Contextual Water Targets Pilot Study Noyyal-Bhavani River Basin, India

May 2019

Ashoka Trust for Research in Ecology and the Environment (ATREE)

This publication is based on the project report submitted to the Pacific Institute, USA as the result of the study on contextual water targets in the Noyyal-Bhavani river basin, India.

Study duration: October 2018 to April 2019

Financial support: Pacific Institute, USA

Additional financial support: World Wide Fund for Nature-India (WWF-India).

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Suggested Citation:

R. Apoorva, Kulranjan, R., Pranuti, C. L., Vivek, M., and Srinivasan, V. 2019. *Contextual Water Targets Pilot Study: Noyyal-Bhavani River Basin.* Bengaluru. Ashoka Trust for Research in Ecology and the Environment (ATREE).

Front-cover Photo Caption: Noyyal outflows from the Orathupalayam dam, which had become a reservoir of polluted water for years.

Front-cover Photo Credit: Apoorva R. (2019)

Back-cover Photo Caption: Untreated sewage in a drain flows towards the River Noyyal near Tiruppur city, Tamil Nadu

Back-cover Photo Credit: Rashmi Kulranjan (2019)

Acknowledgement:

We are grateful to Mr. Ganesh Shinde from ATREE for his help and guidance related to land use classification and GIS maps in this project. We would like to thank all the participants of the project consultative meeting held in Coimbatore in March 2019 for sharing their ideas and contributing to the discussion. We are thankful to Ms. Upasana Sarraju for proofreading and formatting this report.

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List of Abbreviations

BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
CETP	Common Effluent Treatment Plants
CGWA	Central Ground Water Authority
CGWB	Central Ground Water Board
CII	Commercial, Industrial and Institutional
CPCB	Central Pollution Control Board
CWC	Central Water Commission
CWMA	Cauvery Water Management Authority
CWSS	Combined Water Supply Scheme
DACP	District Agricultural Contingency Plan
DBU	Designated Best Use
EC	Electrical Conductivity
FSSM	Faecal Sludge and Septage Management
ICESCR	International Covenant on Economic, Social and Cultural Rights
LBP	Lower Bhavani Project
MINARS	Monitoring of Indian Aquatic Resources
MOEF	Ministry of Environment and Forests
MoUD	Ministry of Urban Development

NRDWP	National Rural Drinking Water Programme
NTADCL	New Tiruppur Area Development Corporation Limited
PIL	Public Interest Litigation
PPP	Public-Private Partnership
SBM	Swachh Bharat Mission
SEZ	Special Economic Zone
SLB	Service Level Benchmark
STP	Sewage Treatment Plant
TNPCB	Tamil Nadu Pollution Control Board
TNSDMA	Tamil Nadu State Disaster Management Authority
TWAD	Tamil Nadu Water and Drainage Board
ULB	Urban Local Body
UNFCCC	United Nations Framework Convention on Climate Change
ZLD	Zero Liquid Discharge
WASH	Water, Sanitation and Hygiene
ETP	Effluent Treatment Plant
FC	Faecal Coliforms
IETP	Individual Effluent Treatment Plant
LPCD	Litres Per Capita Per Day
TDS	Total Dissolved Solids
UGD	Under Ground Drainage

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Executive Summary

The Noyyal and the Bhavani are urbanising sub-basins of the larger Cauvery river basin in South India. The Noyyal consists of two large industrial cities — Coimbatore and Tiruppur. The Bhavani includes primarily ecologically-sensitive forest areas and agricultural lands. The sub-basins are drained by the rivers Noyyal, Bhavani and Moyar. This river basin is economically important as it houses clusters of textile industrial units that cater to both the domestic and global market, earning significant revenue for the state. At the same time, the basin faces severe water-related challenges.

This report contributes to Pacific Institute's ongoing programme towards catalysing corporate water stewardship. The report is based on a pilot study in the Noyyal-Bhavani river basin.

There are multiple water-related challenges within the basin. There are also opportunities to address some of them through the collective action of the basin-water users. This report maps the key basin water challenges around six themes: a) access to WASH, b) water quantity, c) water quality, d) water-ecosystem impacts, e) water-crisis-preparedness, and f) water governance. Basin context metrics are defined to characterise the water challenges in the basin.

Industrial pollution within the basin has been a persistent problem with adverse implications on human health, livelihoods and ecosystems. Recent interventions such as the *Zero Liquid Discharge* standard for textile dyeing and bleaching facilities within the basin have attempted to address the problem; the effectiveness and impacts of which requires further assessment. Pollution of surface-water and groundwater from inadequately-treated sewage and poor on-site sanitation systems respectively is yet to be effectively addressed.

Domestic water provisioning in the basin requires greater attention towards ensuring equitable distribution and improved access, especially for marginalised groups such as slums in urban settlements. There is a data gap on the status of WASH access in the commercial/industrial sector.

Groundwater regulation is weak with enforcement challenges on-ground. Approximately 45% of groundwater blocks in the basin are classified as being 'over-exploited'. Groundwater depletion coupled with incidences of droughts adversely affects the basin water security.

There is a need for integrated basin-level thinking and planning for improved water resource management and fair water allocations to different sectors. Water governance is fragmented due to which groundwater–surface-water linkages are not well recognised. There is a need for infrastructure planning that integrates water and wastewater.

Environmental flows in the R. Bhavani are affected by numerous hydro-power dams in the upper reaches as well as diversions for meeting domestic, irrigation and industrial water demands of large parts of both the sub-basins.

The report includes recommendations and opportunities to address some of the critical shared water challenges related to water quantity, water quality and governance in the basin.

Chapter 1 Context-Based Water Targets

Motivation

Water is becoming increasingly more important to corporate bottom lines. Sustainability of the resource base, floods and droughts pose increasing threats to supply chains. At the same time, diversions of water to industries are also being increasingly challenged by stakeholders, posing reputational risks to brands. In India, corporate water reporting has become mandatory for large firms.

In response, a growing number of corporates have been expanding their efforts to understand and mitigate water risks, and to realise opportunities via improved water management and demonstrated corporate stewardship.

The focus of corporate stewardship activities has primarily been on what companies could do to improve efficiency and pollution reduction "within the fence", activities that do not fully account for the basin context or address the root causes of water challenges. When companies do consider the basin context, they often do not account for how their water relates to the collective needs of other companies, communities, and nature. However, corporations are increasingly realising that water is a common pool resource. Therefore, the risks faced by individual facilities are created by water challenges shared by all stakeholders in the basins in which they operate.

Moreover, water challenges are highly heterogeneous and context-specific. Most companies do not know where to begin. In recent years, there has been a growing call for a more consistent approach to selecting performance metrics and targets that allows companies to (1) better consider the basin context, and (2) align their efforts with other basin stakeholders when feasible and appropriate.

Common Framework for Shared Water Challenges

Identification and prioritisation of water issues will be centred around the following six broader themes of water challenges:

1) Access to Water, Sanitation and Hygiene (WASH)
2) Water Quantity
3) Water Quality
4) Water-Ecosystem Impacts
5) Water-Crisis Preparedness and
6) Water Governance

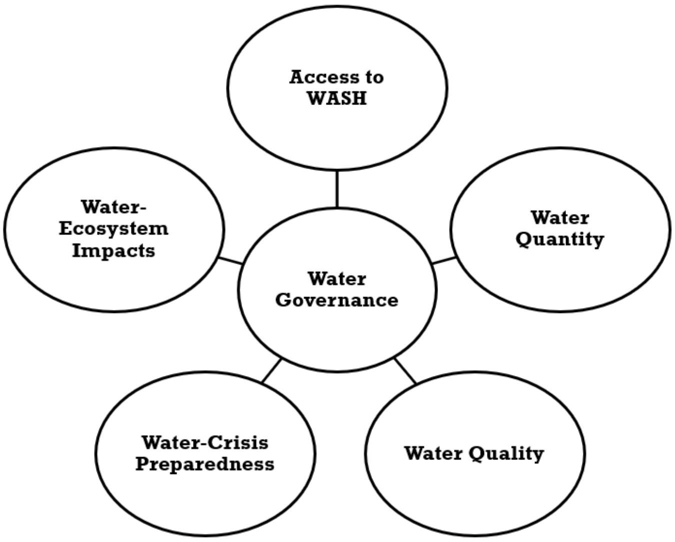


Figure 1.1. Themes of Water Challenges.

Water governance is a cross-cutting theme linked to each of the other five themes in this framework (**Figure 1.1**). Therefore, relevant governance aspects related to each of the five themes will be incorporated in the chapters on the respective themes. River-basin-scale governance challenges will be described separately under the theme of water governance.

The key water challenges that presently exist and are likely to emerge in the near future based on the business-as-usual scenario and anticipated policy changes are described for the Noyyal-Bhavani sub-basins. The water challenges presented in this report were identified, on a qualitative basis, using existing literature on the basin and key informant interviews with stakeholders in the basin including government representatives. The interviewees include representatives from academia, government, non-governmental organisations, and industry who are knowledgeable on water management in the Noyyal-Bhavani river basin (**Appendix A**).

Study Region

The Noyyal and the Bhavani are sub-basins of the Cauvery, one of the largest river basins in South India. They are drained by the rivers Noyyal and Bhavani, which flow from west to east to join the river Cauvery. The sub-basins are primarily located in the state of Tamil Nadu, with small parts of the upper Bhavani catchment in the neighbouring states of Karnataka and Kerala. Tamil Nadu is the lower riparian state in the Cauvery river basin that spans three States (Karnataka, Tamil Nadu and Kerala) and the Union Territory [1] of Puducherry. In this context, it is important to note that there has been a decades-old inter-state water conflict among the Cauvery basin riparian states over water sharing. Recently, in 2018, the Cauvery Water Management Authority, a river basin institution, has been constituted to monitor and regulate the sharing of the Cauvery river water among the riparian states. However, there is no river basin institution at the sub-basin scale for water management in the Noyyal-Bhavani sub-basins.

The Noyyal is a rapidly urbanising sub-basin spanning an area of 3,510 sq. km. It includes the industrial cities of Coimbatore and Tiruppur. Over time, land use in the sub-basin has witnessed a shift from agriculture towards urban and industrial uses. Tiruppur city is well-known as a global textile export hub contributes to 90% of knitwear exports from India (CPCB, 2014). The textile wet-processing industry has had serious negative externalities on the environment over the past decades. Release of inadequately-treated textile effluents has led to severe pollution of the seasonal river Noyyal and local aquifers with adverse livelihood, environmental and health impacts. Multiple interventions to address the pollution problem in the Noyyal sub-basin have been implemented with varying degrees of success and this is an ongoing process.

The Bhavani sub-basin with an area of 6,500 sq. km is primarily agricultural, with forests and plantations in the upper part of the basin. The upper Bhavani has several hydro-power reservoirs. Inadequacy of environmental flows in the ecologically-sensitive regions in the sub-basin is reported to have adverse impacts on biodiversity and the ecosystem. The east-flowing Moyar and Bhavani rivers are impounded by the Bhavanisagar Dam at their confluence which serves irrigation requirements of farmers in the command area of traditional Kodiveri irrigation canals and the Lower Bhavani irrigation project.

[1] Union Territory is a type of administrative division in India that is governed directly by the Union Government.

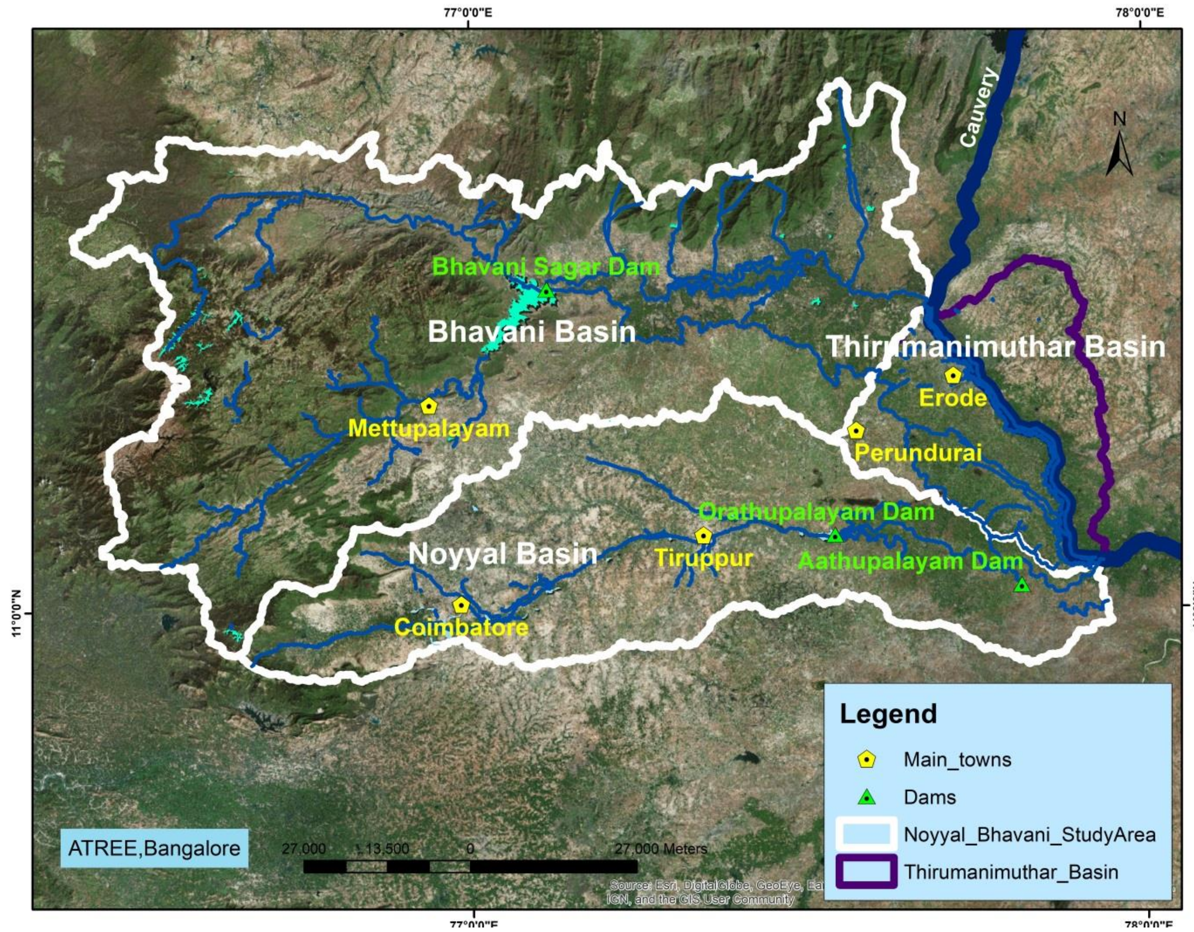


Figure 1.2. Noyyal, Bhavani and Thirumanimuthar Sub-Basins in Tamil Nadu, India.

The Bhavani had been reported to be a closed river basin with highly intensified irrigated agriculture and groundwater depletion in parts of the basin (Lannerstad and David, 2009). The sub-basin also has a significant number of industries, including textile industries. Pollution of the R. Bhavani (river to be denoted henceforth as R.) and its tributaries due to domestic sewage and industrial effluents is a problem that has yet to be effectively addressed.

The Noyyal and the Bhavani are interconnected sub-basins because surface water from the Bhavani is pumped into the Noyyal sub-basin to meet the domestic water needs of Coimbatore and Tiruppur cities, industrial water needs of the textile industries and irrigation, further downstream, through the Lower Bhavani Project. Much of the return wastewater flow in the Noyyal is essentially imported from the Bhavani sub-basin.

The textile industrial cluster in the region extends beyond the Noyyal-Bhavani sub-basins in Erode district. The R. Cauvery flows through the Thirumanimuthar sub-basin (**Figure 1.2**) that includes Erode city and Perundurai town. This sub-basin is shown to indicate approximately the geographical spread of the textile cluster in the region. However, the analysis of the water challenges and baseline conditions will be limited to the Noyyal-Bhavani sub-basins.

With this preliminary introduction to the Noyyal-Bhavani river basin context, the study framework will be described followed by a summary of key water-related challenges in the basin. To help better understand the nature of water-related challenges in the basin, a short note on some key water management principles and practices in India is provided in **Appendix B**.

Objectives and Approach

The objectives of this pilot study in the Noyyal-Bhavani basin are two-fold:

1) To identify shared water challenges in the basin,
2) To understand baseline conditions in the basin and the desired end state, through basin-level metrics wherever possible.

Basin Context Metrics

For each of the key issues identified under the themes of water challenges, relevant basin context metrics are defined.

Baseline Conditions and Desired End State

For each basin context metric, the present state (based on the latest available data within a time period window) and the desired end state is described. The baseline understanding is based on aggregating and interpreting of secondary data sources and reports, using quantitative information where possible. For the more qualitative metrics related to challenges, such as water governance, the description is based on insights from key informant interviews and a review of the literature.

For the basin context metrics, the end state is defined based on commonly agreed desired state that is consistent with the SDGs and local, national and global public policy.

Summary of Shared Water Challenges

Table 1.1. Water Quality Criteria for Designated Best Uses of Inland Surface Water Bodies.

Theme	Main Water Challenges	Basin Context Metrics
Access to WASH	➢ Access to water is good, but **adequate water provisioning is challenged** by seasonal variations in resource availability, rapid urbanisation and basin water stress. ➢ Drinking water quality may be compromised by industrial pollution in some areas. ➢ More data is needed on usability and sustainability of newly constructed toilets. ➢ **Full chain sanitation systems and services are inadequate**. Inadequate sewage treatment and faecal sludge disposal are contaminating ground and surface water.	The metrics need to be separately assessed for rural and urban areas. a) Potability of drinking water supplies b) Adequacy in water quantity supplied [in litre per capita per day (LPCD)] as per Tamil Nadu Water and Drainage (TWAD) Board norms c) Reliability in access assessed in terms of frequency and duration of water supply d) Ease of access with respect to distance and time costs involved in accessing water e) Affordability in access to water f) Access to toilets g) Acceptability/use of toilets h) Mode of sewage/sludge management – Underground Drainage (UGD) and sewage treatment plants (STPs) infrastructure/mechanism for sludge management
Water Quantity	➢ **Water stress** due to the gap between availability and demand in the river basin is exacerbated by high variability in rainfall and occurrences of droughts. ➢ **Sustainability** of water resources in the basin is challenged by groundwater over-extraction and declining spring discharges.	a) Stage of groundwater development as classified by the Central Ground Water Board (CGWB) b) Depth to groundwater levels c) Water-use efficiency measures in agriculture d) Water-use efficiency measures in industry

	➢ **Non-usability or limited usability** of surface water resources in the basin due to water pollution.	
Water Quality	➢ **Pollution of water bodies due to the discharge of industrial effluents and sewage** is an important and persistent challenge, with adverse impacts on human health and livelihoods and ecosystem health.	a) Water quality indicators – rivers Noyyal and Bhavani & wetlands + River Health Index proposed to be developed by WWF-India for this basin (to serve as baseline) b) Water quality indicators – groundwater c) Management of sewage and faecal sludge d) Management of industrial effluents e) Recycling of treated wastewater f) Biological & chemical treatment capacity in the basin relative to wastewater generated (quantitative: ratio)
Water – Ecosystem Impacts	➢ **Maintenance of adequate environmental flows** in the R. Bhavani is a challenge because of hydro-power diversions and water allocations to different sectors. ➢ **Wetlands and rivers in the basin are threatened by pollution** due to sewage and industrial effluents adversely impacting the ecosystem services.	a) Presence of flows at different locations along the R. Bhavani through different seasons of the year. b) Water quality [electrical conductivity (EC), DO, biochemical oxygen demand (BOD), Faecal Coliforms (FC)] at different locations along the R. Bhavani and its tributaries through different seasons of the year. c) Water quality (EC, DO, BOD, FC) at different locations along the R. Noyyal through different seasons of the year. d) Water quality in the notified wetlands in the basin. Parameters to include at least PH, EC, BO, BOD, nitrates, and ortho-phosphates. e) Biodiversity in the notified wetlands in the basin: migratory birds, fish species, benthos.

Water Governance	➢ **Lack of river basin planning** and management coupled with fragmented governance of water resources adversely affects basin water security and fair water allocations. ➢ **Groundwater regulation and management is weak**, with adverse impacts on the health of aquifers and water availability for life and livelihoods.	a) Presence of river basin management plan b) Multi-stakeholder efforts at river basin management c) Presence of state and basin-level groundwater regulations d) Comprehensive water accounting in the basin e) Participation of local communities in improving water and sanitation management. f) Participation in irrigation water management. g) Corporate water reporting

Chapter 2 Access to Water

Key Challenges

- Access to water is good, but **adequate water provisioning is challenged** by seasonal variations in resource availability, rapid urbanization and basin water stress.
- Drinking water quality may be compromised by industrial pollution in some areas.

Universal access to adequate and safe water across seasons and in an affordable and reliable manner is important to meet drinking and domestic water requirements. SDG 6.1 defines a safely managed drinking water service as "one located on premises, available when needed and free from contamination".

This assessment is focussed only on household access to water as there is a paucity of data in the public domain on water access in commercial, industrial and institutional (CII) establishments in the basin.

This chapter begins with a discussion of the key water provisioning challenges in the basin. This is followed by a description of baseline conditions, a short note on water supply governance and an outline of basin context metrics.

Context: Access to Water in India

Unlike in developed countries, in India, water supply is characterised by some common features —

- Intermittent public water supply; limited number of hours once every few days
- Multiple source dependence by households to fulfil domestic water needs
- Price of public water supply is generally more affordable than alternative sources

In India, access to water for domestic use needs to be understood through the following dimensions (adapted from Anand et al. 2016) —

a) Safe water quality (i.e. potability) for protection of human health
b) Adequate water quantity to meet basic human needs and as per norms
c) Seasonal adequacy in water access, especially during dry summer months.
d) Reliability in access assessed in terms of frequency and duration of water supply
e) Ease of access with respect to distance and time costs involved in accessing water
f) Affordability in terms of how much households need to pay for accessing water vis-à-vis their income

As there are differences in the nature of water provisioning in urban and rural areas, household-scale water access is analysed and presented separately.

The Ministry of Urban Development has defined service level benchmarks (SLBs) for a set of nine indicators related to urban water supply (**Appendix C**). These benchmarks include 100% coverage of water supply connections, 135 LPCD water supply, 100% water metering and 24 hours continuous supply of water. Although the SLB indicators are inadequate in representing the status of water supply in urban areas in the country, the data pertaining to some of the indicators provide some insights related to public piped water supply systems.

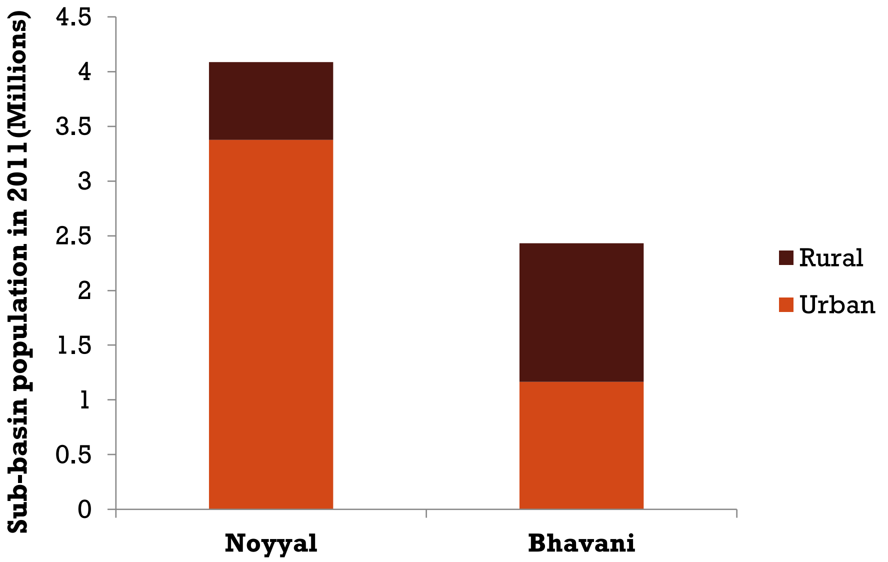


Figure 2.1. Extent of Urbanisation in 2011.

