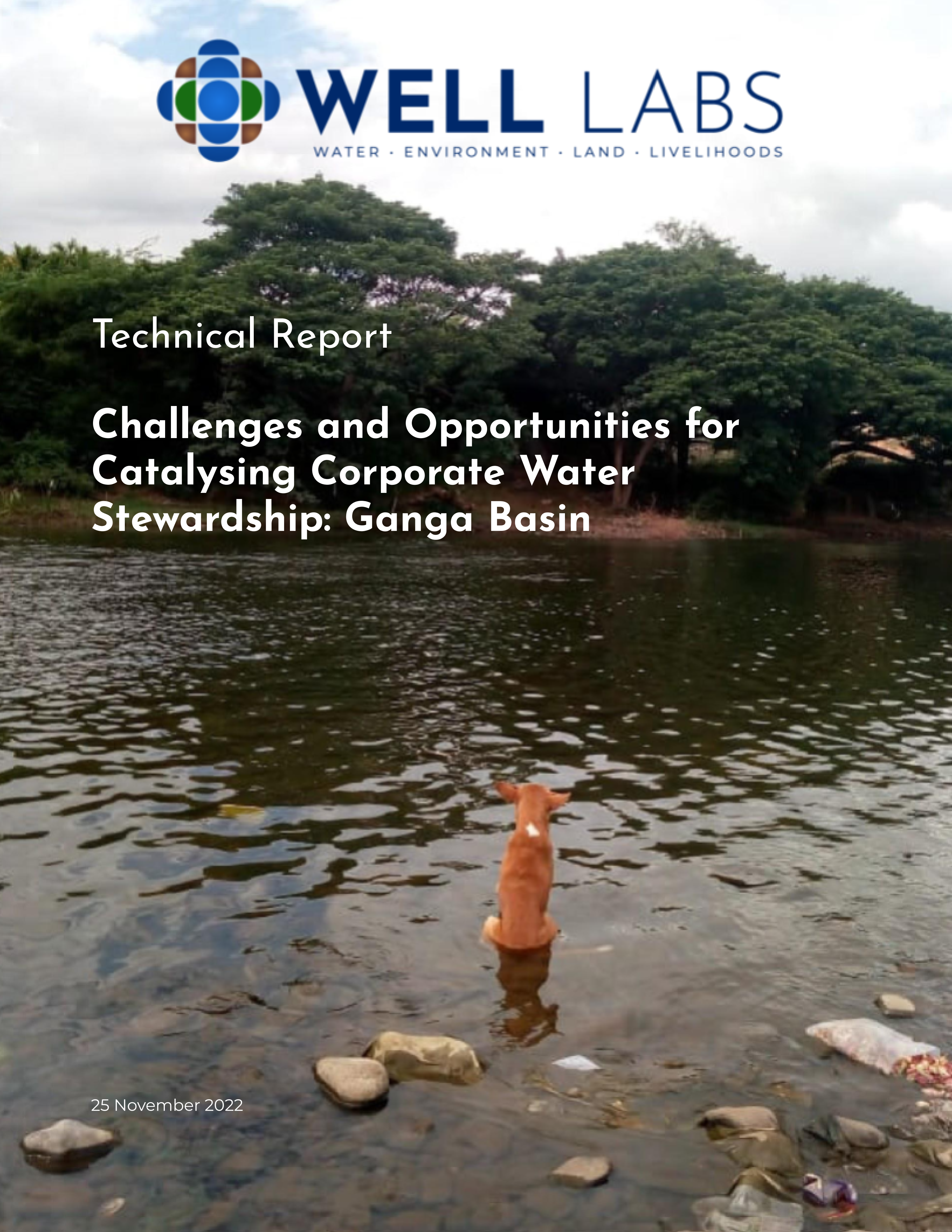

WELL LABS

WATER · ENVIRONMENT · LAND · LIVELIHOODS

Technical Report

Challenges and Opportunities for Catalysing Corporate Water Stewardship: Ganga Basin

25 November 2022

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The CEO Water Mandate, an initiative of the United Nations Global Compact, has partnered with a number of leading global companies to launch an industry-driven, CEO-led initiative, the Water Resilience Coalition. The Coalition aims to preserve the world's freshwater resources through collective action in water-stressed basins and ambitious, quantifiable commitments. As part of this initiative, the Water Resilience Coalition has undertaken analyses to understand the status of water-stressed basins across the world in order to drive water-related collective action among companies with the goal to create positive impact in 100 basins across the world.

Study duration: October 2021 to May 2022

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Editor: Clean Copy

Layout: Srilakshmi Viswanathan

Cover and back photographs: Rashmi Kulranjan *(These are representative images. The cover photo was taken on the banks of the Bhavani river in Tamil Nadu and the back page photo is of the Noyyal river, also in Tamil Nadu)*

Suggested Citation: Kulranjan, R., Shinde, G. N., Katral, V and Palur, S. 2022. Basin diagnostics for catalysing corporate water stewardship - Ganga Basin. Water, Environment, Land and Livelihoods (WELL) Labs. Bengaluru.

Acknowledgement: We are grateful to Mr. Lakshmikantha NR and Dr. Ashish Sinha from ATREE for their help and guidance related to estimating water stress in the basin and for contributing to discussions in this project. We are thankful to Mrs. Anjali Neelakantan for contributing to the recommendations chapter in this report.

The authors conducted this work when they were with the Centre for Social and Environmental Innovation at the Ashoka Trust for Research in Ecology and the Environment (CSEI-ATREE). WELL Labs is now taking it forward in collaboration with ATREE.

Table of Contents

Executive Summary

The Ganga basin is the largest in India. Some of the major cities in the basin include Delhi, Agra, Jaipur, Bhopal, and Allahabad. The river basin is economically important as it is home to some notable companies like Pepsico, Nestlé, and The Coca-Cola Company. The basin is also a major agricultural belt and extremely important to food production in the country.

This report contributes to a broader effort to mitigate water stress through facilitating corporate water stewardship by the Pacific Coalition, Pacific Institute, and the UNGC CEO Water Mandate via the Water Resilience Coalition. The Water Resilience Coalition's ongoing corporate water stewardship programme is an attempt to catalyse collective action in water-stressed basins toward the most pressing water challenges.

The report presents our current understanding of six water challenges in the Ganga river basin. Water quality issues and water stress were identified as the main areas of concern. Opportunities to address these water challenges have also been identified.

In the Ganga basin, the following challenges were identified:

First, a major portion of the basin has limited access to safe drinking water sources and low use of safe sanitation facilities. A lack of available and reliable water sources, improper infrastructure, and cultural biases have resulted in restricted access to WASH (water, sanitation, and hygiene) services. The huge consumption of water by the agricultural sector also affects the availability of water for domestic purposes.

Second, pollution due to the release of untreated sewage and industrial pollution is a major concern as most sub-basins have low treatment capacity. Illegal housing and industrial areas in many parts of the basin preclude the creation of proper drainage systems. A huge amount of money has been allocated to increasing treatment capacity in the basin, but this has not been implemented. Insufficient monitoring also results in many water bodies being neglected.

Table 1.1: Summary of the major water challenges identified in the Ganga basin

Water challenge	Major issues identified
WASH	• About 107.8 million people in the basin do not have access to functional tap connections. The primary reasons identified for this are inadequate infrastructure, contaminated sources of water, over-abstraction of groundwater, and a lack of coordination between government departments. • About 88 million people in the basin do not use safe sanitation

	facilities. The main reasons identified for this are the lack of adequate water sources, the absence of a system to ensure the maintenance of built toilets, and caste and cultural biases, especially in rural areas. ● Both geogenic Arsenic and industrial contamination of groundwater are of concern in regions that are groundwater reliant.
Water quantity	● All sub-basins except Gambhir and Yamuna sub-basins are at low to medium levels of water stress. The basin is about 1194 billion cubic metres (BCM) of water short every year to remain within safe limits of use. The primary reason for this is the growth of water-intensive crops in dry regions and a lack of monitoring and regulating systems for groundwater abstraction.
Water quality	● Treatment capacity in the basin is only 1.6% of the total effluents being generated. About 12393 million litres per day (MLD) are not treated in the basin. The primary reason for this is the lack of funds for the maintenance of treatment plants, the low skill level of the maintenance staff, and insufficient data on the amount of sewage being generated to plan for treatment capacity. ● Over 99% of lakes and rivers do not adhere to the water quality standards; this can damage ecosystem function or human health. The salinity of 70.8% and the nitrate levels of 30.8% of monitoring wells are above the permissible limits. The primary reason for this is insufficient monitoring of water bodies and a lack of adequate centralised and decentralised treatment facilities.

Opportunities

Based on the assessment of the baseline indicators in the Ganga basin multiple opportunities for collective action were recommended. For solving the issue of water quality, increasing the capacity of treatment of wastewater and treatment of geogenic and industrial contaminants is needed. Nature-based solutions are needed to be installed across the basin to ensure water bodies have good ambient quality. To solve the water quantity issues, assistance needs to be provided to help farmers make sustainable transitions to low water using crops that also earn sufficient income. Recharge in the basin also needs to be increased, particularly of flood waters and potentially treated wastewater.

Chapter 1: Introduction

The Ganga (Ganges) is a transboundary river with headwaters in the Hindu Kush Himalayan region. It begins at the confluence of the Bhagirathi and Alaknanda at Devprayag in the Tehri Garhwal district of Uttarakhand in India and flows for almost 2,500 km through India and Bangladesh before emptying into the Bay of Bengal. The river starts in the mountains at Rishikesh and enters the plains at Haridwar, in Uttarakhand. The upper Ganga basin is the part just below the Kanpur barrage in Uttar Pradesh (Bhadwal et al., 2017).

The upper Ganga basin is 4,03,227.61 sq. km in area. It consists of seven major rivers: Yamuna, Betwa, Chamba, Ken, Gambhir, Banas, and Ramganga-Deoha. The basin spreads across seven Indian states. The population in the basin is 193.09 million, of which 36.4% reside in urban areas and the rest in rural areas (Census 2011). Some notable companies active in the basin are Pepsico, Nestlé, The Coca-Cola Company, Jindal Handtex Pvt Ltd, Vimal Food Industries, and Everest Beverages & Food Industries Private Limited. Agriculture and industries (manufacturing industries including beverages, textiles, and transport equipment; commercial establishments including hotels, restaurants, and schools) also have a presence in the basin.

There are multiple water challenges in the basin. Identifying these challenges helps to prioritise the water issues to which businesses can contribute. Using performance metrics and targets, businesses can make basin context–specific efforts that they can align with those of other stakeholders. This report, therefore, maps out the challenges in the basin and opportunities to address them through collective action using six themes: i) WASH, ii) water quantity, iii) water quality, iv) important water-related areas, v) water governance, and vi) water crisis.

For each water challenge there are different basin context metrics. Further, for each basin context metric or indicator used, the state of each sub-basin, challenges, gaps, and opportunities for businesses have been described. Along with this, the current and desired states for each basin context metric have been laid out. An analysis of each sub-basin was conducted using secondary data available on government websites, Geographical Information System (GIS) layers, and a review of the literature.

The Sustainable Development Goals or SDGs were agreed upon by world leaders in the year 2015. The 17 goals aim at creating a better world by the year 2030 by ending poverty, fighting inequality, and addressing the urgency of climate change. The 6th goal focuses on ensuring availability, sustainable management of water and sanitation for all, wastewater and ecosystems, and acknowledging the importance of an enabling environment. Each water challenge was analysed using various targets under this goal as indicators.

Base layers

The basin, sub-basin, stream, and river networks were delineated using Cartosat DEM version3 in the ArcGIS software. The district shapefile was downloaded from the Bhuvan-2D archive, compared with secondary data on government websites, and corrected accordingly (e.g., new districts were digitised). The district shapefile was then combined with the secondary data using the GIS tool. Values at the district level were then brought to the sub-basin level using the 'Tabulate Intersection' tool to get weighted averages.

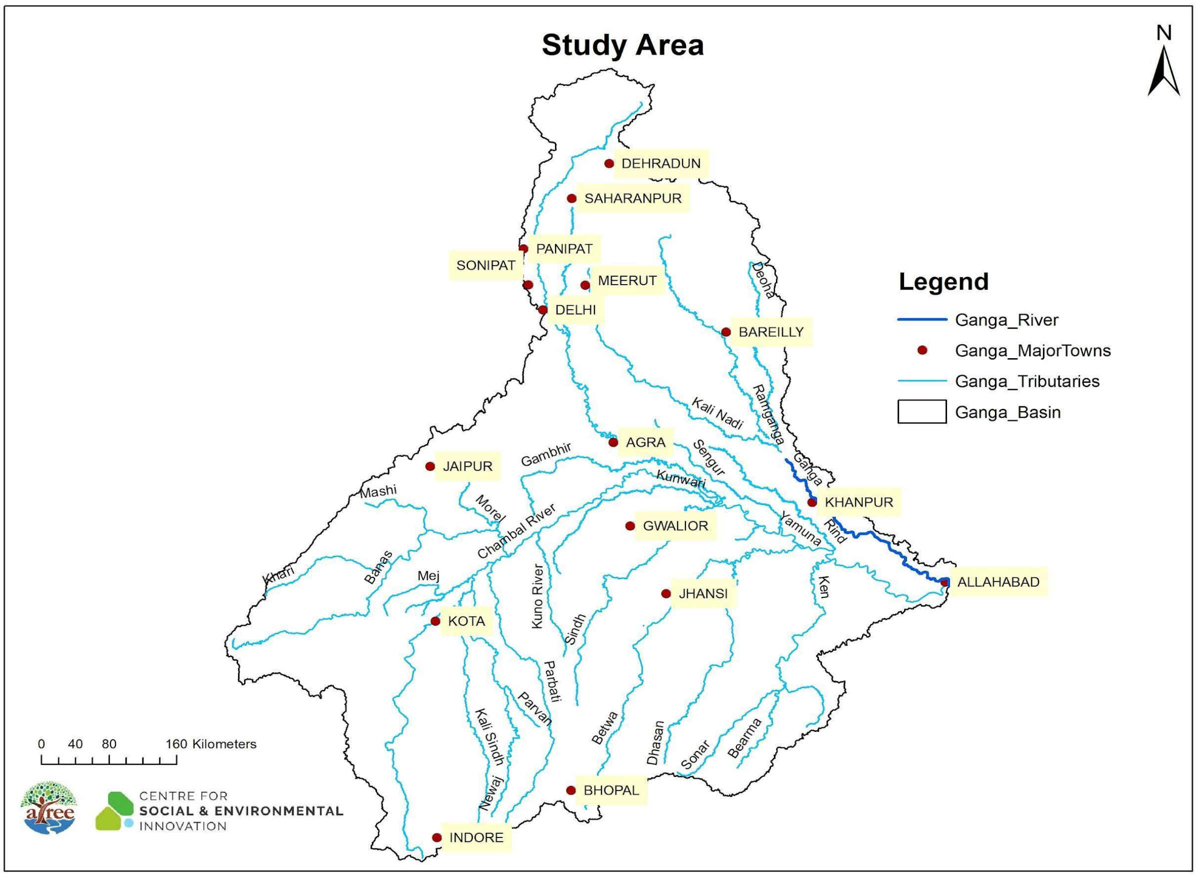

Figure 1.1: Study area map of the upper Ganga basin, Ganga River, and its tributaries

