systems to wastewater treatment plants. Wastewater from vegetation and agriculture land is collected and conveyed through stormwater drains into water bodies.

5. **Wastewater Treatment and Discharge:** Wastewater from vegetation and agriculture land is discharged into the waterways through stormwater drains.

   Wastewater generated from residential, commercial and public spaces goes into the various public STPs for treatment through sewer drains. This treated water is then given to Water Resource Department from PMC out of which some amount of it is used in agriculture and the remaining is discharged into various waterways carrying wastewater.

   Some private entities like private residential townships have installed their own centralized STPs for wastewater treatment and they reuse the treated wastewater for non-domestic purposes like flushing and landscape water requirements, thus preserving the region's natural waterways from being polluted.

   A significant amount of untreated wastewater is also found to be directly being discharged into the Mula-Mutha River making them heavily polluted due to shortage of STPs in the city.

   The urban water cycle of Pune City Taluka has been shown in Figure 18.

5.1.2 Pimpri Chinchwad City Taluka

The main steps of urban water cycle for Pimpri Chinchwad are:

1. **Source:** The major source of water supply in Pimpri Chinchwad City Taluka is surface water, which is used to meet the domestic and non-domestic water requirements of residential, commercial, industrial, agricultural, and vegetation spaces. Major source of water supply remains the Pavana dam on the Pavana River.

   Over the past few years, use of groundwater has also increased, tapped through bore wells as PCMC runs short of water during summer months and is not able meet the rising water demand. It is found to be unregulated, resulting in its excessive exploitation. Tankers are also found to be used during months of water scarcity.

   In addition to this, rainwater harvesting in buildings is also found for meeting mostly non-domestic water requirements. The untapped rainwater is discharged into the waterways as untreated run-off.

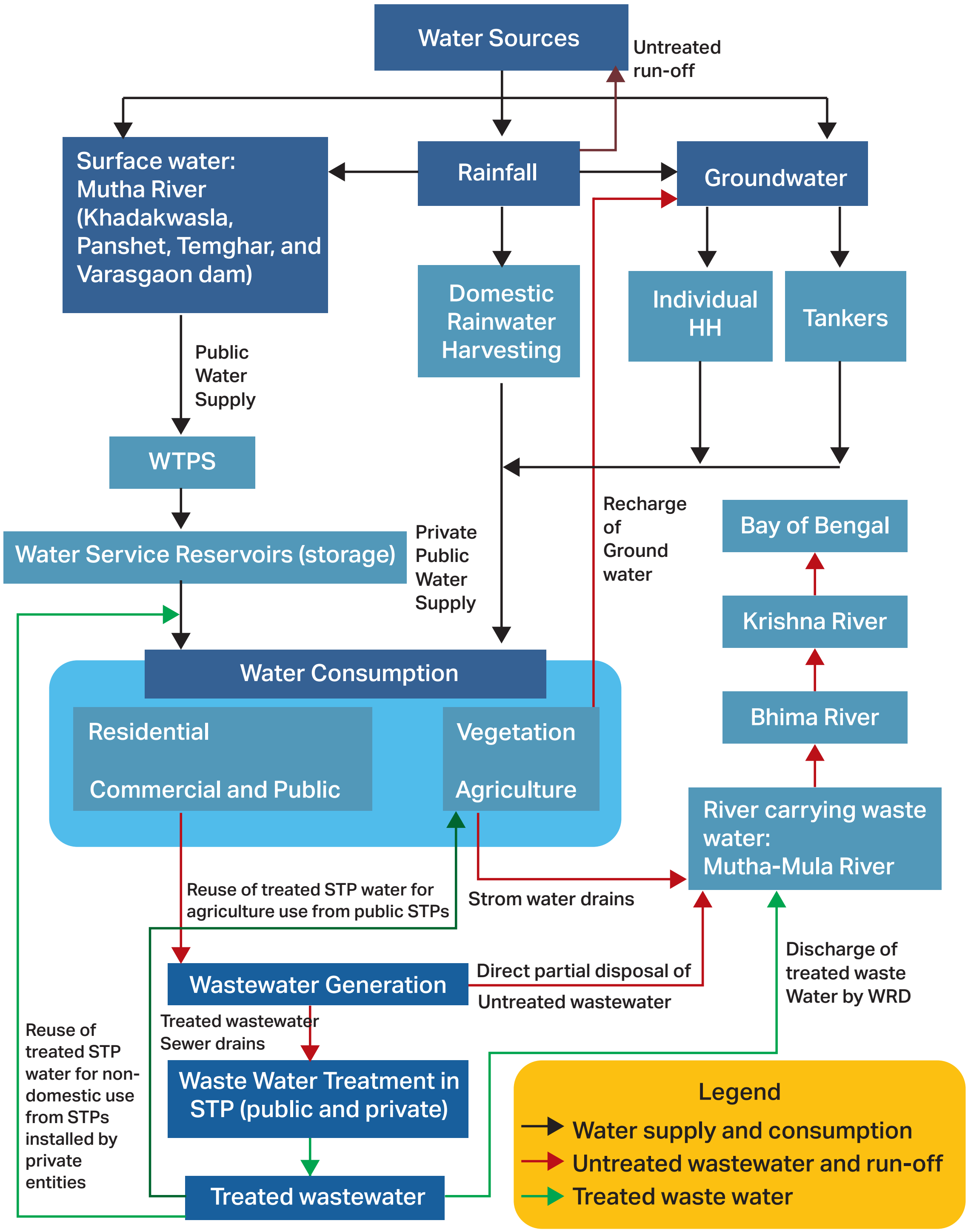

FIGURE 18: Urban water cycle of Pune City Taluka

There is one more important source of water. Mula River flows on the southern periphery of the city but its water is being used for generating electricity only.

2. **Treatment, Storage and Distribution:** Water tapped from the Pavana dam is transferred to various WTPs built across the city for treatment. The treated water is then distributed and stored in large water storage tanks. This treated water is then supplied from these water service reservoirs to the respective zones through a network of pipes consisting of different diameters. The distribution system in the city is based on the division of the entire city into two distinct parts on the basis of its topography, created by the ridge running in the east-west direction—gravity zone and pumping zone. These zones are sub-divided into eight water districts from WD-I to WD-VIII—for ease of distribution.

3. **Use:** The supplied treated water from water service reservoirs is then used by residential, commercial, public, agriculture, and industries in the city.

4. **Collection:** The wastewater from residential, commercial, industrial and public spaces is then collected and conveyed by sewer systems to wastewater treatment plants. Wastewater from vegetation and agriculture land is collected and conveyed through stormwater drains into Pavana, Indrayani and Mula rivers.

5. **Wastewater Treatment and Discharge:** Wastewater from vegetation and agriculture land is discharged into the waterways through stormwater drains.

