Report

Situation Analysis: Chikkaballapur-Chintamani Transformation Lab

Radhika Sundaresan, Rajesh Ramamoorthy, Shreya Nath, Shashank Palur, Cheshta Rajora, Namrata Narendra, Muhil Nesi, Abhilash Paswan

Open access. Some rights reserved. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. View the full licence here.

This work was funded by UK aid from the UK government and by the International Development Research Centre, Ottawa, Canada as part of the Climate Adaptation and Resilience (CLARE) research programme. The views expressed herein do not necessarily represent those of the UK government, IDRC or its Board of Governors.

Published January 2025

This is a work-in-progress draft. The latest version can be found here.

Authors Radhika Sundaresan, Rajesh Ramamoorthy, Shreya Nath, Shashank Palur, Cheshta Rajora, Namrata Narendra, Muhil Nesi, Abhilash Paswan

Technical Review Devaraj de Condappa, Mallika Sardeshpande, Richard Taylor, Veena Srinivasan, Susan Varughese

Editorial Review Syed Saad Ahmed

Data Visualisation Abhilash Paswan and Vidhyashree Katral

Cover Image Mallapalli lake in Chintamani. Photo by RB Productions

Suggested Citation Sundaresan, S., Ramamoorthy, R., Nath, S., Palur, S., Rajora, C., Narendra, N., Nesi, M., & Paswan, A. *Situation Analysis: Chikkaballapur-Chintamani Transformation Lab*. (2025). Water, Environment, Land and Livelihoods (WELL) Labs, Institute for Financial Management and Research (IFMR) Society. Bengaluru.

About CLARE

CLARE is a UK-Canada framework research programme on climate adaptation and resilience, aiming to enable socially inclusive and sustainable action to build resilience to climate change and natural hazards. CLARE is an initiative jointly designed and run by the UK Foreign, Commonwealth and Development Office and Canada's International Development Research Centre. CLARE is primarily funded by UK aid from the UK government, along with the International Development Research Centre, Canada.

About CLARITY

Climate Adaptation and Resilience in Tropical Drylands (CLARITY), a research project under CLARE, is building equitable, sustainable, and climate-resilient development pathways in tropical drylands. This Global South-led project will result in the creation of long-term assets (data and tools) and capacities to achieve transformational change.

CLARITY focuses on 'Transformation Labs' (T-Labs) in Niger-Nigeria, Tanzania, and India. These labs are collaborative spaces for communities and researchers to develop sustainable, equitable pathways. In India, we are establishing two Transformation Labs in semi-arid regions in the state of Karnataka: Chikkaballapur-Chintamani and Raichur. Both are at the urban-rural interface and are characterised by shallow and deeper aquifers that have been rapidly depleting for almost two decades.

Our approach is solutions-focused, transdisciplinary, and novel in three ways. We are:

1. Co-constructing narratives of water management with marginalised groups based on video diaries and interviews, training para-hydrogeologists in the community, and collecting and analysing data for local action.

2. Using the narratives and data to build models that generate disaggregated and technically, socially plausible pathways.

3. Engaging with key changemakers to ensure the research gets embedded in wider policy processes and communities of practice by sharing tools, training materials, interactive reports, and games.

About WELL Labs

Water, Environment, Land and Livelihoods (WELL) Labs co-creates research and innovation for social impact in the domains of land and water sustainability. We design and curate systemic, science-based solutions using a collaborative approach to enable a high quality of human life while simultaneously nurturing the environment.

WELL Labs is based at the Institute for Financial Management and Research (IFMR) Society. Together with Krea University and other centres at IFMR, such as the Abdul Latif Jameel Poverty Action Lab (J-PAL) South Asia and Leveraging Evidence for Access and Development (LEAD), WELL Labs is part of an ecosystem of labs and research centres with a mission to help prepare for an unpredictable world.

About the Authors

Radhika Sundaresan is a Senior Researcher in the Urban Water programme at WELL Labs. She has worked at the intersection of water, climate and policy for over five years. She is a Fulbright Scholar and a Young India Fellow.

Rajesh Ramamoorthy is a Consultant – Senior Project Manager at WELL Labs. He holds a Master's degree in Water Science and Governance from TERI School of Advanced Studies.

Shreya Nath leads the Urban Water programme at WELL Labs. Her role involves mapping urban systems to uncover ways to build climate-resilient cities. Shreya has over eight years of experience in sustainable architecture and urban planning.

Shashank Palur is a Hydrologist with the Urban Water programme at WELL Labs, where he works on water and wastewater issues. He has more than five years' experience of working on water resources management across different terrains.

Cheshta Rajora is a research associate in the Urban Water programme at WELL Labs. She has over four years' experience in water resources management and has contributed to better policy formulation and impactful field initiatives.

Namrata Narendra was a research associate in the Urban Water programme at WELL Labs. She has worked with various community groups on water access and governance issues in cities and towns.

Muhil Nesi is a PhD student in the Environmental Social Sciences Department, Eawag. She was a Senior Research Associate with the Centre for Social & Environmental Innovation at ATREE.

Abhilash Paswan was a Consultant at WELL Labs.

Table of Contents

Glossary

Accrued income	The income that an organisation has earned but not yet received.
Agricultural labourer	A person who works on another person's land for wages in money, kind, or share. See the complete definition here.
CMC	City Municipal Council
Cultivator	A cultivator is engaged in the cultivation of land owned, held from the government, or held from private persons or institutions for payment in money, kind, or share. See the complete definition here.
District	A district is an administrative subdivision of a state in India. It comprises several talukas (see below).
Financial year (FY)	In India, the financial year begins on April 1 and ends on March 31.
Lakh	100,000
Lpcd	Litres per capita per day
mbgl	Metres below ground level
MLD	Million litres per day
Master plan	A master plan is a dynamic, long-term urban planning document that guides the city's land use and development regulations, and sets out proposals for housing, industry, transportation, community facilities, etc.
Municipality	In India, smaller cities and towns have municipalities (also known as municipal councils), while large cities have municipal corporations. This report uses municipality interchangeably with urban local body.
Non-revenue water	Non-revenue water is water that is pumped and then lost or unaccounted for. Water utilities suffer from the huge financial costs of treating and pumping water only to see it leak back into the ground. They also lose revenue due to unauthorised connections.
Panchayati raj institutions	The Constitution (73rd Amendment) Act, 1992 and Constitution (74th Amendment) Act, 1992 devolved powers and functions to panchayati raj

	institutions to promote local self-governance in India. It consists of a tiered system: gram panchayat at the village level; taluka panchayat at the taluka level; and zilla panchayat at the district level.
Pourakarmikas	Pourakarmikas are sanitation workers engaged by urban local bodies in Karnataka to collect solid waste and keep public spaces clean.
Revenue expenditure	Government expenditures that do not lead to the creation of fixed assets are called revenue expenditures.
Self-help group	A self-help group is a community-based microfinance group, usually comprising women, where members provide financial and other kinds of support to each other to start new businesses or income-generating activities.
Taluka	A taluka is an administrative subdivision of a district for revenue purposes. It comprises several villages.
Transformation Labs (T-Labs)	T-Labs are collaborative spaces where communities take an active role in co-developing sustainable, equitable pathways to build resilience in tropical drylands.
Ward	Municipalities are divided into electoral constituencies known as wards. Each ward elects its representative, known as a councillor or corporator.
WTP	Water treatment plant

Executive Summary

India's urbanisation narrative is entering a new phase, one in which the significance of small and medium towns is on the rise. Cities are continuously sprawling outwards, with expanding urban boundaries. This overspill of population and increasing demand for resources such as water and agricultural produce is accommodated by the peri-urban interface of cities. Small and medium-sized towns also play a vital role in the process of peri-urbanisation in India, but are not taken into account in the literature (Shaw & Das, 2018).

A peri-urban region is a socioeconomic-environmental interface where agriculture, urban dimensions, and natural resources constantly interact with one another (Allen, 2003; Narain & Nischal, 2007). The fact that what is peri-urban today would be urban tomorrow makes it significant to plan for the sustainable development of peri-urban areas, especially through the lens of water security. Many towns already struggle to meet the requirements and aspirations of their growing populations and lack essential infrastructure for fundamental services, especially water and sanitation.

Chintamani is one such town in Chikkaballapur district[1] in the Indian state of Karnataka. Part of the peri-urban region surrounding state capital Bengaluru, Chintamani is representative of many towns located in India’s semi-arid climatic zones that suffer from the problems described above. The district has no perennial water sources for agriculture or drinking water supply. The only source is groundwater, which has been overexploited.

The town is plagued by challenges relating to both groundwater and surface water management, such as:

1. **A high borewell failure rate** due to a lack of knowledge of the region’s geology and aquifers.
2. **Using municipal funds to extensively pump groundwater** leaves limited resources to operate and manage water and wastewater infrastructure.
3. **Unaccounted water use** leads to revenue losses for the municipality[2] and a lack of clarity regarding water demand.
4. **Dumping of untreated sewage into water bodies** leads to pollution.

Limited financial resources, staff, and technical capacity often prompt towns to address immediate needs through short-term measures, resulting in disjointed,

[1] A district is an administrative subdivision of a state in India. A district comprises several talukas.
[2] In India, smaller cities and towns have municipalities (also known as municipal councils), while large cities have municipal corporations. This report uses municipality interchangeably with urban local body.

piecemeal interventions that fail to address problems comprehensively. These fragmented systems are more susceptible to issues like water scarcity, droughts, and extreme-weather events in regions prone to climate variability.

Ramamoorthy et al. (2024) delve into Chintamani's water balance and its water management challenges. This situation analysis builds upon the report and presents measures to improve the town's water security, such as:

1. **Create a comprehensive water security plan** that takes into account surface water and groundwater hydrology, aquifer characteristics, water use patterns, and governance frameworks.

2. **Rejuvenate lakes** to reduce groundwater dependence and improve groundwater recharge.

3. **Improve wastewater treatment and reuse** by ensuring that all households are connected to the sewerage and broken lines are repaired.

4. **Increase community engagement** to ensure the sustainability of water management interventions in the long run.

1.0 Introduction

1.1 Chikkaballapur district

Chikkaballapur district is in the south-eastern part of Karnataka, about 75 km from state capital Bengaluru. Carved out from Kolar district in 2007, it has six talukas[3]: Bagepalli, Chikkaballapur, Chintamani, Gowribidanur, Gudibande, and Sidlaghatta.[4] Chikkaballapur district has an area of 4,045 sq. km, of which approximately 12.29% is classified as forest area (mostly dry deciduous and scrub type vegetation).

Hereafter, Chikkaballapur district and Chintamani town will be referred to as Chikkaballapur and Chintamani respectively.

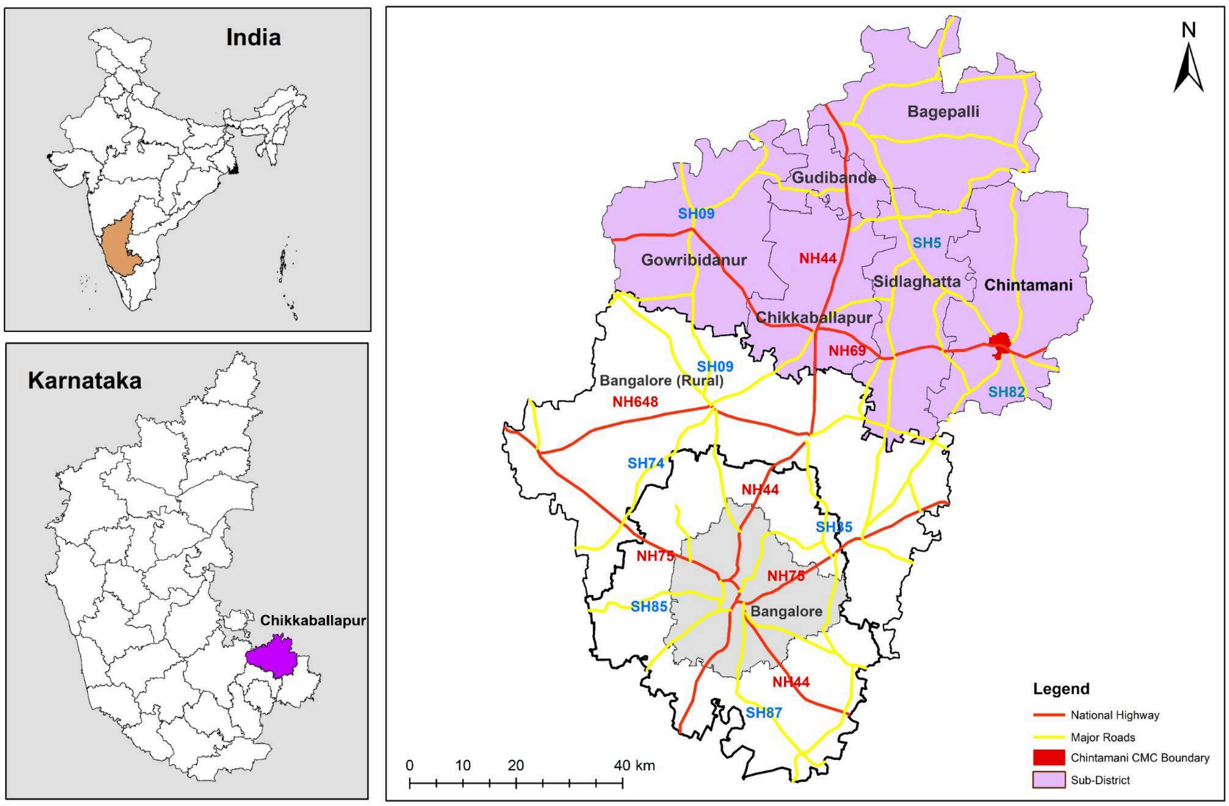


Figure 1: *(top left)* Map of India showing the state of Karnataka (brown); *(bottom left)* districts of Karnataka; and *(right)* Bengaluru (the grey demarcates the city's municipal limits and the white Bengaluru Urban and Rural districts) and Chikkaballapur (pink).

[3] A taluka is an administrative subdivision of a district for revenue purposes. It comprises several villages
[4] In 2022, the six talukas were reorganised into eight: Bagepalli, Chikkaballapur, Chintamani, Gowribidanur, Gudibande, Sidlaghatta, Manchenahalli, and Cheluru.

Population

According to the 2011 census, Chikkaballapur's population and population density are 12.54 lakhs (1.254 million)[5] and 298 per sq. km respectively. The district has a sex ratio of 968 females per 1,000 males.

Climate

Chikkaballapur, located in a semi-arid region, has mild winters and hot summers. December is the coldest month, with a mean daily minimum temperature of 15.7°C, while April is the hottest month, with a mean daily maximum of 36°C.

Relative humidity of over 75% is common during monsoon. Wind speeds exceeding 15 kmph are common during the months of June and July.

The recorded annual potential evaporation is around 1,950 mm. The annual rainfall in the district is 621 mm and the number of rainy days 30–35. Nearly 67% of the rain falls during the southwest monsoon (June-September) and 14% during the northeast monsoon (District Disaster Management Authority Chikkaballapur, 2019).

Economy

Agriculture is the predominant economic activity in the district — 65% of its working population of 6.4 lakh are cultivators[6] (2.12 lakh) and agricultural labourers[7] (2.07 lakh). The primary cereal crops are maize and ragi, while the main oilseed is groundnut. Sericulture is a traditional activity in the district, contributing to about 16-17% of the state's total cocoon production. Horticulture is also an important economic activity — the district's proximity to Bengaluru has led to an increase in fruit and vegetable cultivation (NABARD, 2023).

The district is chronically drought-prone (District Disaster Management Authority Chikkaballapur, 2019). This is attributed to the cultivation of water-intensive crops and a lack of water conservation measures and drainage systems. Chikkaballapur has among the highest poverty levels in the state. Its per capita income in 2015-16 was ₹99,600 — less than the state average of ₹1,42,267 for the same period (NABARD, 2020).