Context: Access to Water in the Noyyal-Bhavani Basin

Within the Noyyal-Bhavani basin, the Noyyal sub-basin is urbanising rapidly (Kulranjan, 2018) and its urban population as of 2011 constituted approximately 83% of the total population in the sub-basin (**Figure 2.1**). As there is a difference in the nature of water provisioning in urban and rural areas, water supply systems need to be adapted and upgraded to meet the changing demand for services. There is a time lag in ensuring adequate and safe water services under the dynamic state of the basin.

The increased urbanisation needs to be understood in tandem with the water resource availability in the basin. The Bhavani sub-basin's groundwater resources are reported to be stressed due to unsustainable groundwater abstraction practices (CGWB, 2017a). The Noyyal is described to be water deficient as the demand for water exceeds the available water resources within the sub-basin (Appasamy and Nelliyat, 2007). In response, the large cities of Coimbatore (population: ~1.6 million) and Tiruppur (population: ~0.5 million) in the Noyyal sub-basin meet a significant part of their domestic water requirements through river water imports from outside the sub-basin, which will be discussed in detail in **Chapter 4**.

In the basin, domestic water is sourced from surface water reservoirs on the rivers Bhavani, Siruvani and Aliyar and from local groundwater through open wells and bore wells. Several settlements in the Noyyal sub-basin including the larger cities of Coimbatore and Tiruppur have dual water supply systems, with imported river water being preferred for potable use and local groundwater preferred for non-potable domestic end-uses. Some settlements are completely dependent on local aquifers. The households in the upper catchment of the Bhavani sub-basin, in The Nilgiris district access water from springs. Public water is supplied through household water connections and public street taps. Water is also supplied by the government through water tankers in specific areas when required. Households also access water from private water tankers and small-scale water vendors. Some households have private bore wells. In rural areas, water is also accessed from public hand pumps.

There are gaps in public water supply distribution in an adequate and equitable manner during the dry summer season (March–May). Groundwater stress and

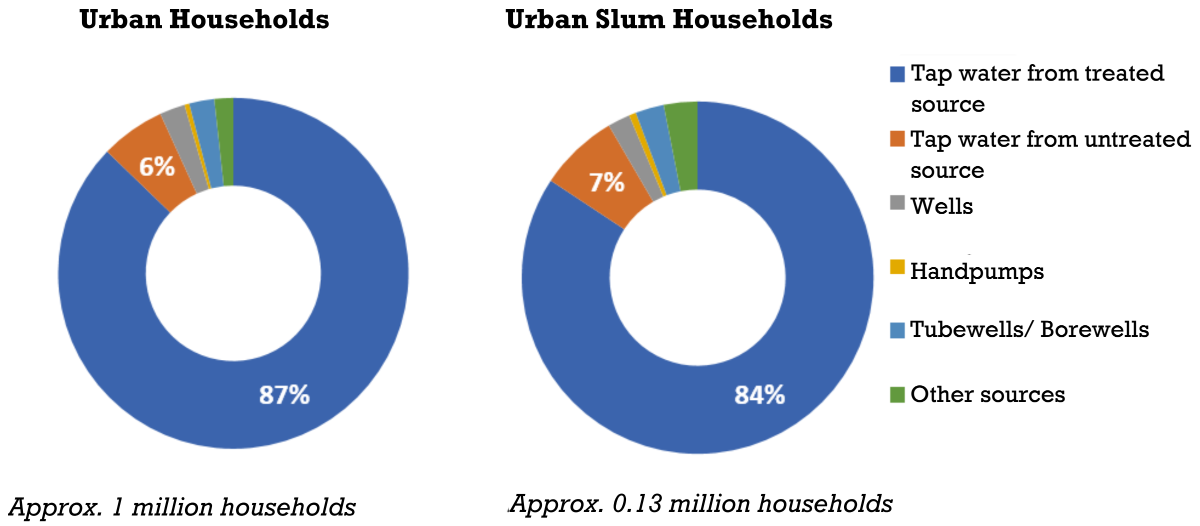


Figure 2.2. Main Source of Drinking Water—Urban Households (2011).

competing water allocations constrain this further.

Access to Water in Urban Areas

Safe Water Quality

For the protection of human health, safe water free of microbial and chemical contamination is required at the point-of-use. Piped water that is supplied by the municipalities at the public taps and household connections is treated to address microbial contamination. Even when households access treated piped water, intermittency in water supply requires them to store water. This increases the risk of microbial recontamination of water during handling and storage.

However, not all sources of water accessed by the households are treated. In the case of groundwater accessed through wells or water tankers, the risks to potable water quality are mainly with respect to microbial contamination and elevated levels of Total Dissolved Solids (TDS), hardness and nitrates. In areas with industrial water pollution, the groundwater is contaminated with various pollutants including heavy metals rendering the water unsuitable for domestic use. Groundwater quality in the basin is discussed in **Chapter 5** on Water Quality.

The Census of India 2011 data shows that the main source of drinking water accessed by urban households in the basin is 'tap water from treated source' (**Figure 2.2**). This includes treated water supplied through household piped connections and public taps. About 15% of households access water from untreated sources, which typically includes bore wells, private water tankers and water vendors.

Point-of-use treatment at the household level such as UV-treatment and boiling may help mitigate health risks to an extent for microbial contaminants, but cannot ensure the protection of public health where such sources are contaminated as a result of industrial pollution. Overall, the focus on public health and water has been only on microbial contamination. Research studies on the location, extent of contaminant plumes and their long-term consequences are largely missing in the Indian context.

Adequate Water Quantity

Universality in access to water is emphasised by SDG 6.1. The coverage of public water supply connections for some of the cities/towns in the Noyyal-Bhavani basin for which data is available is shown in

Table 2.1. This shows that universal coverage of public water supply is yet to be reached in the basin.

Average piped water supply to households provides an overall idea of the extent of the public water supply. The domestic water supply norms for Urban Local Bodies (ULBs) by the TWAD Board are shown in **Appendix C**. Among the ULBs, the Municipal Corporations are the largest in size by population while the Town Panchayats refer to smaller towns.

The average public water supply for the majority of the cities and towns in the basin is estimated based on data from the TWAD Board for 2016-17 and projected population (with the base as population census of 2011). This is mapped in **Figure 2.3**. The minimum water supply norms for town panchayats, municipalities and municipal corporations considered are 70 LPCD, 90 LPCD and 135 LPCD, respectively. From the map, it is seen that 60% of the towns and cities in the basin receive the minimum average public water supply. It is estimated that in the larger cities of Coimbatore and Tiruppur, average water supply is approximately 116 LPCD and 65 LPCD, lower than the water supply norm of 135 LPCD and thus remain deficient.

Although this indicates city-level public water supply, it does not explain several important aspects in household access to water such as inequities in water access spatially within individual towns or seasonal variations in public water supply. During summer months, the frequency of water supply is reduced due to water shortages. However, some of the towns in

Table 2.1. Coverage of Water Supply Connections & Continuity of Public Water Supply.

City/Town Name	Coverage of water supply		Continuity of water supply	
	Benchmark – 100%		Benchmark – 24 hours	
	Current 2017–18	Target 2018–19	Current 2017–18	Target 2018–19
Coimbatore	85%	90%	6 hours per day	8 hours per day
Gobichettipalayam	82%	90%	3 hours	4 hours
Mettupalayam	95%	95%	24 hours	24 hours
Ooty	70%	90%	6 hours	8 hours
Sathyamangalam	50%	90%	2 hours	2 hours
Tiruppur	85.2%	87.4%	1 hour once in 2 days	1 hour once in 2 days
Vellakoil	55%	60%	24 hours	24 hours

(Source: Compiled from SLB data for each city/town)

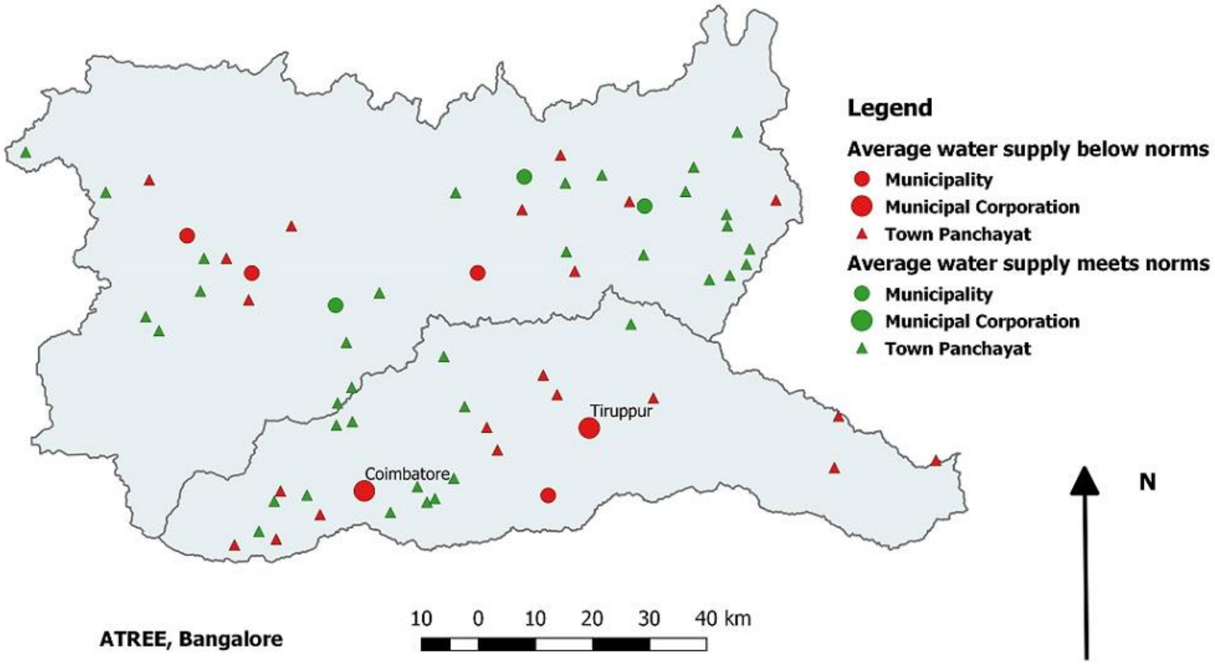


Figure 2.3. Average Public Piped Water Supply to Towns and Cities in the Basin.

the Noyyal sub-basin may be resilient to some extent due to the dual supply of river water and local groundwater as observed in two towns in the basin (Lele et al., 2018a).

Reliability in Water Access

In intermittent piped water supply systems, the adequacy in water access is determined by the characteristics of water supply as well as household water storage capacity. The frequency and duration of water supply are important characteristics of intermittent systems.

One of the SLB indicators for ULBs is continuity of water supplied and the benchmark is 24-hours continuous supply. The current water supply duration and planned target improvements are shown in **Table 2.1** for some of the towns/cities in the Noyyal-Bhavani basin. This is only indicative because water supply frequency varies spatially within cities and across seasons. During the dry season, with depleted reservoir storage levels, water may be supplied only once in 10-12 days or more in some areas.

When the frequency and duration of water supply is inadequate to meet their water requirements, households supplement public water supply with water from tankers, vendors and wells, often at higher prices than public water supply

Ease of Water Access

In the Noyyal-Bhavani basin, 46% of the total urban households had piped water connections within the house premises. Many connections are shared by two or more households residing within the premises. The households without piped water connections on premises access public water from the nearest street taps. Therefore, the ease of access to public water supply depends on both the distance to the tap as well as the time involved in collecting water, especially from shared water taps. Census 2011 data on the main sources of drinking water shows that a large proportion of urban households access water from sources outside their premises [2] (**Figure 2.4**). For slum households, the dependency on water

[2] In urban areas, the location of a water source within 100 m from the household premises refers to 'near the premises'. The location of the source beyond 100 m refers to 'away from the premises'.

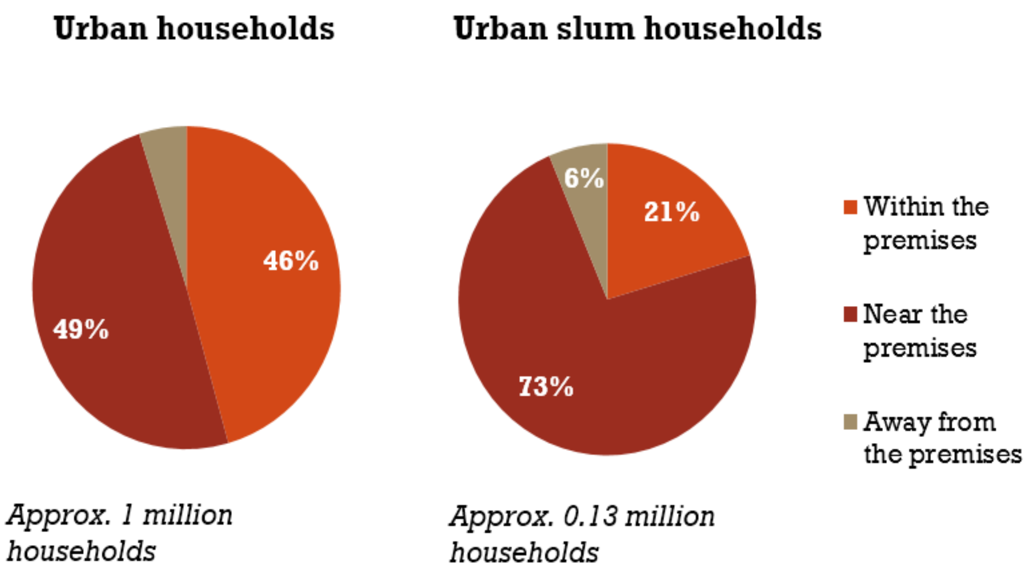


Figure 2.4. Location of Main Source of Drinking Water —Urban Households (2011).

sources outside their premises is very high (~ 80%).

This poses a particular burden on slum households. The combined factors of intermittent supply, limited household water storage capacity and shared water access points not only limits the quantity of water accessed, but also affects the ease of access. Households must wait for water supply, the timings of which may not always be fixed.

Affordability in Domestic Water Access

Public water supply is more affordable than alternative sources such as private water tankers. Inadequate or infrequent public supply implies higher water-related expenditure incurred by households in purchasing water from alternative sources. Most often, the higher costs fall

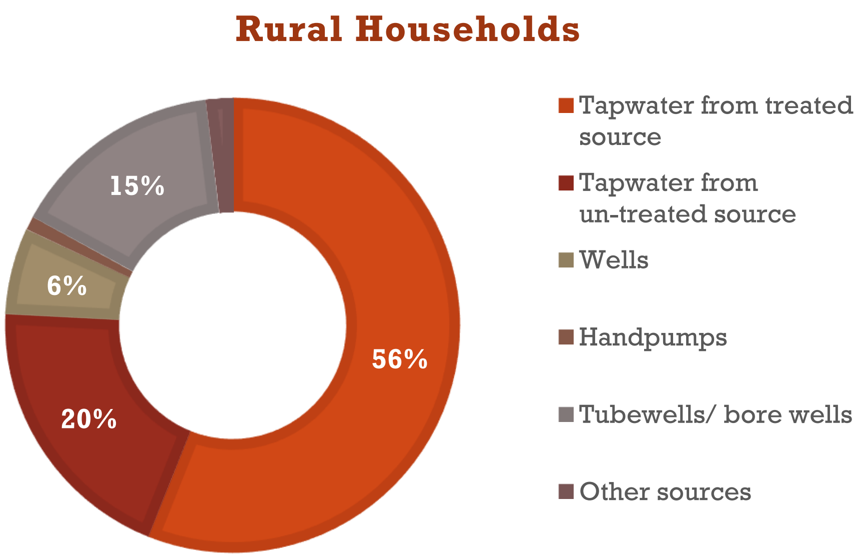


Figure 2.5. Main Source of Drinking Water — Rural Households (2011).

disproportionately on low-income households.

Access to Water in Rural Areas

The TWAD Board provides bulk water supply to villages through various water supply schemes. While most of the villages are dependent on groundwater, there are several Combined Water Supply Schemes (CWSS) that include both local groundwater and river water imports.

Safe Water Quality

The Census 2011 data shows that 'Tap water from treated source' is the main source of drinking water accessed by little more than half the rural settlements in the basin. A significant rural population accesses water from open wells and bore wells as well as untreated tap water (**Figure 2.5**). This implies that the rural population is more vulnerable than their urban counterparts with respect to the quality of drinking water. Compared to other districts in the basin, villages in Coimbatore are reported to have better access to treated tap water (**Figure 2.6**).

From the National Rural Drinking Water Programme (NRDWP) database, it is observed that groundwater is reported to have hardness and TDS concentrations above permissible limits in several parts of the basin. Groundwater contamination due to nitrates, chlorides, sulphates, fluoride, iron and alkalinity is reported in several wells. Microbial contamination is also reported.

Adequate Water Quantity

The domestic water supply standard for rural areas by the TWAD Board is 40 LPCD. From the NRDWP database, the rural water supply status for villages in a sample of 19 administrative blocks in the Noyyal-Bhavani river basin was analysed. Of them, in 18 blocks (i.e. 95% of blocks), the water supply norm of 40 LPCD was reported as being met.

An assessment based on the higher 55 LPCD domestic water supply standard as recommended by the 2013 Framework of the NRDWP shows that none of the 19 administrative blocks in the basin completely met the standard. This implies that the lower of the average basic minimum water supply standard for rural areas is just being met. The spatial variation in access to water within settlements and the seasonal variability in access to adequate water is not represented by these figures.

Ease of Water Access

Census 2011 data on the main sources of drinking water shows that most of the rural

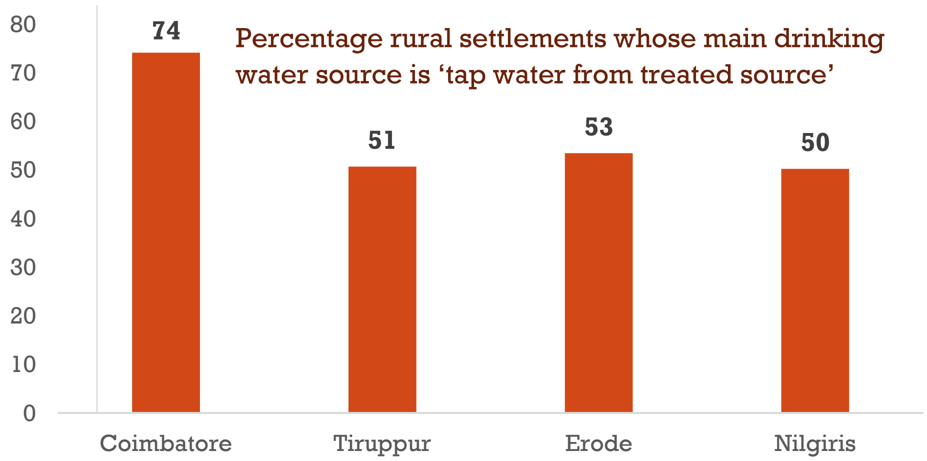


Figure 2.6. District-Wise Rural Household Access to Treated Tap Water (2011).

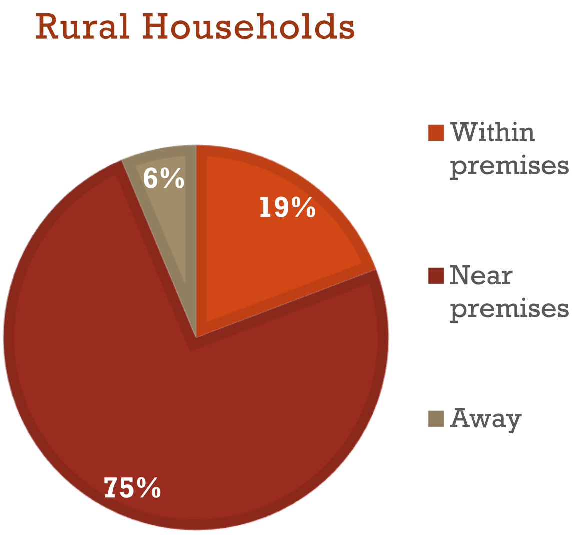


Figure 2.7. Location of the Main Source of Drinking Water—Rural Households (2011).

households in the basin access water from sources outside their premises (**Figure 2.7**). Less than 20% of the total rural households had piped water connections within the house premises.

The location of a water source within 500 m from the household premises refers to 'near the premises' while the water source location farther than 500 m refers to 'away from the premises'.

Water Supply-related Governance

Bulk Water Supply

In the Noyyal-Bhavani basin, bulk water is supplied by the TWAD Board to the ULBs and villages. In this context, it is important to note that drinking water followed by domestic water, have the highest priority in water allocations according to the National Water Policy, 2012 and the state has the responsibility in the provisioning of water and sewerage services. For this reason, the quantity of domestic water supplied has tended to be relatively stable even during droughts.

The changing rural-urban dynamics in the basin due to urbanisation is associated with transitions in water supply and governance institutions. As cities expand their boundaries to include surrounding villages, it is important to note that there are time gaps in the provisioning of adequate water supply services as the supply standards and status of water infrastructure are different in rural and urban areas.

Retail Water Supply

The water distribution is the responsibility of the local administrative body. In a study that assessed the water service delivery of two small towns in the Noyyal sub-basin, it was noted that the responsiveness and accountability of the local administrations in terms of addressing day-to-day citizen grievances, responses to summer shortages and maintenance of records was good (Lele et al., 2018a). For rural settlements, it is observed that transparency in disclosure of data pertaining to rural water supply schemes through the NRDWP online management information system is reasonably good.

With the exceptions of the cities of Coimbatore, Tiruppur and a few villages, where water supply is the shared responsibility of the government and private agencies through public-private partnerships (PPPs), water supply is solely the responsibility of designated government agencies. The examples of PPPs in the region are briefly noted in **Appendix D**. In case of domestic water access, the question is if the PPP projects in the region are implemented and aligned with the human right to water and the National Water Policy that prioritises drinking and domestic water supply over other sectoral needs. But further primary research on this is needed.

Basin Context Metrics: Access to Water

The basin context metrics related to access to water are summarised in **Table 2.2.** The present state and desired end state are described for each metric.

Table 2.2. Basin Context Metrics—Access to Water.

Basin Context Metric	Current State	Desired End State
Potability of drinking water supplies	The main source of drinking water is of treated nature in 87%, 84% and 56% of urban, urban-slum and rural households, respectively (Census, 2011).	The supply of adequate water of potable quality to all households to meet potable needs such as drinking and cooking.
Adequacy in water quantity supplied (in LPCD) as per TWAD Board norms	Most of the cities/towns (60%) and villages (95%) in the basin receive the minimum required quantity of water on an average.	Rural and urban LPCD norms completely met throughout the year.
Reliability in access assessed in terms of frequency and duration of water supply	In urban areas, water supply frequency ranges from 1 hour every two days to 6 hours per day. Supply frequency and duration is lower during the summer months.	Adequate frequency and duration of water supply to meet household demand throughout the year.
Ease of access with respect to distance and time costs involved in accessing water	The main source of drinking water is outside the household premises for 51%, 79% and 81% of urban, urban-slum and rural households, respectively (Census, 2011). Time costs involved in collecting water depends on the distance to the tap and the number of households collecting water per tap.	For rural areas, the NRDWP (2013) defines that access to water should be within 100 m from the household or 30 minutes of time taken for fetching water in a day.
Affordability in access to water	Public water supply is more affordable than alternative sources such as private water tankers. Inadequate or infrequent public supply implies higher water-related expenditure incurred by households in purchasing water from alternative sources. Often, the higher costs fall disproportionately on low-income households.	Improved public water supply coverage and frequency to ensure that the price paid by households for accessing safe and adequate water is linked to consumption.

Chapter 3 Access to Sanitation

Key Challenges

- More data is needed on usability and sustainability of newly constructed toilets.
- **Full chain sanitation systems and services are inadequate**. Inadequate sewage treatment and faecal sludge disposal are contaminating ground and surface water.

Universal access to adequate and equitable sanitation and ending of open defecation are highlighted by SDG 6.2.

This chapter describes the status of sanitation access to households in the Noyyal-Bhavani basin. There is a data gap on the status of sanitation facilities in the CII sector in the basin.