   Wastewater generated from the city goes into the various public STPs for treatment through sewer drains after which the treated wastewater is discharged into various waterways carrying wastewater. Due to lack of sufficient STPs and CETPs, a significant amount of domestic and industrial effluents are being discharged into the Pavana, Mula and Indrayani rivers making them heavily polluted.

   Some private entities like private residential townships have installed their own centralized STPs for wastewater treatment and reuse the treated wastewater for non-domestic purposes like flushing and landscape water requirements, thus preserving the region's natural waterways from being polluted.

   The urban water cycle of Pimpri Chinchwad City Taluka has been shown in Figure 19.

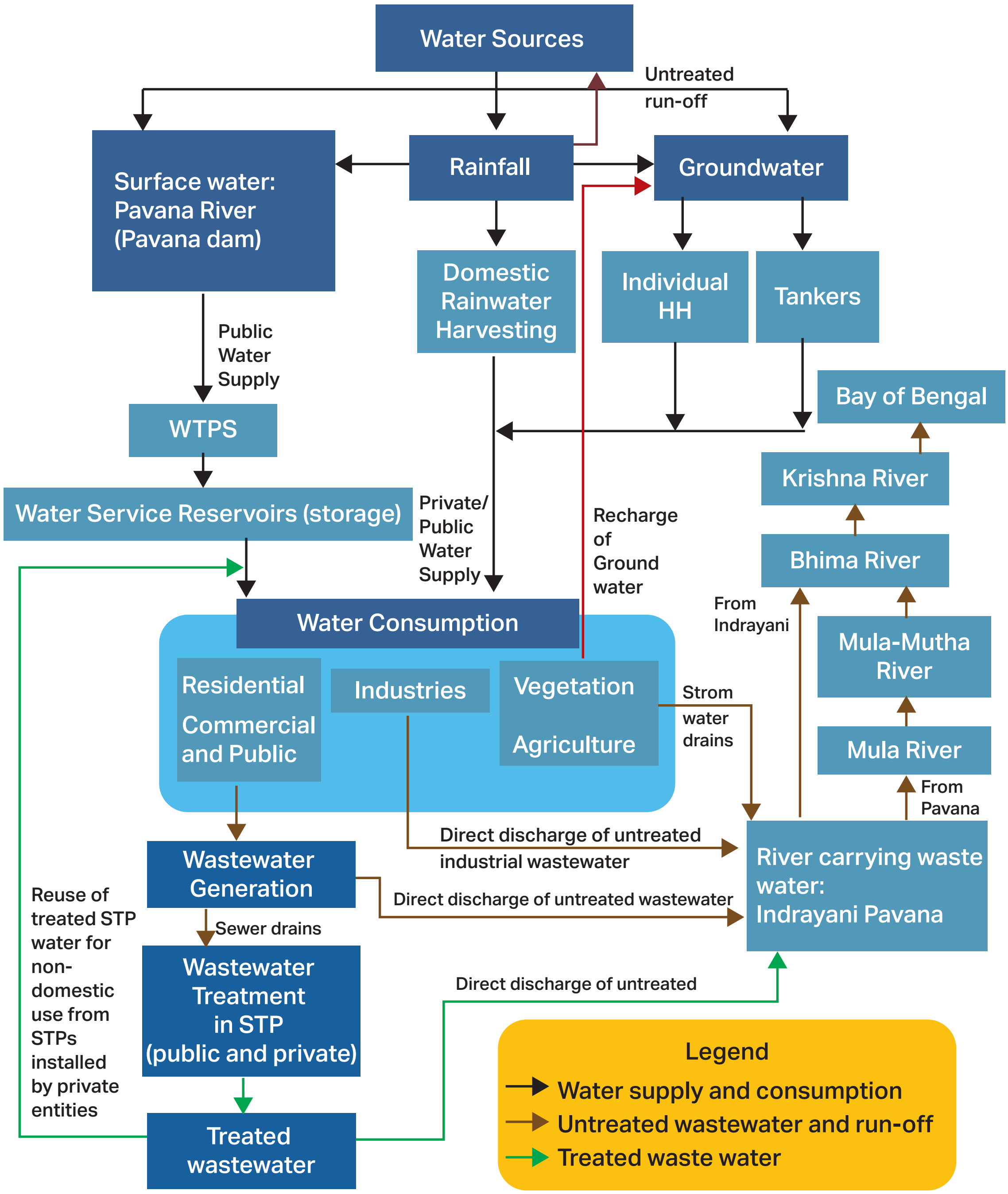

FIGURE 19: Urban water cycle of Pimpri Chinchwad City Taluka

5.2 Water Demand and Supply

The sustainability and quality of water in any city is closely linked to the quantity and quality of basic infrastructure facilities that support it.

Water demand is normally classified as domestic water demand and non-domestic water demand. Domestic water demand covers the use of water for drinking, washing, bathing, flushing, etc. Non-domestic water demand includes the water demand for industries and other uses.

5.2.1 Pune City Taluka

Here we have considered only the domestic water demand (for residential, commercial, institutional, and other public spaces) for computation. Industrial and irrigation water demand has been excluded due to unavailability of data (also as agriculture area is on a decline and there are no heavy industries, the overall water demand will not get affected.)

Table 8 depicts the water demand and supply statistics for 2011 and 2019. Quantities have been listed considering as water supply for 2011 and as water demand for 2019. Some of the attributes for 2019 like population and total water demand have been computed by author due to unavailability of data. Taking this as reference, water demand estimations for 2025 have been computed.

TABLE 8: Water supply and demand statistics for 2011, 2019 and estimations for 2025[48]

Head	2011	2019
City population	3,115,431*	3,729,118***
Per capita average water supply/demand	194 lpcd*	200 lpcd****
Total water supply (extracted from surface water) (MLD)	1123*	-
Water allocation from Irrigation Department (MLD)	900*	900
Losses 25% + 5 % NRW (MLD)	337*	-
Net water supply to Pune city from surface sources after losses (MLD)	732*	-
Domestic water demand of city (MLD)	605***	745.8***
Groundwater extraction (MCM)	56.6 **	113.2 **
WTP Installed capacity (MLD)	908 *	1034.5*****
Wastewater generation	(80% of 732) = 586 ***	(80% of 745.8)= 596.6***
STP Installed Capacity (MLD)	527 *	567*****

48 Details available at https://pmc.gov.in/informpdf/CDP/2_CDP_Physical_Social_infra.pdf; last accessed on October 12, 2021

TABLE 8: Water supply and demand statistics for 2011, 2019 and estimations for 2025[48]

Head	2025
City Population***	4,267,485
Total Domestic Water Demand (MLD)***	853.5
Per capita average water demand (in lpcd)****	200
Groundwater extraction (MCM)**	-
WTP Installed capacity (MLD) ***	1034.5
Waste water generation***	(80% of 853.5) = 682.8
Required STP Installed Capacity (MLD)	Increase to 717 MLD******

*Revising/Updating the City Development (CDP) of Pune City-2041 under JNNURM, Volume I, PMC, 2012

