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PLANNING FOR REUSE OF TREATED WASTEWATER AT THE STATE LEVEL

GUIDANCE DOCUMENT FOR POLICYMAKERS AND PRACTITIONERS

UTTAR PRADESH

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Executive summary

Reuse of treated wastewater is emerging as a priority. Wastewater treated as per standards becomes 'new water' for our towns, industries, agriculture and for our biodiversity and land. It has the potential to supplement and curtail dependence on freshwater for different uses, hence contributing to reduced withdrawal from surface and groundwater.

Different states and cities in India are in the process of developing their policy and guidelines for reuse of treated wastewater. What is important is to develop a buy-in, in terms of planning for a planned and prioritized framework of treated wastewater at state and town/city level. This approach should be the initial consideration when planning the establishment of new sewage treatment plants (STPs) in urban areas, as well as when refurbishing or replacing large STPs with smaller-capacity ones. The focus should shift towards treating wastewater with the aim of reuse rather than solely meeting disposal standards, which is the current practice.

In 2024, the Centre for Science and Environment (CSE) launched a national study entitled *Waste to Worth: Managing India's Urban Water Crisis Through Wastewater Reuse*. Based on a comprehensive analysis of 35 case studies across 16 cities in seven Indian states, the report assesses the current state of treated wastewater reuse in India. It examines existing policies, programmes and on-ground practices, and provides valuable insights for policymakers and practitioners. It also highlights the critical importance of prioritizing treated wastewater reuse as a public good, particularly for irrigation and groundwater recharge, while ensuring equity and justice for underserved communities. This guidance template for Uttar Pradesh is a follow-up of *Waste to Worth*.

Uttar Pradesh generates 5,500 million litres per day (MLD) of sewage across 762 urban local bodies (ULBs), but only 3,296 MLD is treated. This represents a significant untapped resource that could be repurposed to meet urban demands and sustain river flows. Approximately 50 per cent of Uttar Pradesh's wastewater treatment capacity is concentrated in five major cities: Lucknow, Kanpur, Prayagraj, Ghaziabad and Varanasi. Consequently, most of the limited water reuse efforts are also confined to these cities.

To effectively implement treated wastewater reuse, Uttar Pradesh needs a comprehensive policy framework. A crucial step is to assess existing treated water infrastructure, identify potential demand centres, and develop strategies for optimal resource utilization.

This guidance document includes a two-step framework of analysis:

1. **Geographical prioritization** of districts of a state, based on a given set of parameters, for addressing reuse of treated wastewater, in districts where this is available.
2. **Sectoral prioritization** of reuse of treated wastewater in a district or town, considering sectors or user groups.

Geographical prioritization: Characterization of districts of Uttar Pradesh into high-, medium- and low-priority levels for groundwater stress zones; groundwater development stage; drought-prone areas; rainfall levels; and water demand across domestic, industrial and agricultural sectors.

- Districts falling in the **high-priority category** such as Agra, Ghaziabad, Bareilly, Kanpur Nagar, Meerut, Saharanpur and Lucknow have a combination of extremely high or very high groundwater stress zones and are also in over-exploited or semi-critical groundwater development stages. They also have a high or very high domestic and industrial water demand but limited water availability due to low rainfall or drought-prone areas.

- The districts falling in **medium-priority districts** such as Aligarh, Firozabad, Varanasi and Gorakhpur have high or medium groundwater stress and semi-critical or safe groundwater development stages. Water demand in these districts is moderate across domestic, industrial and agricultural sectors, and rainfall conditions are typically moderate.

- The districts falling under **low-priority category** such as Bhadohi, Balrampur, Shravasti and Azamgarh have low to medium groundwater stress and safe groundwater development stages. These districts typically have low to very low water demand across all sectors, with adequate rainfall and relatively lower drought risk.

Sectoral prioritization: The following is a sectoral prioritization for reuse of treated wastewater, based on desk research of Uttar Pradesh. Prioritization of reuse of treated wastewater should be done on the basis of an open consultative process. A competent authority at the town level where the STPs are should propose a prioritization for reuse that is then vetted and finalized through a consultative process.

The following is the potential or high-priority reuse options for different districts of the state:

- **Domestic water supply:** Top-priority districts such as Agra, Aligarh, Lucknow and Ghaziabad can rank domestic water supply as the highest priority to reflect the high population density and significant demand for potable water in these urban centres.

- **Industrial water demand:** Industrial districts such as Meerut, Gautam Buddh Nagar and Kanpur can place industrial water demand at the top of their priority list. These districts are significant industrial hubs where water is essential for industrial processes.