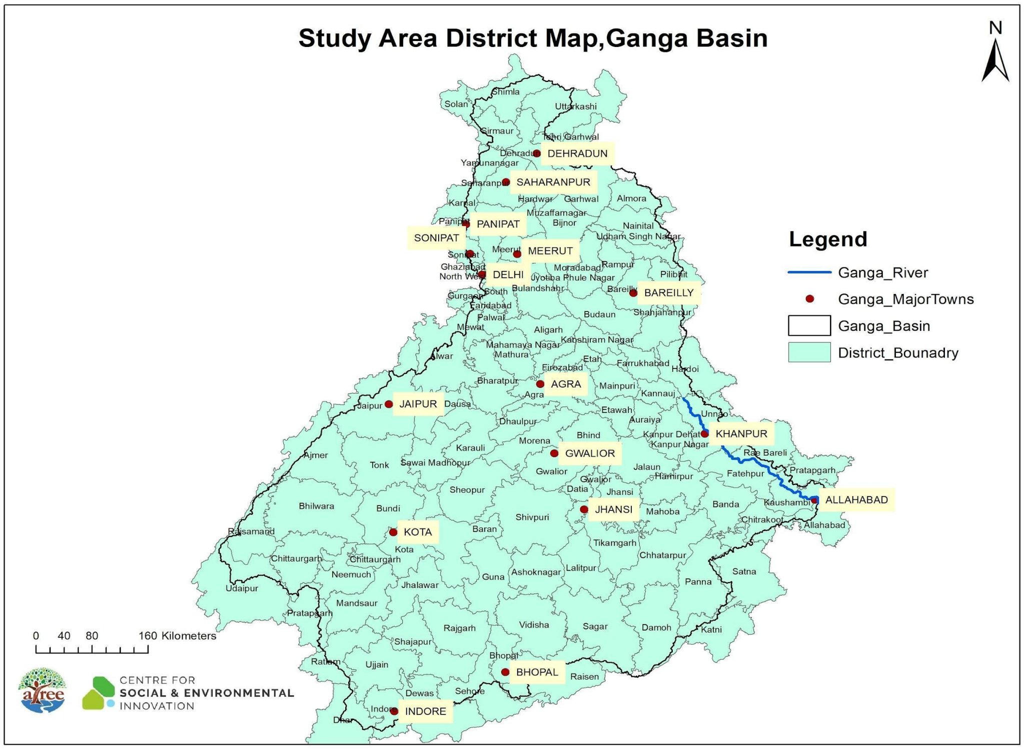

Figure 1.2: Study area map showing the district boundary

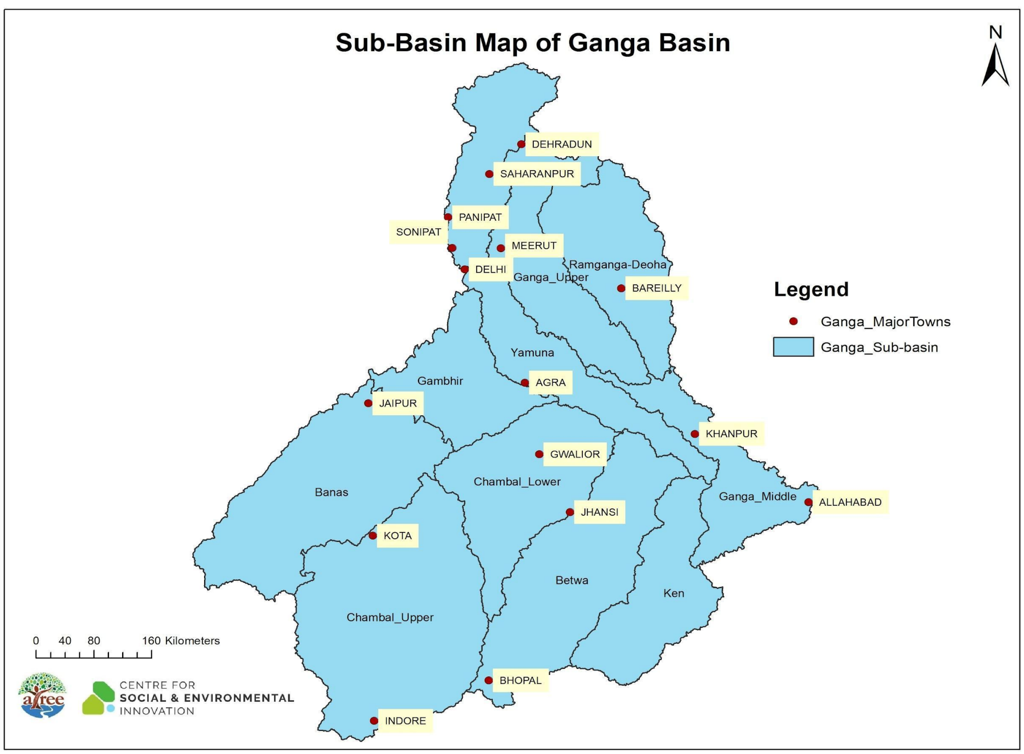

Figure 1.3: Study area map showing the upper Ganga sub-basin

Chapter 2: Access to Water, Sanitation and Hygiene

Access to safe drinking water

SDG 6.1 seeks to achieve access for all to safe drinking water. This indicator, therefore, tracks the population that has access to improved drinking water sources including piped water, boreholes or tubewells, protected dugwells, protected springs, rainwater, and packaged or delivered water.

The data on the access to functional household tap connections (FHTC) was collected at the district level for all the districts in the basin (NJJM, 2022). Using the weighted average method, the values were calculated at the sub-basin level. The percentage of households with functional tap connections was then estimated for each sub-basin. In the upper Ganga basin, 49.9% of households have access to functional tap connections. The middle Ganga sub-basin has the lowest access, at 33.6%, while the Yamuna sub-basin has the highest access, at 69.9%. Sub-basins that are more urbanised have better access to functional household taps.

The Jal Jeevan Mission project by the Government of India aims to provide a functional tap connection with treated water to every rural household for drinking purposes. It aims to ensure access to 55 litres per capita per day (lpcd). Under this mission, which was launched in 2019, the government seeks to enable every household in every village to have an FHTC by 2024 (Ministry of Jalshakti, 2019).

Most households in rural areas still depend on water from tanks, rivers, lakes, or sources that are not within their premises. The sources of water are limited because of issues like low base flows in the river or low-quality water that is unsuitable for consumption (Mukherjee, 2022).

Some existing gaps in the drinking water sector are as follows:

- There is inadequate infrastructure to raise the service level from 40 to 55 lpcd. There is an absence of source sustainability measures in the form of rainwater harvesting or groundwater recharge structures. Grey water management is inadequate, resulting in the contamination of water sources.
- Groundwater resources are under increasing pressure due to over-reliance and unsustainable consumption. Wells, ponds, and tanks are drying up, which means that fetching water in these districts has become harder as the water table has fallen.
- As per the Central Ground Water Board (CGWB), many assessment units are contaminated with nitrate and/or salinity due to geogenic and anthropogenic causes.

- There has been a failure in the operation and management of infrastructure, an absence of institutional arrangements, and mismanagement of resources (Snehalata et al., 2014).

Access to safe sanitation

SDG 6.2 aims to achieve access to sanitation and hygiene for all. This indicator, therefore, tracks the population that has access to improved sanitation facilities including flush/pour flush to the piped sewer system, septic tanks, or pit latrines; and ventilated/improved pit latrines, composting toilets, or pit latrines with slabs.

Data on the number of households with access to toilets (SBM, 2021) and the proportion of the population using safe sanitation services (National Family Health Survey, 2020) was collected at the district level for all districts in the basin. Using the weighted average method, values were calculated at the sub-basin level. Then the following were estimated for each sub-basin: i) the percentage of households with access to individual or community toilets in the region and ii) the percentage of the population living in households that use an improved sanitation facility.

In the upper Ganga basin, 99.9% of households have access to toilets while only 54.4% of the population uses safe sanitation facilities. The middle Ganga sub-basin has the lowest access, at 28.0%, while the Gambhir sub-basin has the highest access, at 67.2%.

The Swachh Bharat Mission was launched in 2014 with the aim of achieving universal sanitation coverage. The mission has strived to improve the living conditions of people by constructing individual and community toilets and eliminating open defecation (Ministry of Drinking Water and Sanitation, 2014). Complete (100%) coverage of toilets has been possible as the government has created community and public toilets wherever private toilets were impossible to build. Private toilets are difficult to build in many places due to the lack of awareness of the linkage between sanitation and health, the lack of space in which to build toilets in individual houses, and the sheer unaffordability of private toilets, even with external subsidies. While under the mission the government was able to achieve a high level of coverage, most toilets are either not functional or not used. For this reason, the proportion of the population using safe sanitation services has been used to get a better understanding of the on-ground situation.

Even with the high coverage of toilets in the basin, usage of them is extremely low. Uttar Pradesh has low coverage for both household sanitation and drainage services. The general rural population opines that owning and using a toilet is not a household priority but a luxury. In this regard, the middle Ganga sub-basin is worse off than other sub-basins, as the majority of its population resides in rural areas. Most community and public toilets lack tap water connections. Low latrine usage is due to a lack of awareness of the importance of sanitation, water scarcity, poor construction standards, and the expensive policy on standardised latrines by the government (Snehalata et al., 2014; Akhilesh & Gudavarthy, 2022).

Some existing gaps in the use of safe sanitation services are as follows:

- Lack of awareness programmes to address cultural and caste biases.
- Lack of reliable sources of water.
- Lack of monitoring systems to ensure that toilets are maintained after construction.

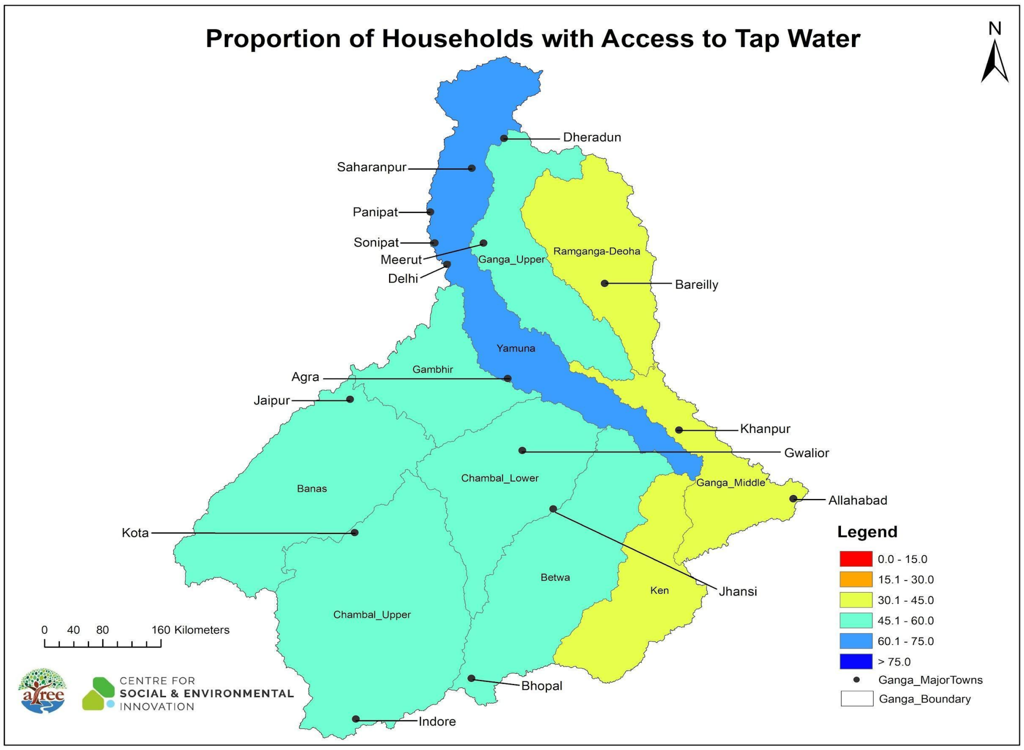

Figure 2.1: Map showing the proportion of households with access to tap water

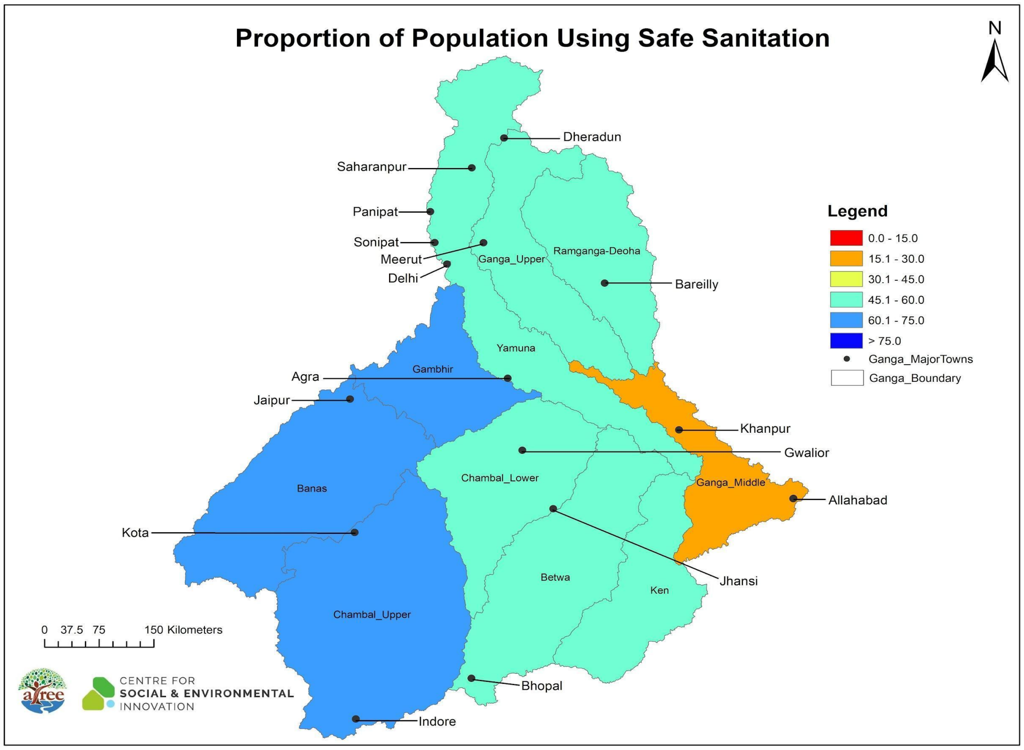

Figure 2.2: Map showing the proportion of the population using safe sanitation

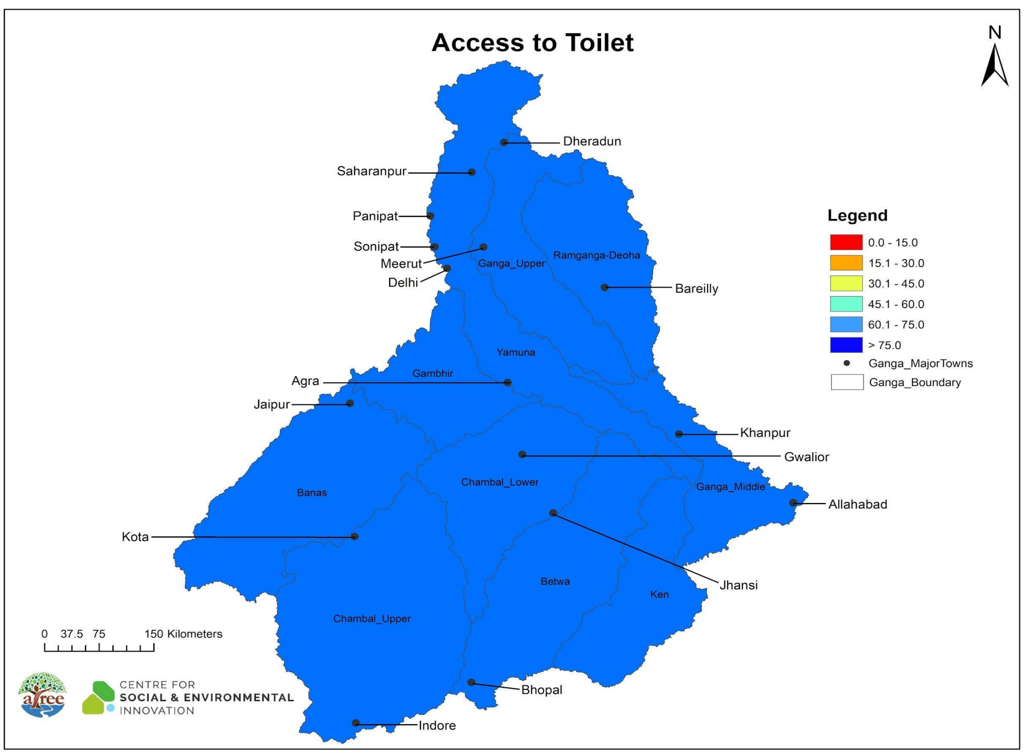

Figure 2.3: Map showing the proportion of households with access to toilets

Table 2.1: Basin Context Metrics- Access to water, sanitation and hygiene

Indicator	Current state	Desired end state
Proportion of the population receiving threshold drinking water services (%)	Around 49.9% of households have access to functional tap connections. About 107.8 million people in the basin still do not have access to functional tap connections.	All (100%) households must have access to functional tap connections.
Proportion of the population using safe sanitation (%)	About 54.4% of the population uses safe sanitation facilities. About 88 million people in the basin still do not use safe sanitation facilities.	The entire (100%) population uses sanitation services.
Proportion of the population with access to threshold sanitation services (%)	All (100%) households have access to either private or community toilets.	All (100%) households have a water supply and access to functional toilets.