** Report on 'Pune's Aquifers: Early insights from a strategic hydrogeological appraisal' in 2019 by Acwadam in collaboration with the Centre for Environment and Education and Mission Groundwater (Bhujal Abhiyan)

***Computed by author by considering exponential growth in population

**** National Building Code (NBC) 2016, IS1172 (1993) Code of basic requirements for water supply, drainage and sanitation, for communities with more than 1 lakh population and full flushing systems

*****Pune Municipal Corporation website

******Computed by author, required capacity is 5% (peak load) of waste water generation in addition to waste water generation capacity

Past scenario in 2011

1. In 2011, average per capita water supply in city was 194 lpcd. The per capita water supply varied from 138 lpcd to 358 lpcd, which is more than the suggested standard of National Building Code of 150–200 lpcd. This shows inequitable distribution of water in the city.
2. As per the agreement between PMC and state irrigation department, the city has been allocated 900 MLD of water against which the city was found to be consuming around 1123 MLD. This clearly reflects that the population is rapidly increasing in the city as the allocated water is not able to meet the population's water requirement.
3. The water transmission losses accounted to 25% of the total water supply against the standard of 20%. The transmission losses were not only due to old and defunct water supply network and poor management rather due to the undulating terrain of the city.
4. According to a report by Acwadam,[49] it shows that Pune's groundwater is depleting at an alarming rate due to rapid expansion of the city. The groundwater extraction was around 56.6 MCM in the year 2011.
5. The treated water from STPs is taken back by the irrigation department from PMC and used in agriculture and discharged in waterways.
6. The water treatment plants were found to have adequate capacity required for the population that is being served by each of the treatment plants, considering average water supply of 194 lpcd.

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[49] Pune's Aquifers: Early insights from a strategic hydrogeological appraisal

7. The quantity of wastewater generated in Pune City was around 586 MLD. Out of this, approximately 527 MLD was treated in the treatment plants. Remaining wastewater was being let into the streams thereby contaminating it. This reflected the scarcity of STPs in the city.

Existing Scenario in 2019

1. Due to significant increase in population, the total domestic water demand of the city increased to 745.8 MLD from 605 MLD in 2011.

2. The PMC continued to consume more water than it was allocated from the state irrigation department even in 2019. Considering the rapid expansion of the city, PMC has been demanding allocation of 1500 MLD of water, as against its usual quota of 900 MLD approved by the Irrigation department, to meet the increasing water demands. In November 2019, the department pushed back by urging the PMC to restrict its consumption, citing the order of the MWRRA in the matter. The PMC has appealed against the MWRRA order and sought a higher quota of water, and a final decision in the matter has to be taken by the state Water Resources department.

3. According to a report by Acwadam,[50] Pune city was found to be roughly using around 113.2 MCM of groundwater as of 2018–19. This exceeds the entire stock of Khadakwasla dam (56 MCM). The groundwater extraction has doubled since 2011.

4. To meet the increasing demand of water, the installed capacity of water treatment plants was increased to 1034.5 MLD. This treatment capacity was found to be adequate for the population, having 745.8 MLD of total domestic water demand.

5. The quantity of wastewater generated in Pune City increased to 596.6 MLD. The installed STP capacity was also increased to 567 MLD. This was found to be insufficient due to which the remaining wastewater was being let into the streams thereby contaminating it.

Future Scenario in 2025

» Pune city is going to experience a rapid rise in population by 2025, which will stand at around 4,267,485. This is going to increase the water demand of the city to 853.5 MLD. Considering the restricted water allocation by the state irrigation department, PMC might have to look at other alternative sources or practice demand side water management.

» The installed capacity of water treatment plants, i.e., 1034.5 MLD (as of 2019), is found to be adequate for the population, having 853.5 MLD of total domestic water demand in 2025.

» The quantity of wastewater generated in Pune city is estimated to increase to 682.8 MLD in 2025. The current STP infrastructure (567 MLD installed capacity) would fail to treat the wastewater being generated, thus polluting the natural waterways.

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[50] Pune's Aquifers: Early insights from a strategic hydrogeological appraisal

5.2.2 Pimpri Chinchwad City Taluka

Here we have considered only the domestic water demand (residential, commercial, institutional and other public spaces) for computation. Industrial and irrigation water demand has been excluded due to unavailability of data.

Table 9 depicts the water demand and supply statistics for 2011 and 2019. Quantities have been listed considering as water supply for 2011 and as water demand for 2019. Some of the attributes for 2019 like population and total water demand have been computed by author due to unavailability of data. Taking this as reference, water demand estimations for 2025 have been computed.

TABLE 9: Water supply and demand statistics for 2011, 2019 and estimations for 2025

Head	2011	2019
City population	1,729,359*	2,659,149****
Per capita average water supply (in lpcd)	170**	165*
Total domestic water supply to city from surface source (MLD)	370**	417*
Domestic water demand of city (MLD)	294****	439****
Water allocation from Irrigation Department to PCMC (MLD)	392***	392***
Groundwater extraction (MCM)	-	-
WTP Installed capacity (MLD)	428**	428*
Waste water generation*****	(80% of 370) = 296****	(80% of 439) = 351.2****
STP Installed Capacity (MLD)	261*****	317*
Head	**2025**	
City Population****	3,497,819	
Per capita average water demand (in lpcd) ****	165	
Total domestic water demand (MLD) ****	577	
Water allocation from Irrigation Department to PCMC (MLD)***	512	
Groundwater extraction (MCM)	-	
Required WTP Installed capacity (MLD)	Increase to 606*****	
Wastewater generation****	(80% of 577) = 461.6	
Required STP Installed Capacity (13 nos.) (MLD) ******	Increase to 485*******	

* https://www.pcmcindia.gov.in/location_info.php

**Pimpri Chinchwad Water Supply System, PCMC, March 2011

***https://www.sakaltimes.com/pune/no-extra-water-pcmc-says-water-resource-dept-12542

****Computed by author

*****Computed by author, required capacity is 5% (peak load) of water demand in addition to water demand capacity

******http://archive.indianexpress.com/news/lack-of-power-backup-takes-the-steam-out-of-stps/1058248/

******* Computed by author, required capacity is 5% (peak load) of waste water generation in addition to waste water generation capacity

Past scenario in 2011

1. In 2011, average per capita water supply in city was 170 lpcd, which lies within the suggested standard of National Building Code of 150–200 lpcd.
2. As per the agreement between PCMC and state irrigation department, the city had been allocated 392 MLD of water. PCMC was found to be using 370 MLD of water, which was within the allocated amount.
3. PCMC had 527 bore wells in 2011, of which a total of 283 borewells were in usable condition while the remaining 244 borewells were in unusable condition.[51] As no survey or assessment was done on the groundwater table and extraction of Pimpri Chinchwad area, no such data exists for the year 2011.
4. The water treatment plants were found to have adequate capacity of 428 MLD required for the population that is being served by each of the treatment plants, considering average water supply of 170 lpcd.
5. The quantity of wastewater generated in Pimpri Chinchwad city was around 296 MLD. The total treatment capacity was 261 MLD of 11 STPs combined in 2011. Remaining wastewater of 35 MLD was being let into the streams thereby contaminating it. This showed the scarcity of STPs in the city.