This chapter provides a brief overview on sanitation in the Indian context and then, describes the status in urban and rural areas in the Noyyal-Bhavani basin. In the context of governance, the faecal sludge policy is briefly mentioned. Thereafter, sanitation-related basin context metrics are outlined.

Context: Access to Sanitation in the Indian Context

In the Indian context, access to sanitation can be understood through the following dimensions (adapted from Anand et al. 2016) —

a) Access to sanitation facility (toilets) and type of toilet access: individual/shared
b) Acceptability/use of toilets
c) Mode of sewage/sludge management: UGD and STP infrastructure/mechanism for sludge management

The type of sanitation infrastructure, status and use needs to be understood separately for rural and urban areas as there are differences with respect to both the infrastructure as well as how sanitation is perceived and practised in the two areas.

The Government of India launched an extensive five-year sanitation programme called Swachh Bharat Mission (SBM) in 2014 with the mission of ending open defecation in the country by October 2019. The programme has focussed on multiple aspects, the primary one being the provision of subsidies for households to construct household-level toilets. The programme has separate components for rural and urban sanitation. At present, household-level toilets are being extensively constructed in the basin under the SBM.

In both urban and rural areas, there is a lag in the development of associated infrastructure in the sanitation chain—faecal sludge management systems, underground sewerage networks and sewage treatment infrastructure—that ensure that sanitation does not have adverse health and environmental impacts. The externalities with respect to inadequate sanitation and wastewater management infrastructure invariably fall on public health and ecosystem health (pollution of surface water bodies and groundwater).

While historically, the focus had been primarily on the collection and treatment of sewage, in recent years, there is a shift in thinking towards addressing management of faecal sludge in a safe and effective manner. Thus, a combination of piped sewerage infrastructure and faecal sludge management infrastructure plus institutions is necessary for preventing the ongoing pollution of surface and groundwater resources in the basin.

Access to Sanitation in Urban Areas

Sanitation Coverage

In India, in urban areas, the status of sanitation in terms of coverage and use of toilets is much better in comparison to rural areas. From the Census 2011 dataset, it is observed that about 55% of the urban households in the basin were reported to have access to latrine facilities within their premises. Of such households, the majority (~80%) had flush or pour-flush type toilets. At present, most of the urban settlements in the basin have been declared as being free of open defecation under the urban component of the SBM programme. This indicates that the programme has progressed towards achieving its physical targets of construction of household-level, community and public toilets.

An emerging challenge is that urbanisation has also resulted in increased population residing in slum settlements. Due to the nature of the slum settlements with limited space, effective community and public toilet infrastructure and management systems remain a problem.

Census 2011 data shows that only 16% of the household toilets were connected to the piped sewer system indicating the high prevalence of on-site sanitation systems in urban areas as well. With the increased construction of toilet facilities and increased generation of sewage and sludge, there is a clear need for integrated planning and management within the entire sanitation chain from generation to reuse/disposal.

Use and Acceptability of Toilets

Multiple studies have shown that not all toilets constructed through various government programmes are well-accepted and used by people (Coffey et al., 2017; Routray et al., 2015). The reasons for not using toilets may range from socio-cultural barriers to lack of adequate water for sanitation. In the Noyyal-Bhavani basin, the acceptability/use of newly constructed toilets under the ongoing SBM programme requires evaluation through primary field-based studies.

Sewage/Sludge Management

The SLBs related to sanitation in urban areas include coverage of toilets, sewerage network coverage, sewage treatment capacity and similar indicators (refer **Appendix C**). With increasing urbanisation, cities and towns are trying to keep pace in providing underground drainage infrastructure and sewage treatment services. Many larger cities have underground sewerage networks to collect sewage from individual households and convey it to centralised STPs. However, not all cities have underground drainage (UGD) infrastructure and in many cities, the infrastructure is partial, serving only parts of the cities. As a result, many larger cities have a mix of on-site sanitation systems and toilets connected to piped underground sewerage networks.

Moreover, even in the larger cities, sewage treatment capacity is inadequate in relation to the sewage generated. Decentralised sewage treatment is practised in pockets by large institutions, large industries and at the scale of large housing complexes in some Indian cities. In the absence of UGD networks, in both urban and rural areas, household toilets are connected to on-site sanitation systems - septic tanks or soak pits. While the former provides safe containment of black water, the latter is associated with adverse impacts such as leaching of nitrates and microbial contamination of local groundwater. Most small towns exclusively have on-site sanitation systems.

Access to Sanitation in Rural Areas

Sanitation Access

In rural parts of the basin, approximately 32% of the households were reported to have access to latrine facilities within their premises according to Census 2011. Of the households with latrines, only about 64% of them had flush or pour-flush type toilets. At present, under the rural component of the SBM programme, in Tamil Nadu, the individual household latrine coverage is reported as 100%. Further, for rural areas, the state of Tamil Nadu has been declared as being free of open defecation based on the coverage of toilet infrastructure constructed under the SBM programme.

Use and Acceptability of Toilets

While the absence of toilets has been one aspect of the problem, the other crucial aspect has been the low usage of the existing toilets by the people. Due to socio-cultural reasons, sections of the population continue to practise open defecation despite the existence of and access to toilets. A related challenge to effective rural sanitation has been the inadequacy of water for sanitation in some areas.

Sewage/Sludge Management

In rural areas, most of the toilets constructed are on-site sanitation systems that require effective management of faecal sludge. However, there are gaps in effective faecal sludge management systems in the basin. Systems for formal collection of faecal sludge from household-level septic tanks and disposal/treatment in a safe manner are practically non-existent. Faecal sludge management has received attention only in the recent past and there are few pilot cases of formal management. In the informal system, faecal sludge is collected by private players and disposed of in a variety of ways ranging from disposal into the UGD and delivery to the STPs to disposal in agricultural fields, on unused open lands, into storm-water drains, into streams and surface water bodies.

Most of the household toilets prior to the SBM programme were on-site sanitation systems. Only about 11% of rural households with toilets were connected to the piped sewer system (Census, 2011). At present, the SBM programme has resulted in the construction of thousands of additional on-site sanitation systems. Therefore, **the safe disposal and management of faecal sludge is an emerging challenge.**

Sanitation-related Governance – Faecal Sludge Policy

The Ministry of Urban Development (MoUD) has released the National Policy on Faecal Sludge and Septage Management (FSSM) in 2017. It recognises the need for each state and city to chalk out their FSSM strategy and integrate it with their sanitation plans. As sanitation is a state subject, individual states need to take steps to realise the objectives of the policy.

At the state level, Tamil Nadu was the first state in the country to issue 'Operative Guidelines for Septage Management for Local Bodies' in 2014 for both urban and rural administrative bodies. To support the Tamil Nadu government's sanitation mission, the 'Tamil Nadu Urban Sanitation Support Programme' (TNNUSP) was launched in 2015. The programme involves the pilot implementation of the full cycle of sanitation in two regions, one of which is in Coimbatore in the Noyyal-Bhavani basin. A faecal sludge treatment plant has been setup in a non-sewered town near Coimbatore and various aspects related to managing sludge from engineering and planning to behaviour change and capacity building are being tested. The status of sewage treatment infrastructure in the Noyyal-Bhavani basin is further described in **Chapter 5** on Water Quality.

Basin Context Metrics: Access to Sanitation

The basin context metrics related to access to sanitation are summarised in **Table 3.1.**

The present state and desired end state are described for each metric.

Table 3.1. Basin Context Metrics—Access to Sanitation.

Basin Context Metric	Current State	Desired End State
Access to toilets	Most rural and urban households have access to either household-level or community/public toilets (SBM, 2019).	Access to functional toilets with water supply to all households.
Acceptability/use of toilets	The present status of acceptability/use of newly constructed toilets under the ongoing SBM programme requires evaluation.	Use of toilets by all households.
Mode of sewage/sludge management – UGD and STP infrastructure/mechanism for sludge management	Informal systems for faecal sludge management; a pilot test of formalised faecal sludge management near Coimbatore city. Inadequate UGD and STP infrastructure; in the process of being built/upgraded in a phased manner.	Functional system for safe and effective management of all faecal sludge and sewage generated by developing the full sanitation chain.

Chapter 4 Water Quantity

Key Challenges

- **Water stress** due to the gap between water availability and water demand in the river basin is exacerbated by high variability in rainfall and occurrences of droughts.
- **Sustainability** of water resources in the basin challenged by over-extraction of groundwater and declining pollution. spring discharges.
- **Non-usability or limited usability** of surface water resources in the basin due to water pollution

The Noyyal-Bhavani river basin is reported to be under water stress due to the gap between the water demand and availability within the basin and unsustainable groundwater abstraction (Appasamy and Nelliyat, 2007; CGWB, 2017a).

The nature of challenges with respect to water quantity in the basin is discussed. This is followed by a brief description of the nature of water demand in the basin.

Water Quantity Challenges

Water Stress

The Noyyal-Bhavani river basin falls within the rain shadow area of the Western Ghats mountain range, as a result of which it receives limited rainfall during the South-West Monsoons. The region receives a significant part of its rainfall from the North-East Monsoons which is reported to be relatively more variable. The exception is the Nilgiris district and surrounding regions which receive heavy rainfall. **Figure 4.1** shows the average annual rainfall in the Noyyal-Bhavani basin districts.

The years with deficient rainfall severely constrain water availability for meeting the needs of different water-users – domestic, hydro-power, agriculture and industrial. This has led to adaptations such as by the farmers in the Lower Bhavani Project (LBP) command area through supplementary groundwater irrigation. In addition to this, the potential impacts of climate change in this basin require detailed scientific research.

Areas that are chronically subject to deficient rainfall are classified as drought-prone areas by the government. In the Noyyal-Bhavani river basin, the areas notified under the Drought-Prone Areas Programme are shown in **Figure 4.2**.

Rainfall variability in the region and vulnerability of certain areas to droughts needs to be assessed with respect to the nature of water demand in the basin. The gap between the demand for water and its availability contributes to water stress within the river basin. This is one of the key water challenges with respect to water quantity.

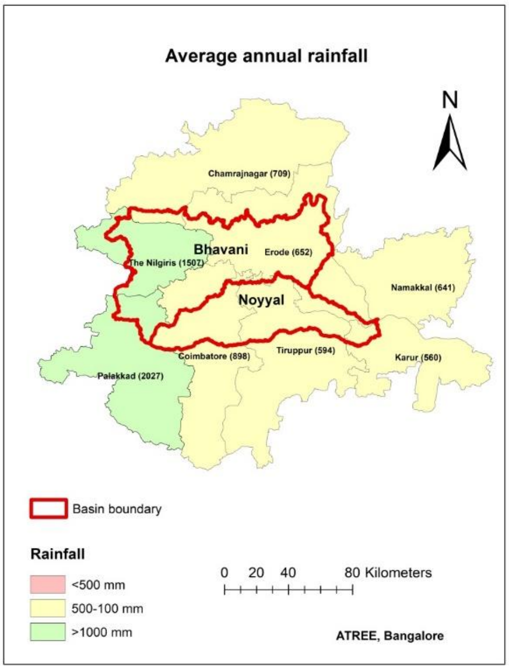


Figure 4.1. Average Annual Rainfall in the Basin Districts.

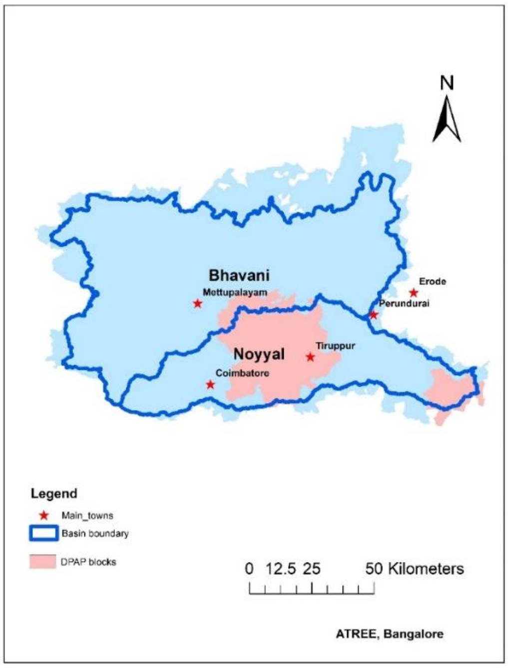
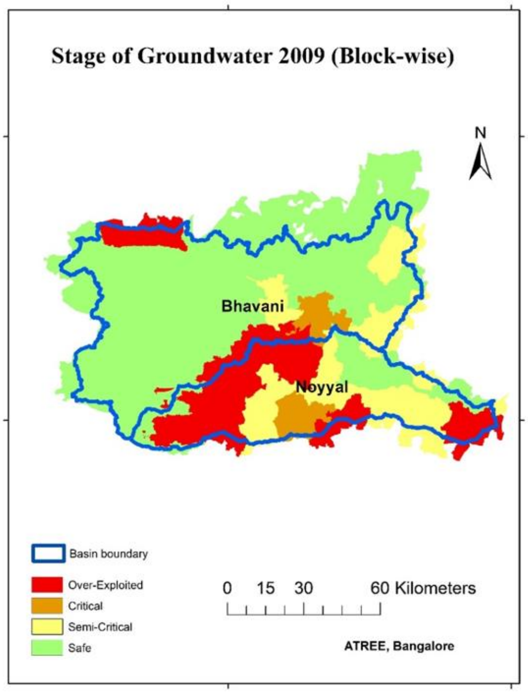


Figure 4.2. DPAP Blocks.



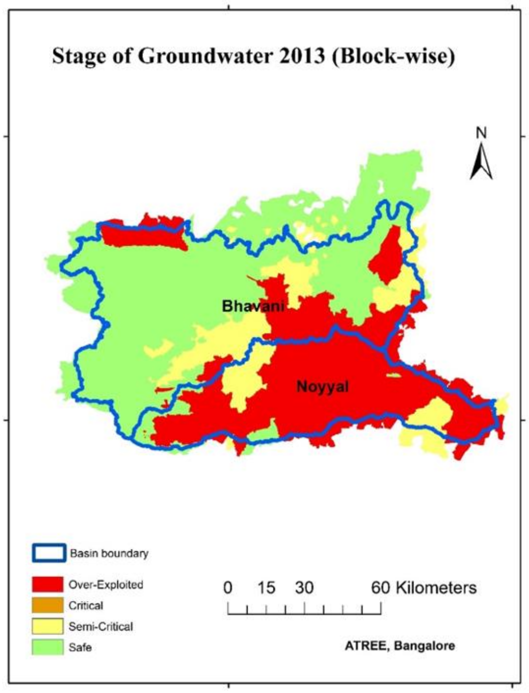


Figure 4.3. Stage of Groundwater Development.

Water Sustainability

Groundwater in the basin is not only an important source of water for meeting the requirements of different sectors but also a buffer against droughts. The availability of groundwater also improves resilience against the adverse effects of climate change.

The Noyyal-Bhavani basin has underlying hard rock geological structures. The shallow unconfined aquifers are closely interconnected with surface water resources. The deeper aquifers, when confined, are reserves of fossil water. Increased dependence on groundwater from deep confined aquifers results in depletion of fossil groundwater reserves. Sustainable use of groundwater in the basin would require that extraction does not exceed recharge.

The CGWB has classified administrative blocks into over-exploited, critical, semi-critical and safe zones based on the degree of groundwater abstraction relative to recharge. The criteria for categorisation of assessment units are shown in (CGWB, 2017b). In the Noyyal-Bhavani river basin, as of 2013, it is observed that 19 of 42 blocks (~45%) are notified as being *over-exploited* while four and six blocks are classified as critical and semi-critical, respectively. From **Figure 4.3**, it is clear that the dependence on groundwater has increased over time resulting in over-exploitation of groundwater in nearly half of the Noyyal-Bhavani basin. The entire Noyyal sub-basin is groundwater stressed. In the Nilgiris district which partly lies in the upper Bhavani sub-basin, the discharge from mountain springs is reported to be declining (Keystone, 2002). The over-extraction of groundwater and decline in spring discharges adversely affects water security in the Noyyal-Bhavani river basin.

Non-Usability of Surface Water due to Pollution

The rivers in the Noyyal-Bhavani basin are polluted due to the discharge of inadequately or poorly treated sewage and industrial effluents. The R. Noyyal has been polluted due to the discharge of untreated or inadequately treated industrial effluents from textile dyeing and bleaching facilities as well as sewage from urban settlements, especially the cities of Coimbatore and Tiruppur. The Orathupalayam reservoir on the R. Noyyal is no longer used for irrigation by downstream farmers.

The rivers Bhavani, the Moyar as well as several lakes and irrigation tanks in the basin are also polluted limiting their potential end-uses. The quality of the surface water resources in the basin will be discussed in detail in **Chapter 5** on water quality.

Table 4.1 Criteria for Categorisation of Assessment Units: Groundwater Development.

Category	Stage of Groundwater Development	Significant Long-Term Water Level Decline Trend	
		Pre-Monsoon	Post-Monsoon
Safe	≤90%	No	No
Critical	>90% and ≤100%	Yes	Yes
Semi-Critical	>70% and ≤100%	No	Yes
		Yes	No
Over-Exploited	>100%	Yes	No
		No	Yes
		Yes	Yes

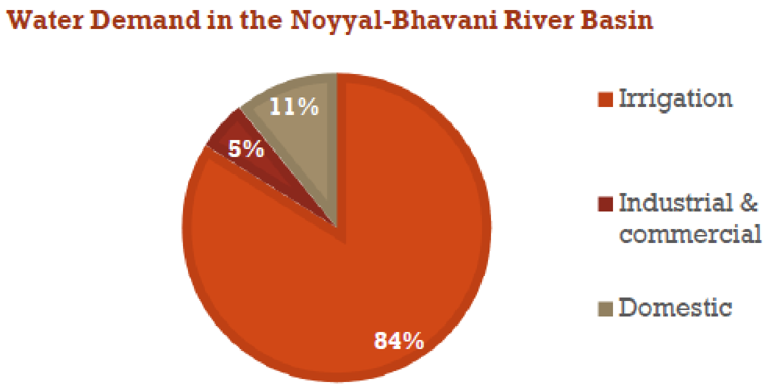


Figure 4.4 Relative Water Demand by Different Water Users

Water Demand in the Noyyal-Bhavani River Basin

Total Water Demand

The relative water demand by the agricultural (irrigation), industrial and domestic sectors is depicted in **Figure 4.4** Relative Water Demand by Different Water Users. The total water demand by these sectors is estimated to be on average approximately 4,040 MLD.

Agricultural Water Demand

Agriculture is the largest user of water in the basin. The agricultural economy is more predominant in the Bhavani sub-basin. The Noyyal sub-basin is highly urbanised. The main crops grown in the districts in the Noyyal-Bhavani river basin are shown in **Table 4.2**.

Crop cultivation is carried out in three distinct seasons: Kharif (June–September), Rabi (October–January), and Zaid (February–May). Some crops are cultivated throughout the year. The timing of the monsoon rainfall plays a major role in agricultural practices in the region. The western part of the basin, especially the Nilgiris district receives heavy rainfall from the South-West Monsoon (June–September).

Table 4.2. Main Crops Grown in the Noyyal-Bhavani River Basin Districts.

Basin District	Major Crops Cultivated (2015–16)
Coimbatore	Coconut and banana plantations, groundnut, maize
Tiruppur	Coconut plantations, groundnut, maize, sorghum and paddy
Erode	Coconut plantations, groundnut, maize and sugarcane
Karur	Coconut plantations, groundnut, sorghum, paddy and horse gram (variety of beans)
The Nilgiris	Spices such as cardamom and black pepper, banana and areca plantations, vegetables like potatoes

The South-West Monsoon rainfall declines from west to east in the basin. The basin also receives rainfall from the North-East Monsoon (November–February). While rainfed agriculture is practised during the monsoon periods, there is significant crop cultivation by irrigation in the basin. A detailed note on irrigation projects and practices within the Noyyal-Bhavani river basin is provided in **Appendix E**.

From preliminary estimates, the total agricultural water demand in the Noyyal-Bhavani river basin is approximately 2,053,836 million litre per year (~ 72.5 TMC feet per year). This includes green and blue water. The irrigation water demand in the basin is estimated to be 1,238,879 million litre per year (~ 43.8 TMC feet per year).

Industrial and Commercial Water Demand

The cities of Coimbatore and Tiruppur in the Noyyal sub-basin are industrial epicentres that have grown rapidly over the years. Coimbatore, the second largest city in Tamil Nadu, is a manufacturing hub known for cotton textiles, automotive components, electric motors, grinders and pumps, jewellery and poultry. The city contributes significantly to the export market. Preliminary estimates of the total water demand by manufacturing industries and the commercial establishments in the basin indicate a minimum requirement of approximately 210 MLD.

Water Demand – Textile Industry

Tiruppur city and the surrounding region are well-known as a textile and knitwear manufacturing hub that caters to both the domestic and international markets. The growth of Tiruppur is closely linked to the growth of its textile industry. The economy of the Tiruppur region has transitioned from agriculture to textile manufacturing over the decades and presently, the textile sector provides the main source of livelihood for people in the region.

The textile industry is estimated to be the largest industrial water user in the Noyyal-Bhavani river basin. Most of the water demand is by the textile wet-processing industries – dyeing, bleaching, and washing. The water demand is met from multiple sources:

a) Groundwater purchased from water tankers. However, groundwater from local aquifers is not preferred due to contamination and salinity problems.
b) Surface water from the R. Bhavani supplied through pipelines to the textile units by the New Tiruppur Area Development Corporation Limited (NTADCL) project.
c) Reuse of treated industrial wastewater. This is a relatively recent transition as a result of two reasons – 1) regulation of water pollution through 'Zero Liquid Discharge' in treatment processes, 2) high pricing of freshwater due to limited availability.

Preliminary estimates indicate that the water demand by the textile industries in the river basin is at least 120 MLD, constituting a little over 50% of total commercial/industrial demand. The freshwater demand is estimated to be approximately 60 MLD, of which approximately 40 MLD is from the R. Bhavani and the rest from groundwater. The extent of wastewater treatment in practice and reuse of treated wastewater is not clear. For the estimation, wastewater recycling and reuse within the textile wet-processing industry is assumed to be 50%.

Domestic Water Demand

Domestic water requirements are met from river water imports and local groundwater. Urban and rural water supply schemes to some parts of the basin draw water from the R. Bhavani and R. Siruvani. In areas where piped supply of river water is either not feasible or where the groundwater quality is good, groundwater is supplied by the government. In several areas, there are CWSS, wherein both river water and groundwater are supplied. In the Nilgiris district, mountain springs are the source of water for domestic water needs.

The total urban water demand in the basin for 2019 is estimated to be approximately 362 MLD considering the minimum water supply norms for different classes of urban settlements and projected urban population based on similar decadal growth rates. The total urban domestic water supply reported by the TWAD Board for all the towns and cities in the basin is estimated to be approximately 331 MLD as of 2016-17 (**Figure 4.5** Total Domestic Water Demand). Detailed analysis of the water supply and estimated demand across towns shows that while some towns are reported to have adequate water supply, some of them are severely constrained.

The total rural water demand in the basin is estimated to be 67 MLD as per the TWAD board norm of 40 LPCD. The rural water demand would be approximately 91 MLD considering the NRDWP recommendation of 55 LPCD water supply in rural areas. From the NRDWP database, the total rural domestic water supply in the basin is estimated to be approximately 60 MLD.

Therefore, the total domestic water supply in the basin is estimated at 391 MLD. The total domestic water demand is estimated to be ~440 MLD, with a shortfall in supply of approximately 50 MLD.

Hydro-Power Water Demand

The Bhavani sub-basin has several hydro-power projects which impound and store water from the upper reaches of the R. Bhavani. The total capacity of the hydro-power projects in the basin is ~885 MW. This accounts for nearly 40% of the hydro-power generation in the state of Tamil Nadu. Additionally, a pumped storage hydro-electric project of 500 MW capacity is planned to be commissioned within the next 5 years. Although the hydro-power reservoirs do not contribute to consumptive water use, they affect water availability in the basin in two ways:

a) The timing of the release of water from the hydro-power reservoirs may not coincide with the water requirements of downstream users.
b) The hydro-power reservoirs contribute to evaporation losses.