A study by Esteves et. al. (2016) states that the district is predominantly rainfed, with a low percentage of land area under irrigation, making it highly vulnerable to climate

---

[5] 1 lakh = 1,00,000

[6] A cultivator is engaged in "the cultivation of land owned, held from the government, or held from private persons or institutions for payment in money, kind, or share. See the complete definition here.

[7] A person who works on another person's land for wages in money, kind, or share. See the complete definition here.

variability. A study by Kumar, Raizada, & Biswas (2014) found that among districts in Karnataka, Chikkaballapur has "moderate equity", measured in terms of access to livelihoods and political systems regardless of class or caste. The GDP during 2019-20 was ₹20,54,320 lakh at current price (Indiastatdistricts, n.d).

Urban and Rural Regions of Chikkaballapur District

The district comprises a mix of villages and towns. Most people live in rural areas. The 2011 census states that there are 115 villages in the districts. There are six urban regions (four City Municipal Councils and two Town Municipal Councils) that also serve as taluka headquarters: Chikkaballapur, Sidlaghatta, Chintamani, Gowribidanur, Gudibande, and Bagepalli.

1.2 Chintamani Town

This report and WELL Labs' T-Lab mainly focuses on Chintamani (latitude 13.4020 N, longitude 78.0551 E), the administrative headquarters and economic hub of the district. Chintamani City Municipal Council (CMC) is administratively divided into 31 wards.[8]

Chintamani's population is estimated to have risen by 22% from 76,068 in 2011 to 92,802 in 2022 (Ramamoorthy et al., 2024). The average sex ratio of Chintamani town is 984 females per 1,000 males.

Table 1: Population and households in Chintamani. Source: Census 2011 and Chintamani City Municipal Council

	Census 2011	Projection for 2022
Population	76,068	92,802
Households	17,849	20,622

The literacy rate in Chintamani is 84%, higher than Chikkaballapur district's 70%. The male literacy rate is 88%, whereas the female literacy rate is 79% (Karnataka Census, 2011).

The town's economy is based on agriculture — produce from Chintamani is one of the main sources of food supply to Bengaluru. The 2011 census mentions that the workforce of Chintamani is 50.2% of the population. The data suggests a significant

[8] Municipalities are divided into electoral constituencies known as wards. Each ward elects its representative, who is known as a councillor or corporator.

gender gap in workforce participation: nearly three-fourths of workers are male. Of the total population, 30,592 were engaged in work or business in the Chintamani City Municipal Council area. Of these, 22,268 were males and 8,324 females. Cultivators and agricultural labourers comprise 15.3% and 12.4% of the population respectively.

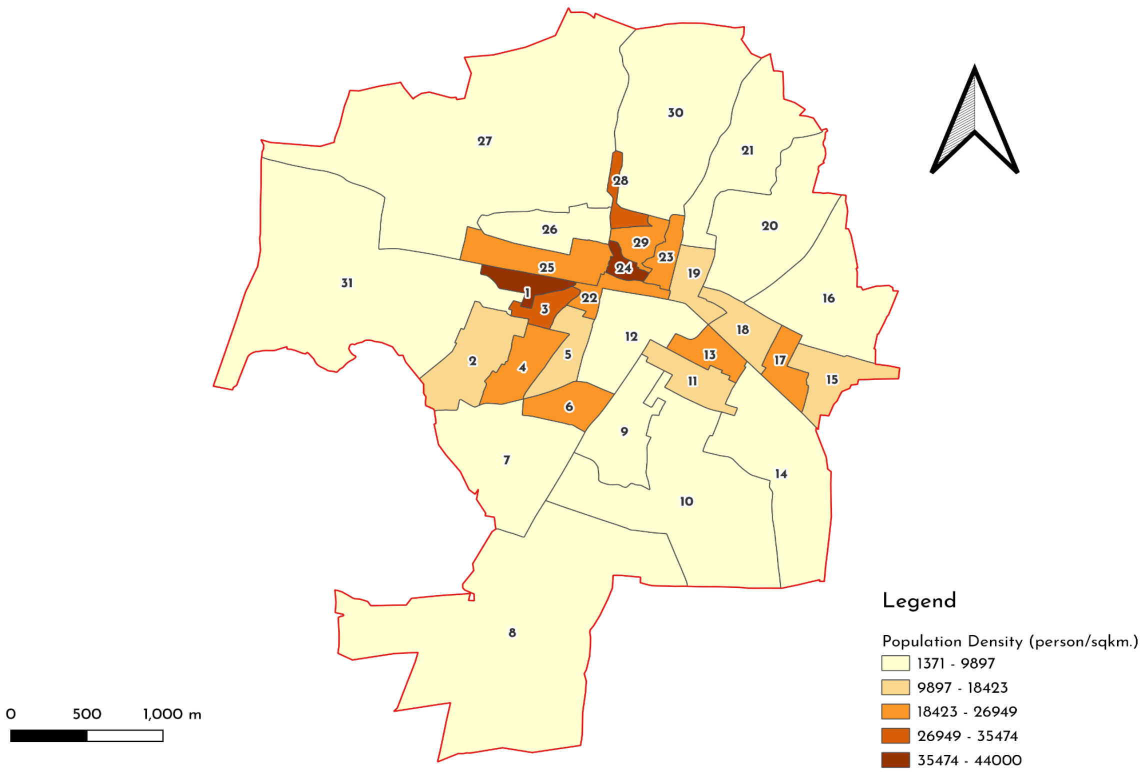


Figure 2: Wards of Chintamani City Municipal Council and their population density

2.0 Water Availability

2.1 Rainfall

Chikkaballapur experiences high inter-annual rainfall variability (District Disaster Management Authority Chikkaballapur, 2019). Similar to the larger district, Chintamani has a dry agro-climatic zone. It also has inter-annual rainfall variability and experiences cyclical years of drought and excess rainfall. The town receives a mean annual rainfall of 787 mm, which is lower than Karnataka's mean annual average of 1,153 mm.

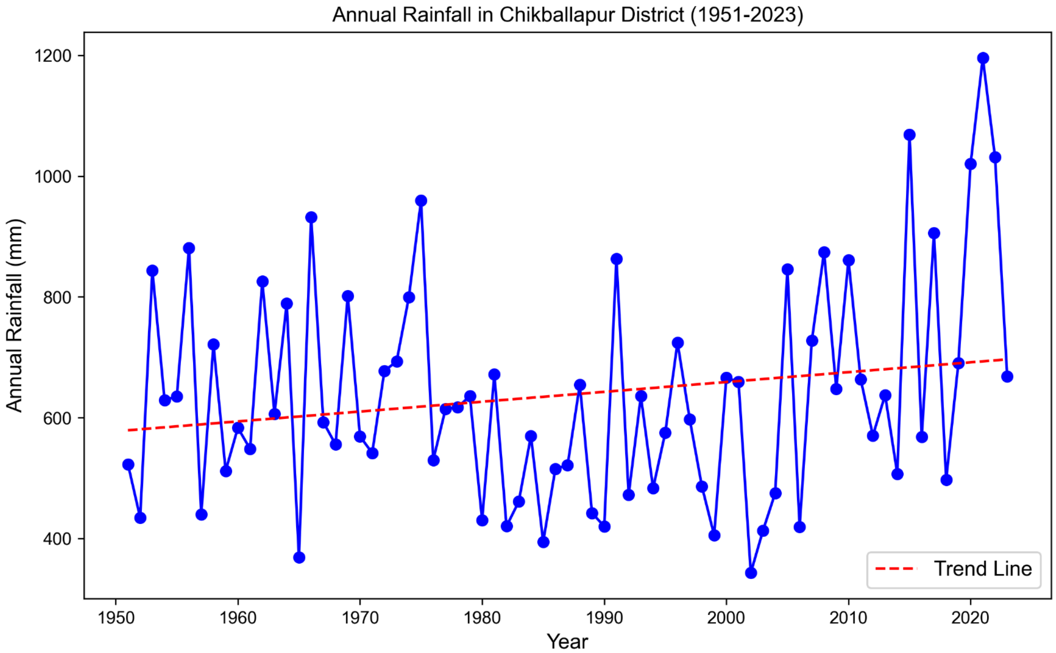


Figure 3: India Meteorological Department gridded datasets (0.25*0.25) of annual rainfall in Chikkaballapur district. Source: Pai et al., 2014

To assess the projected impact of climate change in the region, downscaled debiased datasets covering the Indian subcontinent were used (Mishra et al., 2020). The climate predictions were driven by a bundle of data points from the period between 1951 and 2014, Shared Socioeconomic Pathways (SSPs) scenarios, and new future social development pathways (O'Neill et al., 2016). Shared Socioeconomic Pathways are based on five narratives describing alternative socio-economic developments, including sustainable development, regional rivalry, inequality, fossil-fuelled development, and middle-of-the-road development (Riahi et al., 2017). The datasets, representing four scenarios (SSP126, SSP245, SSP370, and SSP585) forced in the Coupled Model Intercomparison Project phase six (CMIP6) model, were used for this exercise.

The projected precipitation trends exhibit pronounced inter-annual variation and the precipitation range varies according to the scenarios. However, compared to the historical period (1951-2014), there is an overall increasing trend in mean precipitation across all scenarios except SSP126, which shows a decreasing trend.

The temperature has also exhibited a rising trend over Chikkaballapur. Between 1951 and 2014, the mean maximum temperature rose by 0.60°C, whereas the mean minimum temperature rose by 0.83°C. The rise in minimum temperature is more pronounced than the maximum temperature, a trend that is likely to continue in the future. This elevated temperature is likely to impact agricultural outputs and the regional economy.

2.2 Groundwater Profile

Chikkaballapur has no perennial water sources for agriculture or drinking water other than groundwater, which is overexploited. Groundwater occurs under phreatic (unconfined) and semi-confined to confined conditions. The thickness of the regolith overlying the crystalline bedrock varies from 6 to 18 m across the majority of the district, except in parts of Sidlaghatta and Chikkaballapur talukas, where it varies from 40 to 60 m. The water depth in monitoring wells generally ranges from 12 to 49 metres below ground level (mbgl).

The general mode of ground water abstraction is through borewells of depths up to 300 m. Well yields range up to 1,200 cubic metres per day and can be highly variable. Most of the groundwater abstracted in the district is used for agriculture (Central Ground Water Board, 2012).

2.2.1 Aquifer Systems

The region is underlain by hard-rock aquifers. The rocks found in the district have been classified into four categories:

1. **Dharwar schists** are a type of metamorphic rock that form transmissive aquifers when weathered and fractured. Groundwater in these aquifers is typically found under phreatic (unconfined) conditions in the weathered zone, and under semi-confined or confined conditions within the fractures and fissures of the bedrock.
2. **The Gneissic Complex**, which includes granite and gneiss, also forms productive aquifers when weathered and fractured. Similar to the Dharwar

schists, the groundwater flowing in these aquifers exists under both phreatic and semi-confined/confined conditions.

3. **Dolerite dykes** are intrusive igneous rocks that can act as barriers to groundwater flow, creating localised aquifer systems. The groundwater in these dykes is typically found under semi-confined to confined conditions.

4. **Laterite**, a consolidated weathered product of the underlying regolith, also forms shallow aquifers in some areas of the district. However, the groundwater potential of these laterite aquifers is generally low compared to other rock types (Central Ground Water Board, 2022).

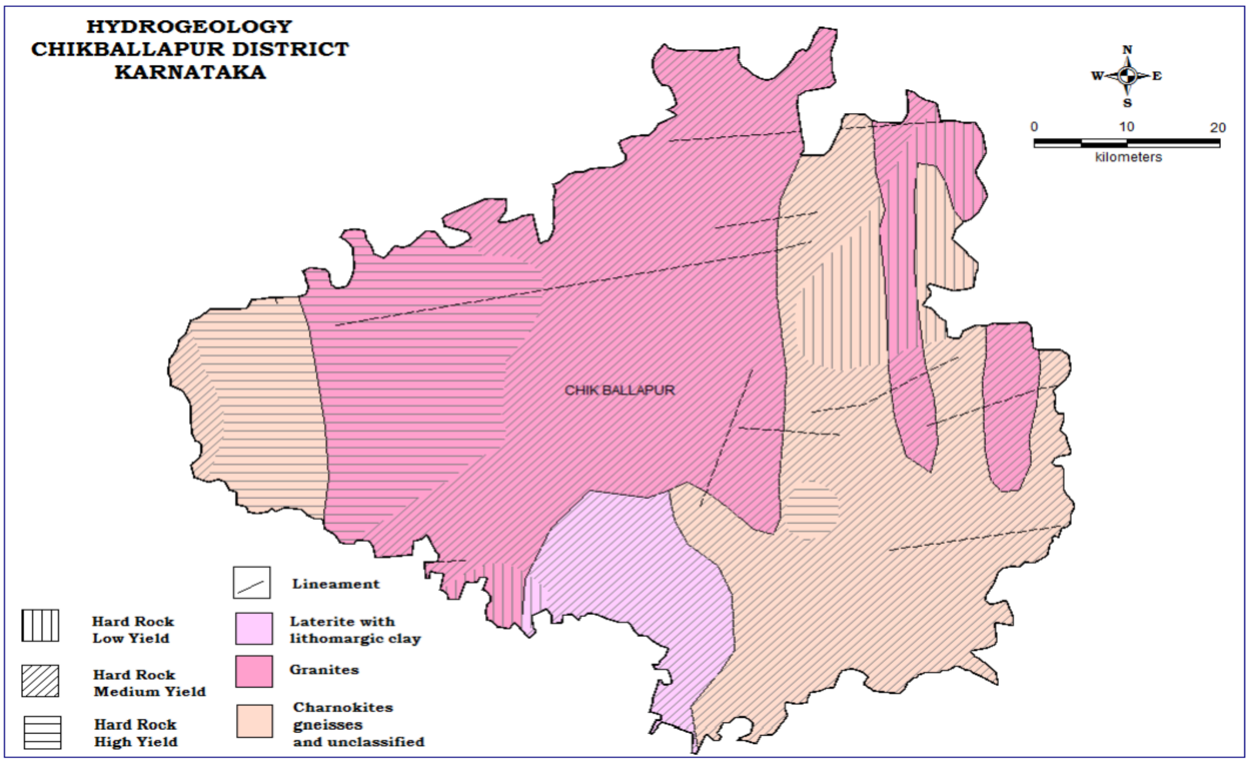


Figure 4: Hydrogeology of Chikkaballapur. Source: Central Ground Water Board, 2012

Chintamani is characterised by a weathered and fractured aquifer system made up of gneisses and granites. The groundwater in hard rock areas mainly occurs in top weathered zones and within the joints and fractures at greater depths. The unconfined (unconsolidated) weathered zone (regolith) is considered a source of water storage to the underlying fracture zone, which is semi-confined (Central Ground Water Board, 2022).