Existing Scenario in 2019

1. Due to significant increase in population, the total domestic water demand of the city increased to 439 MLD from 294 MLD in 2011.
2. As the water demand increased, the PCMC fetched more water (417 MLD) than it was allocated from the state irrigation department, which was 392 MLD.
3. The total water demand in 2019 was estimated to be 439 MLD, out of which 417 MLD was being used from the surface water sources, i.e., Pavana River. The remaining 22 MLD might being met from the extraction of groundwater.
4. The installed capacity of water treatment plants of 428 MLD was found to be sufficient for the treatment of total water being fetched from the surface water source, i.e., 417 MLD.
5. The quantity of wastewater generated in Pimpri Chinchwad increased to 351.2 MLD. The installed STP capacity was also increased to 317 MLD. This was found to be insufficient due to which the remaining wastewater was being let into the rivers like Indrayani and Pavana, thereby contaminating it.

Future Scenario in 2025

1. Pimpri Chinchwad is going to experience a rapid rise in population by 2025, which will stand at around 3,497,819. This is going to increase the water demand of the city to 577 MLD (considering 165 lpcd in 2025). Keeping this in mind, the state irrigation department has

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[51] Details available at https://www.mpcb.gov.in/sites/default/files/focus-area-reports-documents/Report_Groundwater_PIMPRICHINCHWAD.pdf; last accessed on October 12, 2021

proposed to increase the water allocation to PCMC to 512 MLD in 2025. Although this still looks insufficient as compared to the total water demand in 2025. Considering the restricted water allocation by the state irrigation department, PCMC might have to look at other alternative sources or practice demand side water management.

2. The installed capacity of water treatment plants, i.e., 428 MLD (as of 2019), is found to be inadequate for the population, having 577 MLD of total domestic water demand in 2025.

3. The quantity of wastewater generated in Pimpri Chinchwad city is estimated to increase to 461.6 MLD in 2025. The current STP infrastructure (317 MLD) would fail to treat the wastewater being generated, thus polluting the natural waterways.

5.3 Inferences

5.3.1 Pune City Taluka

Surface Water Source

Pune has already started facing water shortages in the last few years, which is going to get severe till 2025 due to rapid increase in population, which is estimated to reach 4.2 million. The reservoirs shall continue to run dry during summer months as seen in the previous years, which shall result in water cuts by the PMC. In addition, the state irrigation department is also not willing to increase the water allocation to PMC from 900 MLD. This is because the water stored in reservoirs is not solely being used by Pune city to meet their water demands. This stored water is created for many other ecological functions also. A storage dam serves multiple purposes, like water from these dams is also being used by other surrounding villages for irrigation, etc. This is a clear indication that Pune city is going get water stressed in the coming years.

Groundwater

Considering the amount of groundwater extraction was doubled from 2011 to 2019, it is estimated that it will continue to rise till 2025, affecting its recharge levels. Moreover, no official data of groundwater availability and extraction is available for PMC area, due to which its exploitation will be difficult to control.

Water Transmission and Distribution

The estimated transmission and distribution losses, which account for 25 to 30%, will continue to persist due to the use of old and defunct water supply network.

The inequitable municipal water distribution and reduced water pressure across different parts of the city will also continue due to its undulating landform and no strong measures being taken to manage it.

Water Treatment Plants

The installed capacity of water treatment plants, i.e., 1034.5 MLD (as of 2019), is found to be sufficient for the population, having 853.5 MLD of total domestic water demand in 2025. Hence, taking this scenario there is no need of enhancing the water treatment capacity till the year 2025.

Sewage Treatment Plants

As of 2019, the current number of STPs in the city and their capacities was found to be insufficient to treat the total sewage generated in the city, due to which a significant amount of untreated sewage was directly discharged into the Mutha-Mula River making them heavily polluted. As the sewage generation is going to increase in the coming years till 2025, more amount of untreated waste is going to be discharged in the Mutha-Mula River, raising serious concerns about its degrading quality.

Treated STP Wastewater

The treated wastewater from public STPs will continue to get discharged into the Mutha-Mula River, which gets mixed with the untreated sewage water in it. This nullifies the entire purpose of treating the wastewater. Also, wastewater treatment in STPs incurs huge cost and not utilizing it completely shall defeat the entire purpose.

5.3.2 Pimpri Chinchwad City Taluka

Surface Water Source

Pimpri Chinchwad has already started facing water shortages in the last few years, which is going to continue till 2025 due to rapid increase in population, which is estimated to reach 3.4 million. Considering this, the state irrigation department has decided to increase the water allocation to PCMC from 392 MLD to 512 MLD in 2025. Although the water demand is going to be higher than the proposed water allocation amount, State irrigation department allocates water supply in limited amounts because the water stored in Pavana reservoir is not solely being used by Pimpri Chinchwad city to meet their water demands. This stored water is created for many other ecological functions also. This is a clear indication that PCMC area is going to get water stressed in the coming years.

Groundwater

As no survey or assessment has been done on the groundwater table and extraction of Pimpri Chinchwad area, no data is available for its analysis, thus resulting in its exploitation.

Water Treatment Plants

The installed capacity of water treatment plants, i.e., 428 MLD (as of 2019), is found to be insufficient for the population, having 577 MLD of total domestic water demand in 2025. Hence, taking this scenario there is a need of enhancing the water treatment capacity.

Sewage Treatment Plants

As of 2019, the current number of STPs in the city and their capacities was found to be insufficient to treat the total sewage generated in the city, due to which a significant amount of untreated sewage was directly discharged into the Indrayani and Pavana rivers making them heavily polluted. As the sewage generation is going to increase in the coming years till 2025, more amount of untreated waste is going to be discharged in the Mutha-Mula River, raising serious concerns about its degrading quality.

6. RECOMMENDATIONS FOR SUSTAINABLE WATER MANAGEMENT

To achieve sustainability in water management in cities, it becomes imperative to study and analyse all the aspects related to it. It should cover both micro-scale green development measures like rainwater harvesting to macro scale water source management, water/wastewater/stormwater infrastructure, and landscape preservation. This is known as integrated urban water management (IUWM), a water management approach that has become quite popular in the last decade. IUWM is based on designing solutions which are not isolated in nature but are interconnected water management clusters.

Same approach has been followed in the study of this report, in order to recommend the most appropriate and practical measures to the identified potential risks in the previous chapter for water management in Pune and Pimpri Chinchwad cities.