Basin Context Metrics: Water Quantity

The stage of groundwater development is proposed as a metric for understanding the trends in groundwater extraction relative to recharge in different areas in the basin. Baseline water stress is a useful metric to understand and track water stress in the basin. However, this has not been estimated as it is beyond the scope of this study to undertake detailed hydrological modelling to estimate water availability and withdrawal in the Noyyal-Bhavani basin.

The basin context metrics related to water quantity are summarised in **Table 4.3.** For each metric, the present state and desired end state are briefly described.

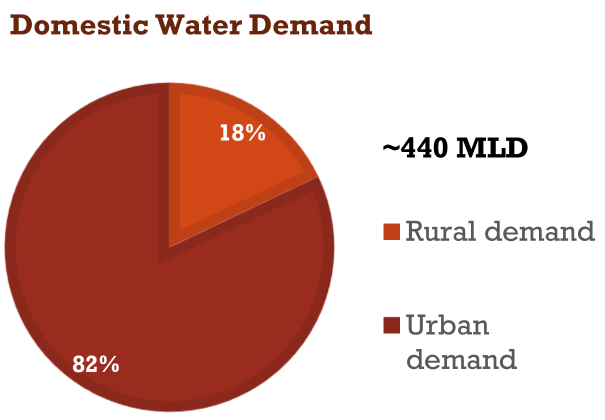


Figure 4.5 Total Domestic Water Demand

Table 4.3. Basin Context Metrics—Water Quantity.

Water-related Challenges	**Basin Context Metric**	**Current State**	**Desired End State**
Water stress due to the gap between water demand and availability in the basin.	Measures for water-use efficiency in agriculture	5.5% of the net irrigated area in Tamil Nadu is under micro-irrigation (drip and sprinkler irrigation) (Kumar, 2012). Irrigated cultivation of water-intensive crops, such as paddy and sugarcane, is based on flood-irrigation practices [Water-Use Efficiency (WUE) of 65%] from canals or bore wells. Drip irrigation (WUE of 90%) incentivised by the Tamil Nadu state government through financial subsidies for farmers, is practised limitedly on few crops such as coconut and banana plantations.	Improved WUE in irrigation practices including water-intensive crops.
	Measures for WUE in the industrial sector	Zero Liquid Discharge (ZLD) rule is applicable to textile industries in the basin, requiring the units to recycle and reuse water to the maximum possible extent (90–95%). The extent of wastewater recycling within textile facilities in practice is not known.	Improved efficiency in industrial water use through process and technology improvements. Wastewater reuse and recycling wherever feasible or required by law.
Sustainability of water resources challenged by over-extraction of groundwater and declining spring discharges.	Stage of groundwater development as classified by CGWB	~45% of the blocks in the Noyyal-Bhavani basin are over-exploited. Most of the Noyyal sub-basin is classified as being over-exploited. Only 31% of the blocks in the Noyyal-Bhavani basin are classified as being safe.	All the blocks in the Noyyal-Bhavani basin are classified as being safe. Groundwater extraction is less than recharge. Rejuvenation of depleted deep aquifers.

Chapter 5 Water Quality

Water pollution, its prevention and management are the most critical challenges within the Noyyal and Bhavani sub-basins. Pollution of surface water bodies – rivers and wetlands – and groundwater due to the discharge of untreated sewage, industrial effluents and agro-chemical run-off is a challenge. The textile dyeing industry, recognised for its high pollution potential, has been the main contributor of industrial water pollution in these sub-basins (Appasamy and Nelliyat, 2000; Blomqvist, 1996; CPCB, 2014; Grönwall and Jonsson, 2017a; Pranaw et al., 2014).

This chapter describes the key issues related to addressing the water pollution challenge in the Noyyal-Bhavani basin. The R. Noyyal and Bhavani have very different economic contexts and therefore face different challenges. The R. Noyyal has been subject to industrial pollution by untreated textile effluent discharges and untreated sewage from urban settlements. In the recent past, the extent of pollution has been severe and rendering the river water unsuitable for drinking, fisheries and irrigation end-uses especially downstream of the textile industrial cluster of Tiruppur. In contrast, the R. Bhavani is largely agricultural and non-point source pollution is a bigger concern here. For both sub-basins, ground and surface water quality challenges are distinct and are presented separately.

To understand the context better, a brief outline of the nature of growth of the textile industry, its impacts and the interventions for regulating pollution are summarised as a case study. This is followed by a description of the baseline status of surface and groundwater quality within the basin and the basin context metrics for water quality.

Sub-Basin Contexts

The R. Noyyal originates in the Western Ghats and flows eastwards through the districts of Coimbatore and Erode to join the R. Cauvery. The larger cities of Coimbatore and Tiruppur lie along the course of the Noyyal. After its upper reaches, the R. Noyyal is polluted due to the discharge of sewage and industrial effluents. There are several wetlands in the Noyyal sub-basin, especially in Coimbatore district. Many of these wetlands are actually "system tanks" (water storage structures, built for irrigation many centuries ago, that are fed by the river and overflow back into it) that are connected to the R. Noyyal. Because these tanks or wetlands support rich wetland ecosystems, there are described briefly here but in greater detail in **Chapter 6** on Water-Ecosystem Impacts. Several wetlands in the basin are polluted due to the discharge of untreated sewage, industrial effluents and dumping of municipal solid waste.

There are 23 check dams along the course of the river (CPCB, 2014). The irrigation dam at Orathupalayam, located further downstream along the river in the lower part of the sub-basin, is the only major reservoir on the R. Noyyal. The Orathupalayam dam is located downstream of the Tiruppur industrial area and has, therefore, being a recipient of highly polluted water contaminated by effluents and sewage. As a result of this, the Orathupalayam dam has not used for irrigation as intended and is at present non-functional with the sluice gates are kept open. Similarly, the Aathupalayam irrigation reservoir, downstream of the Orathupalayam, has also been a recipient of polluted water. At the very end of the Noyyal, just before it joins the Cauvery, the Central Water Commission maintains a water quality monitoring station.

The R. Bhavani, the R. Moyar and some of their tributaries flow through forested areas in their upper reaches. While, the R.

Bhavani is polluted at different points along its course due to the discharge of sewage, industrial effluents and agro-chemical run-off, it is clearly not as polluted as the Noyyal.

The Bhavanisagar is the largest reservoir in the Bhavani sub-basin meant for meeting domestic, irrigation, industrial and hydro-power water needs. The Kodiveri canals and the LBP canals channelise water from the R. Bhavani for irrigation. The Kalingarayan canal, a historical irrigation diversion canal, connects the R. Bhavani to the R. Noyyal, before their points of confluence with the larger Cauvery. Some of the wetlands in the sub-basin are polluted.

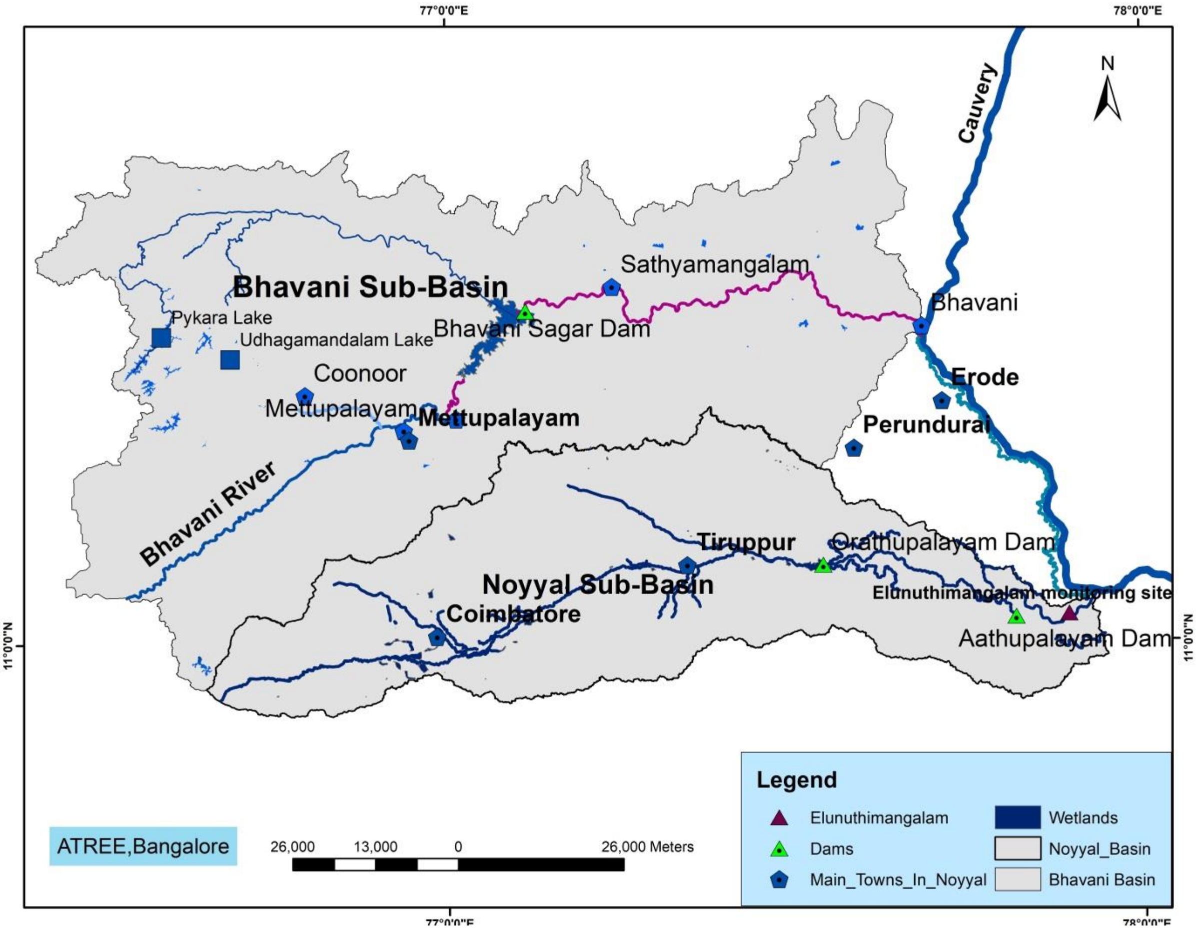


Figure 5.1. The Noyyal and Bhavani Sub-Basins with Water Quality Monitoring Sites.

Case Study: Industrial Pollution by the Textile Industry

Nature of the Textile Industry

Tiruppur is an industrial city well-known for its hosiery and knitwear industry that contributes significantly to the global market. It is situated on the banks of the River Noyyal, downstream of Coimbatore city. The textile exports from Tiruppur began in the 1970s and the growth was exponential after 1991 (Grönwall and Jonsson, 2017a). The rapid growth of the textile industry has contributed to the economic growth of the region by providing employment for thousands of people engaged in the sector. At the same time, the dyeing and bleaching wet-processing industrial units have polluted the River Noyyal and the local groundwater.

The textile dyeing and bleaching units operate across a large geographical area extending beyond Tiruppur Municipal Corporation into neighbouring districts of Erode and Coimbatore. Within the exception of the State Industries Promotion Corporation of Tamil Nadu Ltd. (SIPCOT), a Special Economic Zone (SEZ) located in Perundurai, Erode, most units are located outside formal industrial clusters. In Coimbatore district, the textile units are primarily engaged in spinning and weaving activities while the wet-processing units are primarily located in Tiruppur and parts of Erode district.

Water Management in the Textile Industry

In the initial years, the textile industry in Tiruppur met its water requirements from the R. Noyyal or local wells. With the growth of the industry and the increasing discharge of textile effluents into the R. Noyyal and the local aquifers, the quality of both river water and local groundwater deteriorated. This led the textile wet-processing industries to source their water from groundwater wells located in peripheral areas, creating an active tanker water market. It was estimated that 85% of the water requirements were met from such groundwater imports (Appasamy and Nelliyat, 2000). In the 1990s, the textile industry in India underwent a major shift with the introduction of reactive dyes, which required large amounts of colour fixation salts. Conventional primary and secondary treatment was not sufficient to remove such salts from the effluents. This contributed to high concentrations of TDS and hardness in the river and groundwater (Grönwall and Jonsson, 2017b). Most effluents were released untreated into the R. Noyyal.

Impacts of Pollution in R. Noyyal

The pollution in the River Noyyal has led to adverse impacts on public health, ecosystems and livelihoods downstream of the textile cluster in Tiruppur. The Orathupalayam irrigation reservoir located downstream of Tiruppur, constructed in 1992 turned into an effluent tank within a few years and was rendered unusable. Industrial pollution has affected agricultural productivity and other livelihoods such as fisheries (Appasamy and Nelliyat, 2000).

Pollution Regulation and Compensation

There have been various government orders and court proceedings at the state and national levels from the late 1980s for the regulation of pollution from the textile industry (Grönwall and Jonsson, 2017a). The efforts are ongoing, and not all interventions have been effective.

As early as 1989, the Tamil Nadu government issued an order[3] restricting textile dyeing and other highly polluting industries from being located within 1 km from water bodies that included the R. Noyyal, Bhavani and the Moyar and hydro-power and irrigation dams in the Noyyal-Bhavani basin. The restriction was later extended to 5 km through a subsequent government order[4] in 1998. However, in 2010 the Tamil Nadu government has decided to consider applications of expansion from existing industries located in restricted locations on merit-basis with recommendations of the Tamil Nadu Pollution Control Board (TNPCB) and conditions of ZLD with reject management systems[5].

The main driver of change was a Public Interest Litigation by a farmers' association (Noyyal River Ayacutdars Protection Association) versus the dyeing units led to an interim order by the Madras High Court in 2004 to restrain the dyeing units from discharging effluents directly or indirectly into the River Noyyal. This was followed by the issuance of show-cause notices to all the textile dyeing and bleaching units in Tiruppur district (729 units as of then) by the TNPCB requiring them to implement effluent treatment standards and achieve ZLD by May 2005. Despite multiple extensions, there was a failure to comply. This led the farmers' association to file a contempt petition in the Madras High Court in 2010 for wilful disobedience of the 2006 interim order. As a result of this, *in 2011 the Madras High Court ordered the immediate closure of all textile dyeing and bleaching units in Tiruppur district*. Criminal proceedings were to be launched against the offenders (Grönwall and Jonsson, 2017a). This High Court order was implemented by the TNPCB. These interventions have resulted in effluent treatment capacity in the basin and operationalisation of a technology standard, 'Zero Liquid Discharge' for larger textile dyeing and bleaching units, but anecdotal evidence suggests that some of the textile units migrated out of Tiruppur district while others relocated and continued operations illegally (Rajasekaran RK, 2018; Ramesh and Ananth, 2013).

Following precedents of similar cases elsewhere, the Supreme Court of India directed the constitution of a Loss of Ecology (Prevention and Payments of Compensation) Authority (LOEA), a quasi-judicial body, with the mandate to implement '*polluter pays principle*'. In the Noyyal sub-basin, the LOEA calculated the compensation to be paid to the pollution-affected farmers in downstream areas on the basis of loss of crop productivity and pollution levels in the affected villages (Nelliyat, 2007). One of the important outcomes of pollution regulation interventions was the establishment of 18 textile CETPs and 112 Individual Effluent Treatment Plants (IETPs) in operation in the region (**Figure 5.2**).

[3] Government Order No. 213, Environment and Forests (EC-1) Department, Government of Tamil Nadu, dated 30 March 1989.
[4] Government Order No. 127, Environment and Forests (EC-1) Department, Government of Tamil Nadu, dated 8 May 1998.
[5] Government Letter No. 46/EC-3/200, Environment and Forests Department (EC-3), Government of Tamil Nadu, dated 8 March 2010.

Post-Lawsuit

Since 2006, the NTADCL project began to supply piped water from the R. Bhavani to the textile industries in Tiruppur region. The total water intake from the R. Bhavani was designed at 185 MLD, of which 125 MLD was planned to be supplied to the textile wet-processing industry (Madhav, 2008). This led to a shift in the freshwater source for the industry from groundwater to river water. With progress in the implementation of ZLD processes within effluent treatment plants, the freshwater demand from the NTADCL project reduced significantly. Anecdotal evidence also suggests that the groundwater tanker market is beginning to revive.

Surface Water Quality in the Noyyal Sub-Basin

The TNPCB monitors the surface water quality at different points along the river. The TNPCB is reported to have installed online continuous water quality monitoring stations at three locations along the R. Noyyal (GoTN, 2016); but the data are not publicly accessible. The water quality of these wetlands around Coimbatore and at Elunuthimangalam water quality monitoring station in the lower Noyyal sub-basin (**Table 5.1**) show that pollution issues vary along the course of the river.

Noyyal Wetlands

We were unable to obtain recent data on wetland water quality, but our field visits

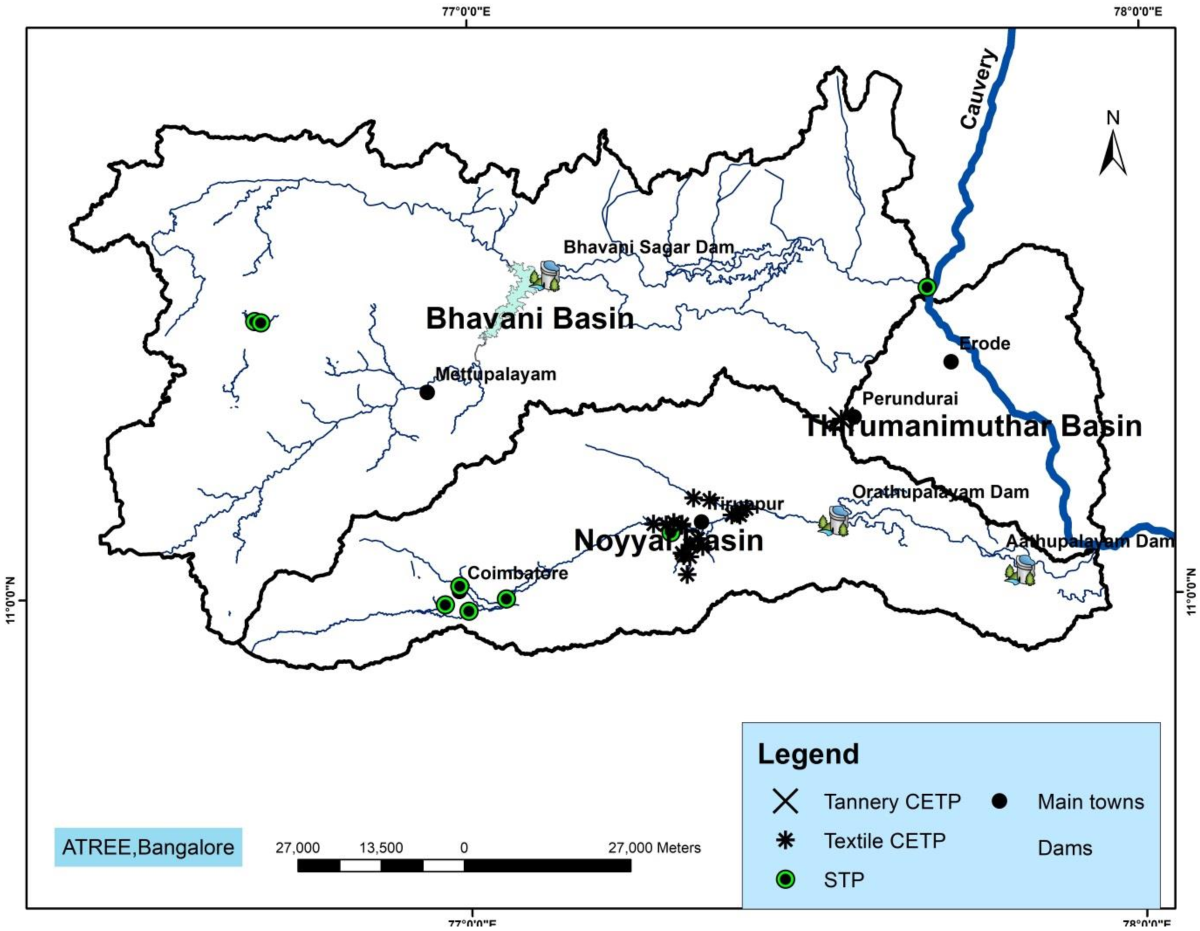


Figure 5.2 Municipal STPs and Textile CETPs

suggest that the situation has not changed significantly in terms of domestic sewage contamination. An assessment of the water quality in four wetlands in Coimbatore in May 2008 indicates varying degrees and causes of pollution (**Table 5.1**). Discharge of domestic sewage, industrial effluents and dumping of municipal solid waste are reported to affect wetland water quality. Elevated BOD levels suggest that all the wetlands suffer from domestic pollution. Additionally, high TDS and chloride levels at Ukkadam may possibly be attributed to textile dyeing and bleaching units adjoining the wetlands (Chandra et al., 2010).

An earlier assessment of the water quality of eight wetlands in Coimbatore (including Ukkadam and Perur) in 1999 showed elevated levels of iron (above drinking water quality standards[6]) in all the eight wetlands. Some of the wetlands exceeded drinking water quality criteria[6] for heavy metals such as nickel, lead, chromium, manganese and cadmium (Mohanraj et al., 2000). The Nanjarayan tank (Koolipalayam reservoir), a wetland on the Nalluru (a tributary of the R. Noyyal) in Tiruppur is also reported to be polluted; the water quality does not meet even Class E irrigation water quality standards[7] (Pranaw et al., 2014).

R. Noyyal

There is a large variation in the concentration of various pollutants in the river. An assessment by the national-level pollution regulatory authority, the Central Pollution Control Board (CPCB) notes that *TDS level in the R. Noyyal was in the range 900–6600 mg/l and chloride concentration was in the range 230–2700 mg/l* (CPCB, 2014).

One assessment by the CPCB indicates pollution of the R. Noyyal around Tiruppur. Elevated levels of TDS and chlorides beyond drinking[6] and irrigation[7] water quality limits were reported at two sampling locations (one before and the other after the CETPs and IETPs along the R. Noyyal). The concentrations of calcium, magnesium, and sulphates were observed to be higher at the upstream location. This has been attributed to either re-suspension of old sediment or discharge of industrial effluents (CPCB, 2014). This study was undertaken at a time when textile dyeing and bleaching industries were mandated to adopt the ZLD technology standard (which is discussed in a subsequent section).

An assessment at Orathupalayam dam on the R. Noyyal is located 32 km downstream of Tiruppur by the CPCB at showed high levels of TDS and chloride concentration in the reservoir. The reservoir was also reported to contain sediments of heavy metals – chromium, copper, zinc and lead (CPCB, 2014). The Orathupalayam dam has been decommissioned. At present, the dam gates are left open and the river water is not stored in the reservoir.

Elunuthimangalam is a long-term water quality monitoring station on the R. Noyyal managed by the Central Water Commission (CWC). The site is downstream of the textile industrial cluster of Tiruppur and the Orathupalayam reservoir (**Figure 5.1**). The average values of water quality parameters monitored at this site (**Table 5.1**) over a ten-year period up to 2011 (CWC, 2011) that have exceeded the Bureau of Indian Standards (BIS) Drinking Water Standards 10500-2012. The average values of other parameters monitored – pH, dissolved oxygen, sulphates, iron and fluoride – were found to be within permissible limits with respect to this standard.

From **Table 5.1**, it is observed that the average EC is high and it exceeds the Indian Standards for drinking water as well as the tolerance limits for irrigation. The high levels of EC reflect high salt concentration in the river, indicating potential chemical contamination by

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[6] BIS Drinking Water Quality Standards IS 10500:2012

[7] IS 2296:1982 Class E – Irrigation Water Quality.

industrial water pollution. Sodium chloride/sodium sulphate is used in the textile dyeing process for the efficient fixing of dyes on the fabric (CPCB, 2014). The high average EC and chloride concentrations in the river at Elunuthimangalam site, downstream of the textile cluster, points towards the discharge of inadequately treated textile dyeing effluents into the R. Noyyal during the period 2001–11.