Chapter 3: Water Quantity

Level of water stress

SDG 6.4.2 seeks to ensure sustainable withdrawal and supply of freshwater by tracking how much freshwater is being drawn by all economic activities, and comparing it to the total renewable freshwater resources available.

The amount of water abstracted was estimated for three sectors: agriculture, industry, and domestic. For the agriculture water demand, the data for the area covered under each crop was obtained at the district level. The data for potential evapotranspiration (PET), rainfall (IMD, 2021), and crop coefficient (Kc) was also obtained at the district level. The effective rainfall (ER) table was used to estimate the portion of the rainfall that is necessary to meet crop water needs (Annexure A). The following formulae were then used to estimate the crop water requirement (CWR) and the irrigation water requirement (IWR) for each sub-basin:

CWR = PET × Kc × Area under crop

IWR = CWR – ER

For the domestic water demand the population for each district was obtained. A water demand of 55 lpcd (DDWS, n.d.) and 135 lpcd (CPHEEO, 1999) was assumed for villages and towns, respectively. The domestic water demand for each district was then estimated using the following formula:

Domestic water demand = ((Population in villages × 55) + (Population × 135)) × 365

For industrial water demand, data for the type and number of manufacturing, commercial, and institutional industries in each district was obtained. Data on the number of employees in each establishment was also acquired. The litre per employee per day (lped) coefficient was applied to estimate industrial and commercial water use (R et al., 2021).

Using the weighted average method, the amount of water abstracted by each sector was calculated at the sub-basin level. The sum of the three water demands gave the total water demand of all sectors in the basin.

To estimate the water availability in the basin, the amount of utilisable surface water and groundwater recharge amounts were obtained from government reports(Central Ground Water Board, 2021;Central Water Commission, 2014) The calculations are done with the assumption that all the water in the basin can be captured for use. The level of water stress was calculated as the proportion of water demand to the total water available after accounting for environmental flows. A threshold of 20% or 40% was used to demarcate medium or high water stress status, respectively (Xu & Wu, 2017).

For total freshwater, all sub-basins are at a high level of stress.In terms of surface and groundwater abstraction as well all the sub-basins are at high levels making it highly unsustainable. The total water demand for the agriculture, domestic, and industrial sectors is 315185 million litres per day (MLD). Agricultural water has the highest demand in the basin, requiring around 298074 MLD of freshwater. The domestic sector accounts for the second-highest freshwater consumption, requiring about 1,62,43 MLD. Preliminary estimates have shown that the industrial sector in the basin requires about 868 MLD of freshwater.

Around 80–85% of the water is used by the agricultural sector, which has an efficiency of only 35% (Ghosh, 2018). Large-scale irrigation in the basin has enhanced the economy in the region. The variation in recharge due to the land use change, and cheap and hence unsustainable water abstraction for irrigation, has put severe pressure on local water resources (Mijic, n.d.). Extensive groundwater abstraction has resulted in reduced base flows in the Ganga river. This affects crop production, which depends on surface water sources (Mukherjee et al., 2018). Surface water is abstracted more at the canal head areas, thus forcing farmers in the canal tail areas to over-abstract groundwater (Khan et al., 2014). There is also evidence of a huge amount of leakages from the canals built in the 19th and 20th centuries, which have significantly influenced groundwater trends today (The Hindu, 2016). About 95% of farmers still use the flooding method to irrigate their crops.

In addition to agriculture, the expansion of cities into megacities and large-scale industrialisation along the banks of rivers have added pressure to water availability (Kaushal et al., 2019). Encroachment and diversion of catchment areas for construction and developmental activities have reduced the rainwater retention capacity, thus preventing groundwater from getting recharged (Shrivastava, 2012).

Some existing gaps in the efficient use of freshwater are as follows:

- In the irrigation sector, there is no database for agricultural water utilisation. There is also a lack of monitoring systems for regulating uncontrolled groundwater abstraction. Water use efficiency methods like the proper lining of canals, and the use of mulches to save soil moisture, have not been effectively implemented in the basin. The lack of reuse options for irrigated water is another major issue in areas with high freshwater consumption. There has been a lack of awareness programmes for farmers to check their soil health and implement water-efficient irrigation systems.
- In the domestic sector, water loss is of two types: real and apparent. Real loss includes water lost through leakages in the distribution systems, service connections, and storage tanks (including overflow). Apparent loss includes meter and record inaccuracies and unauthorised water use including theft and unauthorised connection.

- A lack of efficient cooling technologies especially in high water demand industries like textile, paper and pulp, and iron and steel results in extensive consumption of water. Due to a lack of information, awareness, and motivation, few industries have proactively adopted the available best practices. Improper and irregular water auditing in industries is another reason for inefficient water use (Central Water Commission, 2014).

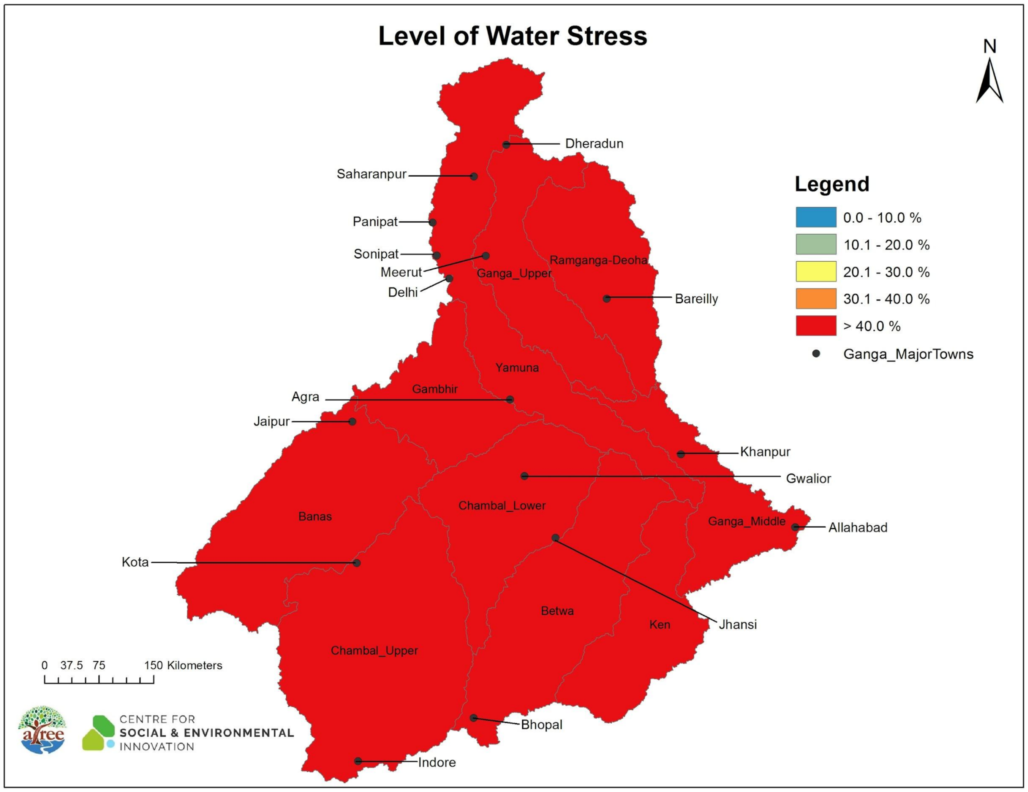

Figure 3.1: Map showing the level of water stress

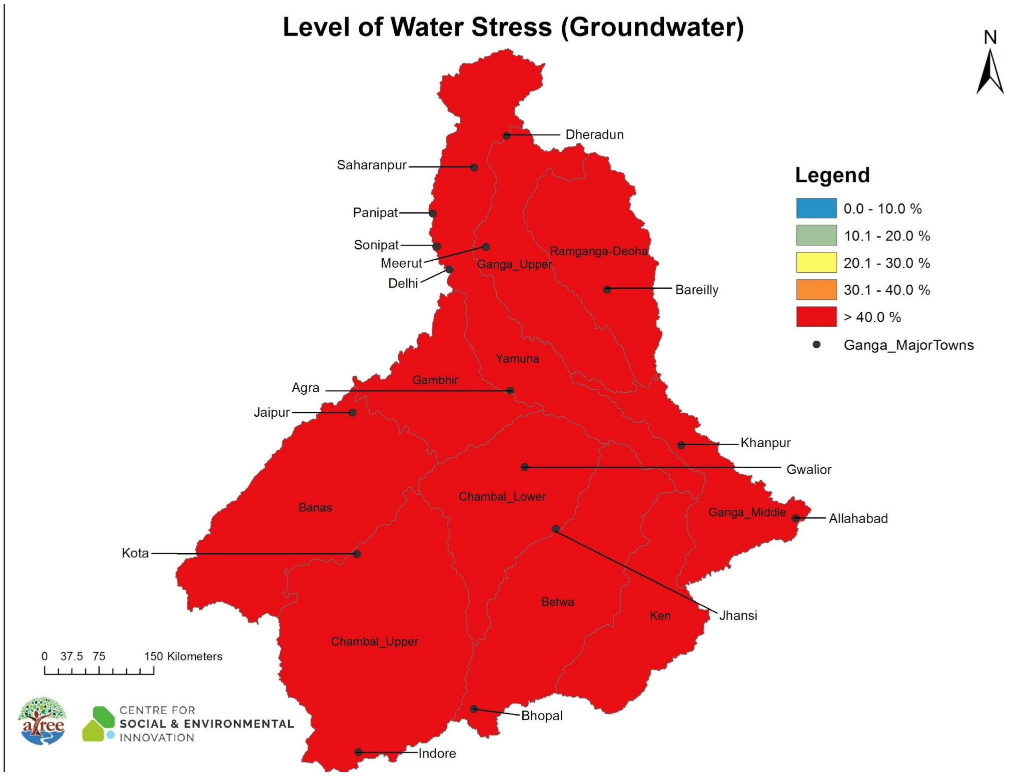

Figure 3.2: Map showing the level of water stress of the groundwater

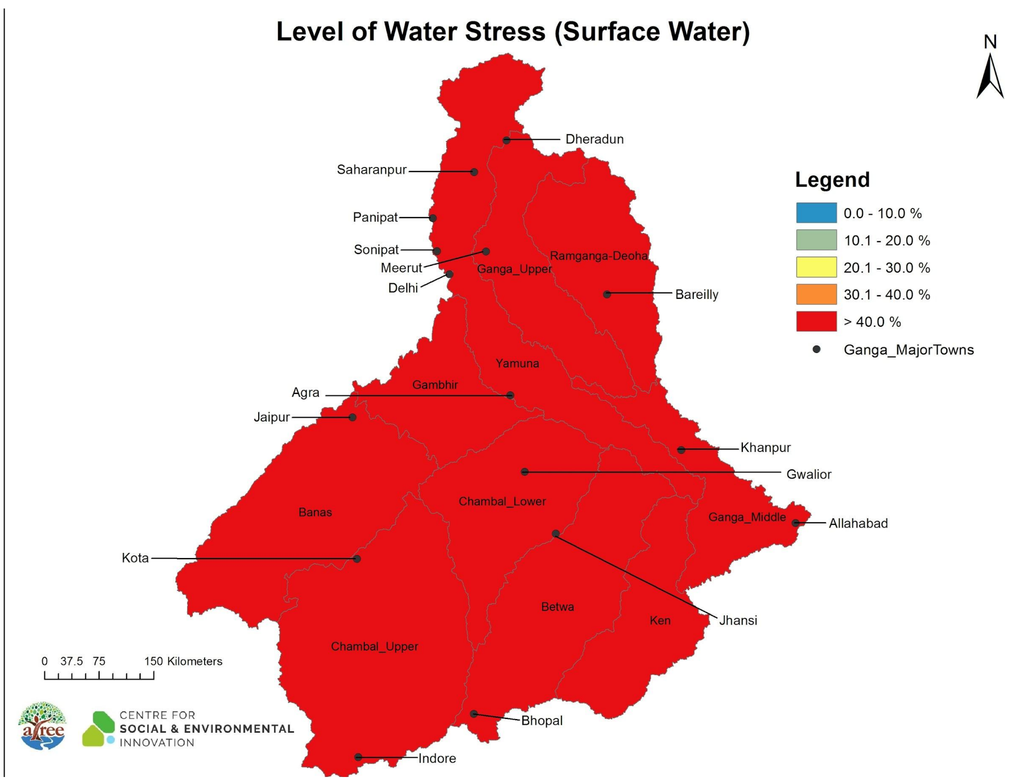

Figure 3.3: Map showing the level of water stress of the surface water

Table 3.1: Basin Context Metrics- Water Quantity

Indicator	Current state	Desired end state
Proportion of unsustainable water withdrawals reduced (%)	All sub-basins except Gambhir and Yamuna sub-basins all are at low to medium levels of water stress. High rainfall and groundwater recharge recharge due to alluvial aquifers are the reason for more water availability.The basin is about 1194 billion cubic metres (BCM) of water short every year to remain within safe limits of use. The agricultural sector is a major freshwater user because of the increase in water-intensive crops and leakages from the distribution system. Government subsidies exist for drip irrigation, the practice of which is limited. The zero liquid discharge (ZLD) rule is applicable to the electroplating industry in Rajasthan; it requires units to recycle and reuse water to the maximum possible extent (90–95%). The present extent of wastewater recycling practised within these facilities is not known.	1. Less than 20% water stress. 2. Improved water use efficiency for irrigated crops. 3. Improved efficiency in industrial water use through process and technological improvements. Wastewater reuse and recycling wherever feasible or required by the law.

Chapter 4: Water Quality

Treatment of domestic and industrial wastewater

SDG 6.3.1 tracks the percentage of wastewater flows from households, services, and industrial premises that are treated in compliance with national or local standards.

The capacities of all the Sewage Treatments Plants (STPs) and Effluent Treatment Plants (ETPs) in each district were acquired. The water demand of both the domestic and industrial sectors was also obtained. Using the weighted average method, the values were calculated at the sub-basin level. A proportion of the total wastewater generated by the domestic and industrial sectors and the total capacity of the STPs and ETPs were then estimated for each sub-basin.

The amount of effluent generated by the domestic and industrial sectors is 12598 MLD. Of this, the domestic sector contributes 1,2994 MLD of wastewater, and the industrial sector 520 MLD. The existing treatment capacity is around 1.63% of the effluent generation. This shows the dismal reality of wastewater treatment, which is a major cause of the pollution of water bodies in the basin.

The population of the basin is predominantly poor, with unplanned urban and industrial development in the area adding stress to underdeveloped sanitary conditions. Multiple unauthorised colonies and illegal industries along the rivers that have no proper sewer connections directly discard sewage and effluents into the river (Babu, 2021). In most places, there are no on-site treatment facilities, which results in wastewater ending up in water bodies. Moreover, the STPs that have been sanctioned have not yet been constructed. The government's method, of adopting only engineering-centric approaches to solve the issue by creating only large STPs, has indeed added to the problem (Kaur, 2018).

Some existing gaps in the wastewater treatment capacity are as follows:

- Union and state governments do not have the funds to bear maintenance costs.
- There is a low level of skill among the maintenance staff.
- There is no sewerage network in the city.
- Limited access to a piped water supply results in low estimates of sewage generation, which is a reason for the inadequate installation of STPs.