A recent resistivity study (Ramamoorthy et al., 2024) indicates that the town has an aquifer profile consisting of:

- **Thin topsoil layer** followed by a loamy-clayey soil layer of 5 to 10 m
- **Weathered zone** with a thickness of 10 to 15 m
- **Saturated bedrock** with fissures with a thickness of up to 20 m
- **Unweathered bedrock**, commonly referred to as basement rock

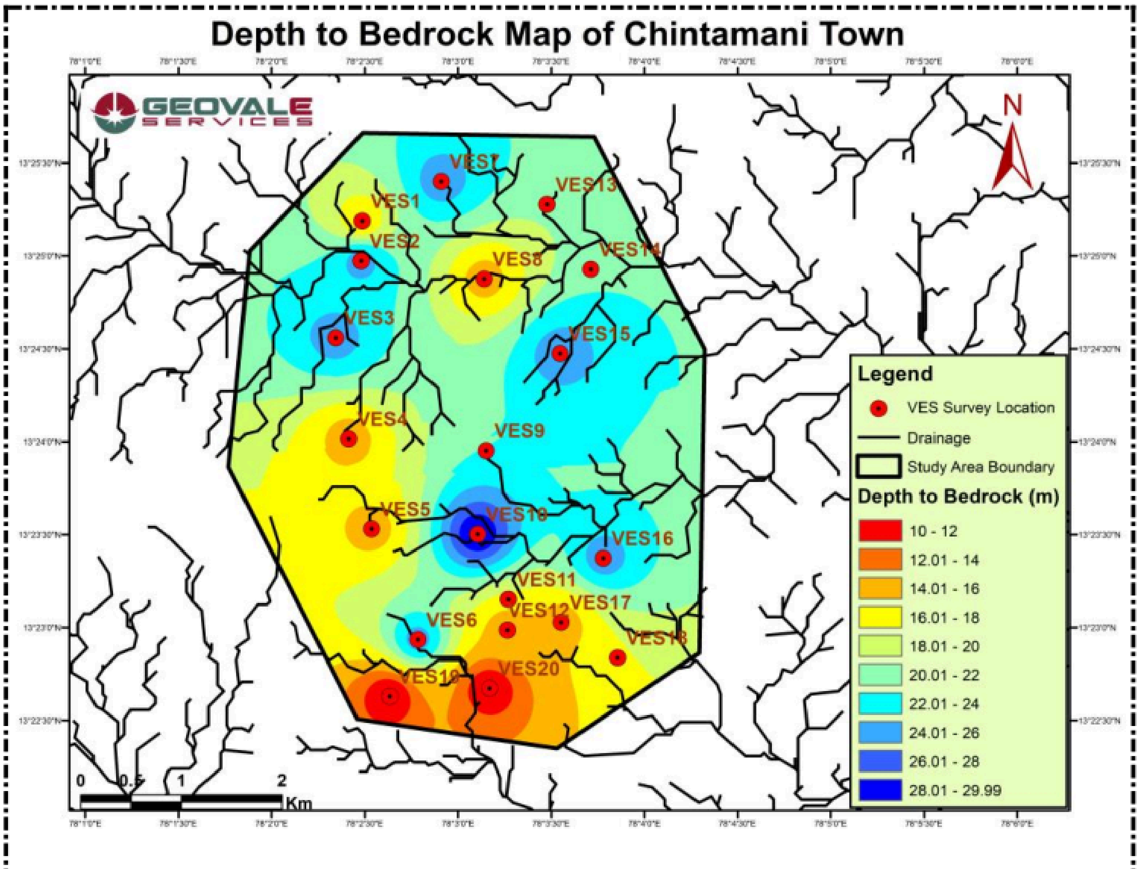


Figure 5: Depth-to-bedrock map for Chintamani. Source: Vertical Electrical Sounding (VES) surveys carried out by Geoovale, December 2022

Hard-rock aquifers underlying Chintamani can be characterised as having sufficient (although not large) storage. They are prone to depletion through excess abstraction[9] (Cuthbert et al., 2023), especially during consecutive years of low rainfall. The weathered zone provides the capacitive function, while the fissured bedrock acts as the transmissive layer.

Figure 5 above shows that the deepest depth to unweathered bedrock distance is along two north-easterly flowing streams: 1) in the town's northwest, near Nekkundi lake and 2) southeast, along Malapalli lake. However, in some locations, the bedrock

[9] Excess abstraction is when the aquifer extraction rate is higher than the recharge rate.

appears at shallower depths. Locations that recorded the maximum weathering depth indicate zones that could be targeted for recharge, either through rainwater harvesting or other surface water structures.

2.3 Surface Water Hydrology

It is essential to understand Chintamani's topography, surface water bodies, demarcation of catchment areas, and water flows to boost the town's water security.

Chikkaballapur has three river basins, namely North Pennar, South Pennar, and Palar. Chitravathi, Arkavathy, Papagni, and Penna[10] are seasonal rivers flowing through the district. Papagni originates near Sidlaghatta district in Karnataka and flows in the north-eastern direction before joining Pennar near Kamalapuram, a town in Andhra Pradesh. Its catchment area runs through Bagepalli, Chintamani, Sidlaghatta, Madenapally and Chittoor. There are no discharge measurements available for the river (Krishniah, 2014).

Chintamani lies in the upper region of the Palar basin. It has three distinct catchments:

1. Nekkundi-Bhukkanahalli

The catchment of Nekkundi is part of a cascading lake system — when one lake fills up, the excess empties into the next one in the chain, which lies outside the town boundary. Within the town's boundary, Nekkundi lake's catchment lies in the northwest. The stormwater run-off and the sewerage network in the area flow towards the lake due to the natural slope. The Bhukkanahalli lake is to the northeast, just outside the town limits. It is situated downstream of Nekkundi lake, so it receives the lake's overflow in addition to stormwater and sewage from its own catchment.

2. Gopasandra

This catchment spans the central and south-eastern parts of the town, which are the most built-up and densely populated. It originates at the Kadu Malleshwara hillock. Aside from Gopasandra lake, there are two other lakes — Mallapalli and Chikka Mallapalli — in this catchment area.

3. Kannampalli

This catchment is in the southern part of Chintamani and falls largely outside the municipality's jurisdiction. Kannampalli lake is fed by two hill catchments: Kailasgiri and Kadu Malleshwara hillocks on the periphery of the town. Though the smallest catchment of the three, Kannampalli is important because it has been a drinking

[10] Penna is distinct from Pennar

water source for the town for many years. The municipality treats the water from the lake before supplying it to residents.

The ridges between these catchments intersect in the town's centre.

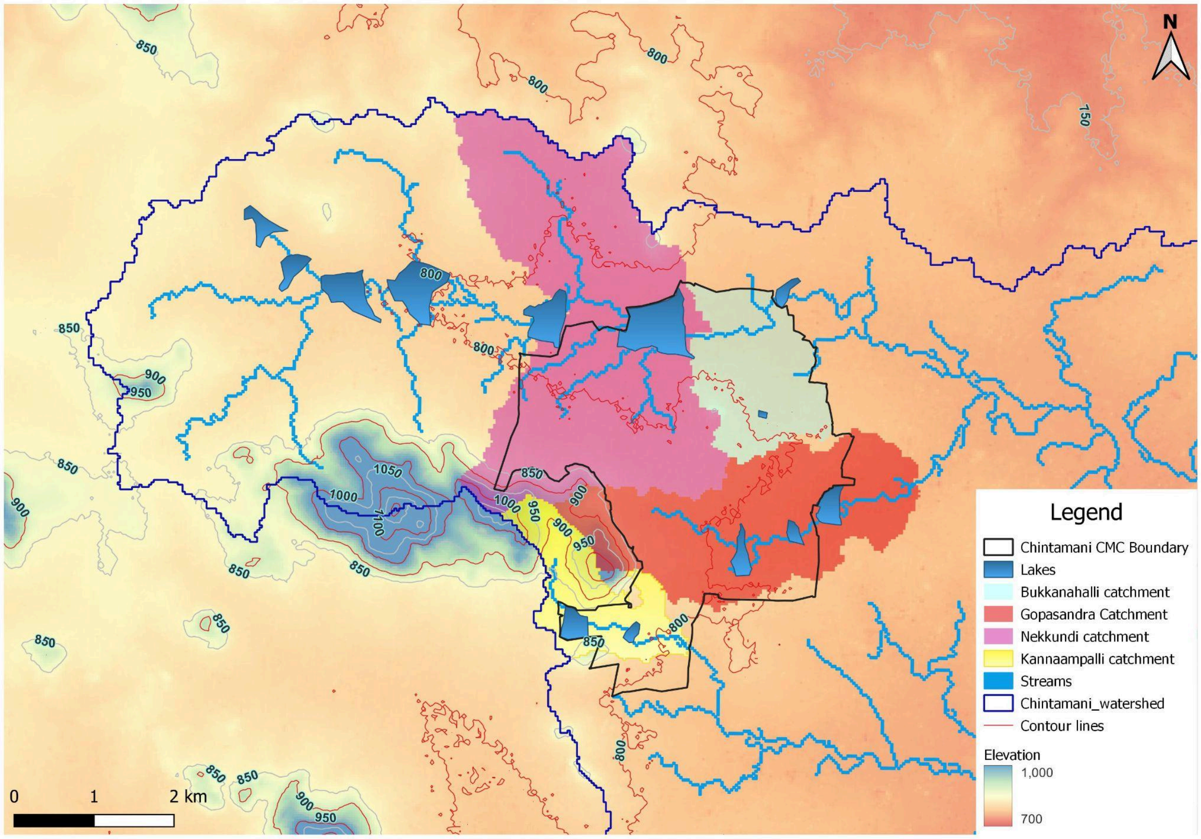


Figure 6: Map of Chintamani town watershed and catchment areas of its lakes. Source: Cartosat 2 from Bhuvan-National Remote Sensing Centre; K-GIS, Karnataka State Remote Sensing Applications Centre

Table 2: Catchments in Chintamani town. Source: Ramamoorthy et al., 2024

Catchment	Catchment area (sq. km)	Lakes falling under the catchment	Lake size (sq. m)
Nekkundi - Bhukkanahalli	13.4	Nekkundi	470,427
		Bhukkanahalli	49,375
		Ramakunte	7,728
Kannampalli	2.1	Kannampalli	108,976
		Chikka Kannampalli	31,305

Gopasandra	5.9	Gopasandra	117,211
		Mallapalli	88,791
		Chikka Mallapalli	38,948

Figure 7: Nekkundi (top left), Kannampalli (top right), and Gopasandra (bottom) lakes in late 2022. Credits: Shashank Palur and Rajesh Ramamoorthy, WELL Labs

3.0 Water Supply and Use

3.1 Domestic Water Supply and Consumption

In September-October 2022, WELL Labs conducted household surveys in Chintamani along with the organisations TIDE and Bremen Overseas Research & Development Association (BORDA). The respondents comprised 12-15 households per ward, a total of 427 households across the town. The findings from the household survey were extrapolated to the projected current population of ~92,000.

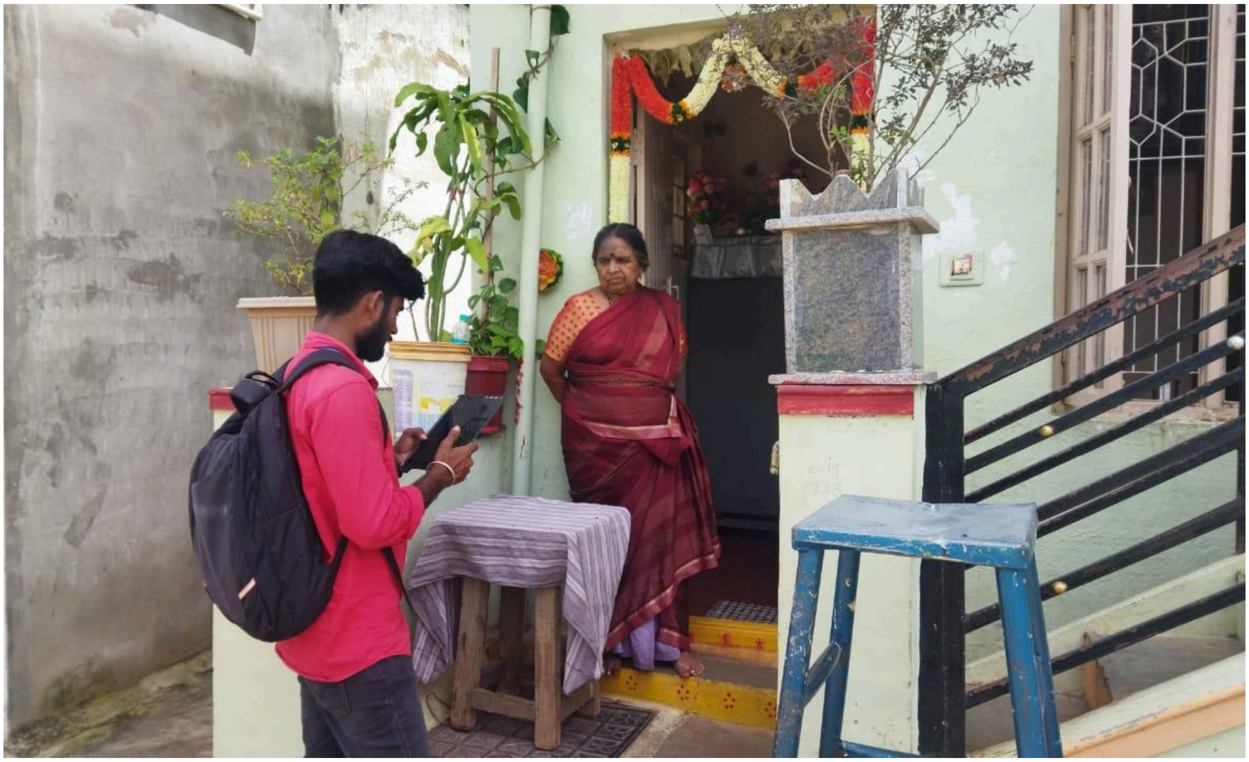


Figure 8: Household surveys on water consumption in Chintamani. Credit: TIDE

Chintamani's total domestic consumption was estimated to be 6.9 million litres per day (MLD) (Ramamoorthy et al., 2024). A majority of households (86.7%) depended on a single source of water — municipal piped supply — while 6.9% supplemented their municipal supply with private tankers. A small portion of households used open wells or private borewells, either along with or without municipal supply.

Among the 427 surveyed households, 29% of households were located in lower-income neighbourhoods (spread across 16 of the town's 31 wards). In these neighbourhoods too, most households depended on municipal supply. A small proportion (less than 2%) used handpumps.

Most households received the municipal supply once every 7-8 days for 2-3 hours. Some received water less frequently — once in 10 days.

There was wide variation in water consumption patterns across the town. Most (70%) of the surveyed households consumed between 45-70 litres per capita per day (lpcd) and the remaining 30% consumed significantly higher — 100-175 lpcd. Given the limited sample size of the household survey, these differences might require further investigation.

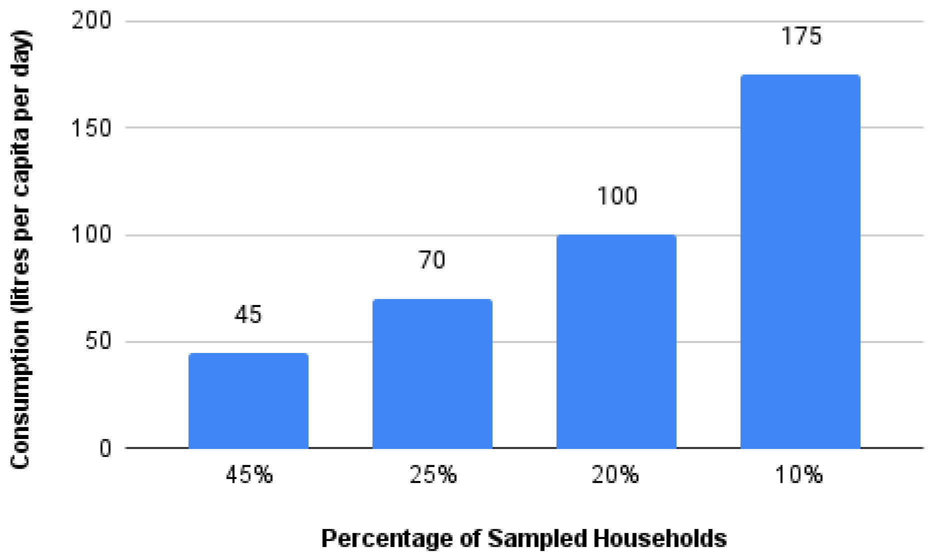


Figure 9: Household water consumption

3.2 Commercial and Institutional Water Use

Commercial and institutional consumption account for a small portion of the overall water consumption.

TIDE and BORDA conducted a solid waste survey in October-November 2021, which revealed that there were 1,847 commercial and institutional water users in the town. These were largely shops and small eateries, followed by garages, hospitals, and educational institutions (see Figure 10 for more details).