6.1 Upgradation in Urban Water Cycle

6.1.2 Pune City Taluka

Suggestive upgradation of water cycle for the Pune City Taluka has been shown in Figure 20, where the lacunas of existing water management of the city has been tried to fill. This is based on the projections computed for the year 2025 in the last chapter: Potential Risks to Water Management.

1. Identification and filling up of data gaps

It should be emphasized on collecting information by research for filling in the missing data in order to find best suited solutions to issues of poor water management in Pune city. For example, there is a dearth of data on groundwater availability and extraction for Pune city, due to which it poses a challenge in regulating the groundwater use, thus resulting in its exploitation. Therefore, identification of such gaps related to water data in Pune city should be done and required measures should be taken for data generation.

2. Modifications in existing water infrastructure

» **Water Transmission and Distribution:**

Minimizing the distribution and transmission losses of water by refurbishing the old water supply network and covering the newly added areas.

Ensuring equitable distribution of water supply in all areas of the city with 24X7 pressurized water supply.

» **Water Treatment Plants:**

There is no need of enhancing the treatment capacity of existing WTPs till the year 2025. The installed capacity of WTPs, i.e., 1034.5 MLD (as of 2019) if utilized completely, would be sufficient for the population having 853.5 MLD of total domestic water demand in 2025.

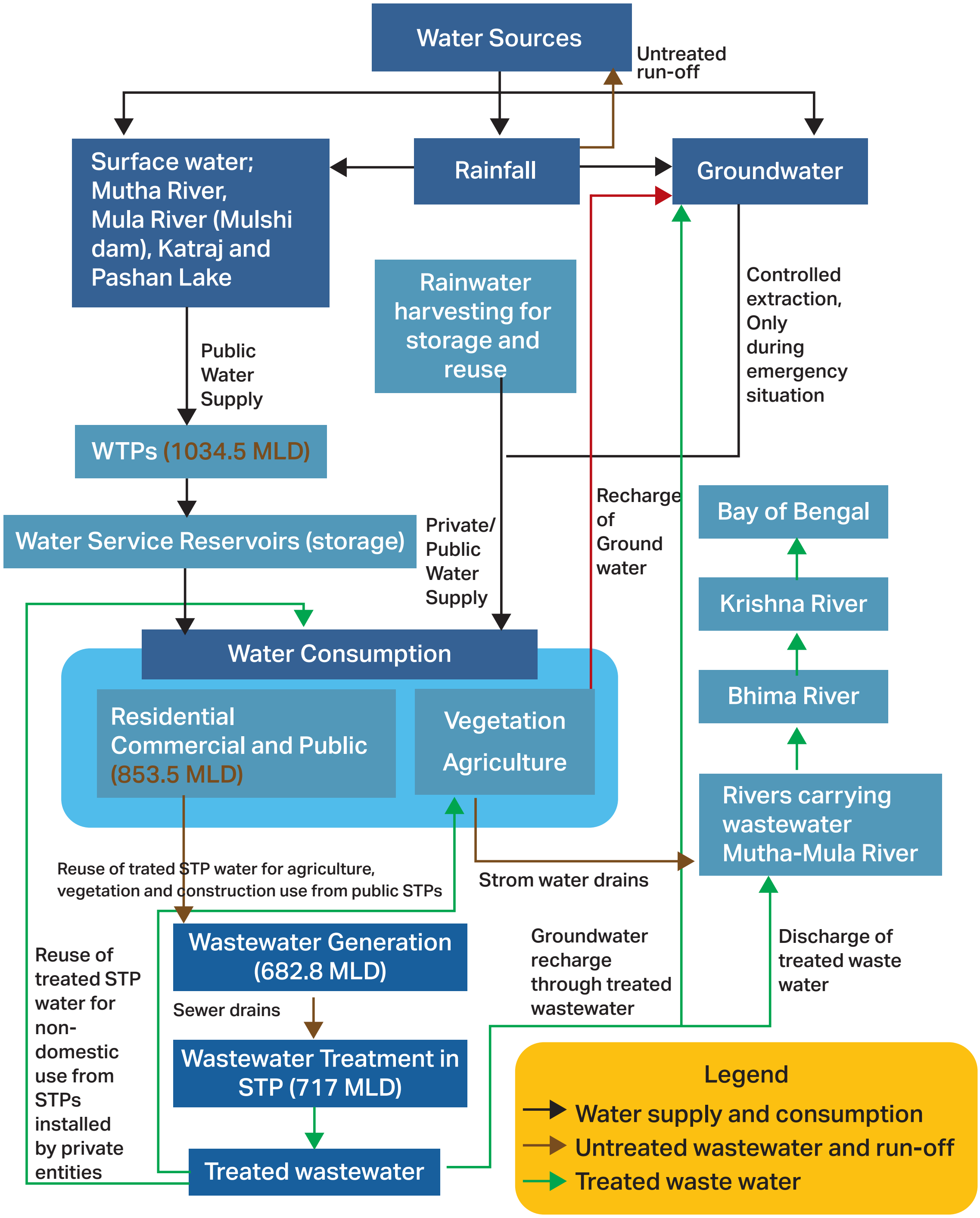

FIGURE 20: Upgraded urban water cycle of Pune City Taluka for 2025[52]

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[52] Projected values in the upgraded water cycle have been computed and shown in Table 8

» **Sewage Treatment Plants:**

Increasing the capacity of public STPs (~717 MLD) in order to treat the entire sewage generation of the city in 2025. The quantity of wastewater generated is estimated to increase to 682.8 MLD in 2025, which the current STP infrastructure (567 MLD installed capacity) would fail to treat it.

Provision of city-wide sewerage network (including slums and the suburbs) covering each and every household, which shall ensure complete collection of sewage.

» **Water Metering:**

100% coverage of metered connection across the city to ensure fair revenue collection and controlled water usage.

» **Water Quality of Waterways Carrying Wastewater:**

Zero discharge of untreated wastewater from the city into the water bodies like Mutha-Mula River should be ensured in order to protect it from polluting and maintain its natural good quality. Complete wastewater from Pune city should be treated in STPs, ensuring there is no direct untreated wastewater discharge into the water bodies.

3. **Potential Water Sources for Use in Future:** Pune city has ample reliable water sources and is not a water scarce region. Although the city gets limited water supply tapped from Khadakwasla dam as allocated by the state irrigation department. The water scarcity faced by the city during certain periods of the year is due to poor management of water sources. Identification and assessment of potential water sources in the area should be conducted. There are potential alternative water sources available which if tapped efficiently could help in overcoming the issue of water scarcity.

» **Surface water sources:**

Mulshi dam on Mula River is a potential source, which could provide water for rising irrigation and domestic demand of the city. However, the availability of these resources for such use will depend on the state government's decision.

FIGURE 21: Mulshi dam on Mula River near Pune city[53]

[53] Details available at https://www.townpune.com/mulshi-dam-pune/; last accessed on October 12, 2021

Revival of degraded Katraj and Pashan lakes in Pune city could become an additional potential freshwater source for the region in future. The lakes were once a major source of water for the people living in the city. Over the years, due to rapid urbanization the lakes got degraded and today lie in a pathetic condition.