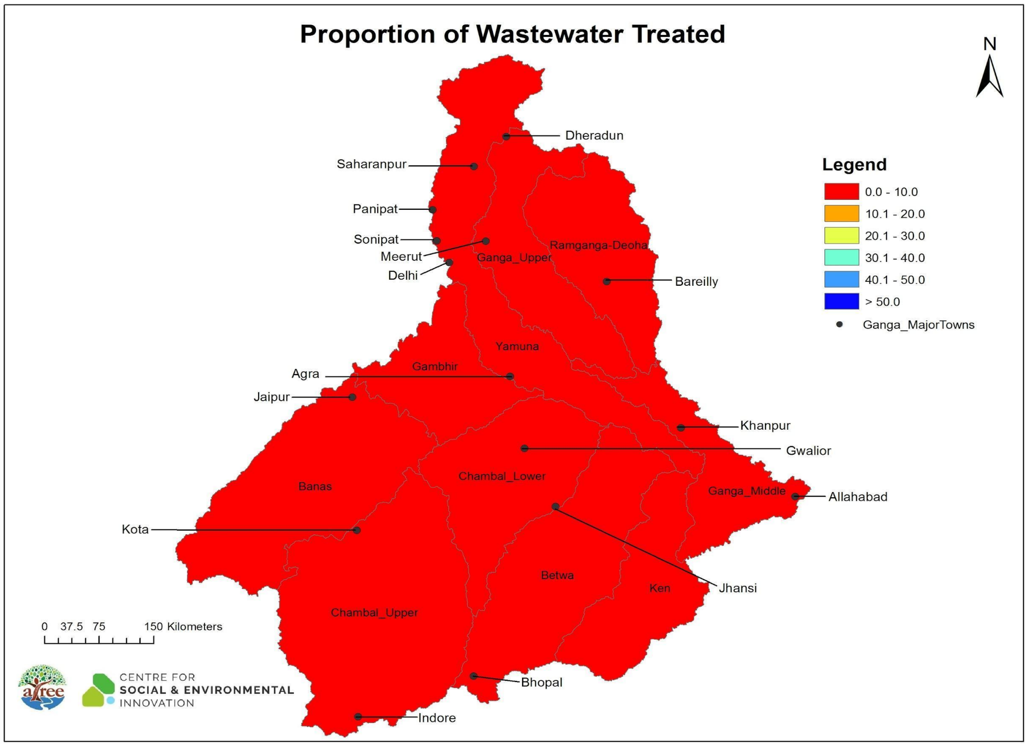

Figure 4.1: Map showing the proportion of wastewater being treated

Water bodies with good ambient water quality

SDG 6.3.2 tracks the percentage of water bodies (rivers, lakes, and groundwater wells) in a country with good ambient water quality. Good water quality according to this indicator is an ambient quality that does not damage ecosystem function or human health. For this indicator, the proportion of lakes, rivers, and groundwater wells with good ambient water was estimated.

The water quality for all lakes, rivers, and groundwater was obtained for different parameters. The water quality of these bodies was then compared with the local water quality standards and SDG targets (Annexure B) to see if they satisfied the standards of good ambient water quality. The percentage of water bodies that meet the good ambient quality standard was estimated for each sub-basin as well. It was found that very little data was available for the water quality of surface water bodies. Among the ones that were reported, it was observed that the overall ambient water quality was bad. Few regions in the basin are also affected by arsenic contamination (Figure 4.13) which is present in the water due to geogenic reasons.

During non-monsoon periods, the flow in rivers is low. Additionally, groundwater over-abstraction results in lower base flows in the rivers in the basin. Lower flows prevent rivers from maintaining self-purification capacity, thus contributing to the high concentration of pollutants. A major source of pollution in these water bodies is the unabated discharge of sewage from domestic sources (PTI, 2019; ENVIS, n.d.).

Inland salinity is caused by the practice of surface water irrigation without consideration for the groundwater status. The gradual rise of groundwater levels with time has resulted in water logging and heavy evaporation in semi-arid regions, leading to salinity problems in command areas (CGWB, n.d.). The groundwater in the basin is also highly polluted by nitrate. The high level of nitrogen pollution is caused by the extensive use of nitrogen fertiliser and manure, and domestic sewage (Munoth et al., 2015).

Some existing barriers to achieving good ambient water quality for water bodies are as follows:

- Data is unavailable for a large number of surface water bodies as they are not monitored.
- Wastewater treatment facilities are inadequate.
- There are no comprehensive solid waste management plans in the basin.
- There are no comprehensive fecal sludge management plans in the basin.

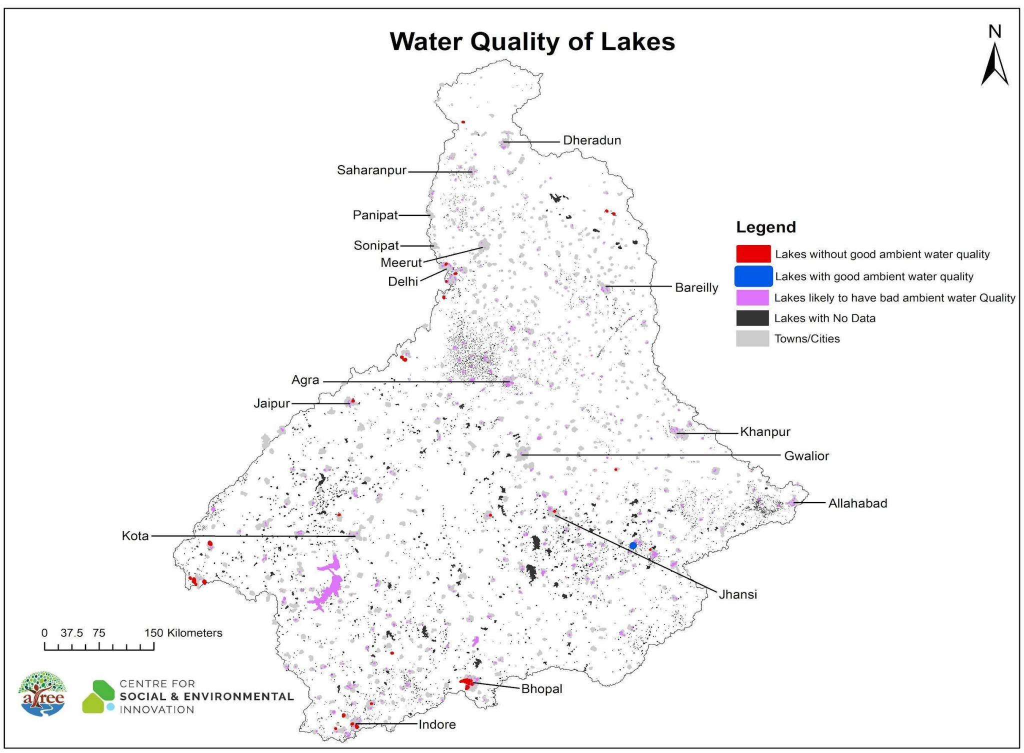

Figure 4.2: Map showing the water quality of lakes

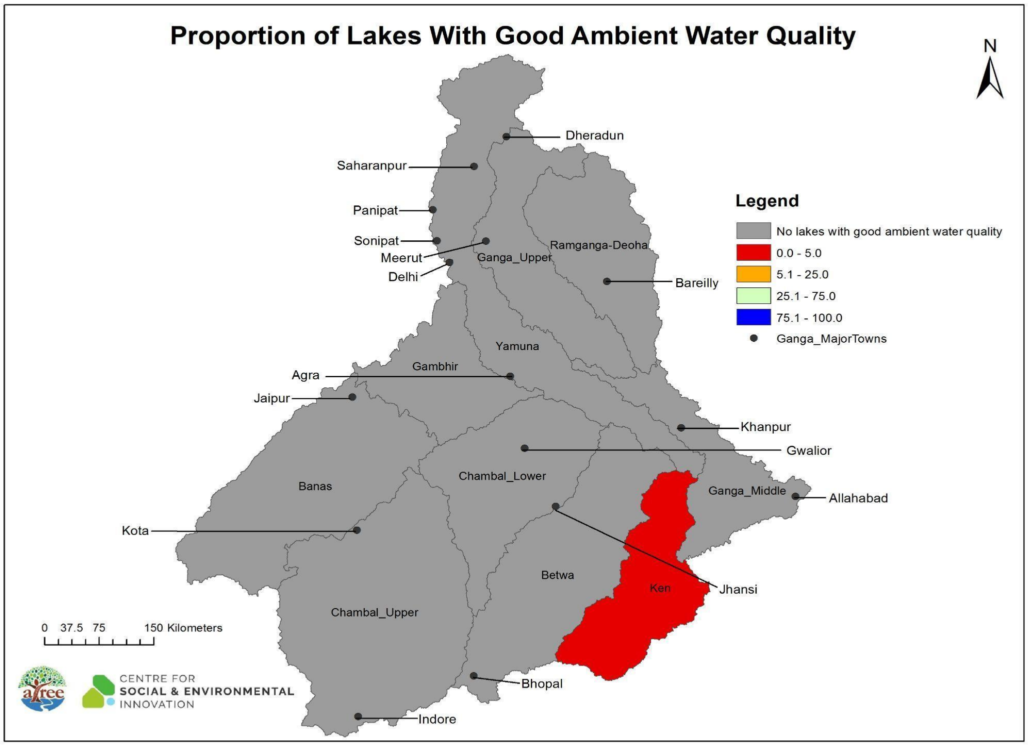

Figure 4.3: Map showing the proportion of lakes with good ambient water quality

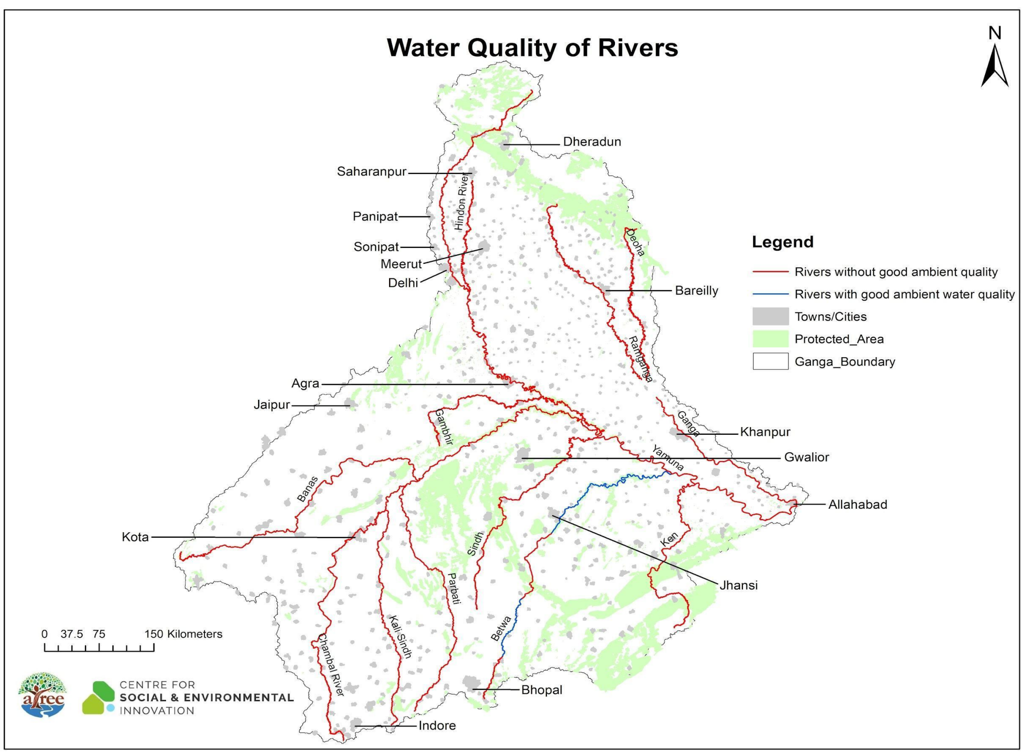

Figure 4.4: Map showing the water quality of rivers

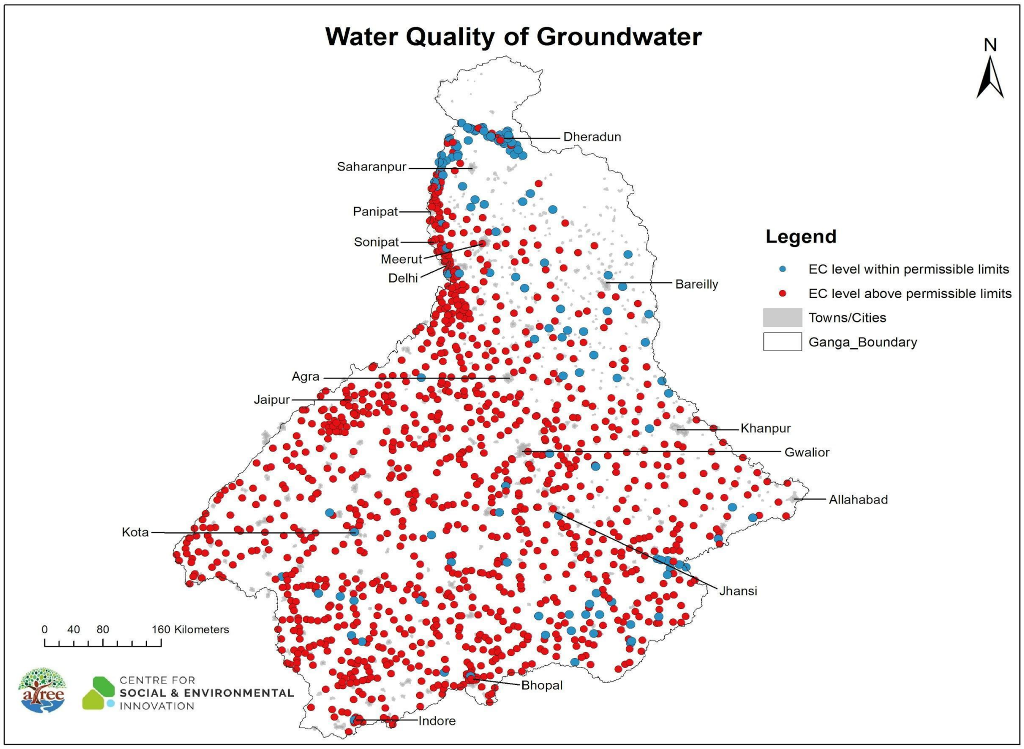

Figure 4.5: Map showing the water quality of groundwater – Electrical Conductivity (EC) (SDG)

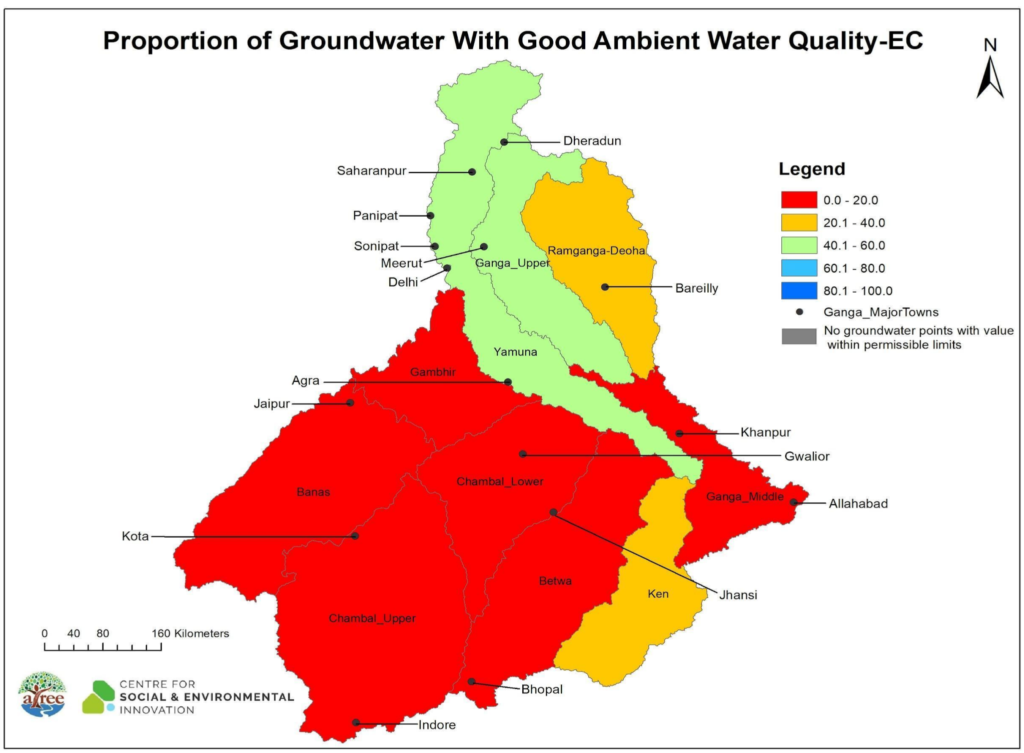

Figure 4.6: Map showing the percentage of groundwater with good ambient water quality – EC (SDG)