At the Elunuthimangalam site, the CWC also analyses the water quality for the following heavy metals – arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel and zinc. CWC assessments clearly show the presence of heavy metals in the river, indicating industrial pollution (**Table 5.1).** The concentrations of lead, cadmium and nickel exceed drinking water standards. This is indicative of severe industrial pollution in the R. Noyyal that has adverse implications on different end-uses of water and poses a threat to human health and ecosystem health. According to the recommended limits for reclaimed water for irrigation (Rowe and Abdel-Majid, 1995), the limit for cadmium is 10 μg/l and 50 μg/l for long-term and short-term uses, respectively. Although no limits on magnesium have been established for protection of human or aquatic health, the BIS has recommended a limit for magnesium in the drinking water standard. It is important to note that magnesium is an element used in textile, tanning and paper industries. The presence of textile dyeing industries and the absence of tanning and paper industries upstream of the monitoring site, clearly point towards chemical contamination from textile effluent discharges.

From the water quality data of the R. Noyyal, it can be inferred that the river water pollution continues to pose a threat to ecosystem health, irrigated agriculture and associated livelihoods.

Surface Water Quality in the Bhavani Sub-Basin

Multiple points along the R. Bhavani are regularly monitored by the pollution regulatory authority. Upstream, the Ooty (Udhagamandalam) lake, a protected ecotourism site, is polluted due to inadequately treated sewage. The Pykara lake which is polluted due to the discharge of industrial effluents flows into the R. Moyar and the R. Singara with adverse impacts on public health, ecosystems and hydro-power equipment.

The R. Bhavani has been subject to pollution from various sources, primarily untreated sewage from human settlements. The river and its tributaries also receive industrial effluent discharges deteriorating the river water quality. The R. Kallar is polluted due to discharge of untreated sewage and industrial effluents, and contributes to pollution in the R. Bhavani adversely affecting drinking water quality for downstream urban habitations like Mettupalayam.

Nilgiris Wetlands (upper reaches of Bhavani)

The Ooty (i.e. Udhagamandalam) and the Pykara lakes are important sources of water for the Nilgiris plateau. The Ooty lake is being monitored by the CPCB under the national-level programme Monitoring of Indian Aquatic Resources (MINARS). An analysis of the data from this programme for the period 2007–2014 shows that BOD, and total and faecal coliform concentrations greatly exceed the reference standards (**Table 5.1**). The pollution of the Ooty lake has been reported to be primarily due to inadequate treatment of sewage from Ooty hill-station. The sewage treatment capacity in Ooty town has been reported to be inadequate to meet the present sewage load, and the existing STPs have been reported to be non-compliant on various parameters (WWF, 2017).

The pollution of the Pykara lake has been reported to have severe adverse impacts on the ecosystem in the Nilgiris and Moyar sub-basin. The Pykara lake feeds the R. Moyar and the R. Singara, which flow through ecologically protected areas that include national parks and tiger reserves. The lake itself is located in a sensitive ecosystem that supports biodiversity. The pollution of the Pykara lake has been attributed to industrial effluents discharged from the large Sterling Biotech factory, that manufactures gelatin (WWF, 2017) and has been the focal point of a long-standing environmental movement in the region. The pollution of the R. Moyar has also been reported to have adverse impacts on the associated downstream hydro-power plant pipelines and equipment (Arasu, 2017; WWF, 2017).

Water Quality of the R. Bhavani and its tributaries

The CPCB has identified a 60 km stretch on the R. Bhavani from Sirumugai to Kalingarayan as a polluted river stretch for the restoration of water quality (polluted stretch shown in pink in **Figure 5.1**). This is based on the exceedance of BOD parameter with respect to water quality criteria for 'drinking water source with conventional treatment with respect to BOD'. The average water quality at different points on the R. Bhavani and the Kalingarayan Canal is shown in **Table 5.1** for the year 2018. Data for the years 2015–2017 show higher levels of FC above desirable limits.

Recent water quality assessments in the upper Bhavani sub-basin point towards river pollution due to discharge of untreated domestic sewage and industrial effluents. The Kallar, a tributary of the R. Bhavani is polluted due to discharge of untreated sewage from Coonoor town and industrial effluents from a large cordite factory. The Mettupalayam municipality located downstream receives poor quality water as a result of pollution and restrictions in the flow of the R. Bhavani due to barrages constructed for hydro-power generation (Hindu, 2016; WWF, 2017).

Groundwater Quality in the Noyyal-Bhavani Basin

The groundwater quality is observed to be poor in several parts of the Noyyal and Bhavani sub-basins. Various datasets were analysed to understand the quality of groundwater in different parts of the basin.

The NRDWP includes assessments of the quality of the drinking water source in rural habitations across India. From the NRDWP database, it is observed that groundwater is reported to have hardness and TDS concentrations above permissible limits in several parts of the basin. Groundwater contamination due to nitrates, chlorides, sulphates, fluoride, iron and alkalinity is reported in several wells. Microbial contamination is also reported. **Figure 5.3** shows the four blocks where more than 10% of the groundwater samples tested under the NRDWP exceed permissible limits on one or more of the above-mentioned water quality parameters during the period 2007–2014.

An analysis of the groundwater quality data maintained by the State Ground and Surface Water Resources Data Centre, Tamil Nadu for the parts of Coimbatore, Tiruppur and Erode districts within the basin in 2016 shows that the mean values of TDS, hardness and magnesium are above the acceptable limits for drinking water (**Table 5.2**; *Data Source A*). Elevated levels of sulphates and chlorides were observed in some of the sample wells. High concentration of fluorides above acceptable limits was detected in 10% of the total sample. This was observed predominantly in Mettupalayam and Avinashi regions.

The average groundwater quality for the samples within the Noyyal-Bhavani sub-basins in the districts of Coimbatore, Tiruppur, Erode and Nilgiris is shown in **Table 5.2**; *Data Source B*. The average values are based on the CGWB's analysis of groundwater samples collected in the district in May 2016. The spatial distribution of the sample wells in shown in **Appendix F**. The wells that exceed drinking water limits and those that are within acceptable and maximum permissible drinking water limits[12] are shown.

The groundwater quality observations indicate severe industrial pollution and pollution from sewage/on-site sanitation and agro-chemical run-off.

Key Issues related to Water Quality in the Noyyal-Bhavani River Basin

The problem of water pollution in the Noyyal-Bhavani basin is complex and multi-dimensional. Four key issues related to water quality management emerged as important from key informant interviews.

Incomplete Monitoring of Zero Liquid Discharge

One of the biggest successes from the law suits in the Noyyal sub-basin was the implementation of ZLD. Unfortunately, in the absence of long-term water quality data, we were unable to conclusively assess if ZLD has made a difference. From key informant interviews, it appears that larger units have been able to invest in improved technologies and comply. But anecdotal evidence points to continuing illegal night-time discharges of effluents into sewers by smaller units. Furthermore, many units have simply relocated to outside the basin, sometimes just to neighbouring districts.

Illegal Discharges to Groundwater

One concern that emerged from interviews and field observations was that textile units might have begun injecting effluents into groundwater. The elevated

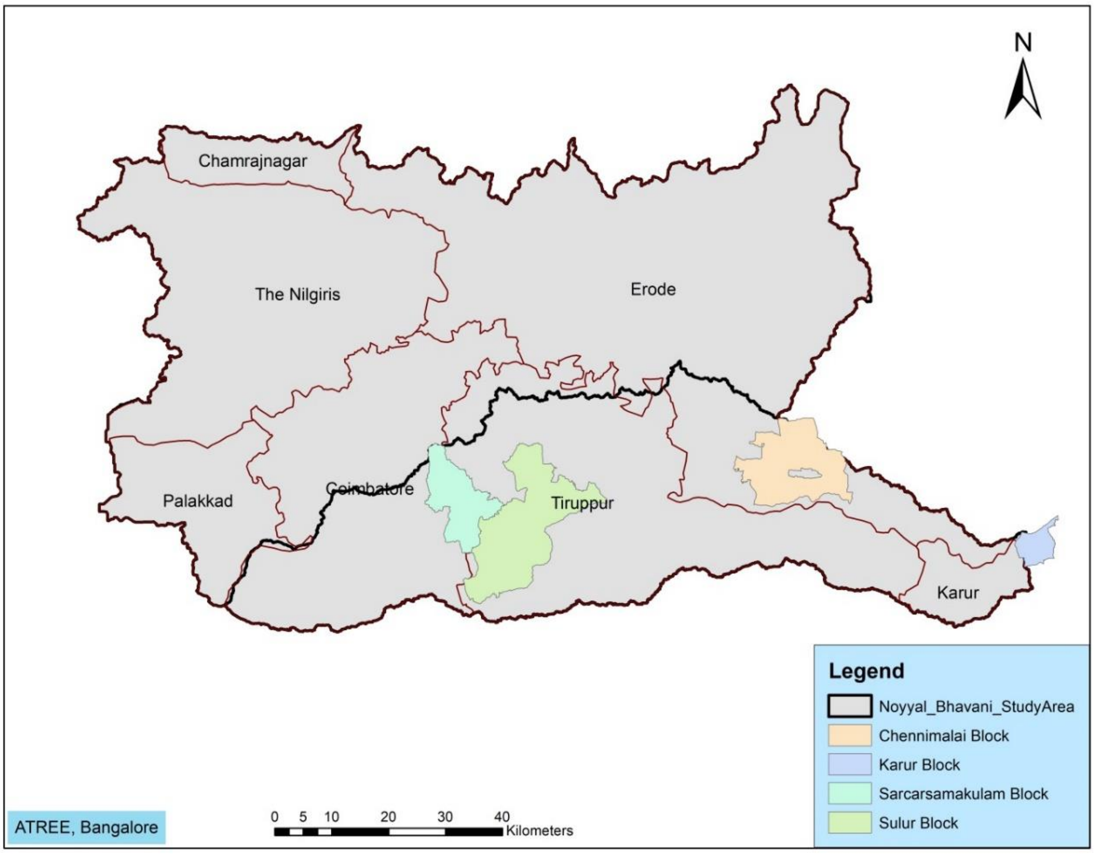

Figure 5.3. Contaminated Groundwater Blocks Observed from NRDWP Database (2007-2014).

EC levels in groundwater in the Tiruppur district, corroborate this. However, in the absence of systematic plume mapping, it is virtually impossible to understand the extent of such violations.

Inadequate Planning/Enforcement of Textile Sludge Disposal

The implementation of ZLD technology in the textile wet-processing units is anecdotally reported to result in reuse of treated wastewater up to 85–90% with freshwater only required as make-up water. The ZLD process also generates textile sludge that is hazardous in nature and requires safe handling and management.

Initially, the textile sludge was required to be stored at the textile units. Later, the dry sludge was permitted to be sent for use as fuel in the cement industry (Grönwall and Jonsson, 2017b). It is reported that earlier textile sludge was also being disposed on land (Srinivasan et al., 2014).

Costs of Upgradation

The upgradation of effluent treatment technology including ZLD and associated processes involves large capital investments. As the textile dyeing and bleaching facilities in the Noyyal-Bhavani basin are small-scale units, they lack the ability to invest in expensive treatment processes. Further, given the competitive nature of the global textile market, they are under constant pressure to reduce their costs of production. Further, based on the estimation of the LOEA, the compensation to be paid to downstream pollution-affected farmers was collected by the textile units.

In this context, CETPs were setup with financial support from the Tamil Nadu state government for collective treatment and management of effluents from the small textile wet-processing units. At present, there are 18 textile CETPs in the basin. However, the twin pressures of adhering to adequate effluent treatment as well as competing in the global textile market is borne entirely by the small and medium textile wet-processing units in the basin. The textile supply chain up to the end consumer is largely insulated from the externalities involved in the manufacture of textiles on the environment, health and livelihoods of people residing in the river basin.

Basin Context Metrics: Water Quality

Water quality is an important theme related to water management in the Noyyal-Bhavani river basin. The basin context metrics, present state and desired end state for water quality are described in **Table 5.3**.

Table 5.1. Surface Water Quality.

Location	Period	pH	EC (µS/cm)	DO (mg/l)	BOD (mg/l)	COD (mg/l)	TDS (mg/l)	FC (MPN/ 100 ml)	Chloride (mg/l)	Sulphate (mg/l)	Magnesium (mg/l)	Heavy Metals (µg/l)
NOYYAL SUB-BASIN												
Coimbatore Wetlands												
Ukkadam lake	< 2011	**8.62**	**4457**	5.26	2.1	430	2079		**964**	103		
Perur lake		7.88	304	5.56	**4.51**	217	169		76	9.27		
Kurichi lake		7.64	689	**4.21**	**4.96**	300	373		99	27		
Chinnakulam lake		7.73	402	5.26	**5.26**	60	208		71	26		
Orathupalayam Reservoir	> 2011						**4250 – 7900**		**1600 – 2700**			
Elunuthimangalam (site on R. Noyyal)	< 2011		**5256**		**3.1**				**1416**		**104.7**	
	> 2011	-	-	-	2.1– **6.1**	-	-		-	-	-	**Lead (76.5) Cadmium (15.9) Nickel (21.4)**
Reference Standards		6–8.5#	2250#	≥5&	≤3&		2100#	2500&+	600#	1000#	100%	Lead% (10) Cadmium% (3) Nickel% (20)
BHAVANI SUB-BASIN												
Nilgiris Wetlands												
Udhagamandalam lake	2018	6.92	439	**4.77**	**6.8**	43.3	318	1083	53.7	17.1	9.3	-
R. Bhavani sites												
Badrakaliamman koil	2018			7.22	1.05			82				
Sirumugai				7.15	0.98			101				
Bhavanisagar				6.88	1.92			104				
Bhavani				6.13	1.76			346				
Sathyamangalam				6.93	1.56			121				
Kalingarayan Canal (B5)				6.37	1.29			191				
Kalingarayan Canal (B10)				6.44	1.21			210				

Note: DO, BOD, COD, TDS and FC refer to Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Total Dissolved Solids and Faecal Coliforms respectively.
 # Tolerance limits specified under IS 2296:1982 for Class E – Irrigation
& Tolerance limits specified under IS 2296:1982 for Class B – Outdoor Bathing, + Desirable limit is 500 MPN/100ml, maximum permissible limit is 2500 MPN/ 100ml.
% BIS Drinking Water Standard IS 10500: 2012

Table 5.2. District-Level Average Groundwater Quality for 2016.

	Water Quality Parameters	Data Source	N	EC (µS/cm)	TDS (mg/l)	TH (mg/l)	Ca (mg/l)	Mg (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	F^- (mg/l)	NO_3^- (mg/l)	NO_2^- $+NO_3^-$ (mg/l)
BIS Drinking Water Standard[8]	**Acceptable limit**			750	500	200	75	30	250	200	1.0	45	45
	Permissible limit[9]			3000	2000	600	200	100	1000	400	1.5	45	45
Basin Districts	**Coimbatore**	A	27	-	993	455	46	83	312	167	0.4	-	16
		B	13	2240		**635**	94		414	86	0.7	**68**	
	Tiruppur	A	23	-	1290	492	43	93	400	213	0.45	-	28
		B	8	**3618**		**610**	74		694	175	1.05	**68**	
	Erode	A	33	-	881	436	40	82	274	136	0.43	-	23
		B	15	2217		532	92		251	350	1.0	30	
	The Nilgiris	B	4	397		130	46		58	5.3	0.3	**54**	

Note: *EC, TDS, TH, Ca, Mg, Cl^-, SO_4^{2-}, F^-, NO_3^- and $NO_2^-+NO_3^-$ refer to electrical conductivity, total dissolved solids, total hardness, calcium, magnesium, chlorides, sulphates, fluorides, nitrates, nitrites + nitrates, respectively.*

[8] Indian Drinking Water Specification IS 10500:2012 by Bureau of Indian Standards (BIS).
[9] Permissible limit in the absence of alternate source.

Table 5.3. Basin Context Metrics —Water Quality.

Basin Context Metric	Current State	Desired End State
Water quality indicators for R. Noyyal (indicative minimum set of parameters**)	Water quality assessment by the CPCB (as of 2014) indicates that the river water has not been suitable for drinking, fisheries, bathing and irrigation uses. Only a small segment of the river in its upper reaches is non-polluted.	Designated best use of surface water bodies to be determined through public consultations. Desirable: River water quality to meet at least bathing water quality standards.
Water quality indicators for R. Bhavani (indicative minimum set of parameters **)	Water quality in sections of the river has not been suitable for drinking, and bathing uses. The river stretch from Sirumugai to Kalingarayan identified as a "polluted river stretch for restoration of water quality" by the CPCB. Recent water quality assessment by the CPCB (as of 2018) for the identified 60 km stretch indicates that the quality meets outdoor bathing standards.	Bathing water quality standards
Water quality indicators for wetlands (indicative minimum set of parameters **)	Water quality of some of the wetlands in the basin does not meet outdoor bathing or irrigation water quality standards.	Bathing water quality standards
Water quality indicators: groundwater (indicative minimum set of parameters++)	Groundwater quality is not suitable for drinking in several areas in the basin. Contamination due to nitrates, sulphates, chlorides and high TDS levels indicated by secondary data sources (as of 2016). 71% of the groundwater samples (July 2016) meet drinking water quality standards overall in basin districts of Coimbatore, Tiruppur and Erode (N = 83).	Drinking water quality standards
Management of sewage	All the sewage generated in the basin is not treated; untreated sewage is discharged into surface water bodies.	Treatment of all generated sewage. Reuse for commercial and industrial purposes wherever possible.
Management of faecal sludge	Effective management of faecal sludge from on-site sanitation systems in a safe manner encompassing the full chain (collection, transportation, treatment and disposal/reuse) is still in a nascent stage in Tamil Nadu. The Operative Guidelines for Septage Management for Local Bodies in Tamil Nadu (2014) is applicable for the basin.	Effective faecal sludge/septage management for on-site sanitation systems in the basin.

Management of industrial effluents	The ZLD rule is applicable to textile dyeing and bleaching facilities and leather tanning facilities. All other industries are required to discharge their treated effluents on land/into water body as per relevant regulations. Incomplete treatment and illegal night-time effluent discharges reported in the basin. Data gap on extent of effluent treatment within the basin.	Treatment of all generated industrial effluents. Reuse within processes wherever possible. Where legally permitted, discharge of treated effluents on land/into water body.
Recycling of treated wastewater	Reuse and recycling of sewage is not practised by the towns in the basin. Textile wet-processing industries with ZLD technology may reuse up to 90% of their treated effluents. Status of implementation of ZLD is not clear.	For urban settlements, 20% reuse and recycling of sewage is the Service Level Benchmark for ULBs. For textile wet-processing facilities in the basin, ZLD is applicable (i.e. ~95% recycling and reuse).
Biological treatment capacity in the basin relative to wastewater generated (quantitative: ratio)	The sewage treatment capacity in the basin is ~200 MLD. Sewage generation in the basin is not assessed.	1:1 ratio
Chemical treatment capacity in the basin relative to wastewater generated (quantitative: ratio)	Data on effluent generation and effluent treatment capacity in the basin is incomplete. Textile effluent treatment capacity of the CETPs in the basin is ~95 MLD.	1:1 ratio

** *pH, DO, EC, total oxidised nitrogen, orthophosphate, FC, BOD, COD, chlorides, sulphates, calcium, magnesium + heavy metals.*

++ *pH, EC, nitrates, chlorides, sulphates, fluorides, calcium and magnesium.*

Chapter 6 Water-Ecosystem Impacts

Key Challenges

- **Maintenance of adequate environmental flows** in the R. Bhavani is challenged by hydro-power diversions and water allocations to different sectors.
- **Wetlands and rivers in the basin are threatened by pollution** due to sewage and industrial effluents adversely impacting their ecosystem services.

The linkages between water and the ecosystem are important in the Noyyal-Bhavani basin. The upper Bhavani sub-basin that includes the Moyar and the upper Bhavani catchments has an agriculture–forest socio-ecological system that has been witness to significant land use changes including deforestation and degradation (Revi et al., 2015). Mountain springs in the upper catchments are reported to be drying. They contribute to the headwaters of the R. Bhavani, the R. Noyyal and some of the tributaries. The maintenance of adequate environmental flows is one of the challenges highlighted in this chapter. The prevention of pollution of wetlands in the basin is another important challenge related to water-ecosystem impacts.

Water–Ecosystem-related Challenges in the Noyyal-Bhavani River Basin

Maintenance of Adequate Environmental Flows in the Rivers

The National Water Policy, 2012 recognises that "*water is essential for sustenance of eco-system, and therefore, minimum ecological needs should be given due consideration*". It mentions that the flow releases should be proportional to the natural flow regime including groundwater linked base flow contribution in the low flow season (NWP, 2012). In Tamil Nadu, the State Water Policy, 1994 does not recognise environmental flows, while the recent Tamil Nadu State Environment Policy, 2017 mentions accounting for required ecological flows within integrated water resource management.

However, the concept of environmental flows has mainly remained on paper with limited implementation in practice. In India, recently the Union Government has issued an order[10] for the maintenance of uninterrupted flows in the longest river, the Ganga and its tributaries. However, this order is restricted to only the afore-mentioned rivers. For the river Cauvery, a minimum of 10 TMC of water (out of 740 TMC) has been reserved for environmental protection (SC, 2018). For the R. Noyyal and the R. Bhavani, which are tributaries of the R. Cauvery, there are no separate specifications or safeguards for environmental flows.

Environmental Flows in the Bhavani Sub-basin

The upper Bhavani and the Moyar sub-basins are dotted with numerous hydro-power dams (**Figure 6.1**). Diversion of river water for hydro-power generation and regulated releases limits environmental flows in the R. Bhavani in its

[10] River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016.

upper stretches. Inadequate environmental flows are also reported to have adverse impacts on wildlife in the forests and ecologically-sensitive areas in the upper Bhavani and Moyar catchments.

In the near future, the river water flows in the upper Bhavani catchment will also be regulated between the Avalanche-Emerald reservoirs and the Porthimund reservoir through the upcoming Kundah pumped storage hydro-electric project (of capacity 500 MW). This will further control the storage and flows in the river between the two reservoirs.

There are two barrages on the R. Bhavani for hydro-power generation (10 MW capacity each), one upstream and the other downstream of Mettupalayam town. The release of untreated or inadequately treated sewage from towns such as Mettupalayam along the R. Bhavani adversely affects the quality of the river water. The presence of the downstream barrage near Mettupalayam is reported to compound the problem by restricting flows in the river (ToI, 2017).

In its middle reaches, the R. Bhavani is impounded by a large multi-purpose dam, the Bhavanisagar, which supplies water for domestic use, limited hydro-power generation, irrigation, and industrial use (mainly for the textile industry) in both the Noyyal and the Bhavani sub-basins. The flows in the R. Bhavani downstream of the dam are highly reduced and fragmented due to diversion of water into the traditional Kodiveri irrigation canals and the Lower Bhavani irrigation canals. Ecosystem needs is given lower priority at this juncture as water is allocated to different users to meet the increasing water demand. An earlier study had reported the Bhavani sub-basin to be a closed basin (Lannerstad and David, 2009).