- **Groundwater recharge:** Districts such as Agra, Gautam Buddh Nagar and Firozabad can prioritize groundwater recharge, highlighting the critical need to address overexploited groundwater resources. This prioritization is particularly important in regions where groundwater levels have been severely depleted, threatening the long-term availability of water resources.

- **Agricultural water demand:** Agriculture-dependent districts such as Aligarh, Baghpat, Saharanpur etc. can rank agricultural water demand as their top priority. These districts rely heavily on agriculture, and water is a key input for sustaining their agrarian economies. The emphasis on agricultural water demand would reflect the need to balance urban and industrial water needs with the requirements of the agricultural sector.

Like with any guidance document, appropriate contextualization is required to make it relevant.

1. About the guidance document

Introduction

Uttar Pradesh, the most populous state in India, has a population of over 241 million, accounting for 16.5 per cent of the country's total population. It has a population density of 829 per sq. km, more than twice the national average, with 66 per cent of the population engaged in agriculture.[1]

The state contributes 20.8 per cent of India's renewable water resources but faces regional disparities in water availability.[2] Despite the substantial availability of surface water (estimated at 128 billion cubic metres [BCM]), there is a heavy reliance on groundwater (65.32 BCM extractable), which supports two-thirds of irrigated agriculture, almost all industrial needs, and most of the drinking-water demand. This reliance has led to continuous over-extraction, declining water levels, and increasing water stress across 70 per cent of the state's blocks and over 80 per cent of its urban areas.[3] The southern, western, central and eastern regions of the state experience variable groundwater availability and erratic rainfall.

Industrial pollution further exacerbates water quality issues, with 687 industries classified as grossly polluting, discharging 269 MLD of wastewater.[4] The sugar, paper and pulp, and chemical sectors contribute 70 per cent of this pollution, particularly affecting the Ganga River and leading to non-compliance with water quality criteria in 17 rivers due to high BOD levels.[5]

This context underscores the critical need for sustainable water management practices, including reuse of treated wastewater, to address the growing water challenges in Uttar Pradesh.

Background

Uttar Pradesh generates 5,500 MLD (NMCG, October 2024) of sewage across 762 towns, but only 3,201 MLD is treated. This represents a significant untapped resource that could be repurposed to meet urban demands and sustain river flows. Approximately 50 per cent of Uttar Pradesh's wastewater treatment capacity is concentrated in five major cities, i.e. Lucknow, Kanpur, Prayagraj, Ghaziabad and Varanasi. Consequently, most of the limited water reuse efforts are confined to these cities.

The lack of a statewide policy and action plan for treated wastewater reuse has created challenges, especially in cities like Lucknow and Kanpur where large sewage treatment plants (STPs) are producing significant volumes of treated wastewater that is currently not being utilized.

In districts such as Agra, Kanpur, Varanasi and Prayagraj, farmers sparingly use treated wastewater for irrigation, often out of necessity due to groundwater pollution and scarcity. However, the quality of this water is compromised when mixed with chemical effluents, underscoring the need for stringent monitoring and regular third-party testing to ensure safety and compliance with sanitation safety plans.

The situation in areas such as Jajmau, Kanpur, where treated water quality is not assured, highlights these challenges. To address this issue, it is imperative to develop city-specific reuse plans that prioritize the allocation of treated wastewater for agriculture, groundwater recharge, industrial needs, and other applications. These plans should be supported by adequate infrastructure for water conveyance to ensure the efficient delivery of treated water to its intended uses. As agriculture remains the primary area for wastewater reuse, there is also an urgent need for implementing monitoring mechanisms that ensure both the quantity and quality of reused water, with third-party oversight to protect the health and safety of end-users.

In this regard, to help cities CSE published *City-Level Template for Reuse of Treated Wastewater,* which serves as a comprehensive hands-on guide for urban policymakers and city officials to manage and reuse treated wastewater effectively. Given the increasing water stress in Indian cities, this document outlines a structured approach to integrating treated wastewater into urban water management strategies, which helps conserve freshwater resources and ensures better wastewater treatment compliance.

Aim

This study aims to assist Uttar Pradesh with a framework of analysis and a guidance document to identify districts that could be taken up on priority for developing reuse plans and projects, and prioritization for different reuse priorities within a district or town or outside it.