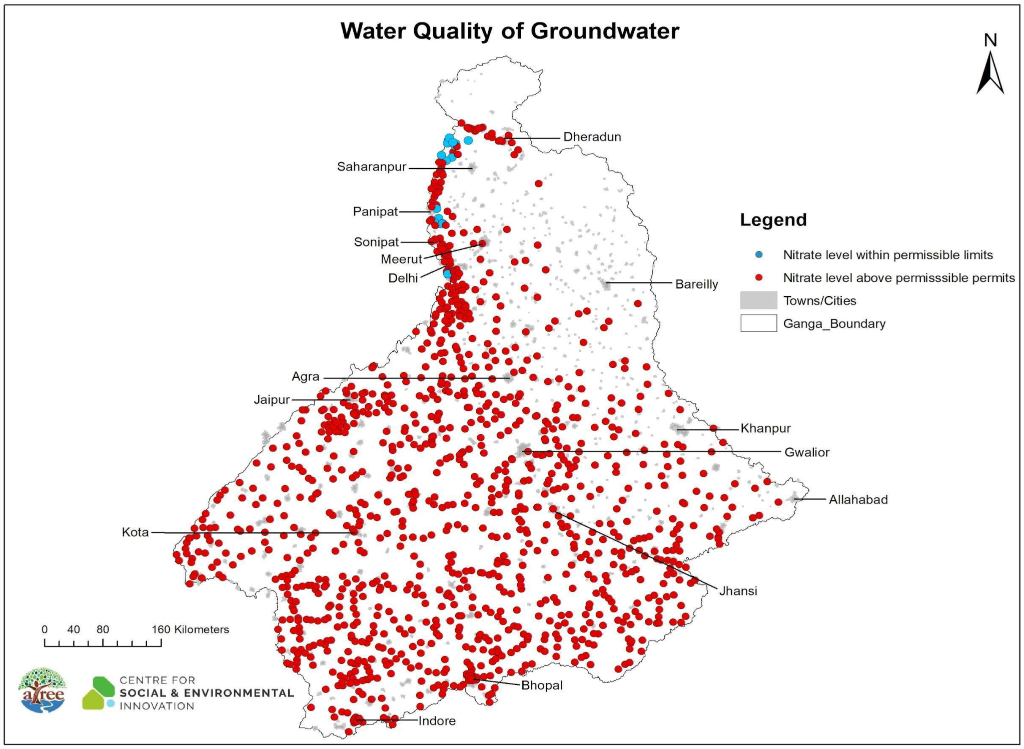

Figure 4.7: Map showing the quality of the groundwater – nitrate (SDG)

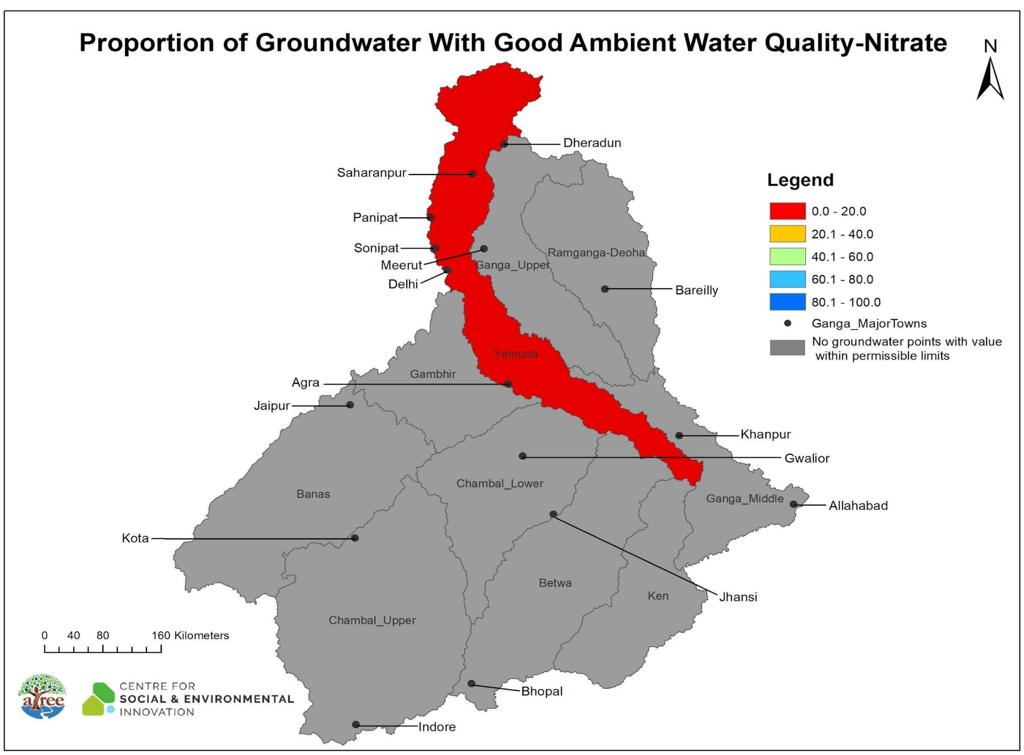

Figure 4.8: Map showing the percentage of groundwater with good ambient water quality – nitrate (SDG)

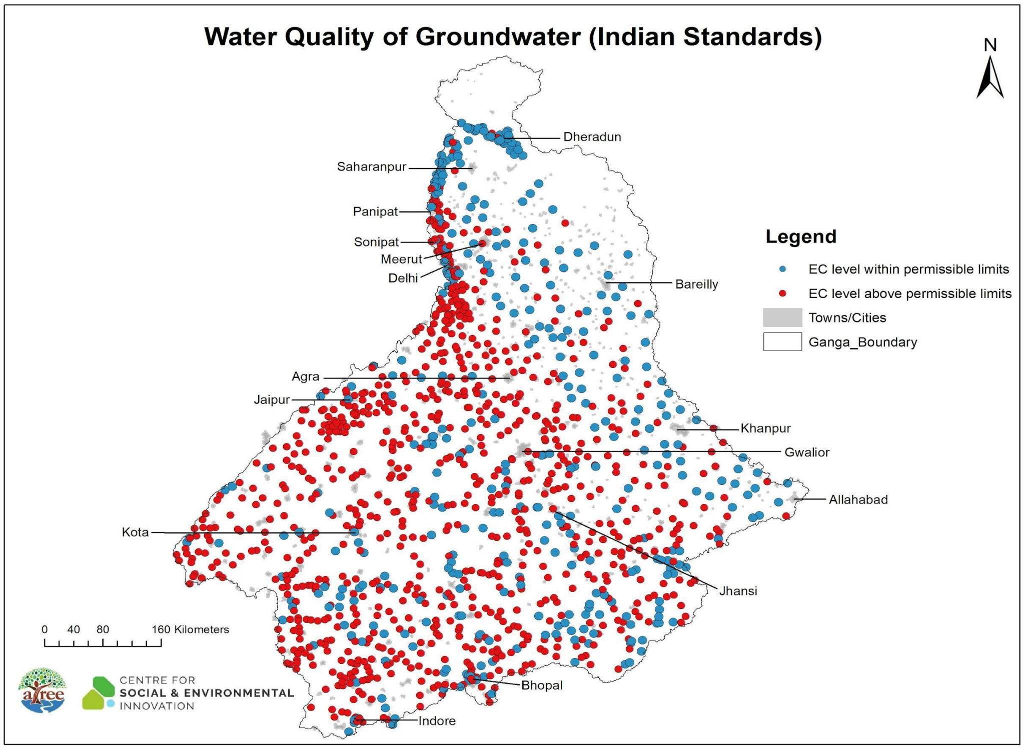

Figure 4.9: Map showing the quality of the groundwater – EC (Indian)

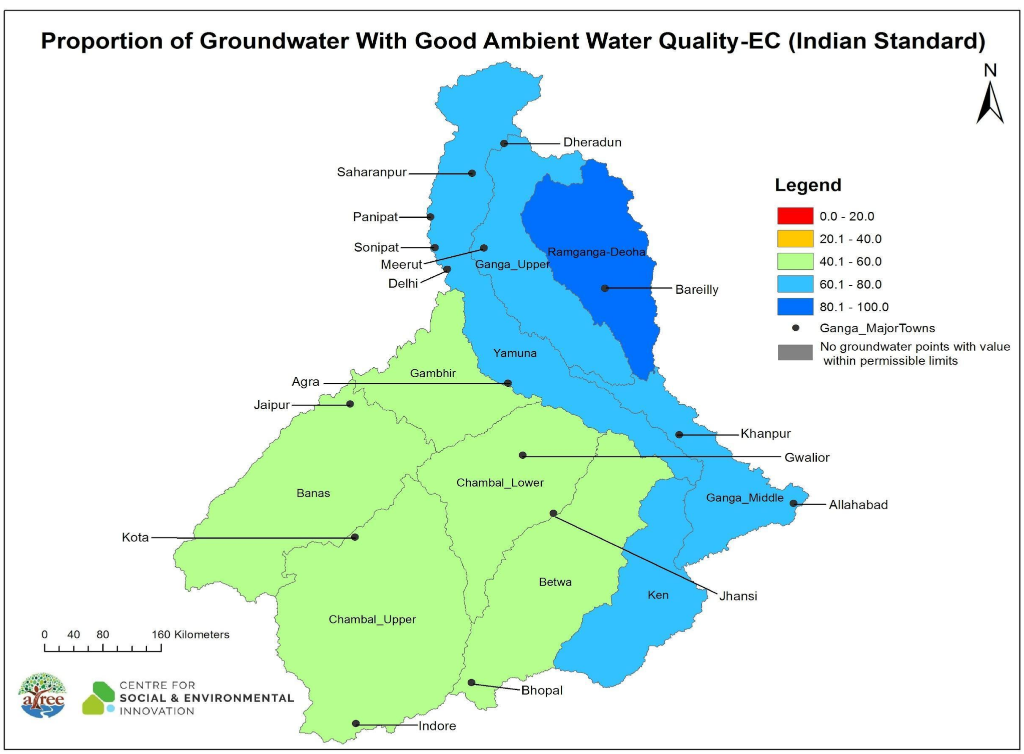

Figure 4.10: Map showing the percentage of groundwater with good ambient water quality – EC (Indian)

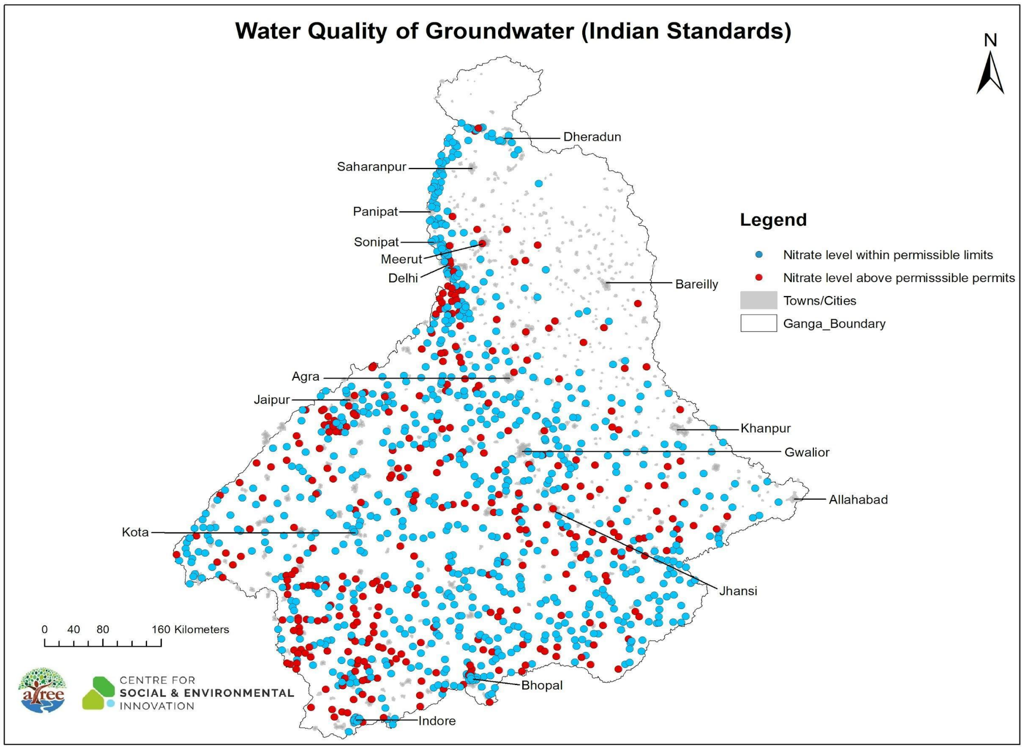

Figure 4.11: Map showing the quality of the groundwater – nitrate (Indian)

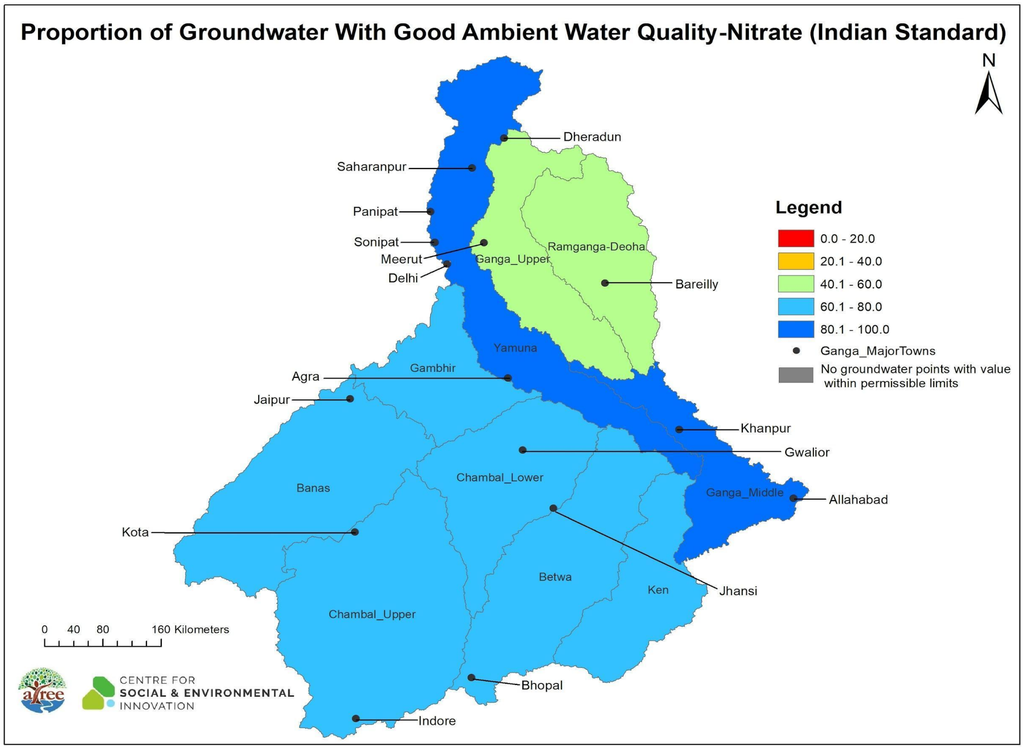

Figure 4.12: Map showing the percentage of groundwater with good ambient water quality – nitrate (Indian)

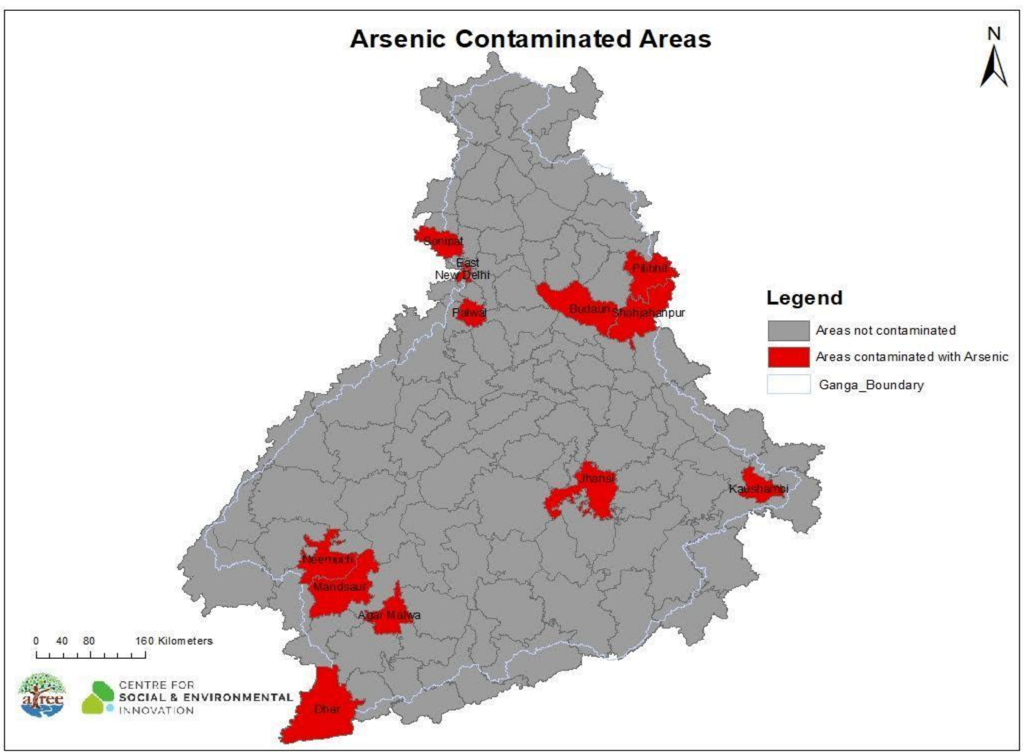

Figure 4.13: Map showing the districts with Arscenic contamination in the groundwater