The upper Bhavani catchments are also characterised by the presence of areas under exotic tree-species such eucalyptus and wattle wood that have replaced significant areas under the native shola

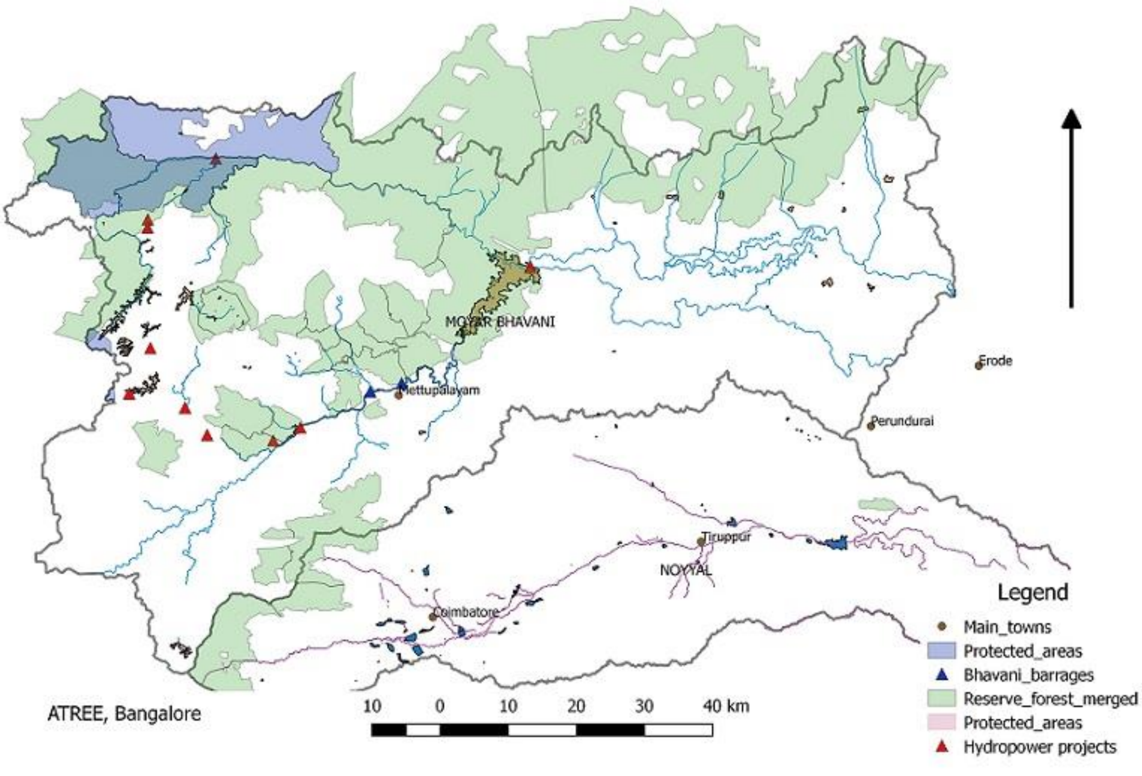

Figure 6.1. Hydro-power projects in the Bhavani sub-basin.

forests. The introduction of these tree plantations along with other land use changes in the Nilgiris over several decades is reported to have adversely affected the hydrology of the catchments (Keystone, 2002).

Environmental Flows in the Noyyal Sub-basin

As the R. Noyyal is seasonal in nature, most of its freshwater flows are during seasons of rainfall. For the rest of the year, the flows in the river are primarily return flows from the settlements along its course. As the wastewater treatment capacity of the settlements is inadequate, untreated sewage is discharged into the river from urban settlements especially the larger cities of Coimbatore and Tiruppur. Much of the wastewater flows in the Noyyal are essentially from the surface water imports from the R. Bhavani to meet the domestic and industrial needs of the Noyyal sub-basin users. Therefore, there is no clear consensus on the concept of environmental flows for the R. Noyyal.

There are several check dams on the R. Noyyal, constructed and maintained by the state government for enhancing groundwater recharge. The check dams also impact continuity in the flows of the river.

The industrial water pollution in the R. Noyyal primarily due to the textile wet-processing units has adversely affected its ecological health. Anecdotal evidence points out that despite the ZLD rule for the textile dyeing and bleaching units in Tiruppur, the problem still persists through illegal effluent discharges into the river.

Maintenance of Wetlands Health and Ecosystem Services in the Basin

India is a signatory to the Ramsar Convention on Wetlands and has designated 27 sites as wetlands of international importance across the country. There is no Ramsar designated site in the Noyyal-Bhavani basin. The Wetlands (Conservation and Management) Rules, 2017 recognises the Ramsar sites and wetlands notified by the Union or State governments for their conservation and management based on the concept of 'wise use'. The rules prohibit several activities such as encroachments, discharge of untreated sewage and industrial effluents, solid waste dumping, etc.

In December 2018, the Tamil Nadu state government constituted the Wetlands Authority of Tamil Nadu to implement these rules in the state (Hindu, 2018a). It is reported that more than 100 wetlands in the state will be notified soon to be prioritised for conservation (ToI, 2018a). The state has also constituted District-level Wetland Management Committees for the management of wetlands over smaller administrative boundaries as well as to provide support to the state wetlands authority.

In the Noyyal sub-basin, 30 system tanks had been constructed historically for flood control and irrigation. The R. Noyyal, being seasonal, had been described to be prone to floods during heavy rains in its upper catchments. The system tanks are connected to each other and the river to help buffer the flood waters. There are also several water bodies that were earlier designed as irrigation tanks. Although tank-based irrigation is not presently practised in the sub-basin, the tanks provide various ecosystem services as wetlands in the region. As the R. Noyyal flows through Coimbatore city, some of the wetlands are located within the present-day city boundary. Encroachments, pollution due to sewage and industrial effluents, eutrophication and dumping of solid waste are some of the key factors adversely affecting the health of these urban wetlands.

Multiple studies have described the biodiversity and water quality associated with one or more of the wetlands in Coimbatore and this has been documented by Pragatheesh and Jain (2013), Quadros et al., (2014). The status of water quality in the wetlands has been described in **Chapter 5** on Water Quality. Fish kills have been reported in some of the wetlands in the region, indicating water contamination (Hindu, 2018b; ToI, 2018b).

In the upper Bhavani sub-basin, the Ooty and the Pykara lakes are wetlands threatened by pollution from sewage and industrial effluents, respectively. The pollution of the Pykara lake is reported to adversely impact the biodiversity and sensitive ecosystem in the region as well as the quality of the R. Moyar and R. Singara which the lake feeds into (WWF, 2017).

Basin Context Metrics: Water – Ecosystem Impacts

The basin context metrics related to water-ecosystem impacts are described in **Table 6.1.** The present state of the wetlands and river flows in the basin and the desired end state are noted for each metric.

Table 6.1. Basin Context Metrics—Water–Ecosystem Impacts.

Water-related Challenges	Basin Context Metric	Current State	Desired End State
Maintenance of adequate environmental flows in the R. Bhavani is challenged by hydro-power diversions and water allocations to different sectors.	Presence of flows at different locations along the R. Bhavani through different seasons of the year.	Hydro-power, irrigation diversions from the R. Bhavani affects the quantum and contiguity of its flows. River water exports to the Noyyal sub-basin for domestic, industrial and irrigation use limits downstream flows. *Detailed water accounting in the basin and analysis of flow records would help understand present flow regime of the river.*	Adequate quantity and contiguity in flows in the R. Bhavani.
	Water quality (EC, DO, BOD, FC) at different locations along the R. Bhavani and its tributaries through different seasons of the year.	R. Bhavani and its tributaries are subject to pollution from sewage, industrial effluents and chemicals from agricultural run-off. A 60 km stretch of the R. Bhavani has been categorised as 'polluted river stretch for restoration of water quality' by the CPCB. Recent water quality assessment by the CPCB (as of 2018) for the identified 60 km stretch indicates that the quality meets outdoor bathing standards.	Designated best use of the river to be determined through public consultations. Desirable: River water quality to meet at least bathing standards (CPCB Class B).
	Water quality (EC, DO, BOD, FC) at different locations along the R. Noyyal through different seasons of the year.	Water quality assessment by the CPCB (as of 2014) indicates that the river water has not been suitable for drinking, fisheries, bathing and irrigation uses. Only a small segment of the river in its upper reaches is non-polluted.	Bathing standards (CPCB Class B).
Wetlands in the basin are threatened by pollution due to sewage and industrial effluents adversely impacting their ecosystem services.	Water quality in the notified wetlands in the basin. Parameters to include at least pH, EC, BO, BOD, nitrates, and ortho-phosphates.	Some of the wetlands in the Noyyal and upper Bhavani sub-basins are adversely affected by water pollution. Various studies have documented the water quality parameters of the wetlands.	Quality of water of the wetlands to support their ecosystem services. Restoration of polluted wetlands. Designated best use of the wetlands to be determined through public consultations.
	Biodiversity in the notified wetlands in the basin: migratory birds, fish species, benthos.	Various studies have documented the biodiversity of specific wetlands in the basin. Long-term monitoring of the wetlands in the basin can help understand changes in biodiversity linked to the wetlands.	Management of wetlands to support their biodiversity and restoration of degraded wetlands.

Chapter 7 Water-Crisis Preparedness

Key Challenges

- **Regular occurrence of droughts in parts of the basin** adversely impacts domestic water availability and agricultural livelihoods.

In the Noyyal-Bhavani basin, water-related crisis and associated preparedness is discussed in relation to the occurrence of droughts and floods. A short note on other water-related risks is also included.

In India, the Disaster Management Act, 2005 is the key legislation that outlines actions for the effective management of disasters. India is a signatory to the Sendai Framework for Disaster Risk Reduction 2015–2030 and has created a National Disaster Management Plan aligned with the framework. The Tamil Nadu State Disaster Management Authority (TNSDMA), constituted under the Disaster Management Act (2005) is responsible for coordinating mitigation, preparedness, response and recovery measures in the state. The disaster governance structure extends to the district-level through the District Disaster Management Authorities and other existing institutions. The State and District-level Disaster Management Plans provide specific guidance related to the management of disasters. The Tamil Nadu State Disaster Management Perspective Plan (2018–2030) is reported to be aligned with the Sendai Framework for Disaster Risk Reduction. It clearly lays down the roles and responsibilities of different state agencies to act during disasters.

The disaster-preparedness measures include Hazard and Vulnerability Risk Analysis, which is reported to be under assessment for different districts and river basins in the state (TN-SDMP, 2018). Early warning systems, risk communication, public education and training of community volunteers as first responders are other preparedness measures specified.

With respect to climate change, India is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and has ratified the Kyoto Protocol and the Paris Agreement. The National Action Plan for Climate Change has been created to mitigate and adapt to climate change. The Tamil Nadu state government has created its State Action Plan for Climate Change which discusses state-level climate projections and water sector interventions for different geographical zones in the state (GoTN, n.d.).

Droughts in the Noyyal-Bhavani Sub-Basins

The state of Tamil Nadu is subject to droughts periodically due to insufficient rainfall from the South-West and North-East monsoons. The rainfall variability in the state during the period 2003–17 is shown in **Figure 7.1**.[11]. In the Noyyal-Bhavani basin, parts of Coimbatore and Tiruppur districts have been identified to be drought-prone areas by the government (refer **Figure 4.2** in **Chapter 4**). It is important to note that these areas in the basin are also groundwater stressed (refer **Figure 4.3** in **Chapter 4**).

[11] Data Source: Statistical Hand Book 2018 – Climate and Rainfall; Government of Tamil Nadu

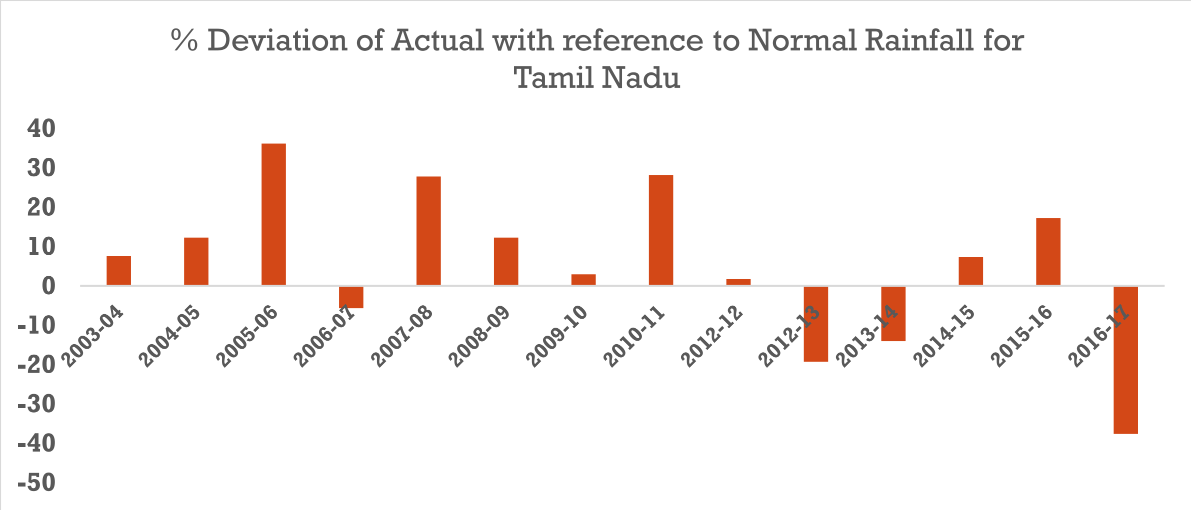

Figure 7.1. Rainfall Variability in Tamil Nadu.

In the basin districts of Coimbatore, Tiruppur and Erode, 66% of the net sown area is irrigated[12] while the rest depends entirely on rainfall. The occurrence of droughts impacts the most those areas dependent only on rainfall for cultivation. The irrigated areas in these basin districts are primarily dependent on groundwater resources (85%[1]), from bore wells and open wells. The high dependence on groundwater coupled with groundwater stress in the region reduces basin water security, especially in the Noyyal sub-basin. Although groundwater can serve as a buffer during periods of drought, its over-exploitation increases the region's vulnerability.

During droughts, the shortfall in water stored in the Bhavanisagar reservoir affects water availability for domestic, irrigation and industrial use in both the sub-basins. Water scarcity limits the frequency of intermittent supply and the quantity of water supplied for domestic use.

Coimbatore city that imports a part of its domestic water from the Siruvani reservoir located outside the basin (in the state of Kerala) witnessed complete stoppage of water supply from the reservoir in January 2017 (Gautham, 2017). The supply shutdown was reported to have occurred for the first time from this reservoir; as a consequence of the severe drought during 2016–17.

Drought-Preparedness

Examples of mitigation measures for both flood- and drought-preparedness include desilting of tanks (to enhance their storage capacity) and removal of encroachments along rivers and storm-water drains (to ensure free flow of water).

Drought-preparedness measures are primarily oriented towards enhancing the storage capacity of surface water bodies such as tanks and reservoirs and augmenting groundwater recharge. A recent order by the Tamil Nadu state government permits farmers, clay potters and the general public to quarry clay, silt and gravel from the beds of tanks, channels and reservoirs (that are under the control of the state) with prior permission for agricultural, pottery and domestic use purposes, respectively (GoTN, 2017). This order is in response to the severe drought witnessed by the state in 2016-17 (TN-SDMP, 2018).

Watershed management projects are also being implemented to facilitate groundwater recharge and improve the resilience of rainfed agriculture.

[12] Data Source: Statistical Hand Book 2018 – Irrigation; Government of Tamil Nadu

Measures that control water demand are advised during periods of drought periods. District Agricultural Contingency Plans (DACPs) [13] provide guidance for the relevant government departments and farmers on the measures to be taken during weather aberrations such as droughts, floods, cyclones, etc. They are targeted towards the agriculture and allied sectors such as horticulture, livestock, poultry and fisheries. The Coimbatore district DACP[14] has provided detailed guidance on crop choice, crop timing and soil management during periods of droughts.

Floods in the Noyyal-Bhavani Sub-Basins

The rivers Noyyal and the Bhavani are subject to flash floods during periods of heavy rainfall. While the seasonal R. Noyyal has no operational reservoir along its course at present (Orathupalayam dam is decommissioned), the R. Bhavani and the R. Moyar are impounded by the large Bhavanisagar reservoir in its middle reaches. There are several hydro-power dams in the upper reaches of the R. Bhavani.

Historically, the R. Noyyal has been reported to have had episodes of sudden flooding during heavy rain events as a result of which system tanks had been constructed along the river for flood control (Quadros et al., 2014). The system tanks were the earliest attempts at managing flash floods in the R. Noyyal. A note from a manual of the Coimbatore district dated 1887 provides the following description (Nicholson, 1887) -

"It is little more than a jungle stream, being dry for many months together, and then in high and rapid flood for days: this alternation has always been its characteristic, the old reports continually alluding to its fitfulness and uncertainty".

At present, the R. Noyyal has flows throughout the year, especially downstream of the cities of Coimbatore and Tiruppur due to the release of treated and untreated wastewater along its course. Flash floods in the R. Noyyal and its tributary Nalluru have been reported in the recent past during periods of heavy rainfall in the catchments. The impacts are restricted to people residing close to the river banks.

In the Bhavani sub-basin as well, flash floods occur in the upper catchments of the rivers Bhavani, Moyar and their tributaries.

Flood-Preparedness

The forecasting of floods in the country is carried out by the CWC. It issues daily flood bulletins to all the relevant government agencies during the monsoon season. The government machinery at the state and district levels have adequate flood-preparedness and flood relief measures, including flood warnings and evacuation measures.

DACPs provide guidance for the relevant government departments and farmers on the measures to be taken and altered during weather aberrations such as droughts, floods, cyclones, etc. They are targeted towards the agriculture and allied sectors such as horticulture, livestock, poultry and fisheries. The Coimbatore district DACP has focussed mainly on droughts and not included specific management guidance for floods most likely because occasional flash floods are not seen as a significant challenge in the district.

In the Bhavani sub-basin, the CWC monitors the water levels in the Bhavanisagar reservoir in order to inform water releases from the reservoir. As the upper catchments of the Bhavani sub-basin receive very heavy rainfall and have

[13] DACPs have been prepared by the Central Research Institute for Dryland Agriculture (CRIDA) of the Indian Council for Agricultural Research (ICAR).
[14] The DACPs for the other basin districts were not available online.

several dams, they are monitored during the monsoon seasons.

Other Water-related Risks in the Noyyal-Bhavani Sub-Basins

Assessment of climate change and water interactions are complex especially in urbanising sub-basins (such as the Noyyal) in developing country contexts where there are multiple stressors that operate simultaneously and various normative goals that are yet to be met (Lele et al., 2018b).

Downscaled climate model information is too coarse for local decision-making; other drivers such as ecosystem degradation and land use land cover change require consideration in addition to climatic drivers. In the Moyar-Bhavani sub-region, a decrease in area under forests and water bodies and an increase in area under agriculture and settlements have been reported over the period 1999-2011. For the broader landscape that includes the Moyar-Bhavani sub-region, an assessment of historical climate change trends showed an increasing trend in temperature over the past 50 years and a significant decrease in average annual rainfall since the 1950s (Revi et al., 2015).

The Nilgiris district in the Bhavani sub-basin is highly susceptible to landslides during seasonal rains. As per the landslide hazard zonation atlas of India, the Nilgiris district has been categorised as one of the severe to very high landslide prone areas of India (TN-SDMP, 2018). Rainfall is reported to be the main trigger for landslides in the district (Chandrasekaran et al., 2019). Deforestation, plantations, and blocks in the surface drainage systems are reported to be some of the causal factors exacerbating these landslides (Chandrasekaran et al., 2019; Vasantha Kumar and Bhagavanulu, 2008). Landslide aspects in the Nilgiris district are reported to have been assessed leading to identification of vulnerable watersheds (TN-SDMP, 2018).

The Nilgiris and Coimbatore districts in the Noyyal-Bhavani sub-basins are classified within Zone III under moderate seismic risk (up to a magnitude of 6.9) as per the seismic zoning map of the BIS (TN-SDMP, 2018).

Basin Context Metrics: Water-Crisis Preparedness

The basin context metric related to water-crisis preparedness is noted in **Table 7.1.**

Table 7.1. Basin Context Metrics—Water-Crisis Preparedness.

Water-related Challenges	Basin Context Metric	Current State	Desired End State
Regular occurrence of droughts in parts of the basin adversely impacts domestic water availability and agricultural livelihoods	Frequency of occurrence of droughts over a ten-year period	Not characterised	Cannot be defined

Chapter 8 Water Governance

Key Challenges

- **Lack of river basin planning** and management coupled with fragmented governance of water resources adversely affects basin water security and fair water allocations.
- **Groundwater regulation and management is weak**, with adverse impacts on the health of aquifers.
- **Prevention and regulation of surface and groundwater pollution** due to the discharge of inadequately treated industrial effluents and domestic sewage.

The challenges in water governance in the Noyyal-Bhavani river basin are both contextual as well as indicative of the larger challenges in water governance in India. Three important challenges related to water governance in the basin are discussed in this chapter. The critical challenge of pollution prevention and regulation in the basin is closely related to the challenge and key issues related to water quality as discussed in **Chapter 5**.

Water Governance-related Challenges

Lack of River Basin Planning & Fragmentation in Governance

There is no river basin institution at the Noyyal-Bhavani basin scale that plans and informs decision-making on water allocations to different users in a fair and transparent manner. As the Noyyal-Bhavani is a part of the larger Cauvery river basin, the formation of a river basin institution at the larger basin scale had been a contentious matter embedded in the long-standing inter-state water conflict between the upper riparian state of Karnataka and the lower riparian state of Tamil Nadu. In 2018, the Cauvery Water Management Authority (CWMA) was constituted to monitor and regulate the sharing of the R. Cauvery water among the riparian states. However, CWMA is not represented by diverse stakeholders representing different water sectoral users in the basin and has limited powers related to basin-level water planning and policy.

The Tamil Nadu state government issued its State Water Policy in 1994 and to our knowledge; this has not been revised and updated till date. The State Water Policy, 1994 recognises the river basin as the unit for planning. However, translation of this policy guideline into practice has been limited.

Although there have been attempts at river basin planning and management in some basins in Tamil Nadu, the initiatives have not sustained. In the early 2000s, the government of Tamil Nadu issued orders[15] for river basin management in two basins – the Palar basin and the Tambaraparani basin – by the constitution of River Basin Management and Development Boards. This was an initiative under the Tamil Nadu Water Resources Consolidation Project. In case of the Palar river basin, one multi-stakeholder workshop on water management in the basin had also been convened and a set of rules called the Palar Basin Rules had been drafted.

In another initiative, The Tamil Nadu government has embarked on a project to improve water management by the agricultural sector through a river sub-basin assessment approach. The Tamil Nadu Irrigated Agriculture Modernization

[15] Government Order No. 31, Public Works (W2) Department, Government of Tamil Nadu, dated 12 January 2001.

and Water-Bodies Restoration and Management (TN-IAMWARM) project intends to enhance the productivity and climate resilience of irrigated agriculture, improve water management practices and support agriculture and allied sectors. The project involves the co-ordination of multiple government departments and attempts to deploy a multi-disciplinary approach that incorporates an environmental and social assessment and management plans at the sub-basin scale. It also provides a platform for stakeholder consultations. The project scope includes the upper Bhavani sub-basin and the Thirumanimuthar sub-basin (that is adjacent to the Noyyal-Bhavani river basin in Erode district) and its duration is 2017–2025 (WAPCOS, 2017).

There are multiple institutions involved in water resources management in the Noyyal-Bhavani river basin such as,

- the state water resources institutions,
- the domestic water supply institutions,
- the state electricity board which plays a critical role vis-à-vis hydro-power generation as well as electricity provisioning for groundwater abstraction,
- the state and regional pollution regulatory authorities,
- the state and regional agriculture institutions, agriculture universities and extension centres.

At present, there is no mechanism for co-ordinated planning and management of water resources across sectors, i.e., bringing together the state institutions and private actors from the agricultural and industrial sectors as well as citizens. Platforms for stakeholder consultation and engagement are either limited or non-existent.

Weak Groundwater Regulation and Management

At present, there is no groundwater management law in the state of Tamil Nadu. The Union Government had enacted the Model Groundwater (Sustainable Management) Act in 2016. As water is a state subject, each of the states needs to separately enact groundwater laws applicable to them. The Tamil Nadu state government has not yet enacted a law based on the framework of the Model Groundwater Act of 2016 passed by the Government of India.

The earlier Tamil Nadu Groundwater (Development and Management) Act, 2003 was repealed in 2013. This Act had provided for the state government to establish a new institution called the Tamil Nadu Groundwater Authority with the powers to notify areas for the development, control and regulation of groundwater. Until the establishment of such an authority, in 2006 the state government had empowered an existing institution—the State Ground and Surface Water Resources Data Centre (SG&SWRDC)—to issue groundwater permits (No Objection Clearance) to industries.

Despite the repeal of the Groundwater Act, 2003; the Tamil Nadu state government has continued to regulate groundwater abstraction for non-domestic end-uses through various government orders. Although these have been challenged by some commercial entities through court petitions, the government orders have been upheld by the judiciary. A recent order by the Madras High Court in October 2018, upheld one of the government orders related to groundwater regulation and held that excessive extraction of groundwater beyond the permitted volume would constitute ‘theft’, punishable under law and can lead to suspension of groundwater extraction permits (TNIE, 2018).

In Tamil Nadu, the ‘over-exploited’ and ‘critical’ groundwater blocks (described in **Chapter 4**) are prioritised for regulation.

There are restrictions on the abstraction of groundwater for industrial and commercial purposes. Further, in 2011, the Tamil Nadu government has identified groundwater development classes (over-exploited, critical, semi-critical and safe) over smaller geographical units than administrative blocks. Such fine-grained classification permits industrial extraction of groundwater in the sub-regions classified as 'safe' within larger 'over-exploited' blocks.