In July 2022, they conducted a follow-up survey of 537 establishments to understand their water supply and consumption patterns. Most of them depended on tankers, followed by private borewells, to meet their water requirements. Municipal supply was of inadequate quantity and not frequent enough.

There were significant differences in water consumption across the surveyed establishments. The largest individual consumers were hostels, hospitals, schools, and colleges. Even though each shop and small eatery individually has less water consumption, their sheer numbers led to such establishments accounting for the highest overall category-wise water consumption.

Each category's weighted average consumption was calculated separately (Figure 11). This average was extrapolated to the total number of units in each category (Figure 10) to arrive at the town's commercial and institutional demand of 0.33 MLD. This amounts to a small portion of the town's overall water demand (Ramamoorthy et al., 2024).

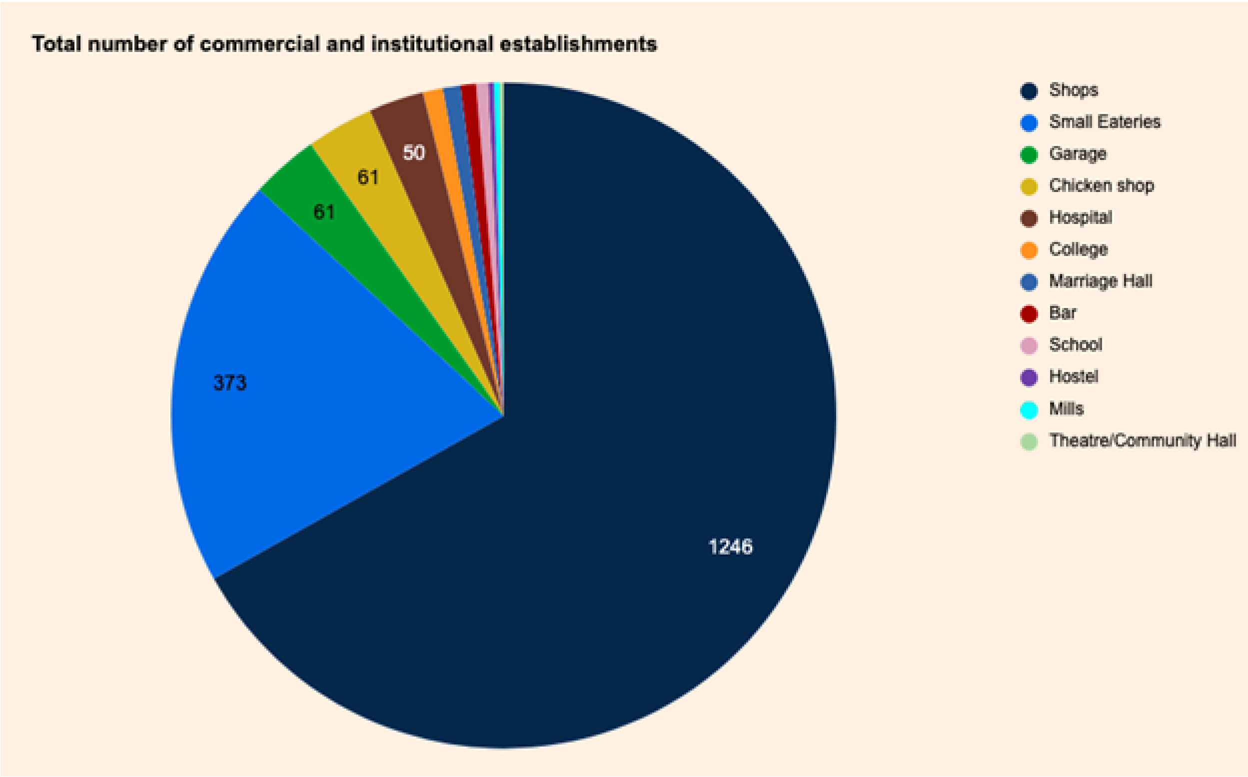


Figure 10: Number of commercial and institutional establishments in Chintamani

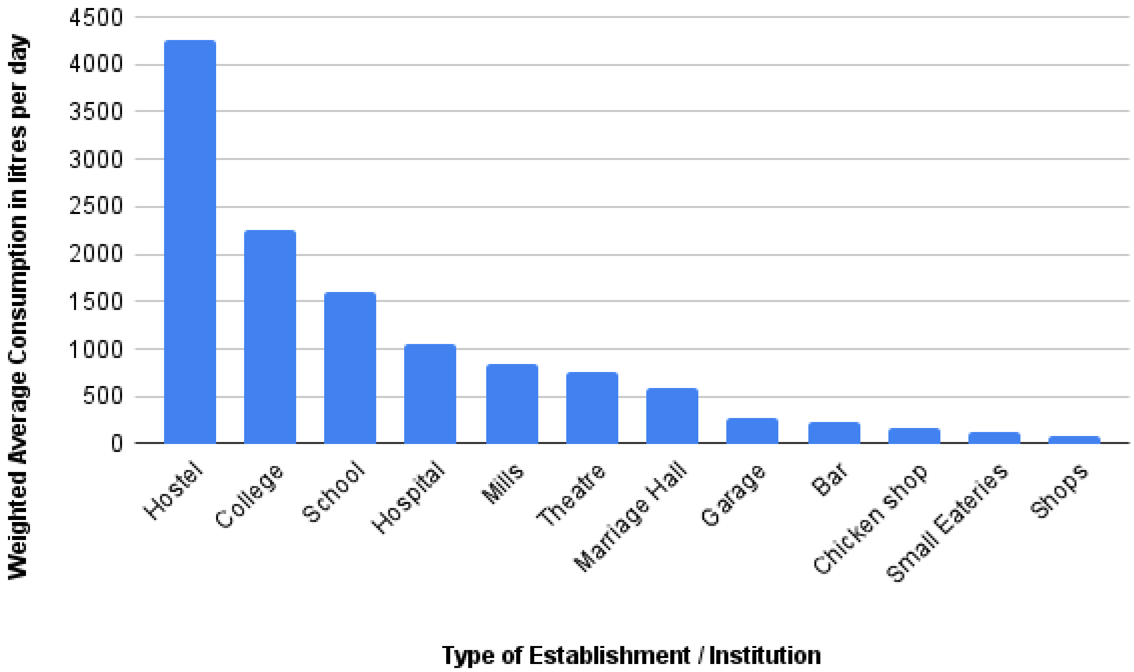


Figure 11: Weighted average water consumption[11] of different categories of commercial and institutional establishments in Chintamani

3.3 Chintamani's Drinking Water Supply System

Kannampalli lake, in the southwest of the town, can supply 1 MLD of water, which is rationed to the end of the year. Water is pumped from a jackwell at the lake to a water treatment plant 3 km away, which has a treatment capacity of 1.6 MLD.

The water treatment plant's performance was assessed in late 2021. It failed to treat water to drinking water quality standards and required a complete overhaul. Water quality tests conducted in July 2022 showed that most parameters were within limits except faecal coliform.

The Chintamani City Municipal Council has begun the process of renovating the water treatment plant and upgrading its capacity to 3 MLD. It also plans to operationalise a defunct plant at Agrahara and upgrade its capacity from 1.5 to 3 MLD.

In late 2022, a new drinking water supply project was commissioned to bring water from Bhaktharahalli Arsikere, a reservoir located 15 km away. It has a capacity of 3 MLD, of which 2 MLD is currently being used on average.

[11] This graph depicts the weighted average consumption within each category, not the weighted average consumption across categories.

The water distribution infrastructure, comprising ground-level service reservoirs, overhead tanks, and pipeline networks, dictate which wards receive water from either surface water sources or borewells or sometimes a blend of both. More often than not, a borewell is considered a dependable source that can plug into the network to bridge deficits. Municipal borewell yields are variable; they depend on rainfall. In good monsoon years, such as 2022, supply increased by 1-1.5 MLD due to the increase in the water table.

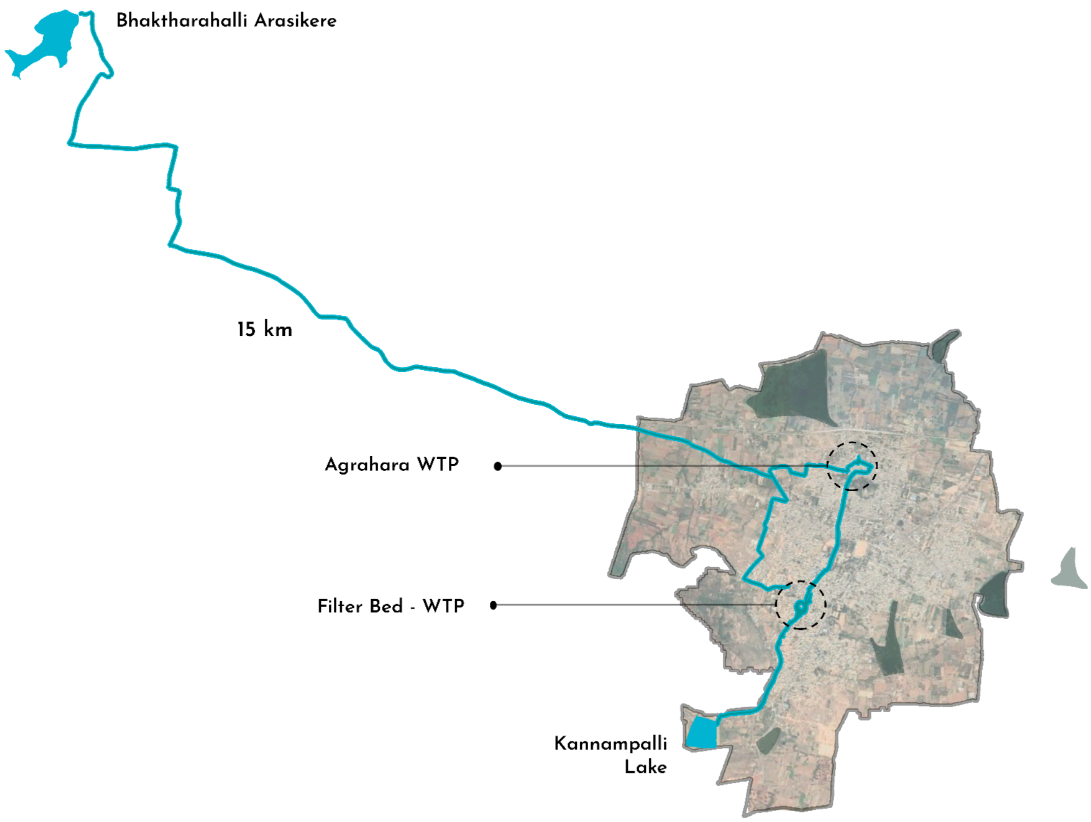


Figure 12: Map of current surface water sources (WTP - water treatment plant)

Unauthorised connections to the water supply network is a huge challenge. Ramamoorthy et al. (2024) estimate non-revenue water to be 40% of the supply. Of this, unauthorised connections account for 1.625 MLD (25%) and leakages in the pipeline network 0.975 MLD (15%).

Table 3: Municipal water supply overview from June 2022. Source: Ramamoorthy et al., 2024

Component	Average annual flow (MLD)
Kannampalli Lake	1.0

Component	Average annual flow (MLD)
Bhaktharahalli Arsikere	2.0
Municipal borewells (municipal groundwater extraction)	3.50
Total municipal supply	6.5
Data source: City Municipal Council officials	
Non-revenue water[12]: Leakages	0.975
Non-revenue water: Unauthorised	1.625
Non-revenue water: Total	2.6
Data sources: City Municipal Council officials for unauthorised connections; Years of partnership with Karnataka: Evolving model for sustainable urban water service delivery for overall non-revenue water average for towns	
Groundwater recharge from freshwater pipelines	0.975

3.4 Chintamani's Water Balance

Ramamoorthy et al. (2024) have calculated Chintamani's water balance, that is, a summary of the town's water flows, including rainfall, run-off, and recharge.

The water balance factors in built-up spaces as run-off rates are dependent on the quantum of built and unbuilt spaces. The built-up space in the town increased from 7% in 1994 to 21% in 2021. Currently, a significant portion of land within municipal limits remains unbuilt — around 75% of the 15 sq. km area is either fallow or agricultural land, although much of it is expected to become urbanised over time. The remaining 4% is occupied by water bodies, such as lakes.

Evapotranspiration loss was estimated to be 20.19 MLD (Ramamoorthy et al., 2024). This includes evaporation that occurs through the soil and other surfaces as well as transpiration from plants into the atmosphere.

[12] Non-revenue water is water that is pumped and then lost or unaccounted for. Water utilities suffer from the huge financial costs of treating and pumping water only to see it leak back into the ground. They also lose revenue due to unauthorised connections.

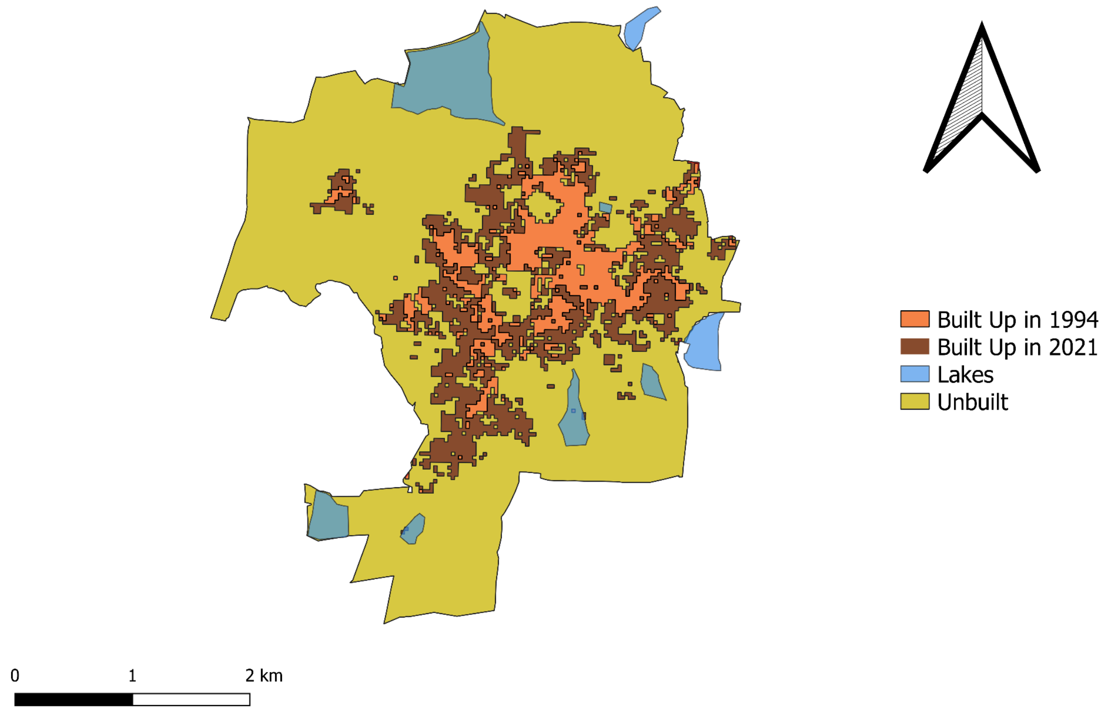


Figure 13: Land use in Chintamani town, 1994 versus 2021. Source: Landsat 8, United States Geological Survey

Table 4: Chintamani's water balance. Source: Ramamoorthy et al., 2024

Component	Average annual flow (MLD)
Rainfall volume	32.34
Data source: Annual District Wise Rainfall report 2022 from Karnataka State Natural Disaster Monitoring Centre *Calculation: Total rainfall volume = (annual rainfall x town area) / number of days in a year*	
Run-off	8.27
Calculation: Curve number method - *Total run-off volume = (run-off from built area) + (run-off from unbuilt area)* - *Total built area / run-off coefficient = 3.12 sq. km / 35%* - *Total unbuilt area / run-off coefficient = 10.98 sq. km / 25%*	
Total natural groundwater recharge	3.88
Groundwater recharge (lakes)	3.06

<table>
<tr><th>Component</th><th>Average annual flow (MLD)</th></tr>
<tr><td colspan="2">Assumptions:
- Natural recharge rate for hard rock aquifers is considered to be 12% of total rainfall falling within town limits (Foundation for Ecological Security, 2010).
- Recharge rate through lakes is considered to be 20% of total volume entering the lake (Foundation for Ecological Security, 2010).
- Total volume of water entering the lake comprises run-off within the town and from lake catchments outside the town boundary along with untreated wastewater flowing into them.</td></tr>
<tr><td>Evapotranspiration</td><td>20.19</td></tr>
<tr><td colspan="2">Calculation:
Evapotranspiration = (total rainfall) - (run-off) - (groundwater recharge)
The groundwater recharge in the above calculation does not include recharge from lakes</td></tr>
</table>

4.0 Water Challenges

4.1 Inadequate Groundwater Quality

The groundwater in most parts of Chikkaballapur has elevated concentrations of fluoride, nitrate, magnesium, and sodium (Atal Bhujal Yojana, 2021).