FIGURE 22: Katraj[54] and Pashan[55] Lake in Pune

» **Groundwater sources:**

PMC should ensure controlled groundwater extraction in the region to keep a check on its level and quality by studying it on regular intervals. In fact, groundwater use should be completely restricted citing its decreasing levels and should only be used during emergency times when the water availability falls short.

» **Treated wastewater source:**

The treated water from STPs can be a potential resource for saving the freshwater extraction from Mutha River. Thus, treated STP water which is being discharged into Mula-Mutha could be reused for non-domestic purposes. This shall also help in reviving the heavily polluted Mula–Mutha River, which could become a potential water resource in future once it achieves the required water quality.

In order to carry out its successful implementation, installation of STPs and reuse of the treated sewage for flushing, gardening, construction, etc., in upcoming residential housing and commercial projects should be promoted.

» **Rainwater harvesting systems:**

Use of rainwater harvesting systems for storage and reuse should be promoted. This could be done by promoting installation of localized rainwater storage systems at individual level

[54] Details available at https://www.tripadvisor.in/LocationPhotoDirectLink-g297654-d12078627-i239497286-Katraj_Lake-Pune_Pune_District_Maharashtra.html; last accessed on October 12, 2021

[55] Details available at https://www.tripadvisor.in/Attraction_Review-g297654-d3705149-Reviews-Pashan_Lake-Pune_Pune_District_Maharashtra.html; last accessed on October 12, 2021

in new buildings for domestic purposes. As this will help in reducing the potable water supply and also reduces run-off, this shall contribute in reduction of water-related infrastructure cost and water bills.

Localized tapping of rainwater for developing human made water bodies should be done. Channelizing of storm water through drains before finally merging with the river, takes a considerable amount of time due to which it experiences evaporation loss, contamination along the way. Instead, this rainwater could be fully utilized by these local human made water bodies to improve the groundwater recharge. Contamination of groundwater also reduces due to the natural percolation of rainwater.

Treated wastewater from STPs could be discharged into these local water bodies for enhancing the groundwater levels as well.

4. Implementation of flood resilience measures

Recurrence of floods in Pune during monsoons can be controlled by keeping a check on increased encroachments (concrete structures) and untreated waste disposal in water bodies, which blocks the flow of rainwater run-off. Development of city flood mitigation and adaptation plan with designed measures like creating an ecological buffer zone could help in limiting the damage caused by the floods.

5. Capacity building and training:

Capacity building and training of existing and new recruits of government staff, municipalities, boards and other parastatal working in water supply and management in the city should be done, to strengthen work practices and thereby improving their overall performance.

6.1.2 Pimpri Chinchwad City Taluka

Suggestive upgradation of water cycle for the Pimpri Chinchwad City Taluka has been shown in Figure 23, where the lacunas of existing water management of the city has been tried to fill. This is based on the projections computed for the year 2025 in the last chapter: Potential Risks to Water Management.

1. Identification and filling up of data gaps

It should be emphasized on collecting information by research for filling in the missing data in order to find best suited solutions to issues of poor water management in Pune city. For example, there is a dearth of data on groundwater availability and extraction for Pune city, due to which it poses a challenge in regulating the groundwater use, thus resulting in its exploitation. Therefore, identification of such gaps related to water data in Pune city should be done and required measures should be taken for data generation.

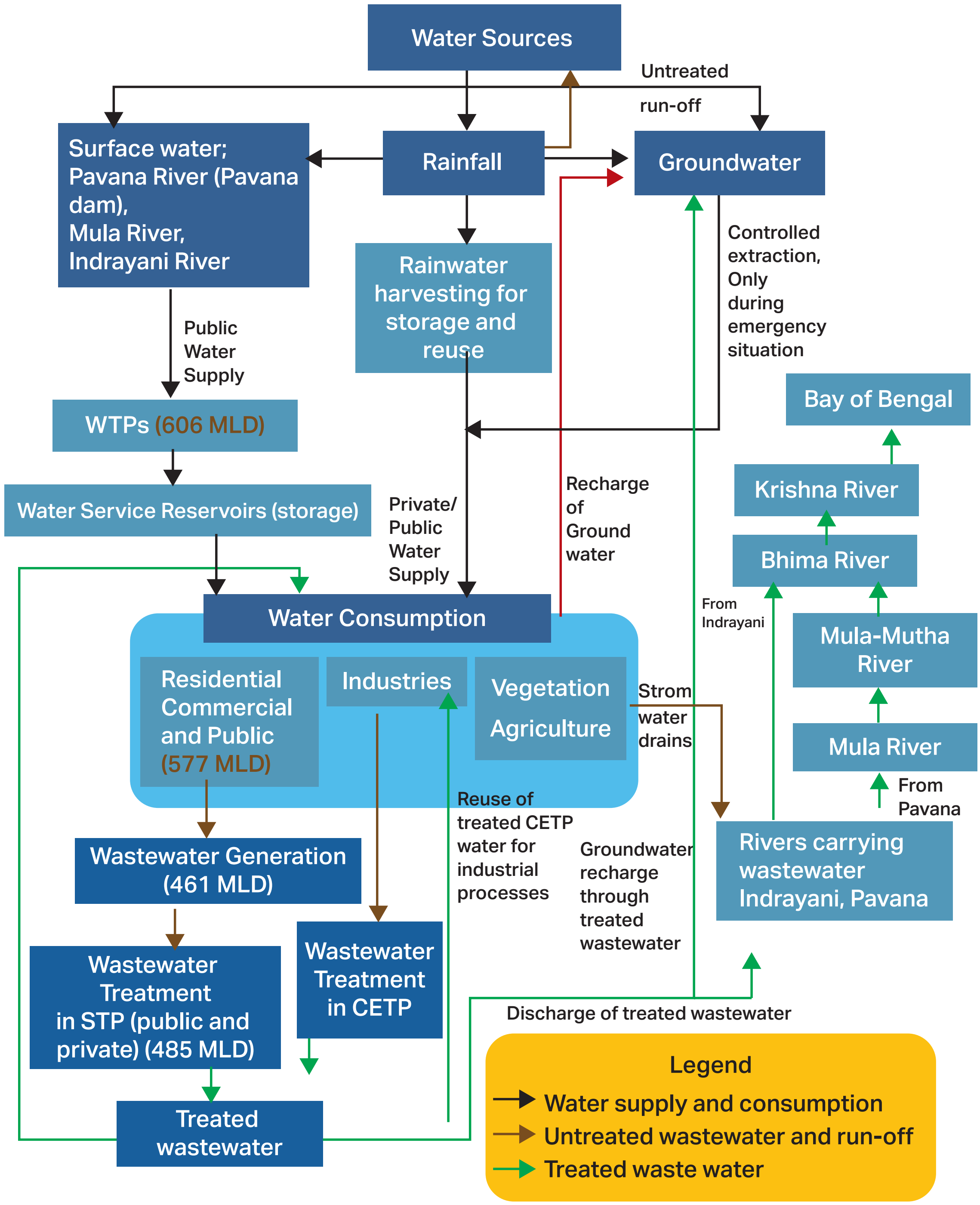

FIGURE 23: Upgraded urban water cycle of Pimpri Chinchwad City Taluka for 2025[56]

[56] Projected values in the upgraded water cycle have been computed and shown in Table 9

2. **Modifications in existing water infrastructure**

» **Water Transmission and Distribution:**

Strengthening and lying of water supply distribution network all across the city (covering the slums and the suburbs).