The largest user of water in the basin is irrigated agriculture. There is significant area under bore well irrigation. The provisioning of free electricity by the government for irrigation incentivises groundwater extraction.

One of core challenges with groundwater regulation is the difficulty in implementation. Firstly, there is a lack of knowledge on the number of wells and the location of wells within the basin. Secondly, even if well details are available, at present there is no mechanism to monitor and regulate water abstraction from the wells.

Monitoring and enforcement of groundwater regulations is weak. Illegal extraction of groundwater is not uncommon.

Prevention and Regulation of Surface and Ground Water Pollution

The water quality governance framework in India is described in **Appendix G** to provide a context to the pollution regulatory system in India and in the Noyyal-Bhavani sub-basins. The case study on industrial pollution in **Chapter 5** provides a context to the pollution regulation efforts in the basin.

The prevention and regulation of pollution in the Noyyal-Bhavani sub-basins is an ongoing process. Various interventions including specific government rules for siting of industries, technology standards such as ZLD, court orders, specific institutional structures such as the LOEA and additional pollution control units within the TNPCB have been implemented in the Noyyal-Bhavani sub-basins.

Despite the regulatory framework for the prevention of pollution, the effectiveness of pollution control in the basin has been low. The spatial applicability of the ZLD rule and the impacts of ZLD on the water quality of the R. Noyyal are not clear. Anecdotal evidence points towards the migration of textile wet-processing facilities from Tiruppur district to areas outside the basin during the period of the closure order by the Madras High Court in 2011. Anecdotal evidence also points towards continuing illegal night-time discharges of effluents into drains, streams and local aquifers. One of the key points that emerged from literature and key informant interviews is that the costs of pollution prevention is very high for the small-scale textile facilities scattered within the region. Except for facilities located within the industrial estate at SIPCOT-Perundurai, all other textile facilities are spread across Coimbatore, Tiruppur and Erode districts in both rural and urban areas.

Basin Context Metrics: Water Governance

The basin context metrics related to water governance are summarised in **Table 8.1.** For each metric, the present state and desired end state are briefly described.

Table 8.1. Basin Context Metrics—Water Governance.

Water-related Challenges	Basin Context Metric	Current State	Desired End State
Lack of river basin planning and management coupled with fragmented governance of water resources adversely affects basin water security and fair water allocations	Presence of river basin/sub-basin management plan	Lack of river basin management plan.	River basin management plan that addresses multiple aspects related to water quality, basin water security, sustainability, crisis preparedness, basin-level governance and fair water allocations to different user groups.
	Multi-stakeholder efforts at river basin management	At present, there are no attempts at multi-sectoral dialogues for river basin management. With respect to agricultural water use, the IAMWARM project adopts a multi-disciplinary approach involving multiple government departments.	Effective platforms for inclusive, multi-stakeholder discussions for river basin management.
	Comprehensive water accounting in the basin	Specific aspects related to water such as basin groundwater availability, domestic water demand for cities and different districts are accounted for planning and water management.	Integrated water accounting comprising surface and groundwater resources, extent of recycling and reuse; water availability and use; and estimated future requirements under different management policies.
	Corporate water reporting	Not assessed.	Water-use reporting by all the large industries in the basin aligned with compatible global standards.
	Participation in irrigation water management	The state government has enacted the Tamil Nadu Farmers' Management of Irrigation Systems Act, 2000. Water Users' Associations comprising of farmers have been constituted.	Effective implementation and functional participatory irrigation management.
	Participation of local communities in improving water and sanitation management	Most water-related data maintained by the state is accessible to the public. Government orders, management decisions and documents are publicly accessible.	Transparency and accountability in water management decisions undertaken by the state through public access to management documents, data and inclusive public consultations.
Groundwater regulation and management is weak, with adverse impacts on the health of aquifers	Presence of state and basin-level groundwater regulations	Lack of state-level groundwater regulation legislation.	Effective state-level groundwater regulation law.

Chapter 9 Recommendations and Conclusions

The preceding chapters have highlighted some of the main water-related challenges in the Noyyal-Bhavani basin. Some of these challenges have been persistent; interventions to address them have been either inadequate or ineffective. The issues related to groundwater regulation and water quality governance in the basin are examples of such complex, persistent and possibly 'wicked' problems. On the other hand, there are also windows of opportunity to address some of the key issues discussed in the basin.

This chapter discusses some of the critical water challenges in the basin, the directly affected water-users and possible opportunities for addressing them. It draws upon insights from the literature review, key informant interviews and a consultative meeting[16] in Coimbatore.

In the context where corporate water stewardship has primarily focussed on 'within the fence' interventions such as those targeted towards improving operational WUE and effluent treatment, efforts towards setting contextual water targets that recognise the need to understand, account for and engage with the river basin realities may help improve corporate water accountability (Pacific Institute, 2017). This pilot study on shared water challenges in the Noyyal-Bhavani sub-basins is situated within the Pacific Institute's programme towards catalysing corporate water stewardship. Therefore, the type of risks associated with the water challenges are discussed with respect to the industrial water-users in the basin.

Water Challenges in the Noyyal-Bhavani River Basin

The shared water challenges in the Noyyal-Bhavani basin related to each of the six themes are summarised in **Table 9.1**. The water-users who are directly affected by these challenges are highlighted. The risks posed by these challenges to industrial water-users are highlighted (**Table 9.2**).

Of these challenges, water quantity and quality with associated governance issues are important in this basin context. These challenges are briefly summarised in this section.

Water Quantity and Governance

In the Noyyal-Bhavani basin, groundwater abstraction has increased over time. The CGWB classification (of 2013) shows that 45% of the groundwater blocks in the basin are over-exploited. The groundwater stress is much higher in the Noyyal sub-basin. The areas declared as being drought-prone by the government coincide with the areas of groundwater stress.

Groundwater governance in the basin is weak. There is no state-level groundwater regulation legislation; specific government orders place restrictions on use of groundwater. However, such orders are not effective due to difficulties in implementation on-ground. There is no mechanism to monitor groundwater use although an existing law [17] requires metering for industrial and commercial end-uses. This is compounded by the knowledge gap on the location and status of wells in the basin.

Groundwater abstraction for irrigation (the largest water user) is incentivised through the provision of free electricity supply by the government. Therefore, the costs of

[16] A consultative meeting was convened by the Pacific Institute/CEO Water Mandate, ATREE and UNGC-India in Coimbatore on 29th March 2019. The participants included representatives from the textile brands, some of the associated textile facilities (which supply to the brands) including some operating in the Noyyal-Bhavani sub-basins and a few non-governmental organizations.

[17] The Water (Prevention and Control of Pollution) Cess Act, 1977

groundwater abstraction for irrigation are primarily the capital costs of sinking the wells and the maintenance costs of the wells.

The demand for groundwater increases during periods of droughts when reservoir storages are depleted. This is compounded during periods of consecutive multi-year droughts when it is critical that water allocations need to be prioritised in a fair and equitable manner. Groundwater stress increases the region's vulnerability during periods of droughts and over the long term, reduces resilience against changes in climate.

The water-use, water-availability, inter-basin transfers and the extent of wastewater recycling needs to be accounted for at the basin level through detailed water accounting and hydrological modelling studies. This needs to be analysed in the context of rainfall variability, basin storage and groundwater status in the basin to understand basin water security and risks.

Water Quality and Governance

Prevention and control of pollution of water bodies from point and non-point sources is one of the key challenges in the Noyyal-Bhavani basin. Industrial effluents have been one of the main contributors of river pollution (especially the R. Noyyal) in the basin. Various interventions including technology standards such as ZLD, establishment of treatment plants, legal suits related to pollution, and targeted efforts at pollution monitoring by the pollution regulatory authorities have helped limit the degree of industrial pollution. However, the nature of the command-and-control pollution regulatory mechanism provides opportunities for rent-seeking behaviour, which hampers efforts towards limiting pollution.

For rivers and wetlands, to our knowledge, the Designated Best Uses of the water bodies are not defined. Therefore, there is no end goal for the restoration of these water bodies. As a result of this, water quality monitoring efforts are not effectively coupled with planning oriented towards assessment of pollution sources, impacts of pollution and interventions for the remediation and restoration of the water bodies in a time-bound manner.

Water quality sampling from rivers by the government is periodic with grab samples collected during day-time. Continuous monitoring of water bodies is still in a nascent stage in the basin, with stations recently established for the R. Noyyal. Continuous monitoring of the rivers would help improve assessments of river water quality especially in the context of anecdotal evidence of illegal night-time discharges of effluents within the basin.

Inadequately treated and untreated sewage from urban settlements contributes significantly to the pollution of the R. Noyyal, the R. Bhavani and various wetlands. Sewage treatment infrastructure is being developed to meet the treatment needs of the settlements in a phased manner. The widely prevalent on-site sanitation systems contribute towards microbial contamination and elevated nitrate concentrations of groundwater. Effective management of faecal sludge is still in a nascent stage.

Agro-chemical run-off also contributes to non-point pollution of water bodies in the basin. The extent of agro-chemical pollution and its impacts requires detailed assessments in the basin.

Table 9.1. Shared Water Challenges and Directly Affected Water-Users.

Themes	Water Challenges	Domestic Users	Agricultural Users & Livestock	Ecosystem Needs	Industrial Users	Hydro-power Needs
Access to WASH	Timely and adequate water and sanitation provisioning under rapid urbanisation and population growth.	✓			✓	
Water Quantity	Water stress due to the gap between water demand and availability in the basin.	✓+	✓+	✓+	✓+	✓+
	Sustainability of water resources in the basin is challenged by over-extraction of groundwater and declining spring discharges.	✓+	✓+	✓	✓+	
Water Quality	Pollution of surface water bodies and aquifers due to discharge of untreated/poorly treated industrial effluents and sewage.	✓+	✓+	✓	✓+	✓
Water – Ecosystem Impacts	Maintenance of adequate environmental flows in the R. Bhavani is challenged by hydro-power diversions and water allocations to different sectors.	+	+	✓	+	+
	Wetlands in the basin are threatened by pollution due to sewage and industrial effluents adversely impacting their ecosystem services.	+	+	✓	+	
Water-Crisis Preparedness	Regular occurrence of droughts in parts of the basin adversely impacts domestic water availability and agricultural livelihoods.	✓	✓	✓	✓	✓
Water Governance	Groundwater regulation and management is weak, with adverse impacts on the health of aquifers, and water availability for life and livelihoods.	✓	✓	✓	✓	
	Lack of river basin planning and management coupled with fragmented governance of water resources adversely affects basin water security and fair water allocations.	✓	✓	✓	✓	✓

Note: ✓ refers to impacts of the challenge on the user; + refers to the users' impacts in contributing to the water challenge.

Table 9.2. Shared Water Challenges and Water Risks to the Industrial Sector.

Themes	Water Challenges	Physical Risk	Regulatory Risk	Reputational Risk
Access to WASH	Timely and adequate water and sanitation provisioning under rapid urbanisation and population growth.	Δ	Δ	
Water Quantity	Water stress due to the gap between water demand and availability in the basin.	Δ		
	Sustainability of water resources in the basin is challenged by over-extraction of groundwater and declining spring discharges.	Δ	Δ	Δ
Water Quality	Pollution of surface water bodies and aquifers due to discharge of untreated/poorly treated industrial effluents and sewage.	Δ	Δ	Δ
Water – Ecosystem Impacts	Maintenance of adequate environmental flows in the R. Bhavani is challenged by hydro-power diversions and water allocations to different sectors.			Δ
	Wetlands in the basin are threatened by pollution due to sewage and industrial effluents adversely impacting their ecosystem services.		Δ	Δ
Water-Crisis Preparedness	Regular occurrence of droughts in parts of the basin adversely impacts domestic water availability and agricultural livelihoods.	Δ		
Water Governance	Groundwater regulation and management is weak, with adverse impacts on the health of aquifers, and water availability for life and livelihoods.		Δ	
	Lack of river basin planning and management coupled with fragmented governance of water resources adversely affects basin water security and fair water allocations.	Δ		

Lack of Support for Small and Medium Enterprises

The costs of effluent treatment are high, especially to meet new technology standards such as 'Zero Liquid Discharge'. Although the state government has helped setup textile CETPs in the region, the costs of pollution prevention is borne mainly by the small and medium textile firms in the region. The pollution prevention costs are not distributed along the supply chain up to the end consumer. The small and medium firms face regulatory pressure by the state and policy pressure by the textile brands and intermediaries to treat their effluents. In the light of the highly competitive global export market and differing standards of environmental regulations in different manufacturing regions, the firms that comply with environmental regulations face higher operating costs. With the high operating costs and the lack of incentives to effectively treat the effluents, anecdotal evidence shows that some of the firms choose non-compliance with local environmental regulations to compete in the global market. In the Noyyal-Bhavani basin, although there are several industrial associations, there is a lack of industrial sector collective action towards improving water stewardship.

Recommendations Towards Addressing Shared Water Challenges

Recommendations and opportunities to address some of the critical shared water challenges in the basin are briefly discussed. These are based on our understanding of the basin water challenges, and insights from the key informant interviews. The discussions that emerged from the consultative meeting held in March 2019 are also listed separately.

Water Quantity and Governance

There is a clear need for **integrated thinking and planning of water resources** at the river basin scale. A holistic understanding of surface- and ground-water use, and fresh- and recycled-water use through **water accounting at the river basin scale** would be necessary for basin-level planning and efforts towards collective action at addressing shared water challenges. Assessments of **upstream use and downstream impacts** are very important to ensure adequate and quality water for downstream users in the Noyyal-Bhavani basin.

In the context of over-exploited aquifers in the basin, there is a need to **strengthen groundwater regulation**. Comprehensive monitoring of the quantity and quality of groundwater is required.

In the Noyyal-Bhavani basin, both surface water (from rivers) and groundwater are tapped by the TWAD Board for domestic water supply and several areas receive dual supply from these sources. This helps towards ensuring that the domestic water demand is adequately met. However, there is **need for greater equity in the distribution of domestic water**. In a similar manner, there is a need for comprehensive planning for **conjunctive use of surface and groundwater** at the basin scale for different water-users.

At the watershed scale, the interventions for **watershed management need to account for water demand management** for effective water resources management. For example – watershed interventions for groundwater recharge in depleted aquifers can be effective if groundwater abstraction and use is also accounted for and regulated.

With the increasing demand for water by industrial- and commercial water-users, and groundwater stress, there is a need to **prioritise wastewater reuse**. Sewage treatment infrastructure for the urban settlements are being planned and developed in the basin. There are opportunities for industrial/commercial establishments to purchase STP treated wastewater for process use as well as improve recycling within their process systems. The larger firms have opportunities for wastewater reuse for non-process end-uses such as toilet flushing and landscaping. In this context, there is an opportunity for multiple stakeholders to collectively plan and develop incentives for the reuse of wastewater.

Water Quality and Governance

To improve the quality of the water bodies in the Noyyal-Bhavani basin, there is a need to **define the designated best use of the water bodies through a public consultative process** and a time-bound strategy to reach the end goal. This is an important step that can help set targets towards remediation and restoration of polluted water bodies in the basin and address the pathways of pollution.

There is a need to extend the water quality monitoring programme to include prioritised wetlands in the basin. **Continuous 24x7 monitoring of surface water bodies and at least monthly monitoring of groundwater** by the TNPCB would help characterise the water quality status in the region and evaluate various interventions to prevent pollution. Continuous monitoring is necessary to detect illegal night-time discharges of effluents into water bodies. The state water quality monitoring programme can be complemented with **citizen science monitoring** of surface water and groundwater. This would help build citizen awareness and boost citizen empowerment with data for seeking greater accountability by the government and private players.

There are opportunities for **improvements in faecal sludge and sewage management** in the basin through effective infrastructure and institutions.

There are opportunities for **improvements in technology** in wastewater treatment, WUE and reuse. For the textile wet-processing industry, there is a need for financially viable and energy efficient technologies for improved wastewater recovery, recovery of salts, and co-processing of sludge. There are opportunities for cleaner technologies such as cleaner dyes, less water-intensive processing, etc.

There is a strong **need to incentivise clean technology and sustainability measures**. The compliance with technology standards such as ZLD requires high capital, operation and maintenance costs and high energy requirements. It also requires clear planning and institutional frameworks for the collection of wastewater from small and medium facilities that are spatially scattered in the basin, effective treatment through common facilities such as CETPs, and management of sludge generated through the processes. In the textile industry context, there is a **need for greater engagement by the global textile brands with the local context of the textile facilities in the basin**. There are opportunities for **collective action investments by the global brands**.

The textile industrial pollution problem in the basin has not been resolved despite various legal, regulatory and technology interventions. In the context of the contribution of the facilities in the basin to both the domestic and global textile market, there is **need for long-term commitments and engagement by the textile brands**. Purely market based entry and exit of brands without rewarding local efforts at environmental compliance and sustainability discourages such efforts and makes it economically more attractive for local facilities to externalise their costs of pollution. There is a need for engagement of the textile brands with the states in the basins and the recognition of the states' efforts in environmental regulations.

Integrated planning of water and wastewater management infrastructure is required in the basin. Most projects focus solely on one aspect–either augmenting water supply, establishment of underground drainage networks, or STPs. For example – the Tiruppur NTADCL project focussed primarily on water supply with no strategy for effluent treatment and management. Wastewater treatment infrastructure lags behind water supply infrastructure in the basin.

Coimbatore Consultative Meeting: Participant Comments & Suggestions

A consultative meeting was convened by the Pacific Institute/CEO Water Mandate, ATREE and UNGC-India in Coimbatore on 29th March 2019. There were about 30 participants including representatives from the textile brands, some of the associated textile facilities (which supply to the brands) including some operating in the Noyyal-Bhavani sub-basins and a few non-governmental organisations.

The first session consisted of presentations by the Pacific Institute on setting context-based water targets and by ATREE on basin water challenges. There were also presentations on success stories by the textile brands and facilities. The second session was initiated with a presentation on basin water security by ATREE. This was followed by a brainstorming workshop to discuss addressing basin water challenges, solutions (internal and external) and barriers to change.

Solutions to Address Basin Water Challenges

Various solutions to address the basin water challenges emerged during the discussions.

Governance-related

- Creation of a basin-level water regulatory authority
- Need for basin-level water budgeting
- Tiered water pricing for incentives to reuse

Education/awareness-related

- Citizen science/community sensitisation on water quality issues
- Investments in water literacy programmes in schools & colleges

Research/information exchange-related

- Local institutions to support research/information exchange related to basin water issues.
- Need for source attribution studies to map pollution load to different polluters.
- Life cycle analyses of the textile industry

Specific Solutions for the Industry

There were specific suggestions for the industrial sector, mainly for the textile industry—

- Creation of discussion and collaboration platforms for:
  - a) Facilities within an industry to discuss issues related to technology, enforcement, compliance, etc.

b) Facilities across industries within a region to discuss shared water challenges and solutions.

- For textile brands – branding to include information to consumers at the point of purchase on the garment water footprint, water requirement for wash care, nature of dyes used (e.g. organic), and fate of wastewater generated [e.g. treated in Effluent Treatment Plant (ETPs)].
- Larger garment facilities to invest in STPs to treat and reuse domestic waste water.
- Purchase of treated waste water for process use where possible. Alternately, partnership models for construction of STPs where the industry individually or collectively invests in the STPs and obtains the right to use a fraction of the treated water.
- Collective industrial investments in sanitation infrastructure in the regions where the facilities are located.
- Subsidised tanker-based effluent pick-up service for small and medium facilities to reduce incentives for illegal effluent discharges.

Barriers To Change

The key barriers to change related to improved water management within the region –

- ➢ Small and medium textile facilities are unable to afford clean technologies without subsidies. There are under immense pressure from the brands to cut costs. There is a need for a clean development mechanism targeted at such facilities.
- ➢ There are several very small-scale home-based facilities which find it difficult to comply with environmental regulations primarily due to their scale of operation.
- ➢ Industrial associations in the region are not interested in sustainability concerns.
- ➢ ZLD compliance is energy-intensive.
- ➢ The problem of corruption of the local pollution regulatory authority is related to its discretionary powers; standardised protocols may help address this.

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Appendix A

Key Informant Interviews

The interviews helped provide useful insights related to water management in the Noyyal-Bhavani sub-basins. The interviewees are listed below. In addition, there are two interviewees who have requested anonymity.

1) Mr. Aloysius (SAVE, Tiruppur)
2) Mr. Ashok Natarajan (TWIC, Chennai)
3) Dr. Ashwin Mahalingam (IIT Madras, Chennai)
4) Dr. Durba Biswas (ATREE, Bangalore)
5) Dr. Jagdish Krishaswamy (ATREE, Bangalore)
6) Dr. S. Janakarajan (SaciWATERs, Hyderabad)
7) Dr. Jenny Grönwall (SIWI, Stockholm)
8) Ms. Mahima Vijendra & Ms. Srinithi Sudhakar (IIHS, Chennai)
9) Mr. Mohanraj (WWF-India, Coimbatore)
10) Mr. K. Nagarajan (CEC, Chennai)
11) Mr. Naveen Kumar, ETP Manager
12) Prof. Paul Appasamy (MSE, Chennai)
13) Mr. Prabu Sekar (Siruthuli, Coimbatore)
14) Mr. S. M. Prithiviraj (CARE-T, Coimbatore)
15) Ms. Roopa Madhav (SOAS, London)
16) Mr. Skandan (Former Chairman, TNPCB, Chennai)
17) Prof. Suresh Kumar (TNAU, Coimbatore)
18) Prof. Venkatachalam (MIDS, Chennai)

Appendix B

Water Management Principles and Practices in India

Prioritisation of Water Allocations

The National Water Policy, 2012 is intended to guide prioritisation of sectors for water allocations in India. The policy prioritises provisioning of safe water for drinking and sanitation followed by water allocations for other domestic needs (of humans and animals). This is followed by water for achieving food security, supporting sustenance agriculture and minimum ecosystem needs. After meeting these needs, the available water is required to be allocated in a manner that promotes its conservation and efficient use. The policy also states that the "*principle of equity and social justice must inform use and allocation of water*" (NWP, 2012).

Human Right to Water

In India, although the right to water is not recognised explicitly as a Fundamental Right in the Constitution, it has been interpreted by the judiciary as a derivative of the Right to Life guaranteed under Article 21 of the Constitution. Therefore, the human right to water is binding in India.

As a member of the International Covenant on Economic, Social and Cultural Rights (ICESCR), the Indian State has an obligation for the progressive realisation of the right to drinking water (mentioned under General Comment No. 15) for its citizens (Panickar, 2007).

Responsibility of the State

Division of Powers

India is a Union of States and the Indian Constitution defines the powers and functions of the central government vis-à-vis the state governments. Water is a 'state' subject, with the jurisdiction of the central government extending to some aspects of water management such as inter-state rivers and inter-state water disputes.

The various states have enacted their own water supply and regulation laws. There are gaps in the implementation of the right to drinking water and the responsibility of the State in fulfilling this right (Panickar, 2007).

Doctrine of Public Trust

The National Water Policy, 2012 also recognises the role of the State in water management. It highlights the need to manage water as a common pool community resource that is held by the State under the Public Trust Doctrine (NWP, 2012). The Indian judiciary has also invoked the Public Trust Doctrine for the protection of environmental resources in the country and has recognised that it is a part of its jurisprudence derived through the English Common Law. In the judgement of the M.C. Mehta vs. Kamal Nath case, 1997; the Supreme Court of India has stated that (AIR2000SC1997[18]):

"The State is the trustee of all natural resources which are by nature meant for

From higher to lower priority in water allocations.

Figure B.1: Prioritization in Water Allocations.

[18] M.C. Mehta vs. Kamal Nath & Ors., Judgement of the Supreme Court of India, 1997.

public use and enjoyment. Public at large is the beneficiary of the sea-shore, running waters, airs, forests and ecologically fragile lands. The State as a trustee is under a legal duty to protect the natural resources. These resources meant for public use cannot be converted into private ownership."

Nature of Groundwater Management

The right to groundwater is linked to land rights in India. It is treated as a right attached to land, which may be restricted by easements as described under the Indian Easements Act, 1882 (Vani, 2009). As a result, excessive abstraction of groundwater leading to groundwater depletion is a challenge in many parts of the country.