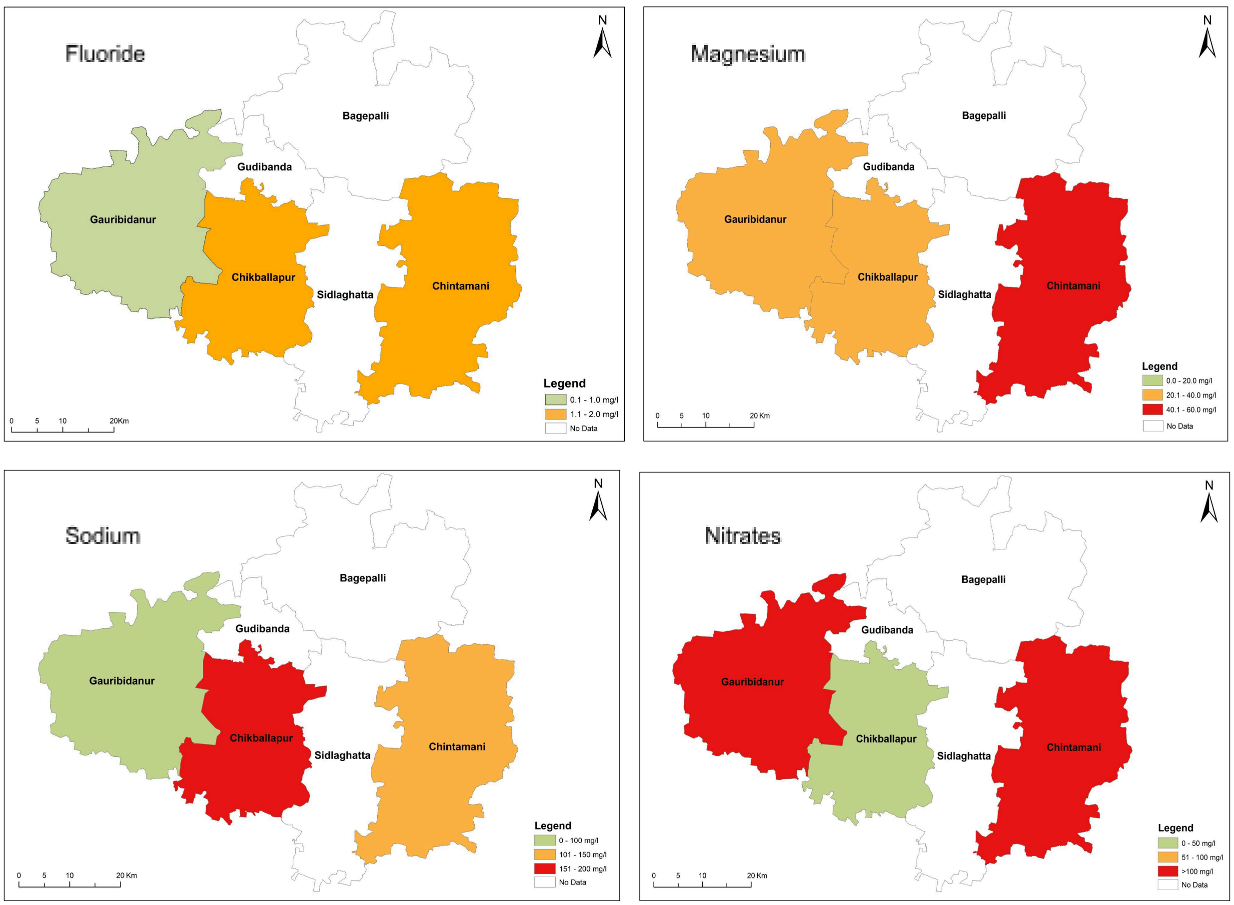


Figure 14: Groundwater contaminants in Chikkaballapur: fluoride, magnesium, nitrates, and sodium (clockwise from top left). Source: WELL Labs

4.2 Inefficient Water Use

The quantum of non-revenue water is as high as 40%.

The town's pipeline network reaches most parts of the town, but there are a large number of unauthorised connections and leakages. This affects the revenues utilities can collect through user fees (Ramamoorthy et al., 2024).

The town's municipal water supply primarily relies on groundwater, supported by surface water. The Chintamani City Municipal Council estimates that on average, it extracts 3-4 MLD from borewells. As per 2022 borewell records, it maintained over 100 borewells. These are run continuously and are connected to nearby pump houses. Most feed ground-level service reservoirs and overhead tanks, from where water is supplied to neighbourhoods — in turns, about once a week. A few borewells supply water directly to localities.

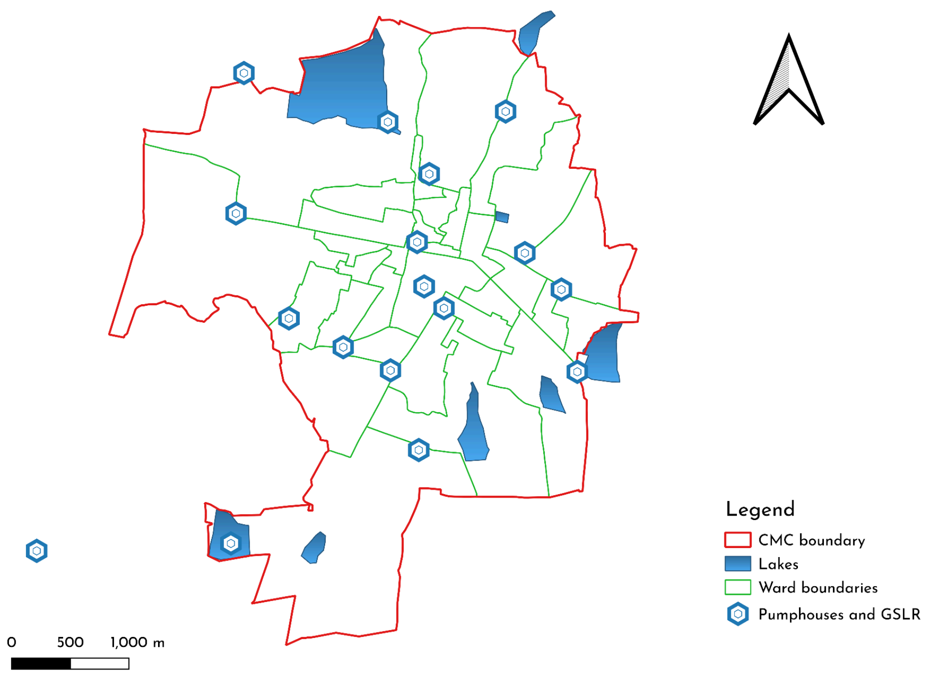


Figure 15: Location of pumping station, overhead tanks, and ground-level service reservoirs (GLSR) in Chintamani. Source: Karnataka GIS, Karnataka State Remote Sensing Applications Centre; Chintamani City Municipal Council data

The town needs to address both heavy groundwater dependence and the high quantum of non-revenue water to boost water security.

4.3 Inadequate Sewage Treatment Capacity

Chintamani's wastewater generation — from domestic and commercial/institutional establishments — is estimated to be 5.72 MLD (Ramamoorthy et al., 2024). Sewerage network maps show extensive coverage, but municipal records reveal that only 4,381 households have sewerage connections, far lower than water supply connections.

The sewage treatment capacity is also inadequate, so only 2 MLD of wastewater gets treated. Thus, most of Chintamani's sewage (65%, 3.72 MLD) goes untreated and flows directly into lakes. A sewage treatment plant has been proposed near

Bhukkanahalli lake, just outside the town boundary, to fulfill the treatment-capacity deficit.

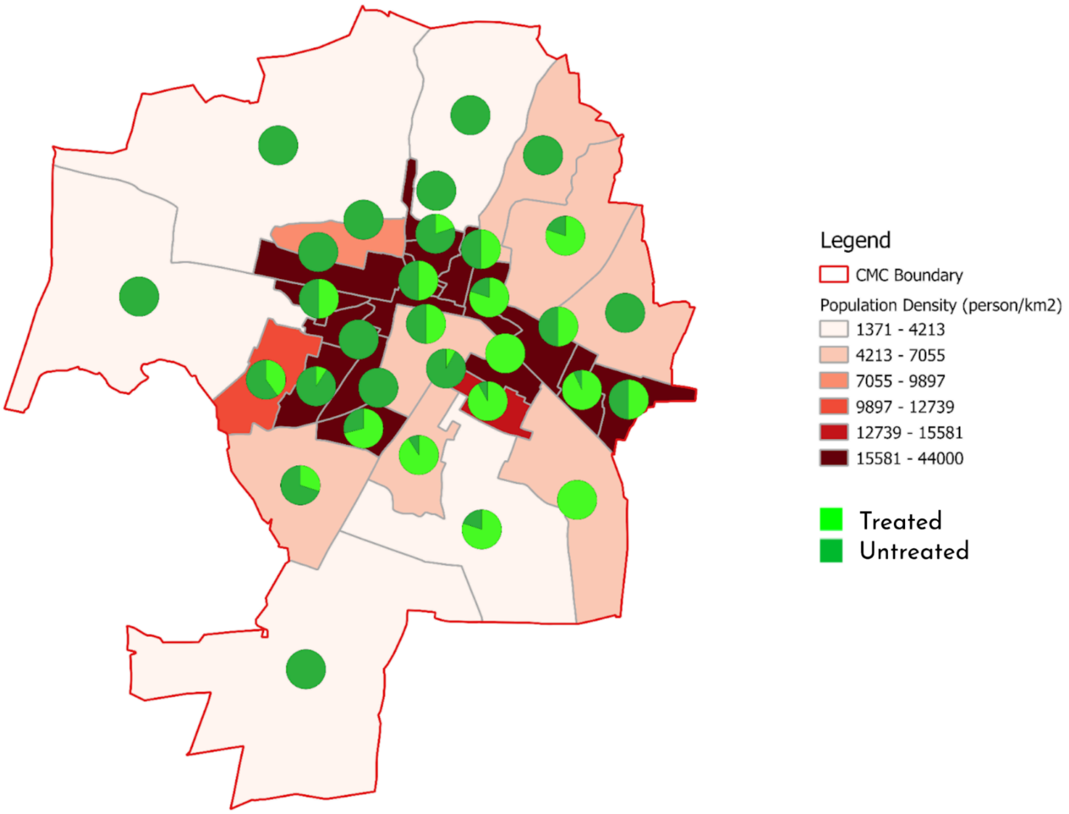


Figure 16: Map showing ward-wise population density and level of wastewater treatment. Source: Karnataka-GIS, Karnataka State Remote Sensing Applications Centre, base sewerage map by the Karnataka Urban Water Supply and Drainage Board

Table 5: Overview of wastewater management

Component	Average annual flow (MLD)
Freshwater consumption	6.82 (domestic) + 0.33 (commercial/institutional)
Domestic wastewater produced	5.46
Commercial/institutional wastewater produced	0.26

Assumptions: *Wastewater produced is 80% of freshwater consumed*	
Total wastewater produced	5.72
Water treated at sewage treatment plants	2
Untreated domestic and commercial/institutional wastewater	3.72
Data source: 3rd-stage underground drainage scheme from the Karnataka Urban Water Supply and Drainage Board; Chintamani City Municipal Council data for sewerage connections	
Reuse within and beyond the city	0

4.4 Biophysical Unsustainability

The shallow aquifer has dried up in many places and the town relies on deep fractures.

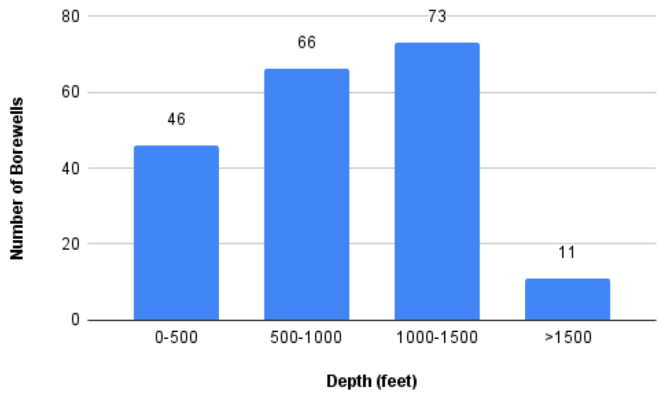
Chintamani is over-reliant on groundwater, which accounts for 50% of its freshwater needs. The municipality pumps deep borewells round the clock, yet is able to supply water to the town's residents only once a week on average (Ramamoorthy et al., 2024).

Figure 18 shows typical borewells in hard-rock areas. These have casing pipes put against the upper-weathered zones that tap the fissures and fractures occurring in the weathered-fractured zone at depth. Some borewells go much deeper in the basement rock, where one can expect a good yield only if it is located in a shear, fracture, or fault zone (Michael et al., 2008).

Around 40% of borewells have failed in Chintamani since 2020.

As per municipal borewell data records from 2020, there were 322 municipal borewells in Chintamani. Of these, only 196 have yielded water at some point; the remaining 126 failed at the time of drilling or in subsequent years. The failure rate has been around 40%, which means that two out of five borewells have failed in the town (Ramamoorthy et al., 2024).

Figure 17 (below): Municipal borewells and their depth. Source: Chintamani City Municipal Council



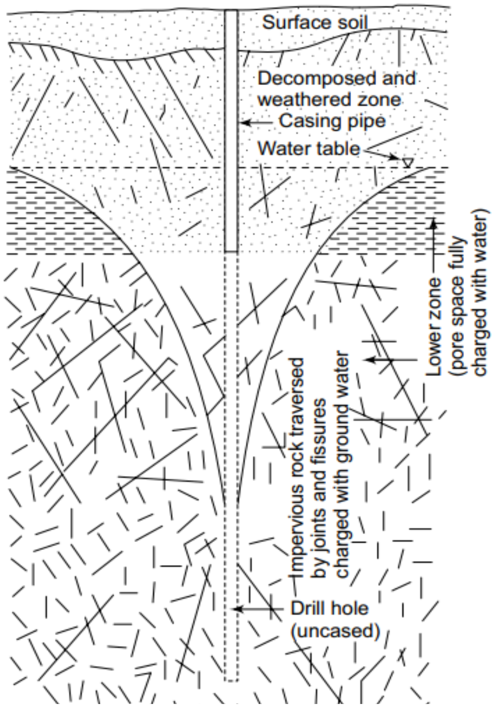


Figure 18 (right): Schematic of a borewell tapping weathered- fractured hard-rock area. Source: Michael et. al, 2008

As shown in Figure 19, most shallow borewells (<500 feet) are around the town's lakes. However, within 100-metre-radius clusters of borewells, we observe that depths vary from 300 feet to 1,300 feet (Ramamoorthy et al., 2024). Based on the depths, many borewells draw from fractures below shallow aquifers. This also means that submersible pumps with higher suction power ratings are needed to pump water.