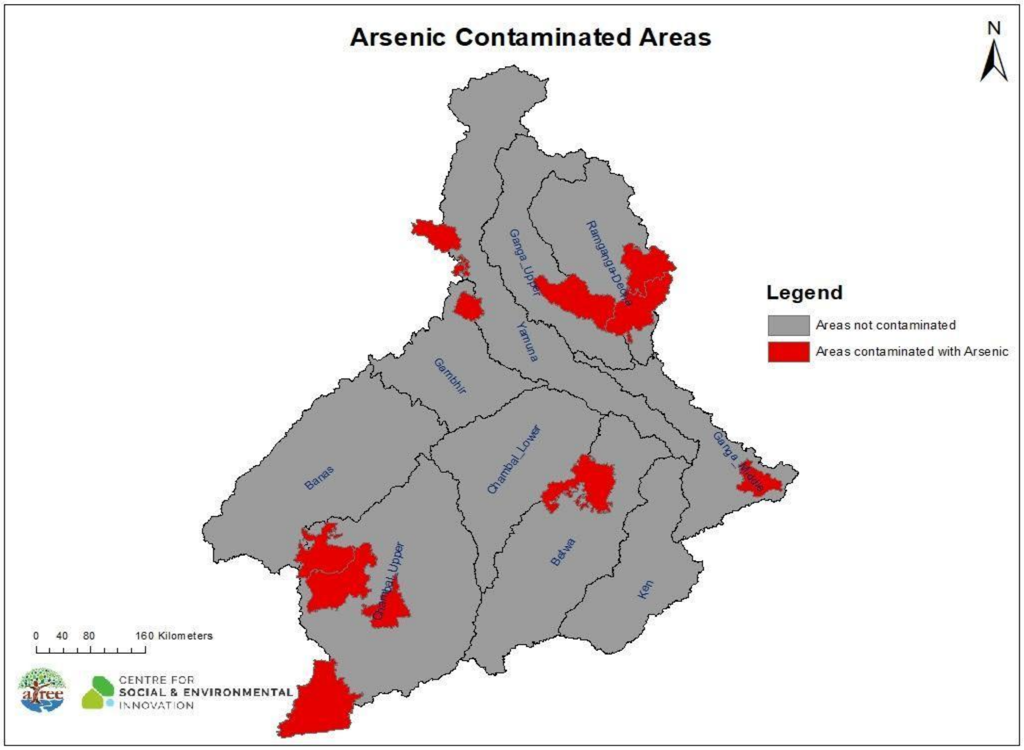

Figure 4.13: Map showing the sub-basins with Arscenic contamination in the groundwater

Table 4.1: Basin Context Metrics- Water Quality

Indicator	**Current state**	**Desired end state**
Proportion of excess pollutant removed (%)	The treatment capacity in the basin is a mere 1.63% of the total effluents being generated. The basin only has the capacity to treat 205 MLD of the total 12598 MLD of wastewater generated.	1. For urban settlements, 20% reuse and recycling of sewage is the service-level benchmark for Urban Local Bodies (ULBs). 2. Treat 100% of the generated industrial effluents. 3. Reuse within processes wherever possible. 4. Where legally permitted, discharge treated effluents on land/into the water body.

Proportion of lakes with good ambient water (%)	Less than 1% of lakes and rivers have water quality standards that do not damage ecosystem function or human health. For the rest of the water bodies, Dissolved Oxygen (DO)<9 mg/l, pH<6 or >8, and nitrate>45 mg/l. The salinity of 10.32% of the monitoring wells is within the permissible limit of EC<500 µS/cm and the nitrate levels of 1.4% are within the permissible limit of <0.25 mg/l (SDG standard). The salinity of 29.2% of the monitoring wells is within the permissible limit of EE\C<746 µS/cm and the nitrate levels of 69.2% are within the permissible limit of <0.25 mg/l (Indian standard).	Water bodies must have water quality standards that do not damage ecosystem function or human health. Surface water DO>9 mg/l, pH = 6–8, and nitrate<45 mg/l. Groundwater ● Indian standard EC<746 µS/cm and nitrate<45 mg/l. ● SDG standard, EC<500 µS/cm, and nitrate<0.25 mg/l.

Chapter 5: Important Water-Related Areas

SDG 6.6.1 aims to track changes in water-related ecosystems over time. Remote sensing data is used to determine the changes to surface water bodies, such as lakes, large rivers, flooded wetlands, and reservoirs. For this indicator, Joint Research Centre (JRC) data was used to analyse 20 years of data on the area covered by surface water bodies in the basin.

Water is necessary to sustain ecosystems, both terrestrial and aquatic, in addition to its use for human consumption. Different levels of flow (high, low, flow during the lean season, flood flows, and drought flows) are necessary to protect the biodiversity of aquatic habitats. There is a need to maintain a balance between how much water is abstracted for anthropogenic use and how much should be left to protect aquatic habitats (Anantha, Bhadbhade, & Dharmadhikary, n.d.).

An analysis of the 20 years of data showed that on average there has been an increase in the area covered by surface water bodies in all sub-basins. The basin consists of water bodies like lakes, ponds, tanks, reservoirs, and old quarries. Most water bodies in the basin are abandoned water-filled quarries. The next most common are lakes and tanks constructed for irrigation purposes. A significant amount of area is under water-logged irrigation (India WRIS, 2014).

More than 80% of the annual flow in the upper Ganga basin occurs during the four-month monsoon, resulting in widespread flooding. Storage of this flow for utilisation during the dry season became prevalent with the expansion of agriculture (Khan et al., 2014). There are over 220 dams in the basin built mostly for irrigation, of which 17 generate hydroelectric power. Some of these dams played an important role in the country achieving self-sufficiency in food production (Rasul, 2014).

Uncontrolled groundwater abstraction through distributed pumping in adjoining aquifers has reduced the baseflow, thus, in turn, lowering streamflow, especially in the summer. This reduction in surface water could have a major effect on food production in the basin (Mukherjee et al., 2018).

Some existing gaps in maintaining an adequate quantity of water in surface water bodies are as follows:

- Not exploring alternatives like reusing and recycling wastewater is the reason for such high demands for freshwater.
- There is no monitoring system in place to regulate groundwater extraction.
- There are no incentives to regulate groundwater extraction.

Table 4.1: Basin Context Metrics- Water Quality

Indicator	Current state	Desired end state
Ecosystem services status risk	All sub-basins have experienced an increase in the area under surface water due to a rise in the number of structures that provide irrigation water. The area under surface water has increased in some basins because of the release of treated and untreated effluents into seasonal water bodies, which has turned them into perennials.	1. Adequate quantity and contiguity inflows in the rivers. 2. An adequate quantity of water maintained in other surface bodies.

Chapter 6: Water Governance

Implementation of integrated water resources management

SDG 6.5.1 aims to track the degree to which integrated water resources management (IWRM) is implemented. This is assessed using four key components of IWRM: enabling environment, institutions and participation, management instruments, and financing. The upper Ganga basin got a score of 43 on the assessment. This score indicates a moderate level of IWRM implementation.

Water is a state issue as per the Indian Constitution – it falls under the control of state governments and there is no dedicated river basin organisation for the management of water resources. Two national laws i.e. the Inter-state River Water Disputes Act, 1956 and River Boards Act, 1956 exist, but they are not strictly based on IWRM (India Code, 1956; Ministry of Water Resources, 1956). There are no basin-level institutional arrangements to monitor the actual operation of an inter-state river water agreement. The National Ganga River Basin Authority was set up by the government in 2009 to abate pollution and manage water at the river basin level. However, top–down approaches, end-of-the-pipe solutions, and a lack of data led to the failure of the Ganga Action Plan that they implemented. In 2016, the National Ganga Council was set up but has not held a single meeting since (DTE Staff, 2018). The huge amounts of funds allocated to the project are not disbursed properly, especially to local institutions working on water challenges in the basin (Tripathi, 2020).

There is no mechanism for the coordinated planning and management of water resources across sectors which can bring together citizens, state institutions, and private actors from the agricultural and industrial sectors. The basin also lacks management instruments to regulate and monitor groundwater use. Aquifer management plans have been prepared at the state level but have not yet been implemented. There are also no established aquifer-level management organisations.

The basin has a large command area with a historic canal, which is unlined. This reduces the efficiency of delivery but contributes majorly to recharges (Gangakosh, n.d.). Yet the management approach in the basin involves a complete disconnect between surface and groundwater.

Some existing barriers to implementing IWRM are as follows:

- Stakeholder participation, management instruments, and financing are low or non-existent at the basin level.
- Stakeholder participation and consultation are low in the context of making water management plans.
- The river basin management authority is inefficient.
- The allocation of funds has been improper.

Operational arrangement for water cooperation

SDG 6.5.2 tracks any operational arrangement for water cooperation within a river basin. This arrangement can be a bilateral or multilateral treaty, convention, agreement, or other formal arrangements between riparian states that provides a framework for cooperation.

Since water flows irrespective of administrative boundaries, management activities should be conducted at the basin level. Still, despite the benefits, the different states within the basin have not entered into any multilateral management agreement (Shahjahan & Harvey, 2011). There is also no water-sharing arrangement at the upper basin level. The Ganga Water Sharing Treaty, 1996 is only for solving disputes between India and Bangladesh over sharing Ganga water. Within the basin, resource allocation is mainly based on drinking and irrigation water requirements (Rahman et al., 2019). There are no schemes for managing water allocation in the basin.

Some existing barriers to the implementation of operational arrangements for water cooperation in the basin are as follows:

- Groundwater is treated as an independent source without consideration for its contribution to baseflows.
- No guidance has been given on how water should be allocated when water levels decline due to anthropogenic effects and not rainfall reduction.
- There is no basin-level organisation responsible for ensuring multilateral cooperation.

Amount of official development assistance received

SDG 6.a.1 tracks the amount of official development assistance (ODA) included in a government-coordinated spending plan. The following are some of the programmes in the upper Ganga basin that have received ODA:

1. The World Bank has provided assistance of USD 1 billion to the National Ganga River Basin Authority.
2. The Japan International Cooperation Agency (JICA) is supporting a project in Varanasi by providing INR 496.9 crore (NMCG, n.d.).

Participation by local communities

SDG 6.b.1 tracks the level of stakeholder participation in water and sanitation management within a country. There is no multidisciplinary institutional structure and few opportunities to bring non-state actors and water users together to actively participate in the consultation process. Decisions for water management are usually taken by state actors within government agencies, and such processes lack transparency. Public consultations are usually not conducted while taking management decisions. The current scheme has no provision for engagement with experts from multidisciplinary fields as well (Harsha, 2018). However, there are a few platforms that exist.

In the basin, of the seven states, only Uttar Pradesh has enacted the Uttar Pradesh Irrigation Management Act, 2009 to implement the participatory irrigation management (PIM) programme. Under the act, farmers are involved in the management of the irrigation system and water distribution. A legal framework would facilitate the creation of farmers' organisations at different levels of the irrigation systems (Ministry of Jalshakti, n.d.).

Under the Jal Jeevan Mission, a programme started by the central government, there is a provision for water groups at the village level (village water and sanitation committee (VWSC)/paani samiti/user group) to plan, implement, manage, operate, and maintain in-village water supply systems (Ministry of Jalshakti, 2021).

Some existing gaps in local participation in water and sanitation management are as follows:

- Platforms for stakeholder consultation and engagement are either limited or non-existent.
- Management decisions are made only in consultation with engineers and bureaucrats instead of involving all the stakeholders.
- Older water distribution projects have deteriorating control and measuring structures, leakages, and seepages, which prevent farmers from taking control of the system.
- There is a lack of funds allocated for the maintenance and operation of structures, preventing stakeholders from managing water resources.

Table 6.1: Basin Context Metrics- Water governance

Indicator	Current state	Desired end state
Implementation of IWRM	The basin-level institutional arrangements in place are not effective, as members do not meet.	1. Effective platforms for inclusive, multi-stakeholder discussions for river basin management.

	There is low fund allocation and disbursement. There is a lack of management instruments available to regulate and monitor groundwater use. The IWRM programme has not been implemented.	2. Documentation of water use by sector as well as the total water availability and estimated future requirements.
Transboundary organisation for catchment management	There is no basin-level organisation to implement multilateral cooperation. There are no schemes that manage intersectoral water allocation in the basin.	Operational arrangement for water cooperation with regular, formal communication between riparian states and exchange of data and information.
Catchment management organisation	Decisions for water management are usually taken by state actors within government agencies; the processes lack transparency. Public consultations are usually not conducted while taking management decisions.	1. A river basin management plan that addresses aspects related to water quality, basin water security, sustainability, crisis preparedness, basin-level governance, and fair water allocations to different user groups. 2. Effective groundwater regulation law. 3. Procedures in law or policy for participation by service users and communities.

Chapter 7: Water Crisis

Disaster reduction strategy

SDG 13.1 tracks the measures that strengthen resilience and adaptive capacity for climate-related hazards and natural disasters in all countries. In India, the Disaster Management Act, 2005 provides for the effective management of disasters. Under this act, the National Disaster Management Authority has been set up; this body lays down all policies and national plans for managing disasters. It also establishes guidelines for states and government departments towards the prevention of disasters. The National Disaster Management Plan, 2016 aligns the national plan with the Sendai Framework for Disaster Risk Reduction 2015–2030. This framework that was adopted at the Third UN World Conference on Disaster Risk Reduction outlines targets and priorities for action to prevent new and reduce existing disaster risks. In addition to this, all states have a state disaster management authority, and district disaster management authorities, which are responsible for coordinating mitigation, preparedness, response, and recovery measures at the local level. Each of these authorities has disaster management plans, in accordance with the Sendai Framework, which lay out the roles and responsibilities of different agencies during a disaster.

Several disaster risk reduction strategies have been adopted at the national and local levels. The following is a list of schemes initiated by the Disaster Management Division:

1. The National Cyclone Risk Mitigation Project (NCRMP) was launched by the Ministry of Home Affairs. It aims to minimise vulnerability to cyclones and make people and infrastructure disaster-resilient. The project costs INR 2,691 crore and is being funded by the central government with assistance from the World Bank (in the form of a loan) and state governments.
2. Infrastructure development for 10 battalions and 10 teams of the National Disaster Response Force (NDRF) scheme was sanctioned to increase the functional efficiency in administration, capacity building, and storage of specialised equipment for NDRF as well as relief stores and resources. The National Disaster Response Reserve (NDRR), India was created to maintain a central inventory of necessary relief equipment for a population of at least 2,50,000 people in the plain areas and store availability for a minimum of 1,50,000 people in hilly areas. The project costs about INR 250 crore.
3. The Aapda Mitra Scheme is a centrally sponsored scheme that focuses on training community volunteers in disaster response in the 30 most flood-prone districts of 25 states in India. It aims to train community volunteers in the skills needed to respond to their community's immediate needs in the aftermath of a disaster. These skills would enable them to complete basic relief and rescue tasks during emergencies. The project costs around INR 15.47 crore.

4. Strengthening of state disaster management authorities (SDMAs) and district disaster management authorities (DDMAs) was done by the National Disaster Management Authority. It aims to improve the effectiveness of all SDMAs and selected DDMAs and to make them operational by providing dedicated disaster management professionals to facilitate prevention, mitigation, preparedness, and capacity building in the context of threatening situations or disasters. The project costs INR 42.51 crore.
5. The NDRF Academy was set up in Nagpur to establish a dedicated practical training institution for first responders in the event of a disaster. The project costs INR 125.01 crore.
6. The National Emergency Communication Plan (Phase II) aims to set up reliable communication links between decision-makers at various levels and operational response teams at the disaster site. The project costs INR 16.4372 crore (Disaster Management Department, n.d.).