The recent Model Groundwater (Sustainable Management) Act, 2016 recognises groundwater as a common pool resource held in public trust by the State. The Act states that "*in its natural state, groundwater is not amenable to ownership by the state, community or persons*". This Model Act seeks to strengthen groundwater regulation in the country and can be effective if individual states enact legislations based on this framework.

There are restrictions on groundwater abstraction by industrial and commercial establishments in areas notified by the Central Ground Water Authority (CGWA), an institution with the mandate to regulate groundwater abstraction and management in the country. In some of the states such as Tamil Nadu, an equivalent state-level institution or the state government regulates groundwater instead of the CGWA. However, in practice, groundwater regulation is weak.

In India, groundwater and surface water are generally seen as distinct resources. The inter-connectedness between surface water, groundwater and soil moisture is not adequately recognised and considered in the planning and management of water resources (Srinivasan and Lele, 2017).

Wastewater Management and Water Reuse

In the context of growing urbanisation in India, management of wastewater—both domestic sewage and industrial effluents—is a challenge that is being increasingly recognised. Existing wastewater treatment infrastructure lags behind the demand, as a result of which it is being poorly managed with negative externalities on public health and ecosystems.

Although there is no policy on wastewater management and reuse at the national level, some of the states have recently begun to develop policies on this important aspect.

Appendix C

Urban Domestic Water Supply Norms in Tamil Nadu

S. No.	Type of Urban Settlements	Water Supply Norm in LPCD
1	Municipal Corporations	135
2	Municipalities adjoining boundary of any municipal corporation	110
3	Municipalities (with UGSS)	135
4	Municipalities (without UGSS)	90
5	Town Panchayats adjoining boundary of any municipal corporation	90
6	Town Panchayats (with UGSS)	90
7	Town Panchayats (without UGSS)	70

Note: LPCD refers to Litre Per Capita Per Day; UGSS refers to Under Ground Sewerage System

Service Level Benchmarks and Indicators: Urban Water and Sanitation

The Service Level Benchmarks (SLBs) defined by the Ministry of Urban Development, Government of India are noted.

Water Supply

S. No.	Indicator	Benchmark
1	Coverage of water supply connections	100%
2	Per Capita Water Supply	135 LPCD
3	Extent of Non-Revenue Water	15%
4	Extent of Metering	100%
5	Continuity of Water Supplied	24 hours
6	Efficiency in Redressal of Complaints	80%
7	Quality of Water Supplied	100%
8	Cost Recovery	100%
9	Efficiency in Collection of Water Charges	90%

Sewerage

S. No.	Indicator	Benchmark
1	Coverage of toilets	100%
2	Coverage of Sewerage Network	100%
3	Collection Efficiency of Sewerage Network	100%
4	Adequacy of Sewerage Treatment Capacity	100%
5	Quality of Sewerage Treatment	100%
6	Extent of Reuse and Recycling of Sewage	20%
7	Extent of Cost Recovery in Wastewater Management	100%
8	Efficiency in Redressal of Consumer Complaints	80%
9	Efficiency in Collection of Sewage Water Charges	90%

Storm-Water Drainage

S. No.	Indicator	Benchmark
1	Coverage	100%
2	Incidence of waterlogging	0

Appendix D

Public-Private Partnership – Water Projects in the Noyyal-Bhavani River Basin

Tiruppur–NTADCL Water Supply Project

Since 2006, Tiruppur Municipal Corporation receives a part of its domestic bulk water supply from a special purpose vehicle called the New Tiruppur Area Development Corporation Limited (NTADCL). The latter was setup primarily to supply water to the textile industries in Tiruppur, with a part of the water supply designated to meet domestic water requirements of Tiruppur Municipal Corporation and nearby villages. One of the criticisms of this concession agreement is that it prioritises water supply to industries over domestic water needs in the region (Dwivedi, 2008).

Coimbatore–24x7 Water Supply Project

In 2018, Coimbatore City Municipal Corporation signed a concession agreement with a private agency called Suez Projects Private Ltd. for efficiency improvements through an upgradation of its water distribution system from intermittent supply to continuous pressurised 24x7 supply for a part of Coimbatore city.

Appendix E

Irrigation in the Noyyal-Bhavani River Basin

The Lower Bhavani Project (LBP) is a major irrigation project in the river basin that impounds and channelises water from the Bhavanisagar reservoir on the R. Bhavani for irrigation in a large command area of 84,000 hectare (**Figure E.**). The LBP has been in operation since 1956. Despite being a large project, the availability of water for irrigation in the command area has been limited by the high variability in rainfall and inflows into the Bhavanisagar reservoir. Further, the command area of the project has a lower priority of water rights in the basin. Due to this, the LBP irrigation schedule itself is operated in a way that water is released in two seasons, there are crop restrictions in the second season and water is supplied by rotation to classified zones in the command area. As a result of water scarcity, the farmers in the LBP command area have adapted in different ways such as supplementary groundwater-based irrigation and adjustment in cropping pattern to suit water availability. The Bhavani itself was reported to be a closed basin (Lannerstad and David, 2009).

In the larger Cauvery basin, historic water rights of the downstream deltaic farmers require that sufficient water is released from the reservoirs upstream that contribute to flows in the R. Cauvery. The Bhavanisagar dam supplements releases of water from the Mettur dam for the Cauvery delta, whenever needed. In addition to this, the water from the Bhavanisagar reservoir is channelised to traditional irrigation canals – the Kalingarayan and the Kodiveri canals – whose water rights precede that of

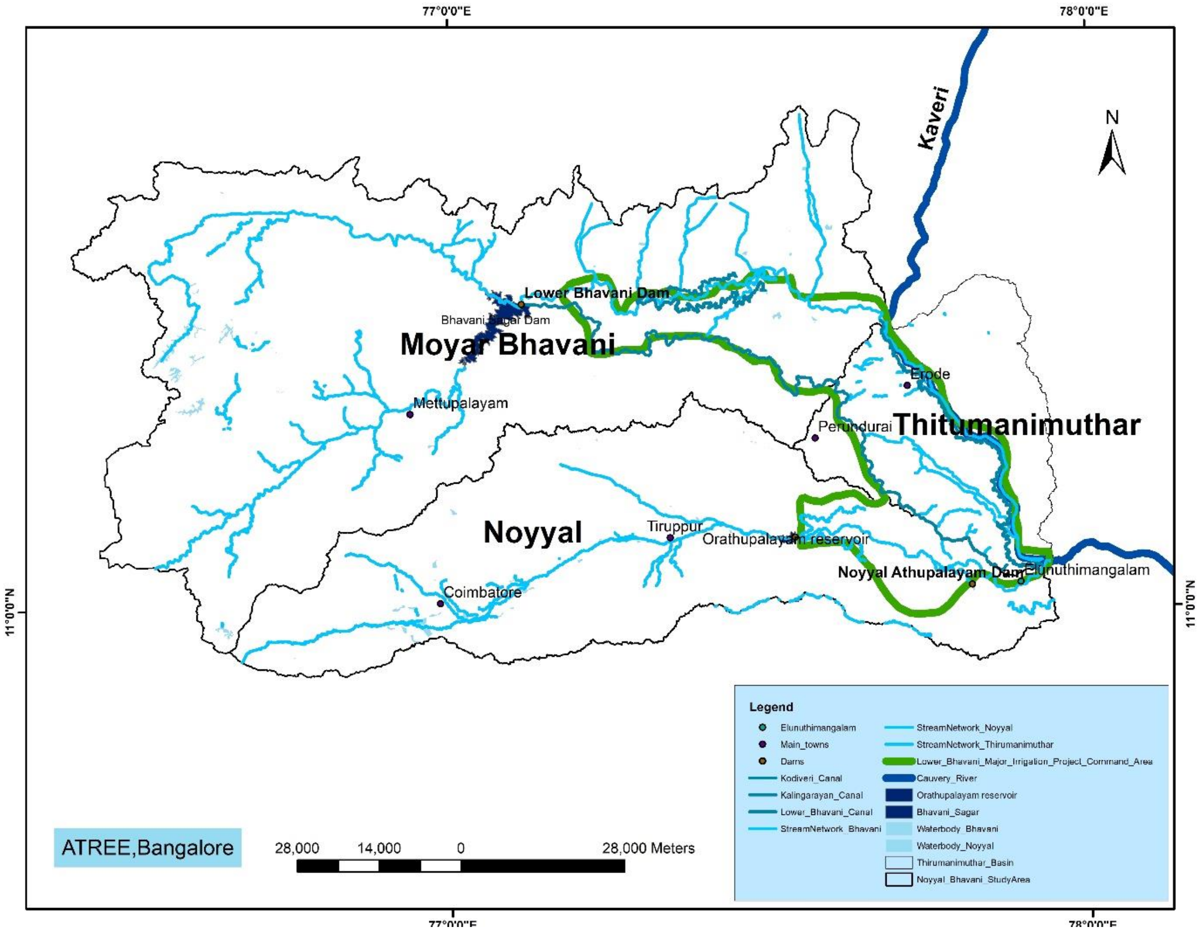
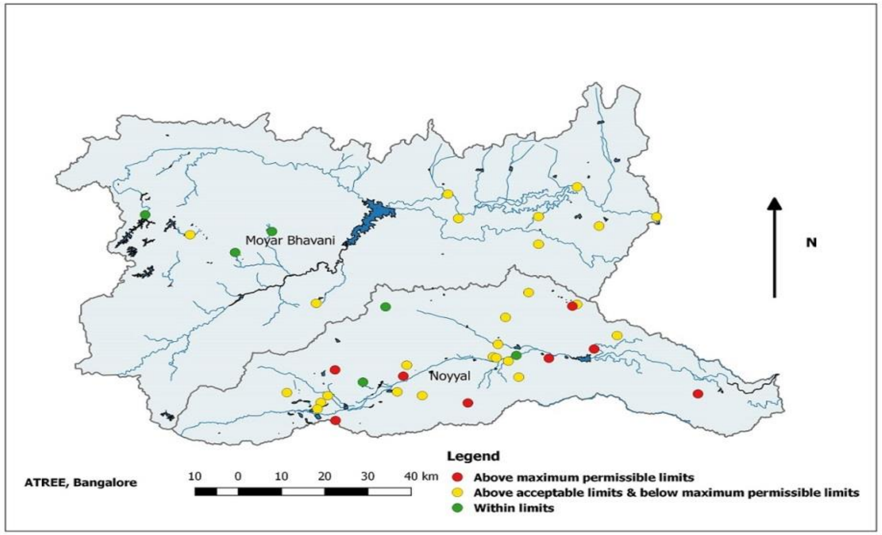


Figure E. 1. Irrigation Reservoirs and LBP Project Command Area.

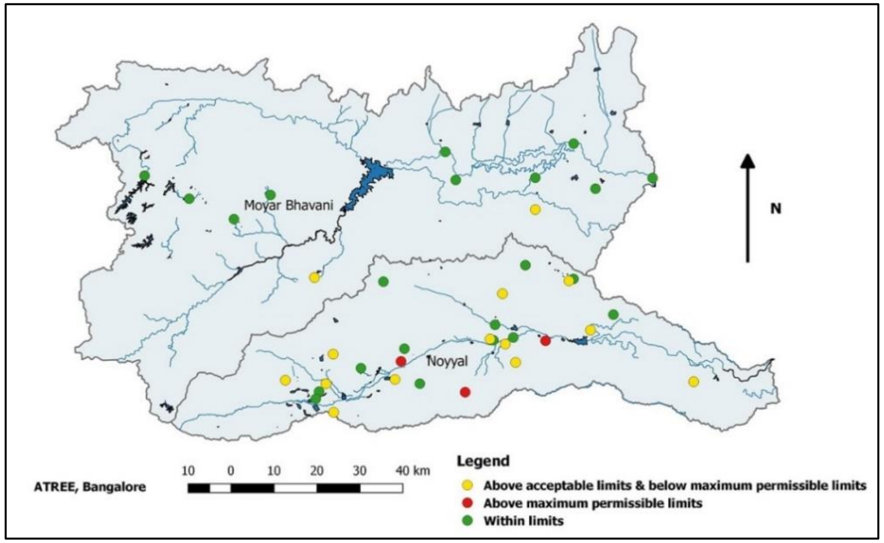
LBP command area (Lannerstad and David, 2009). In the lower Noyyal sub-basin, there are two irrigation reservoirs—the Orathupalayam and Aathupalayam reservoirs. The Orathupalayam dam was constructed on the R. Noyyal in 1992 for irrigation over a command area of 10,000 acre. However, due to the high pollution load in the R. Noyyal due to the discharge of untreated textile dyeing effluents, the Orathupalayam reservoir turned into an effluent storage tank and since the mid-1990s, the water has not been used for irrigation. The Orathupalayam dam is decommissioned and not used for water storage presently. The Aathupalayam reservoir, which is further downstream, receives water from the Orathupalayam as well as excess water from the LBP canal. The pollution in the R. Noyyal, affects the Aathupalayam reservoir as well.

Appendix F

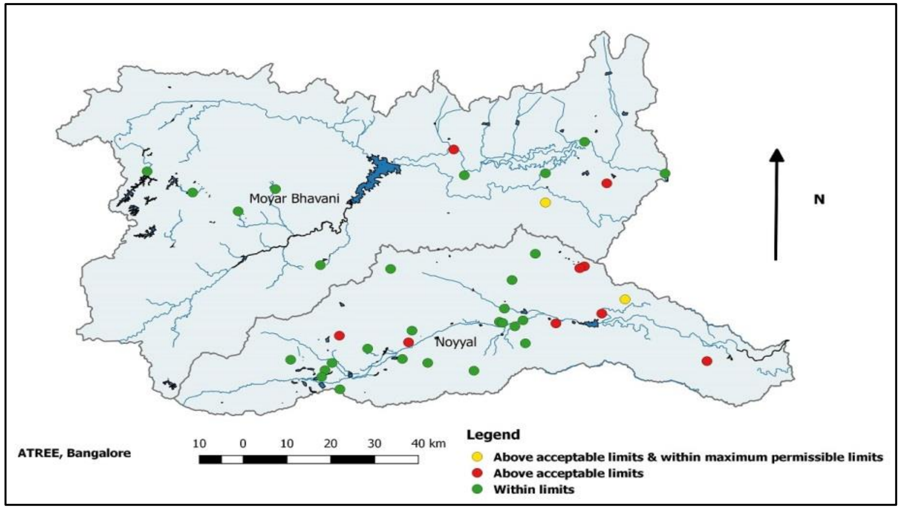
Groundwater Quality in the Noyyal-Bhavani River Basin



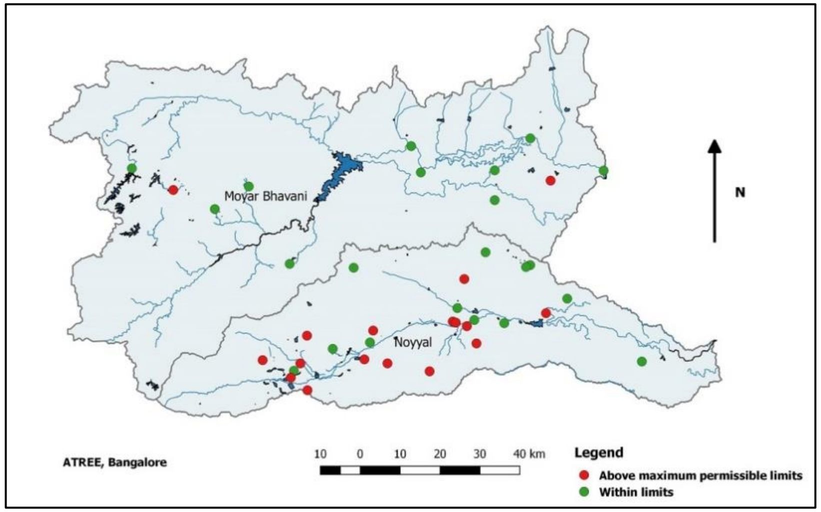
(A) Electrical conductivity of groundwater (μS/cm).



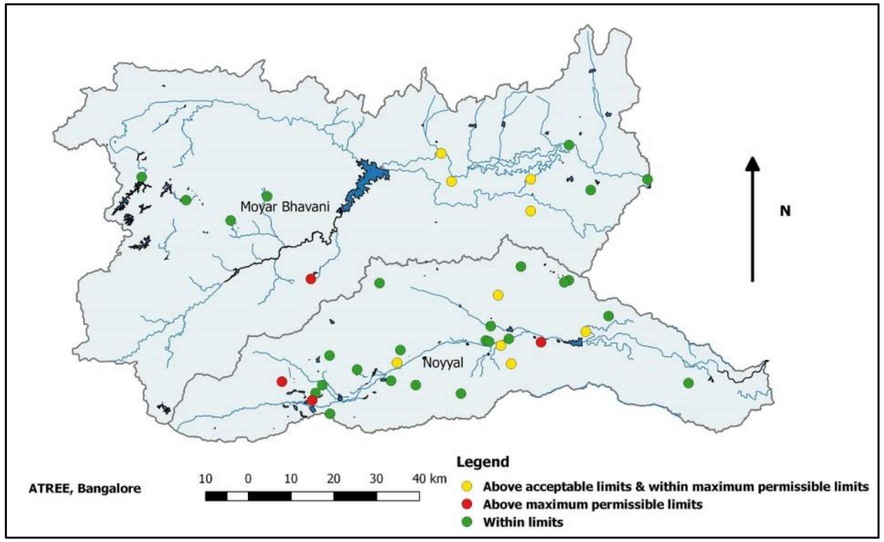
(B) Chloride concentration in groundwater (mg/l).



(C) Sulphate concentration in groundwater (mg/l).



(D) Nitrate concentration in groundwater (mg/l).



(E) Fluoride concentration in groundwater (mg/l).

Figure F.1: Groundwater Quality in the Basin Districts—Coimbatore, Tiruppur, Erode and the Nilgiris (2016)

Appendix G

Water Quality Governance Framework

Legal Framework for Water Quality Governance

The *Water (Prevention and Control of Pollution) Act, 1974* is the key legislation for the prevention and control of water pollution. The pollution regulatory authorities in India, the Central and State Pollution Control Boards (CPCB and SPCBs) are constituted under this Act and are vested with various powers including the power to grant and withdraw consent (or permit) for different types of industrial establishments. The Act prohibits the disposal of polluting matter into any stream, well, sewer or on land.

The *Environment (Protection) Act (EPA), 1986* is an umbrella legislation that empowers the central government to protect and improve the environment including laying down the standards for emission or discharge of environmental pollutants and procedures and safeguards for handling hazardous substances. The Act also empowers the government to make rules to regulate environmental pollution including rules for prohibition and restriction on the location of industries. The central government has delegated its powers vested under the Act to different state governments including Tamil Nadu.

Environmental regulation in India is based on a *command-and-control approach*. The Indian judiciary has also been playing an active role towards implementation of environmental laws in the country through judicial activism. The Supreme Court of India has invoked the '*polluter pays principle*' and the '*precautionary principle*' in its judgements against environmental degradation.

The Indian Constitution guarantees a set of fundamental rights to its citizens including the right to move the Supreme Court to seek constitutional remedies (Article 32) for the protection of the fundamental rights. Further, Public Interest Litigations (PILs) allow any public-spirited citizen or groups to file petitions for the protection of public interest. Also, the courts can take *suo moto* cognizance of a matter that involves violation of fundamental rights of the public. These rights and specific PILs have played an important role in environmental protection in the country.

Institutional Framework for Water Quality Governance

The Ministry of Environment and Forests (MOEF) is the apex policy making body in the field of environment protection in India, as identified under the EPA, 1986. The MOEF acts through the statutory pollution regulatory authorities CPCB and SPCBs.

In Tamil Nadu, the TNPCB monitors industries for compliance with environmental laws including the Environment (Protection) Act – 1986, the Water (Prevention and Control of Pollution) Act – 1974, the Water (Prevention and Control of Pollution) Cess Act – 1977 and the relevant rules following these acts.

Nature of Water Quality Standards

For drinking water, the Indian Drinking Water Specification IS 10500:2012 issued by the Bureau of Indian Standards (BIS) is the reference standard. It prescribes requirements and methods for sampling and testing drinking water in the country.

For inland surface water, the IS 2296:1982 issued by the BIS prescribes tolerance limits for different water quality parameters for different end-uses. A concise version of this standard is shown in **Table G.** for some key water quality parameters. The defined five-fold Designated Best Uses (DBU) ranges from drinking water without conventional treatment to irrigation use. Through a nation-wide network of monitoring locations, the CPCB/CWC monitors the water quality in several rivers in India including the R. Bhavani. However, at present the DBU of rivers have not been defined and thus, there is no reference goal for restoration of water quality of polluted rivers in a time-bound manner. Only a small fraction of wetlands (i.e., lakes, ponds and tanks) are monitored by the CPCB through the National Water Quality Programme. In the Noyyal-Bhavani basin, the water quality of one lake is monitored through this programme. The DBU of wetlands have not been defined.

For irrigation, the Indian Standard Guidelines for the Quality of Irrigation Water (IS 11624:1986) is a standard for advisory purposes. The standard defines water quality criteria and assesses the suitability of irrigation water with respect to soil type and salt tolerance of crops.

There are emission and technology-based standards for water quality management. There are also sector-specific standards for discharge of industrial effluents including standards for the textile industry and Common Effluent Treatment Plants (CETPs). There are no specific standards or guidelines for water quality management for industrial clusters.

The Environment (Protection) Fifth Amendment Rules of 2016 lays down the updated standards for discharge of effluents from the textile industry. The rules also prescribe the standards for discharge of effluents from CETPs. In the Tiruppur textile cluster, the Zero Liquid Discharge (ZLD) rule has been mandated for textile facilities and textile CETPs through the order of the Madras High Court and is being monitored by the state pollution regulatory authority, the Tamil Nadu Pollution Control Board (TNPCB).

A recent order[19] by the TNPCB as of July 2018 requires all textile dyeing, bleaching and printing units to upgrade their ZLD processes with an improved technology for management of the reverse osmosis reject. This is an example of upgradation of technology standards by the regulatory authorities.

Nature of Water Quality Monitoring

The Tamil Nadu Water and Drainage Board (TWAD) tests the quality of the drinking water that is supplied by it to the urban and rural local governments. The CPCB and the TNPCB are involved in the monitoring of water bodies and discharges of sewage and effluents from cities/towns and industries for pollution control and regulation. The national-level water authority, the Central Water Commission (CWC), also monitors water quality at specific sites in different rivers in the country.

In the Noyyal sub-basin, the TNPCB monitors the water quality of the R. Noyyal and is in the process of implementation of continuous online monitoring of the river water quality at three specific locations. In the Bhavani sub-basin, the TNPCB is similarly implementing online monitoring of water quality in the Kalingarayan canal. At present, the TNPCB has established real-time remote monitoring of the operation of all the textile CETPs in the Noyyal-Bhavani river basin. The TNPCB has the power to inspect industrial units and issue show-cause notices to units that fail to comply with the effluent discharge standards or prescribed technology standards.

[19] Board Resolution No. 274-1-19, Tamil Nadu Pollution Control Board, dated 30 July 2018.

Table G.1. Water Quality Criteria for Designated Best Uses of Inland Surface Water Bodies.

Class	Designated Best Use	Water Quality Criteria
Class A	Drinking water source without conventional treatment but after disinfection	• DO ≥ 6 mg/l • BOD ≤ 2 mg/l • Total coliform < 50 MPN/100 ml
Class B	Outdoor bathing	• DO ≥ 5 mg/l • BOD ≤ 3 mg/l • Faecal coliform <500 MPN/100 ml (desirable) & <2,500 MPN/100ml (max permissible)
Class C	Drinking water source with conventional treatment followed by disinfection	• DO ≥ 4 mg/l • BOD ≤ 3 mg/l • Total coliform < 5,000 MPN/100 ml
Class D	Propagation of wildlife and fisheries	• DO ≥ 4 mg/l • Free ammonia < 1.2 mg/l
Class E	Irrigation, industrial cooling and controlled waste disposal	• EC ≤ 2,250 u mho/cm • SAR ≤ 26 • Boron ≤ 2 mg/l