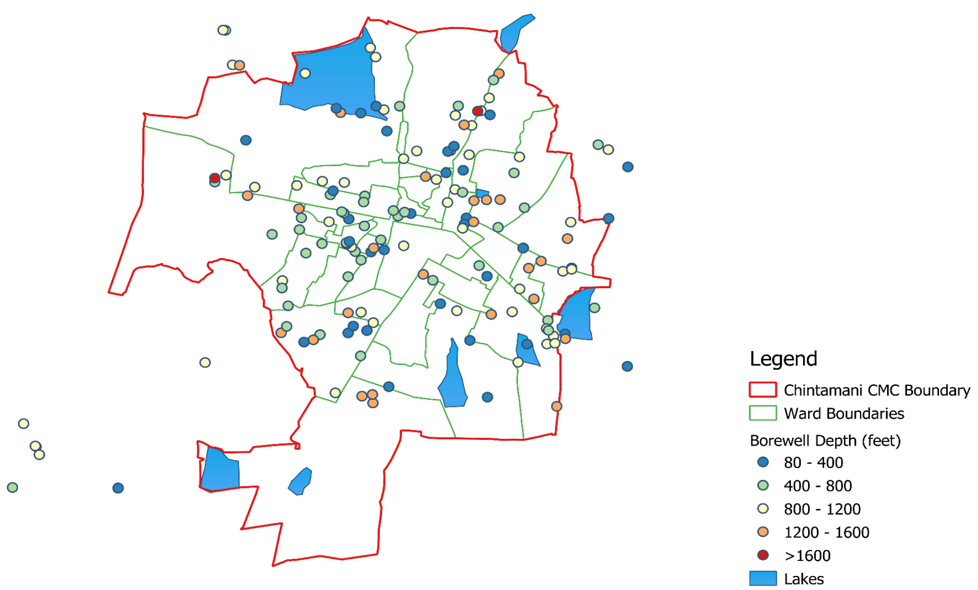


Figure 19 (left): Spatial distribution of municipal borewells: Source: Cartosat 2 from Bhuvan - National Remote Sensing Centre; Karnataka-GIS, Karnataka State Remote Sensing Applications Centre; Chintamani City Municipal Council

The municipality does not have a system of registering privately dug borewells. Attempts made during the household survey in 2022 to understand the extent of private borewells did not yield any useful information (Ramamoorthy et al., 2024).

4.5 Climate Vulnerability

There is massive variability between wet and dry years.

Chintamani faces cyclical years of drought and excess rainfall — 2014, 2016, and 2018 were drought years, whereas 2015, 2017, 2020, 2021, and 2022 were excess rainfall years. The region recorded 50% above average rainfall in 2021 and 2022. At the end of the 2023 southwest monsoon season, Chintamani received below average rainfall. This is typical of the cyclical years of drought and surplus in the region, pointing to a need to prepare for both extremes, particularly worsening water scarcity. The observed annual mean rainfall has a standard deviation ± 201 mm/yr in this region (Ramachandra et al., 2017).

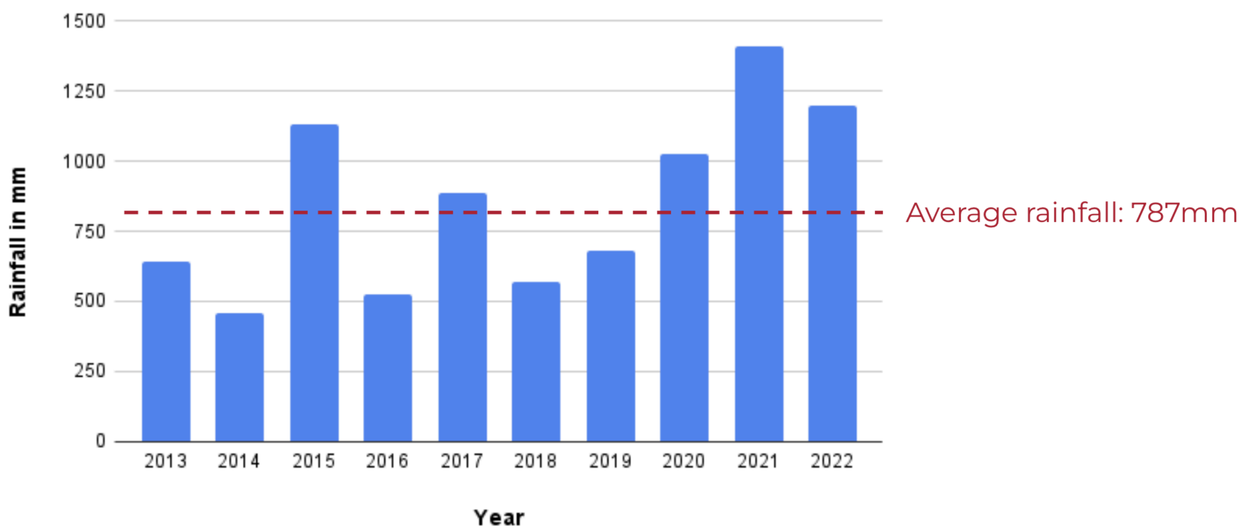


Figure 20: Annual rainfall in Chintamani[13]

In 2018-19, when Chintamani last experienced drought conditions, borewell yields dropped. Municipal officials reported that they used to hire 300-400 private water tankers per day to meet the town's water requirements. These tankers usually transport water from villages beyond the town limits.

[13] The average of 787 mm rainfall is different from the earlier figure in the report (621 mm) because of the shorter time frame under consideration.

4.6 Surface Water Pollution

Chintamani's water bodies are polluted due to inadequate investment in sewage treatment.

Samples collected from three lakes — Kannampalli, Nekkundi, and Gopasandra — showed coliform levels higher than the desirable limit of below 500 MPN[14] per 100 ml. Since there are no major industries in the lakes' catchment area, their high nutrient levels possibly arise from sewage inflows from urban pockets or agricultural runoff.

Table 6: Water quality of Chintamani's lakes. Source: Laboratory test results for samples collected in July 2022 (Ramamoorthy et al., 2024)

Parameters	Kannampalli lake	Nekkundi lake	Gopasandra lake
Total dissolved solids (mg/l)	118	478	828
Total nitrogen (mg/l)	1	2.8	6.1
Ammoniacal nitrogen (mg/l)	<1	<1	1.2
Dissolved oxygen (mg/l)	5.7	5	5.5
Biological oxygen demand (mg/l)	2.4	2	2.6
Chemical oxygen demand (mg/l)	14	10	18
Fecal coliform (MPN/100 ml)	>1600	>1600	>1600

However, the lakes meet the Central Pollution Control Board's standards for water use with conventional treatment. Thus, water from Kannampalli lake undergoes conventional treatment and supply at a water treatment plant before supply.

There is a need for periodic monitoring of the lakes to establish trends in water quality changes and ensure that the treatment infrastructure can handle and purify the water.

[14] Most Probable Number (MPN) index is an index of the number of fecal coliform bacteria that, more probably than any other number, would give the results shown by the laboratory examination. It is not an actual enumeration.

4.7 Water Supply System's Financial Unsustainability

Water supply accounts for nearly 40% of the municipality's operational expenses.

Pumping deep municipal borewells and the town's reliance on groundwater results in high electricity bills. Running water supply infrastructure accounted for close to 40% of the town's revenue expenditure[15] in the financial years (FY)[16] 2019-20, 2020-21 and 2021-22. Half of these expenses are for electricity charges and fuel, whereas the rest is used to pay salaries, and carry out repairs and maintenance. High electricity charges can be attributed to the continuous running of borewells, among other water supply components.

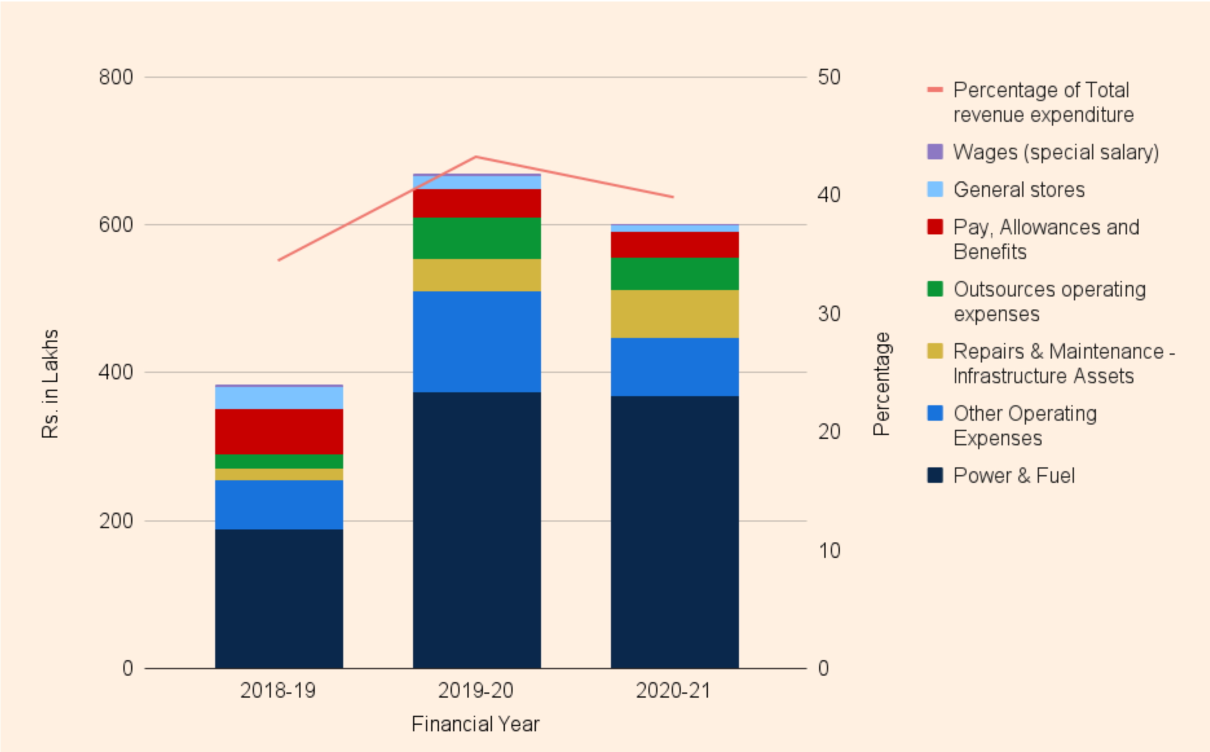


Figure 21: Revenue expenditure on water supply. Source: Chintamani City Municipal Council budget documents for FY 2020-21, 2021-22, 2022-23

The municipality faces challenges in funding operational expenses

This is true of many urban local bodies across Karnataka as their revenue streams fail to keep pace with the escalating demand for essential services. An analysis of Chintamani's budget shows three key reasons behind the town's struggle to generate enough revenues to meet its operational expenses:

[15] Government expenditures that do not lead to the creation of fixed assets are called revenue expenditures.
[16] In India, the financial year begins on April 1 and ends on March 21

1. Unauthorised connections

While the municipality claims that the piped water supply network reaches most households in town, its records from 2021-22 showed only 8,308 water supply and 4,381 sewerage connections. Considering the town's 20,000 households, the glaring disparity indicates a large number of unauthorised/illegal connections.

2. Flat tariff structure

The Chintamani City Municipal Council employs a flat tariff structure of ₹820 for residential and ₹1,640 for commercial establishments per annum. The last revision of water charges took place in the year 2016, reflecting a lack of responsiveness to changing economic conditions.

3. Gap between receivables and receipts

The accrued income (receivables)[17] from water and underground drainage charges is ₹540 lakhs, while the actual receipts under the Water Supply Fund is only ₹18.9 lakhs for FY 2020-21 and ₹23.5 lakhs for FY 2021-22, as per audited accounts.

This stark difference raises concerns about the municipality's ability to verify whether the receivables can be accounted against the municipality's dues as the demand collection balance register is not updated. As a result, the verification of the legitimacy of receivables becomes challenging, impeding effective financial management.

Data for 14 cities, including some state-level averages, show that on average, they recovered less than half (45%) of water supply operations and maintenance costs, let alone capital costs.

Low operations and maintenance cost recovery rates indicate that service charges are well below the levels required for financial sustainability. This undermines the viability of water supply infrastructure, unless there is substantial fiscal support (Athar et al., 2022).

Chintamani's low revenue-expense ratio is the norm rather than the exception. The municipality funds its water supply operations expenses through various sources. A large sum comes from the Government of Karnataka, which releases electricity grants matching the power bills incurred by the municipality. Another vital contributor is the State Finance Commission[18], which covers salaries and thus, reduces the deficit to a range of 20-30%.

---

[17] Accrued income is income that an organisation has earned but not yet received.
[18] State Finance Commissions allocate funds to local bodies in the state, such as panchayati raj institutions and urban local bodies.

The expenditure on water supply and sewerage infrastructure has ranged from 29% to 56% of the total capital expenditure between FY 2019-2021.

Table 7: Capital expenditure (CapEx) for water supply and sewerage. Source: Chintamani City Municipal Council budget documents for FY 2020-21, 2021-22, 2022-23

Financial year	Total CapEx (Rs, in lakhs)	Water supply CapEx (Rs, in lakhs)	Sewerage CapEx (Rs, in lakhs)	Water supply and Sewerage CapEx / Total CapEx (%)
2018-19	446.45	206.78	42.52	56
2019-20	861.47	186.7	62.27	29
2020-21	847.32	233.37	99.4	39

4.8 Institutional Framework for Water Supply and Sanitation

Larger institutional frameworks also prevent the municipality from moving away from the current unsustainable models they are locked into. Municipal governments often lack autonomy, with certain functional domains limited and controlled by state governments (Jain & Joshi, 2015). Karnataka is among the states where water and sewerage functions are managed by boards appointed by the state government in a bid to better manage urban agglomerations that may extend beyond the jurisdiction of a single municipality. Thus, district-level authorities and parastatal agencies play a key role in planning and implementing Chintamani's water supply and sewerage infrastructure.

There following agencies and officials oversee water supply and sanitation at various administrative levels:

1. State: The Directorate of Municipal Administrator (DMA) and Karnataka Urban Water Supply and Drainage Board (KUWSDB)
2. District: The Deputy Commissioner along with the Project Director, District Urban Development Cell (DUDC)
3. City: Municipal Commissioner and President of the Chintamani City Municipal Council

Within the municipality, the engineering section oversees functions such as water supply, supported by field-level staff such as valve men. Similarly, an environment engineer works alongside senior and junior health inspectors to oversee sanitation infrastructure and operations, including solid waste. The municipality has an elected body of councillors representing each ward, who in turn elect a President for a fixed term to preside over council meetings.

The Karnataka Urban Water Supply and Drainage Board, a parastatal body responsible for the planning and execution of water supply and sewerage projects, oversees operations and maintenance for the first 2-5 years, after which the Chintamani City Municipal Council takes over. The latter sets the tariff, collects connection fees and user charges, and manages last-mile infrastructure, such as digging supplementary borewells.

Figure 22 is an adapted version of the 'activity maps' developed by Ramesh & Basu (2021). Their maps showcase water supply and sanitation governance frameworks in two urban local bodies in Karnataka: Shivamogga and Chitradurga.