Financial assistance is provided to states through the Calamity Relief Fund (CRF) and National Calamity Contingency Fund (NCCF) for immediate rescue and relief operations. Allocations for state CRFs are made on the recommendation of finance commissions, contributed to by the central and state governments (National Institute of Disaster Management, 2018).

The Central Water Commission (CWC) is responsible for monitoring flood situations in the country during the designated flood periods by observing water levels/discharges along the major rivers in the country. It issues flood forecasts and warnings to the local administration/project authorities/state governments and other central ministries. The Indian Meteorological Department is the nodal agency that provides cyclone warnings in India. District Agriculture Contingency Plans (DACPs) provide guidance to the relevant government departments and farmers on what measures need to be taken during a natural disaster.

The Ganga Flood Control Commission was created in 1972. It is responsible for preparing a comprehensive plan for flood management and for implementing flood management works within the states in the basin (Shahjahan & Harvey, 2011).

The National Remote Sensing Centre has prepared a Flood Vulnerability Index map for the whole country. The map was made by integrating the maximum probable precipitation, runoff potential, and probable maximum runoff layers in the spatial decision support system environment using a multi-criteria evaluation technique (NRSC, n.d.).

The Indian Meteorological Department also uses the standardised precipitation index to monitor droughts. The index is based on long-term precipitation records in a region. The long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean Standard Precipitation Index (SPI)for the location and desired period is zero. Negative values indicate drought conditions and positive values indicate wet conditions (IMD, 2020).

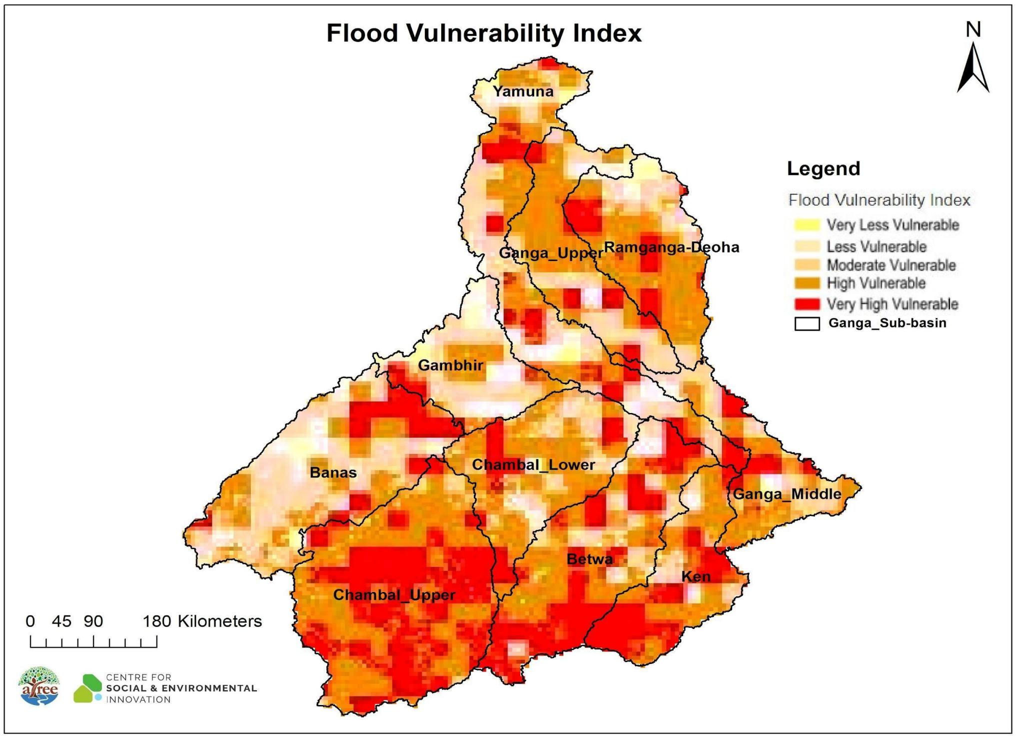

Figure 7.1: Map showing the Flood Vulnerability Index of the upper Ganga basin

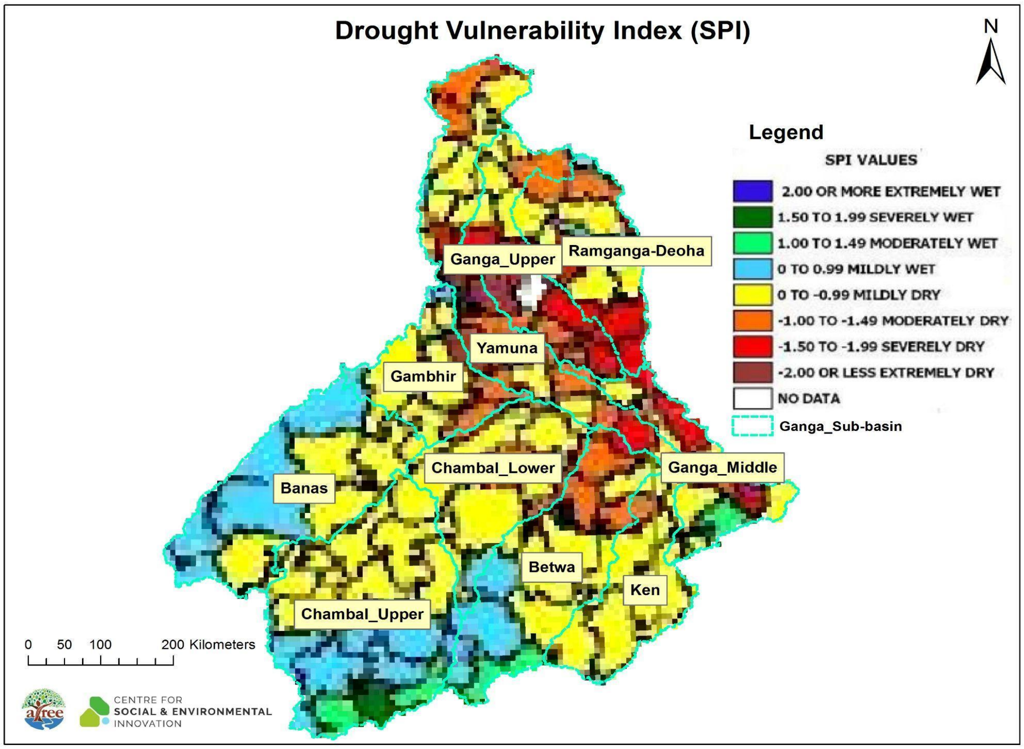

Figure 7.2: Map showing the Drought Vulnerability Index of the upper Ganga basin

Table 7.1: Basin Context Metrics- Water crisis

Indicator	Current state	Desired end state
Number of deaths, missing persons, and directly affected persons attributed to disasters per population of 1,00,000	Disaster reduction strategies exist at the national and local levels. There are enough funds allocated for disaster management. There are early warning systems in place.	Strong resilience and adaptive capacity to climate-related hazards and natural disasters in all countries by reducing the number of deaths, missing persons, and directly affected people.
Disaster risk reduction strategy at the national level	The Disaster Management Act, 2005 provides for the effective management of	National disaster risk reduction strategies in line with the Sendai Framework

	disasters.	for Disaster Risk Reduction 2015–2030.
Disaster risk reduction strategy at the local level	In addition to the National Disaster Management Authority, each state has its own state disaster management authorities and district disaster management authorities which are responsible for coordinating mitigation, preparedness, response, and recovery measures at the local level.	Local-level disaster risk reduction strategies in line with the Sendai Framework.
Direct economic loss in relation to the global gross domestic product (GDP), damage to critical infrastructure, and the number of disruptions to basic services, attributed to disasters	There are enough funds allocated for disaster management. Early warning systems are in place.	Low levels of economic loss, relative to the global GDP, as a result of natural disasters.

Chapter 8: Recommendations

Based on our assessment of the baseline indicators in the Ganga basin, table 8 provides a list of opportunities for collective action.

Table 8: Opportunities for collective action

Indicator	Severity*	Current government efforts (schemes and acts)	Opportunities for collective action		
			Funding	Training	Implementation
WASH	Low	Jal Jeevan Mission (JJM), Swachh Bharath	• Create innovative financing mechanisms for wastewater. • Provide funds for pump solarisation.	• Create and deploy games and audio-visual aids to train the public in safe sanitation practices.	• Provide drinking water and purification systems in rural areas. • Initiate schemes for source sustainability and protection.
Water quantity	High	National Water Policy, 2012, Command Area Development Programme (CADP), Atal Bhujal Yojana,	• Co-create water footprint benchmarks for crops and products that reflect reasonable	• Ensure training and capacity building towards implementing modern agriculture and	• Stimulate groundwater recharge through treated wastewater injection and rainwater harvesting.

		NREGA, JJM, Pradhan Mantri Krishi Sinchayee Yojna (PM-KSY), Ganga River Basin Management Plan, Uttar Pradesh Ground Water (Management and Regulation) Act, 2019, Uttarakhand Ground Water (Regulation and Control of Development and Management) Act, 2016	levels of water consumption per unit of production. • Fund innovative technologies such as pump solarisation.	irrigation techniques in local governments/far mer producer organisations (FPOs).	• Establish a repository of model water management plans and solutions, particularly for demand-side management. • Co-develop data and tools to help local governments (towns/gram panchayats) manage water resources better. • Implement watershed management programmes to increase the resilience of watersheds. • Ensure smart and efficient irrigation scheduling and improved soil and crop management.

Water quality	High	National Mission for Clean Ganga, National Water Quality Monitoring Programme, Namami Gange Programme, Water (Prevention and Control of Pollution) Cess Act, 1977	• Fund innovative technologies for nature-based solutions.	• Run skill development training programmes for the maintenance of treatment facilities.	• Help towns plan and implement sewerage infrastructure. • Provide technical assistance to towns and gram panchayats for accessing government funds. • Pilot wastewater treatment facilities, especially in small towns. • Pilot Natural Biological System (NbS) solutions for treating agricultural runoff, which contaminates water bodies in agricultural areas.
Water governance	Medium	Inter-state River Water Disputes Act, 1956, participatory irrigation management, JJM, Ganga Action Plan	• Demonstrate new funding mechanisms, such as water trusts and drought funds, that allow for the	• Provide IWRM training to government officials.	• Create and maintain crowdsourced dashboards with quality and quantity data for different water sources.

			reallocation of water between sectors.		• Create platforms for stakeholder consultations and engagement, and share knowledge and data on water interventions.
Water crisis	Low	National Cyclone Risk Mitigation Project (NCRMP), Aapda Mitra Scheme, National emergency communication plans, Calamity Relief Fund, Ganga Flood Control Commission	• Fund early warning systems.	• Offer capacity building for early warning systems and better tools for management.	• Implement watershed management programmes to increase the resilience of crops. • Ensure the proper maintenance of water bodies, for instance by increasing their storage capacity so that they can act as buffers during drought or flood events.

*Severity levels based on a qualitative assessment of sub-indicators.

Table 9: Existing multi-sector coalitions/partnerships in the water sector

Water challenge	Organisations	Theory of change	Link
WASH/Water quality	Water Aid, Centre for Urban and Regional Excellence (CURE), and International Water Management Institute (IWMI)	Pilot a small-scale, decentralised faecal sludge management model.	https://www.wateraid.org/in/institutional-partnerships
WASH	Centre for Environment Education and Varanasi Nagar Nigam	Raise awareness and sensitise the community towards cleanliness and sanitation.	https://www.ceeindia.org/clean-ganga-programme-at-varanasi-water-and-sanitation
Water quantity	Abard, Alstom Foundation, Arghyam, Ashoka Trust for Research in Ecology and the Environment, IIT Roorkee, Acwadam, Tata Trust, and Swajal Project supported by World Bank and The Hans Foundation	Initiate community engagement with spring recharge through implementing water recharge structures like percolation pits, terraces, and bunds.	http://chirag.org/what-we-do/natural-resource-management/spring-recharge
Water quantity	National Bank For Agriculture And Rural Development. Action for Social Advancement, and Where	• Organise smallholders into FPOs for backward and forward market	https://www.asaindia.org/project-detail13.html

	There Is a Well	linkages. • Construct dugwells.	
Water quality/quantity	Rajendra Singh Development Foundation and Tarun Bharat Sangh	Train communities to rejuvenate rivers and other natural water bodies as well as to adopt traditional methods of conserving water.	**https://tarunbharatsangh.in/portfolio_page/adapting-to-climate-change-through-water-management-in-eastern-rajasthan/**
Water quality	World Wildlife Fund and Ramganga Mitras	• Implement community-led design initiatives to mitigate water risks to the rivers. • Conduct river health assessment programmes and awareness activities.	**https://www.wwfindia.org/news_facts/feature_stories/the_ramganga_mitras__an_iconic_collective_that_works_together_to_protect_the_river_ramganga/**

Chapter 9: Limitations

1. For assessing the water stress,
    a. The total water availability(surface and groundwater) is not available at the sub-basin scale both in the literature as well as in the government reports. Thus, our study chose the basin wise water availability and divided it between sub-basins based on the area.
    b. The environmental flow data is not available at the sub-basin scale both in the literature as well as in the government reports. Thus, our study has chosen the total quantity allocated at the basin level in the river basin treaties and then divided it between sub-basins based on their area.
2. For assessing the ambient water quality of surface water bodies, data was unavailable for most of the surface water bodies that fall within the limits of a town/city. For these water bodies it was assumed that they are most likely to have bad ambient water quality given the low treatment capacity in the region.
3. For assessing the water crisis, due to data constraints the analysis had to be done at the state level, making it difficult to understand the severity of the situation at local levels like sub-basin.
4. All the water-related data provided by the government reports are present at the administrative boundary level (like the district of the state). While converting this data to a hydrological boundary could have led to the loss of some finer details.