Ensuring equitable distribution of water supply in all areas of the city with 24X7 pressurized water supply.

» **Water Treatment Plants:**

There would be a need to enhance the treatment capacity of existing WTPs to 606 MLD approx. to meet the domestic water demand of population in 2025, which will stand at 577 MLD. The existing total installed capacity of WTPs is 428 MLD.

» **Sewage Treatment Plants:**

Increasing the capacity of public STPs (~485 MLD) in order to treat the entire sewage generation of the city in 2025. The quantity of wastewater generated is estimated to increase to 461.6 MLD in 2025, which the current STP infrastructure (317 MLD installed capacity) would fail to treat.

Provision of city-wide sewerage network (including slums and the suburbs) covering each and every household which shall ensure complete collection of sewage.

» **Common Effluent Treatment Plants:**

Installation of CETPs to treat industrial waste separately, as the city is a major industrial hub. Currently, there are no CETPs in the city and the major chunk of industrial waste is getting discharged untreated in the waterways.

» **Water Metering:**

100% coverage of metered connection across the city to ensure fair revenue collection and controlled water usage.

» **Water Quality of Waterways Carrying Wastewater:**

Zero discharge of untreated wastewater from the city into the water bodies like Pavana and Indrayani rivers should be ensured in order to protect it from polluting and maintain its natural good quality. Complete wastewater from Pimpri Chinchwad city should be treated in STPs and CETPs, ensuring there is no direct untreated wastewater discharge into the water bodies.

3. **Potential Water Sources for Use in Future:** Pimpri Chinchwad city gets limited water supply tapped from Pavana dam as allocated by the state irrigation department. The water scarcity faced by the city during certain periods of the year is due to poor management of water sources. Identification and assessment of potential water sources in the area should be conducted. There are potential alternative water sources available, which if tapped efficiently could help in overcoming the issue of water scarcity.

» **Surface water sources:**

Mulshi dam on Mula River is a potential source which could provide water for rising irrigation and domestic demand of the city as well in addition to Pune city. However, the availability of these resources for such use will depend on the state government's decision.

Revival of Indrayani River could become an additional potential water source in future for the Pimpri Chinchwad. Over the years, the river quality has deteriorated due to the discharge of untreated sewage into it from areas like Lonavla, Dehu, Pimpri, Vadgaon, etc.

FIGURE 24: Indrayani River in Pune district[57]

» **Groundwater sources:**

The PCMC should ensure controlled groundwater extraction in the region to keep a check on its level and quality by studying it on regular intervals. In fact, groundwater use should be completely restricted citing its decreasing levels and should only be used during emergency times when the water availability falls short.

» **Treated wastewater source:**

The treated water from STPs can be a potential resource for saving the freshwater extraction from Pavana River. Thus, treated STP water, which is being discharged into Pavana, Mula and Indrayani rivers could be reused for non-domestic purposes. This shall also help in reviving the heavily polluted Indrayani, Pavana and Mula rivers, which could become a potential water resource in future once it achieves the required water quality.

In order to carry out its successful implementation, installation of STPs and reuse of the treated sewage for flushing, gardening, construction, etc., in upcoming residential housing and commercial projects should be promoted.

Treated water from CETPs should be reused by the industries in Pimpri Chinchwad.

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[57] Details available at https://fineartamerica.com/featured/indrayani-river-bliss-of-art.html; last accessed on October 13, 2021

» **Rainwater harvesting systems:**

Use of rainwater harvesting systems for storage and reuse should be promoted. This could be done by promoting installation of localized rainwater storage systems at individual level in new buildings for domestic purposes. As this will help in reducing the potable water supply and also reduces runoff, this shall contribute in reduction of water-related infrastructure cost and water bills.

Localized tapping of rainwater for developing human made water bodies should be done. Channelizing of storm water through drains before finally merging with the river, takes a considerable amount of time due to which it experiences evaporation loss, contamination along the way. Instead, this rainwater could be fully utilized by these local human made water bodies to improve the groundwater recharge. Contamination of groundwater also reduces due to the natural percolation of rainwater.

Treated wastewater from STPs could be discharged into these local water bodies for enhancing the groundwater levels as well.

4. **Implementation of flood resilience measures**

Recurrence of floods in Pimpri Chinchwad during monsoons can be controlled by keeping a check on increased encroachments (concrete structures) and untreated sewage/industrial waste disposal in water bodies, which blocks the flow of rainwater run-off. Development of city flood mitigation and adaptation plan with designed measures like creating an ecological buffer zone could help in limiting the damage caused by the floods.

5. **Capacity building and training:**

Capacity building and training of existing and new recruits of government staff, municipalities, boards and other parastatal working in water supply and management in the city should be done, to strengthen work practices and thereby improving their overall performance.

6.2 Stakeholder Engagement for Sustainable Water Management

An effective implementation of the measures mentioned above for enhancing water sustainability in the city requires a robust stakeholder involvement. This is an important step which ensures that the water management plans for the city takes into consideration the local requirements, interests and experiences of all the stakeholders. It bridges the gap between experts, implementers, and policymakers. In order to make a sustainable change w.r.t. water management it is essential for the stakeholders to cooperate and collaborate with each other and carry out their responsibilities efficiently. Following are the ways by which the stakeholder participation could be enhanced for ensuring sustainable water management in the city:

TABLE 10: Stakeholders and their responsibilities in ensuring sustainable water management

S. No.	Stakeholders	Roles and Responsibilities
International Level		
1.	International, Regional, and Multilateral Organizations	» Provide funds for city water management projects and conduct promotion programmes » Provide technical assistance and documentation » Create knowledge exchange platforms
National and State Level		
2.	National and State Governments	» Develop policies and legal frameworks that enable and strengthen sustainable water management in cities
3.	Standardization Bodies like the Bureau of Indian Standards, CPHEEO, etc.	» Developing new standards related to water consumption and management w.r.t to changes in technology of the water infrastructure » Identification of gaps and renewing the standards
City Level		
4.	Urban Local Bodies, Municipalities, City Administration, and State Water Regulatory Authorities	» Promote and design the roadmap to follow sustainable water management initiatives and specific solutions for its implementation » Enhancing citizen engagement and sensitize them with benefits of sustainable water management practices. » Strengthening monitoring and tracking of city services by defining KPIs and evaluating them
5.	City Services Companies	» Provide expertise to collaborate with municipalities and ICT companies to develop integrated collaborative models for smart water management » Development of smart and KPI-based city service models
6.	Utility Providers	» Deployment of sustainable water management practices like smart water management