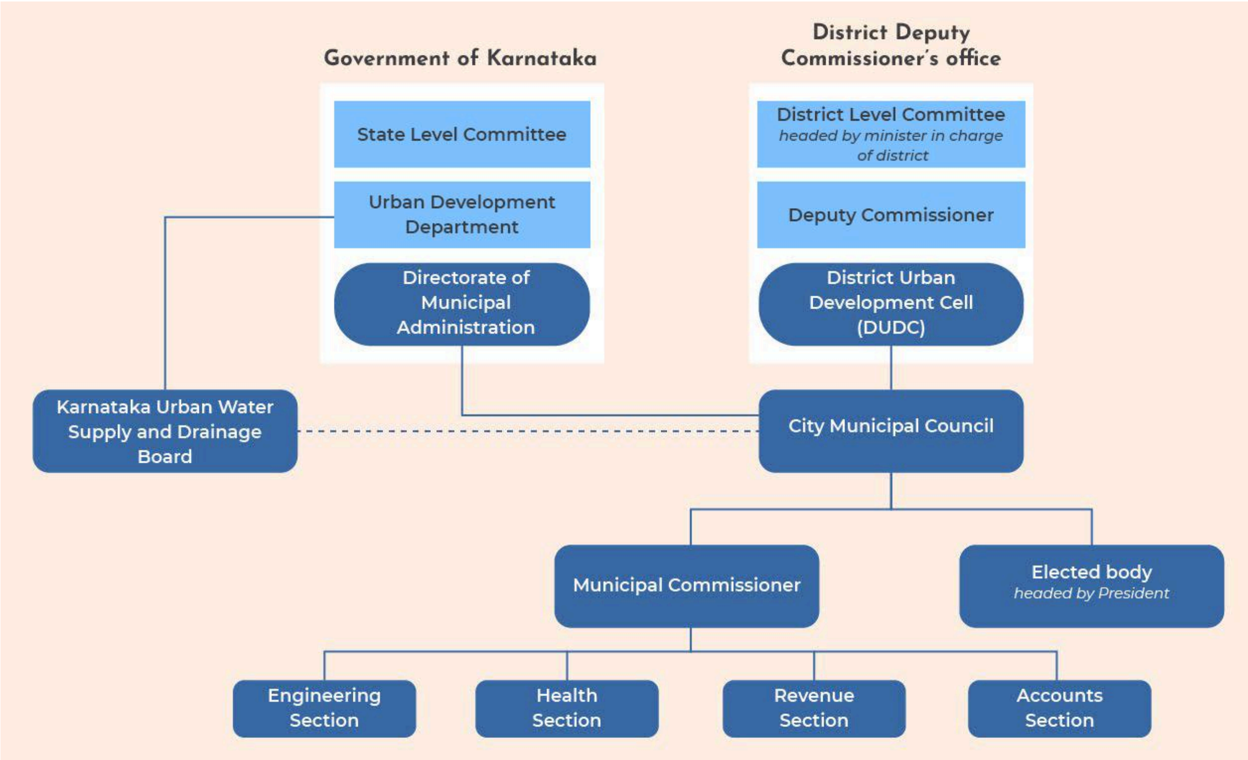


Figure 22: Institutional framework for water supply and sanitation in Chintamani

Their study highlights that the planning process for urban infrastructure remains centralised, with minimal participation from urban local bodies despite the fact that they have to share the financial burden. Often, parastatal agencies engage private consultants to implement projects and urban local bodies might lack the capacity to monitor them. The dependence on external funding sources — be it through the federal or state governments — also impedes municipal wastewater management efforts. Besides, issues such as the availability of land for sewage treatment plants and pumping stations lead to delays in setting up water management infrastructure.

Staff shortage also hinders municipal service delivery. In the Chintamani City Municipal Council, 59% of sanctioned posts were vacant out of an overall strength of 175 as of June 2023 (While there are uncertainties associated with these figures, it nonetheless serves as a valuable initial estimate). This is a particularly acute shortage of pourakarmikas[19] and water supply staff. The inadequate number of health inspectors and the absence of a full-time Assistant Executive Engineer impact the day-to-day operations of essential water supply and sanitation services.

4.9 Urban Expansion

Chintamani's proximity to a metropolis like Bengaluru makes it likely that the town will continue to become more urbanised, underlining the need to prioritise basic infrastructure. Below are land use land cover (LULC) maps of Chikkaballapur and Chintamani for 2021-2022.

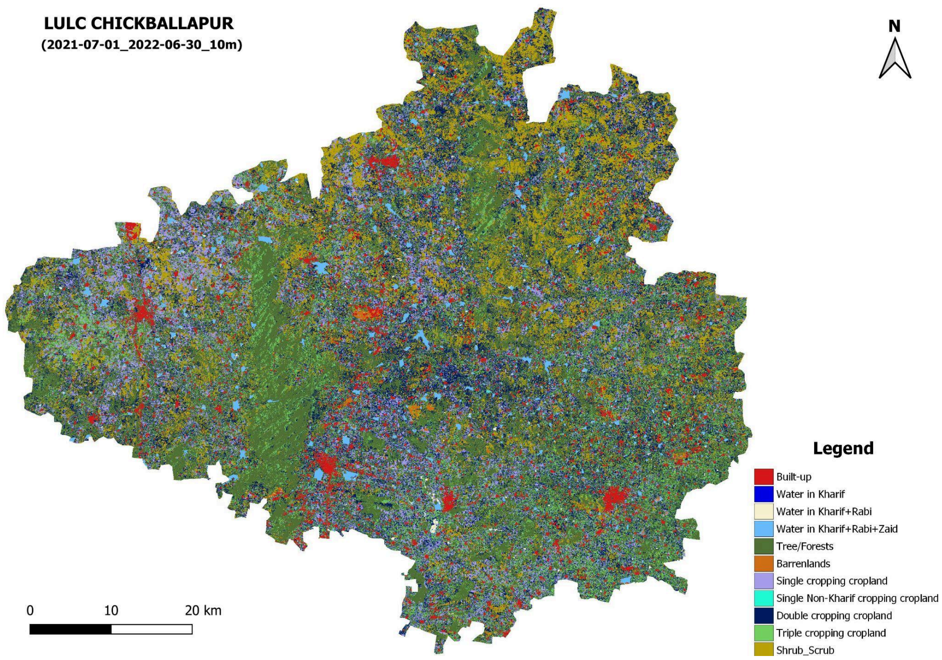


Figure 23: Chikka-ballapur land use land cover. Source: WELL Labs

[19]Pourakarmikas are sanitation workers engaged by urban local bodies in Karnataka to collect solid waste and keep public spaces clean.

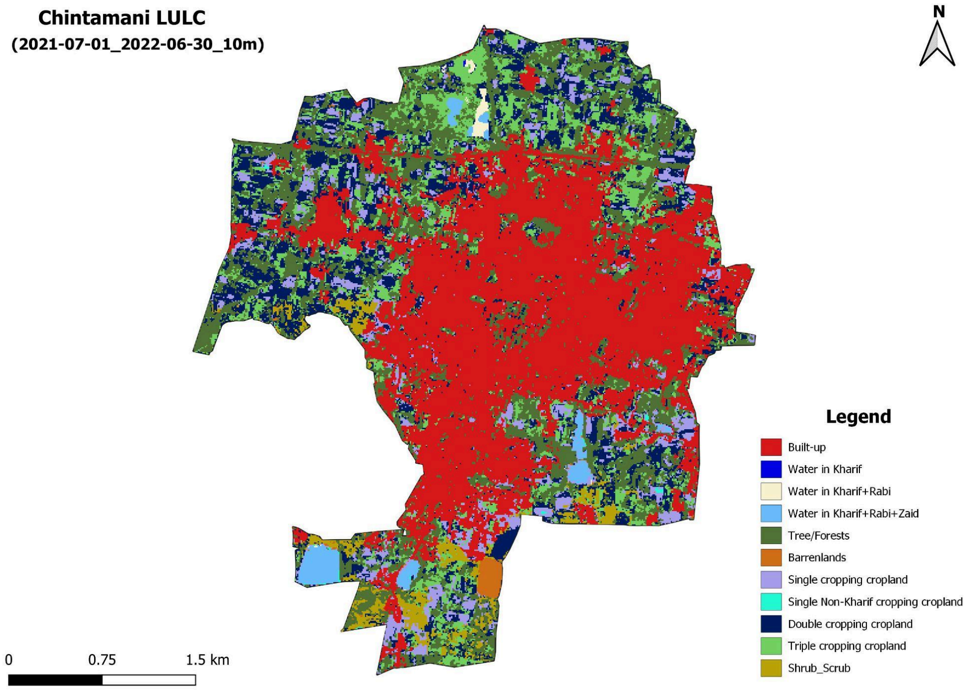
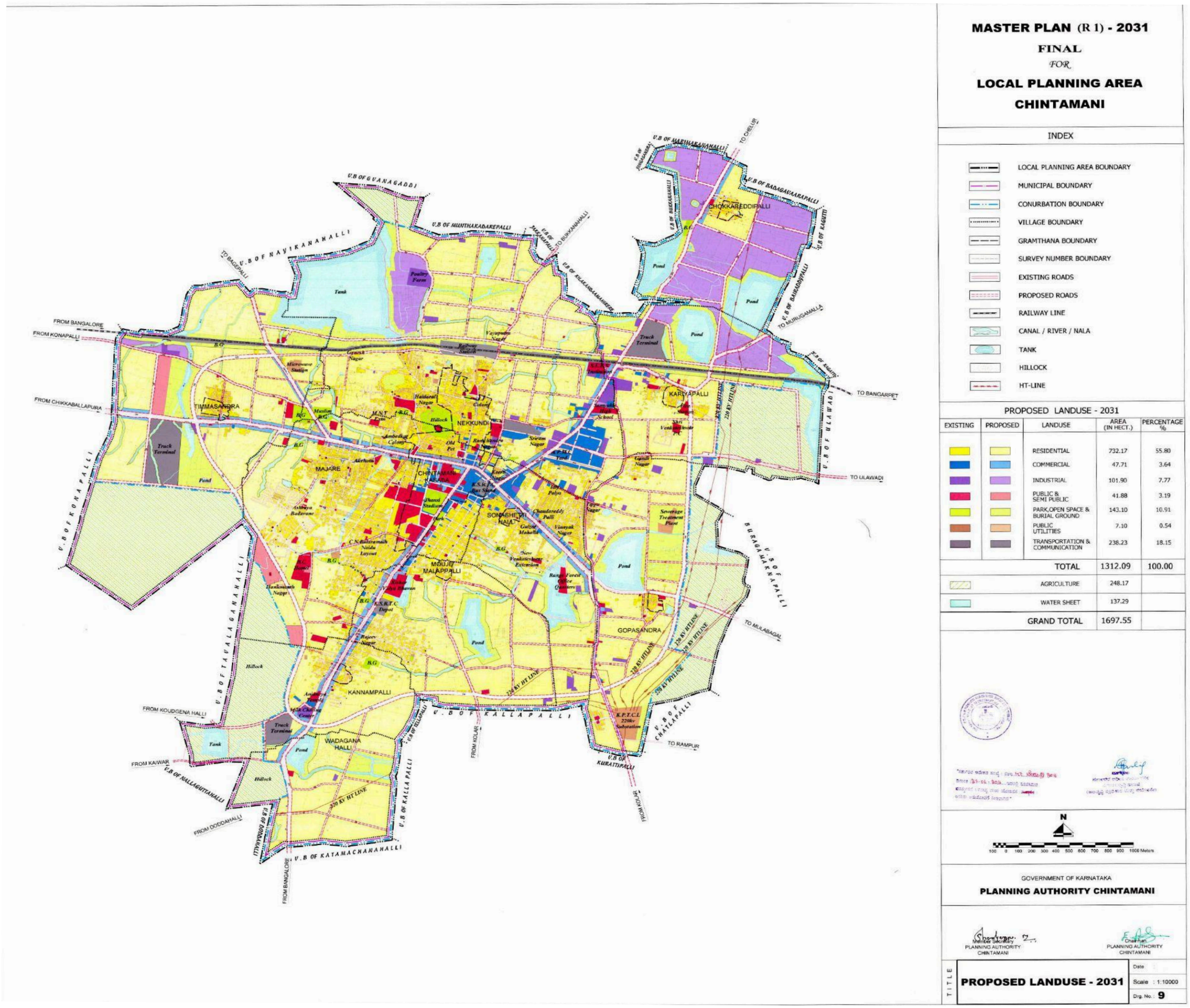


Figure 24: Land use land cover for Chintamani. Source: WELL Labs

The Chintamani Town Planning Authority's Master Plan[20] for 2031 (Figure 25) indicates further planned urbanisation and commercial expansion in Chintamani. Areas around the town's lakes are marked for residential development, which raises concerns regarding increased sewage inflow and the lakes' maintenance. Chintamani's expansion will have spillover effects on the town's water security as well. Thus it is crucial for the city to have a blueprint ready to tackle present issues as well as those of the future, while accounting for adverse climate impacts.

[20] A master plan is a dynamic long-term urban planning document that guides the city's land use and development regulations, and sets out proposals for housing, industry, transportation, community facilities, etc.

Figure 25: Master Plan 2031 for Chintamani. Source: Chintamani Town Planning Authority



5.0 Recommendations

5.1 Restore Surface Water Bodies

Given that Chintamani continues to rely on depleting groundwater for its municipal and private supply, restoring water bodies to get rid of pollution and encroachments is critical for potential surface storage and groundwater recharge. Its largest water body, Nekkundi lake, can provide 1.5-2 MLD of water when filled to capacity (Ramamoorthy et al., 2024). The town could draw up to 4 MLD from all its lakes, as opposed to the 1 MLD it currently sources from Kannampalli lake. Thus, its lakes could perhaps provide 40-50% of its drinking water needs.

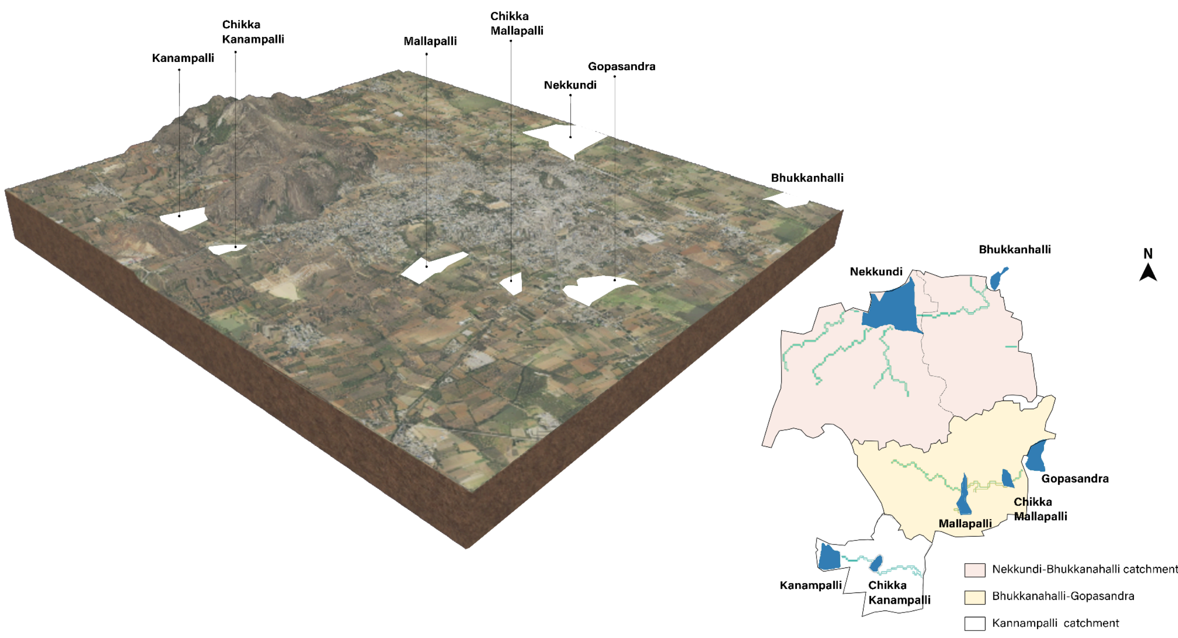


Figure 26: Lakes of Chintamani and their catchment areas. Map not to scale

Local and imported surface water can be sufficient to meet the town's current water demand of 7 MLD in an average monsoon year. However, there would be a need for supplementary sources to meet future demand. Blue-green spaces, which capture run-off and recharge groundwater, could be key to this. The average annual runoff of 8.27 MLD can be captured and used to recharge groundwater (Ramamoorthy et al., 2024). In the context of small towns that are not yet fully urbanised, there is room to plan better as they grow and put in place nature-based solutions that allow more rain to be captured, such as permeable pavements, bioswales, and 'sponge' parks.