References

Akhilesh, P., & Gudavarthy, A. (2022, January 18). A failed attempt to create an equally sanitary India. *The Wire*. https://thewire.in/government/a-failed-attempt-to-create-an-equally-sanitary-india

Anantha, L., Bhadbhade, N., & Dharmadhikary, S. (n.d.). *Environmental flows in river basin planning*. Water Conflict Forum. https://waterconflictforum.org/lib_docs/Environmental%20flows%20in%20River%20Basin%20Planning_revised%20draft%2018122017.pdf

Babu, N. M. (2021, September 13). Cleaning the Yamuna: A story of missed deadlines. *The Hindu*. https://www.thehindu.com/news/cities/Delhi/cleaning-the-yamuna-a-story-of-missed-deadlines/article36422298.ece

Bhadwal, S., Ghosh, S., Gorti, G., Mohan, D., Singh, P., Singh, S., & Yogya, Y. (2017). *The upper Ganga basin will drying springs and rising floods affect agriculture?* Himalayan Adaptation, Water and Resilience. https://lib.icimod.org/record/32708

Central Water Commission. (2014, March). Ganga Basin. Ministry of Water Resources. https://indiawris.gov.in/downloads/Ganga%20Basin.pdf

Central Water Commission. (2014, November). *Guidelines for improving water use efficiency in irrigation, domestic & industrial sectors*. http://nwm.gov.in/sites/default/files/Final Guideline Wateruse.pdf

Census 2011. (2011). *Census of India 2011*. https://www.census2011.co.in/

Central Ground Water Board. (2021). Dynamic Groundwater Resources of India, 2020. Department of Water Resources. http://cgwb.gov.in/documents/2021-08-02-GWRA_India_2020.pdf

CPCB. (2019, October 11). *Water quality criteria*. Ministry of Environment, Forest and Climate Change, Government of India. https://cpcb.nic.in/water-quality-criteria/

CPHEEO. (1999). *Manual on water supply and treatment – 1999*. Ministry of Housing and Urban Affairs, Government of India. http://cpheeo.gov.in/cms/manual-on-water-supply-and-treatment.php

DDWS. (n.d.). *Jal jeevan mission*. https://jalshakti-ddws.gov.in/sites/default/files/JJM_note.pdf

Directorate of Economics and Statistics. *Crop production statistics information system*. Retrieved February 22, 2022, from https://aps.dac.gov.in/APY/Index.htm

Disaster Management Department. (n.d.). *Schemes*. Retrieved December 15, 2021, from https://ndmindia.mha.gov.in/programs#

DTE Staff. (2016, April 5). 78% of sewage generated in India remains untreated. *Down to Earth*. https://www.downtoearth.org.in/news/waste/-78-of-sewage-generated-in-india-remains-untreated--53444

DTE Staff. (2018, August 28). Namami Gange: PM-led body fails to meet even once. *Down To Earth*. https://www.downtoearth.org.in/news/water/namami-gange-pm-led-body-fails-to-meet-even-once-61468

Dutta, S. (2017, July 10). Dealing with dysfunctionality: The problems of India's sewage treatment plants. *NDTV*. https://swachhindia.ndtv.com/dealing-with-dysfunctionality-the-problems-of-indias-sewage-treatment-plants-9659/

ENVIS. (n.d.). *Water quality status of river Yamuna*. Retrieved June 1, 2022, from http://www.sulabhenvis.nic.in/Database/WaterQualityStatus_6984.aspx#:~:text=The%20reason%20of%20deterioration%20of,domestic%20sources%20into%20the%20river

Executive Committee NGT. (2020, January 8). *4th report executive committee constituted by the hon'ble national green tribunal*. https://greentribunal.gov.in/sites/default/files/all_documents/4th-report-alongwith-annexures_compressed.pdf

FAO. (n.d.). *Chapter II: Measurement of effective rainfall*. Retrieved June 6, 2022, from https://www.fao.org/3/X5560E/x5560e03.htm#TopOfPage

Gangakosh. (n.d.). *Water resources projects in Ganga basin*. Retrieved June 1, 2022, from http://117.252.14.242/Gangakosh/Water%20Resources/Projects.htm

Ghosh, S. (2018, September 17). As India's Ganges runs out of water, a potential food shortage looms. *Mongabay*. https://news.mongabay.com/2018/09/as-indias-ganges-runs-out-of-water-a-potential-food-shortage-looms/

IMD. (2020). *Standardized precipitation index products: Dry/wet conditions at the end of south west monsoon (June – September).* https://www.imdpune.gov.in/hydrology/hydr_products.html

IMD. (2021). *Customized rainfall information system (CRIS).* http://hydro.imd.gov.in/hydrometweb/(S(zok2kqe5dooetfmftowh2i45))/DistrictRaifall.aspx

India Code. (1956). *The inter-state river water disputes act, 1956.* https://www.indiacode.nic.in/bitstream/123456789/1664/3/A1956-33.pdf

India WRIS. (2014, March). *Ganga basin*. https://indiawris.gov.in/downloads/Ganga%20Basin.pdf

Iyer, R. R. (2011). National water policy: An alternative draft for consideration. *Economic & Political Weekly*, *46*(26/27), 201–214. https://www.jstor.org/stable/23018819

Kaur, B. (2018, October 15). Namami Gange: 5 reasons why Ganga will not be clean by 2020. *Down To Earth*. https://www.downtoearth.org.in/coverage/pollution/namami-gange-5-reasons-why-ganga-will-not-be-clean-by-2020-61891

Kaushal, N., Babu, S., Mishra, A., Ghosh, N., Tare, V., Kumar, R., Sinha, P. K., & Verma, R. U. (2019). Towards a healthy Ganga – Improving river flows through understanding trade offs. *Frontiers in Environmental Science*, *7*(83). https://doi.org/10.3389/fenvs.2019.00083

Khan, M. R., Voss, C. I., Yu, W., & Michael, H. A. (2014). Water resources management in the Ganges basin: A comparison of three strategies for conjunctive use of groundwater and surface water. *Water Resources Management*, *28*, 1235–1250. https://doi.org/10.1007/s11269-014-0537-y

Mijic, A. (n.d.). *Water resources in India – The story of Ganges basin*. Imperial College London. https://www.imperial.ac.uk/grantham/research/resources-and-pollution/water-security-and-flood-risk/the-ganges-river-basin-in-india/

Ministry of Drinking Water and Sanitation. (2013). *National rural drinking water programme – Guideline, 2013*. https://jalshakti-ddws.gov.in/sites/default/files/NRDWP_Guidelines_2013.pdf

Ministry of Drinking Water and Sanitation. (2014). *Swachh Bharat mission – Grameen*. Retrieved December 15, 2021, from https://swachhbharatmission.gov.in/sbmcms/index.htm

Ministry of Jalshakti. (n.d.). *Status of participatory irrigation management (PIM) in India – Policy initiatives taken and emerging issues*. Department of Water Resources. http://jalshakti-dowr.gov.in/sites/default/files/CADWM_Status_of_PIM.pdf

Ministry of Jalshakti. (2019). *Jal jeevan mission*. Department of Water Resources. Retrieved December 15, 2021, from https://jaljeevanmission.gov.in/

Ministry of Jalshakti. (2021). *National jal jeevan mission – Guidelines*. Department of Water Resources. https://jalshakti-ddws.gov.in/sites/default/files/revised_krc_guidelines.pdf

Ministry of Statistics and Programme Implementation. (2013). *7th economic census*. https://mospi.gov.in/web/mospi/7th-economic-census-ec

Ministry of Water Resources. (1956). *The river boards act, 1956*. http://www.mowr.gov.in/sites/default/files/A1956-49.pdf

Mukherjee, A., Banja, S. N., & Wada, Y. (2018). Groundwater depletion causing reduction of baseflow triggering Ganges river summer drying. *Scientific Reports*, *8*. https://www.nature.com/articles/s41598-018-30246-7#citeas

Mukherjee, D. (2022, April 13). Drinking water: Big gap in reaching goal. *Daily Excelsior*. https://www.dailyexcelsior.com/drinking-water-big-gap-in-reaching-goal/

Munoth, P., Tiwari, K., & Goyal, R. (2015, December). Fluoride and nitrate groundwater contamination in Rajasthan, India: A review. *Hydro 2015 International*. https://doi.org/10.13140/RG.2.1.2859.6241

National Family Health Survey. (2020). *National family health survey – 5 (2019–2020).* http://rchiips.org/nfhs/districtfactsheet_NFHS-5.shtml

National Institute of Disaster Management. (2018). *Training programme on flood risk management*. https://nidm.gov.in/PDF/trgreports/2018/June/11-15_nidm.pdf

National Institute of Disaster Management. (2021). *Disaster risk financing, insurance, and risk transfer*. https://nidm.gov.in/PDF/pubs/WGR_NIDMandIII_2021.pdf

NMCG. (n.d.). *External funding and funding mechanism*. Retrieved June 1, 2022, from https://nmcg.nic.in/external_funding.aspx

NJJM. (2022). *Functional household tap connection (FHTC) in every rural home*. JJM. Retrieved February 10, 2022, from https://ejalshakti.gov.in/jjmreport/JJMIndia.aspx

NRSC. (n.d.). *Flood vulnerability index. National flood vulnerability assessment system*. Retrieved June 9, 2022, from https://bhuvan-app1.nrsc.gov.in/nfvas/#

Parvez, M. B., & Inayathulla, M. (2019). Estimation of surface runoff by soil conservation service curve number model for upper Cauvery Karnataka. *International Journal of Scientific Research in Multidisciplinary Studies*, *5*(11), 7–17. https://doi.org/10.13140/RG.2.2.30526.23366

PTI. (2019, May 30). Ganga river water unfit for direct drinking, bathing: CPCB. *The Economic Times*. https://economictimes.indiatimes.com/news/politics-and-nation/ganga-river-water-unfit-for-direct-drinking-bathing-cpcb/articleshow/69573401.cms

R, A., Srinivasan, V., & Kumar, D. S. (2021). *Commercial, industrial & institutional water use in Bangalore*. ATREE.

https://www.atree.org/sites/default/files/discussion_papers/E%26D%20paper_2021_CII%20water%20use.pdf

Rahman, K. S., Islam, Z., Navera, U. K., & Ludwig, F. (2019). A critical review of the Ganges Water Sharing arrangement. *Water Policy*, *21*(2), 259–276. https://doi.org/10.2166/wp.2019.164

Rasul, G. (2014). Water for growth and development in the Ganges, Brahmaputra, and Meghna basins: An economic perspective. *International Journal of River Basin Management*, *13*(3). https://doi.org/10.1080/15715124.2015.1012518

SBM. (2021). *Swachh Bharat mission target vs achievement of BLS-2012*. Swachh Bharat Mission – Gramin. Retrieved February 11, 2022, from https://sbm.gov.in/sbmReport/Report/Physical/SBM_TargetVsAchievementWithout1314.aspx

Shahjahan, M., & Harvey, N. (2011). Integrated basin management for the Ganges: challenges and opportunities. *International Journal of River Basin Management*, *10*(1). https://doi.org/10.1080/15715124.2011.644853

Sharma, A. (2021, October 28). Here's why India is struggling to be truly open defecation free. *The Wire*. https://thewire.in/government/heres-why-india-is-struggling-to-be-truly-open-defecation-free

Shrivastava, K. S. (2012, May 18). Clean Ganga and Yamuna mission a failure. *Down to Earth*. https://www.downtoearth.org.in/news/clean-ganga-and-yamuna-mission-a-failure-38246

Snehalata, M., Anita Raj, V., Bussena, P., & Venkataswamy, M. (2014). Nirmal gram puraskar and sanitation service levels: The curse of slippage. In . *Sustainable water and sanitation services: The life-cycle cost approach to planning and management* (pp. 136–157). Routledge. https://doi.org/10.4324/9780203521670

The Hindu. (2016, August 30). Water table rises in Ganga basin but so does salinity. *The Hindu*. https://www.thehindu.com/data/Water-table-rises-in-Ganga-basin-but-so-does-salinity/article14598256.ece

Tiwari, R., & Nayak, S. (2013). Drinking water and sanitation in Uttar Pradesh: A regional analysis. *Journal of Rural Development*, *32*(1), 61–74. http://nirdprojms.in/index.php/jrd/article/viewFile/93361/69188

Tripathi, B. (2020, February 23). Ganga mission fails to spend allocated funds while other rivers get little attention. *India Spend*.

https://www.indiaspend.com/ganga-mission-fails-to-spend-allocated-funds-while-other-rivers-get-little-attention/

Warner, S. (2020). *SDG indicator 6.3.2 technical guidance document No. 2*. https://communities.unep.org/download/attachments/32407814/CDC_GEMI2_TechDoc2_Targetvalues_20200508.pdf?version=2&modificationDate=1595432590204&api=v2

Xu, H., & Wu, M. (2017). *Water availability indices – A literature review*. https://water.es.anl.gov/documents/Technical%20Report_%20Literature%20Review%20of%20Water%20Availability%20Indices_030317.ems_vs.pdf

Annexure A

Crop water requirement is the amount of water needed to raise a crop. This includes water necessary to meet both consumptive and special needs, such as land preparation, land submergence, leaching, and so on. Effective rainfall refers to the utilisable rainfall. (Figure 8) can be used to estimate the amount of effective rainfall as related to the mean monthly rainfall in the region (FAO, n.d.).

Normal Monthly Rainfall (mm)	Average Monthly Consumptive Use (mm)																					
	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500	525	550
	Effective Rainfall																					
12.5	7.5	8	8.7	9	9.2	10	10.5	11.2	11.7	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
25	15	16.2	17.5	18	18.5	19.7	20.5	22	24.5	25	25	25	25	25	25	25	25	25	25	25	25	25
37.5	22.5	24	26.2	27.5	28.2	29.2	30.5	33	36.2	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5
50	25	32.2	34.5	35.7	36.7	39	40.5	43.7	47	50	50	50	50	50	50	50	50	50	50	50	50	50
62.5	25	39.7	42.5	44.5	46	48.5	50.5	53.7	57.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5	62.5
75	25	46.2	49.7	52.7	55	57.5	60.2	63.7	67.5	73.7	75	75	75	75	75	75	75	75	75	75	75	75
87.5	25	50	56.7	60.2	63.7	66	69.7	73.7	77.7	84.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5
100	25	50	63.7	67.7	72	74.2	78.7	83	87.7	95	100	100	100	100	100	100	100	100	100	100	100	100
112.5	25	50	70.5	75	80.2	82.5	87.2	92.7	98	105	111	112	112	112	112	112	112	112	112	112	112	112
125	25	50	75	81.5	87.7	90.5	95.7	102	108	115	121	125	125	125	125	125	125	125	125	125	125	125
137.5	25	50	75	88.7	95.2	98.7	104	111	118	126	132	137	137	137	137	137	137	137	137	137	137	137
150	25	50	75	95.2	102	106	112	120	127	136	143	150	150	150	150	150	150	150	150	150	150	150
162.5	25	50	75	100	109	113	120	128	135	145	153	160	162	162	162	162	162	162	162	162	162	162
175	25	50	75	100	115	120	127	135	143	154	164	170	175	175	175	175	175	175	175	175	175	175
187.5	25	50	75	100	121	126	134	142	151	161	170	179	185	187	187	187	187	187	187	187	187	187
200	25	50	75	100	125	133	140	148	158	168	178	188	196	200	200	200	200	200	200	200	200	200
225	25	50	75	100	125	144	151	160	171	182												
250	25	50	75	100	125	150	161	170	183	194												
275	25	50	75	100	125	150	171	181	194	205												
300	25	50	75	100	125	150	175	190	203	215												
325	25	50	75	100	125	150	175	198	213	224												
350	25	50	75	100	125	150	175	200	220	232												
375	25	50	75	100	125	150	175	200	225	240												
400	25	50	75	100	125	150	175	200	225	247												
425	25	50	75	100	125	150	175	200	225	250												
450	25	50	75	100	125	150	175	200	225	250												

Figure 8: Table to estimate effective rainfall

Annexure B

The Central Pollution Control Board classifies water bodies based on various values of a water quality parameter (CPCB, 2019). For our study, we have used Class D in Table 10 as a criterion to identify surface bodies with good ambient water quality that is suitable for the propagation of wildlife and fisheries.

Table 10: Water quality criteria to classify water bodies into designated best use

Designated-best-use	**Class of water**	**Criteria**
Drinking water source without conventional treatment but after disinfection	A	• Total coliforms organism Most Probable Number/100 ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved oxygen 6 mg/l or more • Biochemical oxygen demand over 5 days at 20 °C 2mg/l or less
Outdoor bathing (organised)	B	• Total coliforms organism MPN/100 ml shall be 500 or less • pH between 6.5 and 8.5 • Dissolved oxygen 5 mg/l or more • Biochemical oxygen demand 5 days 20C 3 mg/l or less
Drinking water source after conventional treatment and disinfection	C	• Total coliforms organism MPN/100 ml shall be 5,000 or less • pH between 6 to 9 • Dissolved oxygen 4 mg/l or more • Biochemical oxygen demand 5 days 20C 3 mg/l or less
Propagation of wildlife and fisheries	D	• pH between 6.5 to 8.5 • Dissolved oxygen 4 mg/l or more • Free ammonia (as N) 1.2 mg/l or

		less
Irrigation, industrial cooling, and controlled waste disposal	E	• pH between 6.0 to 8.5 • Electrical conductivity at 25C micromhos/cm max. 2,250 • Sodium absorption ratio max. 26 • Boron max. 2 mg/l

The CGWB uses the BIS standards to classify the quality of groundwater levels. According to these standards, nitrate level in the water should be less than or equal to 45 mg/l and the salinity level less than or equal to 746 µS/cm (BIS, 2012). The SDG indicator uses the criteria given in (Figure 9) to classify the ambient water quality (Warner, 2020).

Parameter Group	Parameter	Target type	Rivers	Lakes	Groundwaters
Oxygenation	Dissolved oxygen	range	80 – 120 (% sat)	80 – 120 (% sat)	-
Salinity	Electrical conductivity	upper	500 µS cm^{-1}	500 µS cm^{-1}	500 µS cm^{-1}
Nitrogen	Total Nitrogen	upper	700 µg N l^{-1}	500 µg N l^{-1}	-
	Oxidised nitrogen	upper	250 µg N l^{-1}	250 µg N l^{-1}	250 µg N l^{-1}
Phosphorus	Total phosphorus	upper	20 µg P l^{-1}	10 µg P l^{-1}	-
	Orthophosphate	upper	10 µg P l^{-1}	5 µg P l^{-1}	-
Acidification	pH	range	6 – 9	6 – 9	6 – 9

Figure 9: Water quality criteria by SG to classify water bodies with good ambient water quality that can support wildlife and fisheries.

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