TABLE 10: Stakeholders and their responsibilities in ensuring sustainable water management

S. No.	Stakeholders	Roles and Responsibilities
7.	ICT Companies (Start Ups and Software Companies)	» Provide the ICT infrastructure to support and integrate smart water management services » Provide technical solutions through research and innovation » Develop financially sustainable business models to enable smart water management implementation
8.	Urban Planners	» Inclusion of water management plan in the studies and city planning processes as a part of a broader approach » To give guidance to concerned stakeholders on city planning needs
9.	Non-government Organizations	» Raise awareness regarding citizen concerns related to water availability » Increase public awareness on urban water issues
10.	Academia, Research Organizations, and Specialized Bodies	» Conduct research and advice and assist the city managers and the policymakers on measures to achieve sustainable urban water management in the city » Drive research and innovation in city water management field
Building/Site Level		
11.	Citizens and Citizen Related Organizations like RWAs	» Participate actively in city's urban water management projects » RWAs and end users should take the necessary documents from the facility manager like plumbing, WTP drawings, AMC, etc., during handing over of the property » Practice water saving measures at an individual level

Disclaimer: This is an indicative list and not an exhaustive list.

6.3 Micro-level Assessment and its Importance in Assessment of City Water Sustainability

The above sections of the report showcased the water statistics of the Pimpri Chinchwad region as published by the government and reliable public sources. However, the basis of arriving at these values is not clear. The reported values could be based on the assessment of water actually supplied by the public sector and the private sector or they might have been derived based on the water supply norms fixed by the government agencies for various socio-economic strata of the city. In either case, the values may not represent the 'real water demand' of the city. An assessment based on actual water supplied does not account for the water lost through leakage or wasted otherwise and these losses become a part of the presumed water requirement, which is not the 'real demand' of the city. Similarly, an assessment made from water supply norms does not account for such drivers of water demand as social, economic, demographic, and geographical factors.

A primary survey was carried out in selective residential townships of Pimpri Chinchwad City Taluka to assess water demand and water use patterns. A rapid water assessment study was conducted in two residential townships: Antheia Township by Mahindra Lifespaces and Blue Ridge Township by Paranjape Developers, and patterns of water consumption in the domestic sector were examined. The study revealed that water demand is influenced by a number of intersecting cultural, climatic, demographic, infrastructural, social, and physiological factors. The greater penetration and use of modern appliances in urban households influence the consumption of water. However, urban planners assess a city's water demand through only one simple statistic, namely the recommended or normative per-capita water supply: a figure that has not been revised for decades, does not appear to reflect social equity, is not supported by any explicitly stated rationale—and is widely variable. In India, for example, the norms, in lpcd, are as follows: 200 as the minimum for domestic consumption in cities with flush toilets, 135 for low-income groups and weaker sections of society, 40 for those collecting water from community taps (BIS, 1993), 150 for megacities and other metropolitan cities, 135 for cities with piped water supply and planned sewerage systems, and so on (Planning Commission, 2007). The World Health Organization classifies water supply in four different categories and suggests 100–200 lpcd as the optimal figure (WHO, 2003). There is little evidence that these norms are based on any real demand assessment.

6.3.1 Findings of Micro-level Assessment for Pimpri Chinchwad City Taluka

A variety of approaches were used for collecting and analysing different types of data. These approaches were drawn from the methods and techniques used in quantitative and qualitative research (Clark and Creswell, 2007). Questionnaires and interviews were used for obtaining data on the following aspects: socio-economic and demographic attributes of respondents, sources of water, behaviour related to water use, water consumption pattern, and water conservation practices. The data were supplemented with results of other studies reported in the literature for India.

Treated wastewater use

One common observation found in the audited townships of Pimpri Chinchwad City Taluka (Antheia and Blue Ridge Townships) was the high potential to reduce the freshwater demand (water source: Mula River in Blue Ridge Township and Pavana River in Antheia Township) by reusing treated water from their private STPs.

Currently, a significant amount of treated water from centralized STPs of Blueridge Township is being discharged in the nearby river, which has the potential to be reused and replace 29.16%[58] of freshwater requirement.

In Antheia Township, the treated water from STP is currently being used for irrigation purpose and would start reusing it for flushing purpose soon. The treated STP water here, has the potential to replace 26.25%[59] of freshwater requirement.

According to the water sustainability study of Pimpri Chinchwad, it is found that the city has huge potential to reduce its freshwater demand by reusing treated STP water and at the same time reduce the pollution in its rivers by restricting direct discharge of untreated wastewater. Therefore, one important inference from both micro (township level) and macro (Pimpri Chinchwad city level) study is to 100% reduce the wastewater discharge from the townships into the city water bodies and its treatment for reuse in various non-domestic purposes (flushing, irrigation, backwash).

Rainwater harvesting systems

As rainwater harvesting is one of the most important techniques for water conservation and reuse, this aspect was studied in the audited townships as well. It was found that the Blue Ridge Township had no provision for rainwater harvesting systems either for groundwater recharge or for reuse purposes. As far as Antheia Township is concerned, provision for groundwater recharge through rainwater was found but the recharge pits capacity was inadequate as it experienced heavy run-off during monsoon months.

According to the water sustainability study of Pimpri Chinchwad, it is found that the rainwater has a good potential for becoming one of the alternative water supply source to the city, through collection and storage using rainwater harvesting systems. Also, it can be used for enhancing the groundwater levels by tapping and directing it to the human made water bodies. Therefore, one important inference from both micro (township level) and macro (Pimpri Chinchwad city level) study is to promote installation of rainwater harvesting techniques at private level for storage and reuse and for improving the groundwater level and quality.

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58 Report on Rapid Water Audit of Blue Ridge Township Pune, New Delhi, TERI 2019

59 Report on Rapid Water Audit of Antheia Township MLDL Pune, New Delhi, TERI 2019

The Mahindra-TERI Centre of Excellence (MTCoE) is a joint research initiative of Mahindra Lifespaces (MLDL) and The Energy and Resources Institute (TERI). It focuses on developing science-based solutions for India's future built environment, with a view to reduce the energy footprint of the real estate industry.

The overall scope of the project includes standardization and measurement of building material, thermal and visual comfort study, development of performance standard matrices, guidelines and numerical toolkits and water related activity for sustainable water use in habitats.

The activities related to the sustainable use of water in habitats, includes both macro and micro level analysis in terms of water efficiency, conservation and management within a premise by end users in Indian cities. The study identifies potential risks associated with water sources, governance, infrastructure and demand & supply and provide recommendations to combat those risks.

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