5.2 Improve Wastewater Treatment and Reuse

Surface water in Chintamani can be used only if the municipality addresses the water pollution caused due to untreated sewage flowing into lakes. Wastewater reuse can also help reduce freshwater demand. Thus, the town should:

1. Plan for adequate wastewater treatment to meet current and future needs. This requires setting up mechanisms to use treated wastewater within the town and its periphery.
2. Improve wastewater infrastructure by ensuring all households are connected to the sewerage and broken lines are repaired. This would ensure that sewage does not enter lakes through stormwater drains.

5.3 Increase Community Engagement

Community engagement is crucial to ensure that community members safeguard water resources in the long term, beyond the duration of a particular initiative. It can also facilitate social inclusion and equity in water management projects.

As part of the Mallapalli lake rejuvenation project[21], WELL Labs conducted a lake-visioning exercise, where residents in the lake's catchment shared how they interact with the lake (for example, for fishing or recreation) and their needs and expectations with respect to the lake. Once the lake rejuvenation is complete, there will be engagement initiatives to set up community-driven ownership of lake assets.

Community engagement would be lacking without the active participation of women. In Chintamani, there is representation of women in water management planning and implementation. Fifty percent of the seats in the Chintamani City Municipal Council are reserved for women. They have also served as the council's President and Vice-president. Moreover, roughly 30% of pourakarmikas are women. However, there is a need for further research to understand gender and inclusion dynamics in Chintamani and work with stakeholders for meaningful, inclusive participation in decision-making.

5.4 Create an Aquifer Management Plan

Nearly 50% of Chintamani's drinking water requirements are being met through municipal borewells as well as privately owned borewells and tankers. This puts a significant burden on the aquifer underlying Chintamani, which is characterised by a weathered-fractured hard rock aquifer system with limited storage capacity. As a result, it is overexploited and borewell failure rates have touched 40% in the past.

[21]WELL Labs is collaborating with DCB Bank and Friends of Lakes to restore Mallapalli lake. Read more about the project here.

An aquifer management plan that incorporates a conceptual understanding of the aquifer characteristics, its storage/recharge potential, and consumption patterns across domestic, commercial, and institutional segments can help overcome groundwater stress.

An important step in putting together this plan is delineating and characterising the aquifer through methods such as surface geophysics constrained by borehole lithological logs. There is also a push for this from the Government of India — its Atal Mission for Rejuvenation and Urban Transformation (AMRUT) initiative[22] mandates that cities prepare an urban aquifer management plan. The Central Ground Water Board leads the National Project on Aquifer Management (NAQUIM), which aims to map aquifers with a thrust on participatory groundwater management.

5.5 Map Financial Flows

About 40% of Chintamani's revenue expenditure is spent on running water supply infrastructure. A major share of this goes towards electricity and fuel charges to operate borewells and pumping infrastructure.

The municipality employs a flat tariff structure, which was last revised in 2016. Besides, there is a huge disparity between the accrued income (receivables from water and underground drainage charges) and actual receipts. Unauthorised connections to the network lead to non-revenue water.

This high operational expenditure, with low operations and maintenance cost recovery, makes it challenging to run water supply services. Thus, mapping financial flows in Chintamani can help identify mechanisms to finance wastewater treatment, lake rejuvenation, and the creation of blue-green infrastructure.

[22] The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched on 25 June 2015 in 500 cities and towns across the country. It focuses on the development of basic infrastructure related to water supply, sewerage and septage management, storm water drainage, green spaces, and non-motorised urban transport. Read more about the initiative here.

6.0 Stakeholders

The primary beneficiaries of the Chikkaballapur-Chintamani Transformation Lab are the Chintamani City Municipal Council and the town's residents. Given that the town is located in a semi-arid area and has intermittent water supply, both the urban local body and the town's residents would benefit from improved water availability, resulting in a more predictable water supply.

Addressing Chintamani's water challenges involves navigating through a network of stakeholders at different levels, beginning with the Government of Karnataka's Urban Development Department and Directorate of Municipal Administration. The latter oversees the functioning of urban local bodies in the state. Parastatal agencies, such as the Karnataka Urban Water Supply and Drainage Board, are also involved in planning and augmenting water supply and sewerage schemes.

At the district level, the District-in-Charge Minister, Deputy Commissioner, and District Urban Development Cell play a supervisory role for all urban local bodies within a district. At the town level, the Chintamani City Municipal Council is responsible for service delivery. It comprises an elected wing headed by a President with a fixed term and an executive wing headed by the Municipal Commissioner. The Member of the Legislative Assembly (MLA) representing Chintamani is consulted for projects and decisions from time to time.

The stakeholder engagement process under the Transformation Lab includes the villages on Chintamani's periphery that are part of its watershed. WELL Labs is engaging with the gram panchayats and taluka panchayats that administer these villages and will also reach out to the zilla panchayat if necessary.[23]

WELL Labs has worked with the NGOs BORDA and TIDE in Chintamani and collaboratively produced a report on Chintamani's water balance. Both organisations have been providing technical support and capacity building to towns in Chikkaballapur district and beyond. The Foundation for Ecological Security (FES) is an NGO with a presence in Chintamani, though it largely operates in rural parts of Chikkaballapur. WELL Labs will leverage existing relationships with them.

WELL Labs has partnered with Friends of Lakes, a citizen group championing scientific lake restoration in and around Bengaluru, to restore Mallapalli lake in Chintamani. There will also be engagement efforts with other NGOs, resident welfare associations, and self-help groups operating in the town.

[23] The Constitution (73rd Amendment) Act, 1992 and Constitution (74th Amendment) Act, 1992 devolved powers and functions to panchayati raj institutions to promote local self governance in India. It consists of a tiered system: gram panchayat at the village level; taluka panchayat at the taluka level; and zilla panchayat at the district level.

7.0 Conclusion

This situation analysis report of Chintamani town and Chikkaballapur district delves into surface water and groundwater hydrology, aquifer characteristics, water use patterns, and governance frameworks to explore urban water challenges and solutions. It highlights the need for further research on how to rejuvenate water bodies, enhance sewage treatment, and recharge groundwater. The preparation of a comprehensive water security plan incorporating the points mentioned above would be a crucial next step.

Chintamani is highly reliant on external funding sources — federal and state government schemes and finance commission grants — to build and run water supply and sewerage infrastructure. The complex institutional framework of district-level authorities and parastatal agencies in planning and implementing water supply and sewerage infrastructure is also an issue. In these aspects, Chintamani is representative of other towns in Karnataka. To overcome these challenges, preparing a water security plan has to be a collaborative and inclusive process involving a range of stakeholders — from decision-makers at the state, district, and town levels to residents.

An enhanced understanding of local water dynamics can facilitate the development of targeted interventions to address water challenges in towns, such as identifying areas for new borewells or rejuvenating lakes. Planning should provide for short-term adjustments to address immediate challenges, encourage medium-term objectives by identifying trends and emerging issues, and support the development of a long-term vision for sustainable water resources management.

References

Alessa, L., Cronan, D., Griffith, D., Kliskey, A., Haro-Martí, M. Ed., Lammers, R., & Oxarango-Ingram, J., Trammell, E. J., & Williams, P. (2023). *Building trust, building futures: Knowledge co-production as relationship, design, and process in transdisciplinary science*. Frontiers in Environmental Science, 11, 1007105. https://doi.org/10.3389/fenvs.2023.1007105

Allen, A. (2003). Environmental planning and management of the peri-urban interface: perspectives on an emerging field. *Environment and Urbanization*, *15*(1), 135–148. https://doi.org/10.1177/095624780301500103

Atal Bhujal Yojana. (2021). *Block Hydrogeological Report: Chikkaballapur, 2020-2021*. https://atalbhujal.karnataka.gov.in/storage/pdf-files/HGR%20final/Chikkaballapura_Updated.pdf

Athar, S., White, R., Goyal, H., & International Bank for Reconstruction and Development / The World Bank. (2022). *Financing India's urban infrastructure needs*. International Bank for Reconstruction and Development / The World Bank. https://documents1.worldbank.org/curated/en/099615110042225105/pdf/P17130200d91fc0da0ac610a1e3e1a664d4.pdf

Badapalli, P.K., Golla, V., & Reddy, C.K.V.C. (2022). *Evaluation of groundwater contamination for fluoride and nitrate in Nellore Urban Province, Southern India: a special emphasis on human health risk assessment (HHRA)*. Applied Water Science, 12(32). https://doi.org/10.1007/s13201-021-01537-8

Bhatia, U., Mishra, V., & Tiwari, A. D. (2020). *Bias-corrected climate projections for South Asia from Coupled Model Intercomparison Project-6*. Scientific Data, 7(1), 338. https://doi.org/10.1038/s41597-020-00681-1

Biswas, H., Kumar, S., & Raizada, A.. (2014). *Prioritising development planning in the Indian*

Semi-Arid Deccan Using Sustainable Livelihood Security Index Approach. International Journal of Sustainable Development & World Ecology, 21(4), 332–345. https://doi.org/10.1080/13504509.2014.886309

Central Ground Water Board. (2012). *Ground water information booklet Chikkaballapur district, Karnataka. South Western Region, Bangalore*. Retreived from https://cgwb.gov.in/old_website/District_Profile/karnataka/2012/CHICKBALLAPUR_DIST_BROCHURE%202012.pdf

Central Ground Water Board. (2022). *National compilation on dynamic groundwater resources of India*. Retrieved from https://static.pib.gov.in/WriteReadData/userfiles/file/GWRA2022(1)HIDO.pdf

Cuthbert, M. O., Gleeson, T., Bierkens, M. F. P., Ferguson, G., & Taylor, R. G. (2023). *Defining renewable groundwater use and its relevance to sustainable groundwater management*. Water Resources Research, 59, e2022WR032831. https://doi.org/10.1029/2022WR032831

Directorate of Census Operations, Karnataka. (2011). *Karnataka - Census of India*. https://censusindia.gov.in/nada/index.php/catalog/604/download/2064/DH_2011_2921_PART_A_DCHB_DAKSHINA_KANNADA.pdf

District Disaster Management Authority Chikkaballapur. (2019). *District Disaster Management Plan 2019-20*. https://ksdma.karnataka.gov.in/storage/pdf-files/ChikkaballapurDDMP.pdf

Esteves, T., Ravindranath, D., Beddamatta, S., Raju, K. V., Sharma, J., Bala, G., & Murthy, I. K. (2016). *Multi-scale vulnerability assessment for adaptation planning*. Current Science, 110(7). https://oar.icrisat.org/9428/

Foundation for Ecological Security. (2010). *Hydro-Geological Study Of Six Micro Watersheds in Chintamani, Karnataka*. Retrieved from: https://fes.org.in/resources/pdf/impact/Karnataka/Ground-water-scenario-in-six-watersheds-Chintamani.pdf

IndiastatDistricts. (n.d.). *District Level Socio-economic Statistical Data Information of Chikkaballapur District in Karnataka*. https://www.indiastatdistricts.com/karnataka/chikballapur-district.

Jain, M. & Joshi, R. (2015). *Municipal finances in India – unresolved issues and way forward*. In *Cities – The 21st Century India*. Bookwell. https://smartnet.niua.org/sites/default/files/resources/municipal_finances_in_india.pdf

Krishniah, Y. V. (2014). *Rainfall analysis and rainfall recharge of the Papagni river basin, Andhra Pradesh*. National Geographical Journal of India. https://www.researchgate.net/publication/299599010_Rainfall_analysis_and_rainfall_recharge_of_the_Papagni_river_basin_Andhra_Pradesh

Michael, A.M., Khepar, S.D. and Sondhi, S.K. (2008). *Water Well and Pump Engineering, Second Edition*. Tata McGraw Hill Education Pvt. Ltd., New Delhi.

Muralidhara Reddy, B., & Sunitha, V. (2020). *Geochemical and health risk assessment of fluoride and nitrate toxicity in semi-arid region of Anantapur District, South India*. Environmental Chemistry and Ecotoxicology, 2, 150-161. ISSN 2590-1826. https://doi.org/10.1016/j.enceco.2020.09.002.

NABARD. (2020). *Potential Linked Credit Plan (PLP) 2020-2021 Chikkaballapura District*. nabard.org/auth/writereaddata/tender/2910195513Chikkaballapur.pdf

NABARD. (2023). *Potential Linked Credit Plan (PLP) 2023-24 Chikkaballapura District.* https://www.nabard.org/auth/writereaddata/tender/0712212836Chickmagalur.pdf

Narain, V. & Nischal, S. (2007). *The Periurban Interface in Shahpur Khurd and Karnera, India*. Environment and Urbanization, 19, 261-273. http://dx.doi.org/10.1177/0956247807076905

O'Neill, B. C., Tebaldi, C., Van Vuuren, D. P., Eyring, V., Friedlingstein, P., Hurtt, G., Knutti, R., Kriegler, E., Lamarque, J., Lowe, J., Meehl, G. A., Moss, R., Riahi, K., & Sanderson, B. M. (2016). *The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6*. Geoscientific Model Development, 9(9), 3461–3482. https://doi.org/10.5194/gmd-9-3461-2016

Pai, D. S., Rajeevan, M., Sreejith, O. P., Mukhopadhyay, B., & Satbha, N. S. (2014). *Development of a new high spatial resolution (0.25× 0.25) long period (1901-2010) daily gridded rainfall data set over India and its comparison with existing data sets over the region*. Mausam, 65(1), 1-18. https://doi.org/10.54302/mausam.v65i1.851

Ramachandra, T.V, Vinay, S., Bhargavi, R., and Bharath, H. Aithal. (2017). *Integrated watershed management for Water and Food Security in Kolar and Chikkaballapur districts, Karnataka*. ENVIS Technical Report 133, Energy and Wetlands Research Group, CES, Indian Institute of Science, Bangalore. https://wgbis.ces.iisc.ac.in/energy/water/paper/ETR133/sec1.html

Ramamoorthy, R., Ganashree, K.S., Kumar, A., Kumar, N., Nath, S., Nesi, M., Palur, S., Rajora C., & Roy, J. (2024). *Mapping water in a small town: Data and insights in water management in Chintamani, Karnataka*. Water, Environment, Land and Livelihoods (WELL) Labs at Institute for Financial Management and Research. https://welllabs.org/chintamani-small-town-urban-water-management/

Ramesh, A., & Basu, A. M. (2021). Governance of domestic water supply in small and medium towns of Karnataka. In *Lecture notes in civil engineering* (pp. 297–312). https://doi.org/10.1007/978-981-33-4114-2_24

Riahi, K., Van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J. C., Kc, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., . . . Tavoni, M. (2016). *The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview*. Global Environmental Change, 42, 153–168. https://doi.org/10.1016/j.gloenvcha.2016.05.009

Shaw, R., & Das, A. (2017). *Identifying peri-urban growth in small and medium towns using GIS and remote sensing technique: A case study of English Bazar Urban Agglomeration, West Bengal, India*. The Egyptian Journal of Remote Sensing and Space Science, 21(2), 159–172. https://doi.org/10.1016/j.ejrs.2017.01.002

Siabi, E. K., Awafo, E. A., Kabo-bah, A. T., Derkyi, N. S. A., Akpoti, K., Mortey, E. M., & Yazdanie, M. (2023). *Assessment of Shared Socioeconomic Pathway (SSP) climate scenarios and its impacts on the Greater Accra region*. Urban Climate, 49, 101432. https://doi.org/10.1016/j.uclim.2023.101432.

Water Resources Department, Karnataka. (2022). *State Water Policy 2022*. Retrieved from https://aciwrm.karnataka.gov.in/storage/pdf-files/Report%20PDFs/StateWaterPolicy-English.pdf