Methodology

i. Collection of data

- Data on statewide water resources, including groundwater, rainfall, drought-prone areas and land use;
- Data on sewage generation, treatment capacity and current reuse practices at the district level across Uttar Pradesh; and
- Data on water demand from various sectors, groundwater levels, groundwater exploration, drought-prone areas, rainfall and land use.

ii. Mapping key supply and demand centres

- Statewide mapping of water resources, including groundwater, rainfall, drought-prone areas and land use;
- Mapping of STPs, their capacity, technology and compliance; and
- Mapping the primary demand centres, i.e. domestic, agriculture and industry.

iii. Analysis

- Analyse the existing state of water supply and demand centres and the opportunities for reuse of treated water.

iv. District-wise priority levels

- Based on the analysis, classification of districts into high, medium and low priority

v. Prioritization matrix development

- The prioritization matrix involves two steps that each state needs to undertake—prioritization of districts (see *Chapter 2*) and prioritization of sectors within districts (see *Chapter 3*).
- A matrix to prioritize sector-wise reuse options in districts to be created, with factors like demand centres, environmental impact and feasibility considered.

vi. Recommendations and action plan

- Actionable recommendations to be developed based on the matrix and assessment to optimize treated wastewater reuse and address gaps in policy and infrastructure.

vii. Reporting

- The findings and recommendations will be compiled into a comprehensive report to guide policy development and future initiatives.

2. Assessment parameters for prioritization

A state-level policy for reuse of treated wastewater will require an assessment of the status of wastewater generation, current and future gaps in water supply and demand, and assessment of various uses in which treated wastewater can be prioritized. This can be done district-wise because most of the districts of India now host at least one large town with an STP that generates treated wastewater.

Water availability

It is projected that Uttar Pradesh has a total of 179 BCM in accessible water resources (109.19 BCM in surface water and 69.92 BCM in groundwater). But there is only 77.99 BCM of usable water, of which 45.84 BCM is taken out of the earth each year.[6] Usable water is only 77.99 BCM, indicating a significant limitation in accessibility. This analysis shows a gap between total resources and usable water, which might be due to factors like pollution or over-extraction.

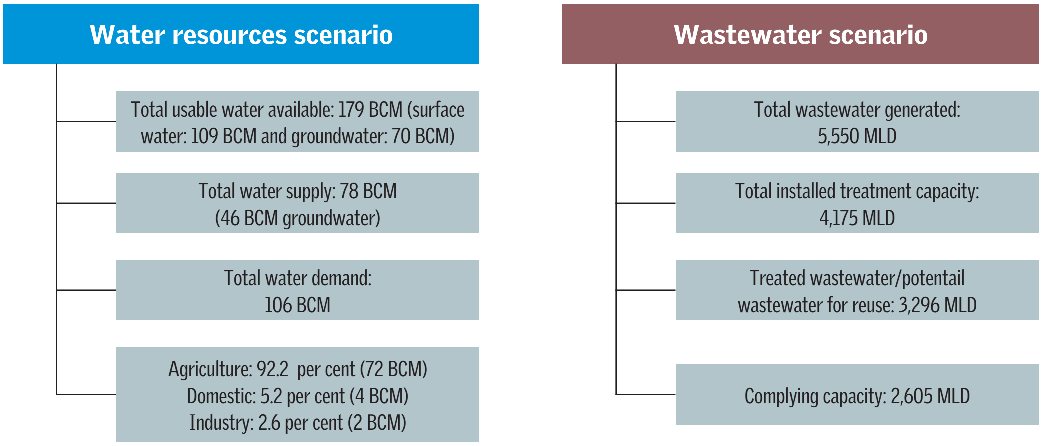
Water demand and gap

The total demand for water is 105.96 BCM while the total supply is 77.99 BCM. Water utilization in Uttar Pradesh is mainly by the agriculture sector, with 92.2 per cent (71.9 BCM) of water currently supplied for irrigation or agricultural use (40.98 BCM from groundwater), 5.2 per cent (4.055 BCM) for domestic uses and 2.6 per cent (2.02 BCM) for industrial and commercial activities. Of the state urban local bodies (ULBs), 95 per cent are entirely dependent on groundwater for drinking water supply, while the remaining 5 per cent are dependent on surface water.[7] The heavy reliance on groundwater for urban supply is noteworthy, especially since 95 per cent of ULBs depend entirely on it. This suggests potential sustainability issues and the need for improved water management strategies.

Current sewage generation scenario

Uttar Pradesh has 762 ULBs, the highest number among all states of India. As per the National Green Tribunal (NGT), 5,550 MLD sewage is generated in Uttar Pradesh. There are 139 STPs with a treatment capacity of 4,175 MLD that actually treat 3,296 MLD of sewage.[8] A total of 73 STPs with a capacity of 2,244 MLD are under various stages of construction, tendering etc. (see *Figure 1: Water and wastewater scenario in Uttar Pradesh*).

Figure 1: Water and wastewater scenario in Uttar Pradesh



Source: CSE

Assessment parameters: Uttar Pradesh districts

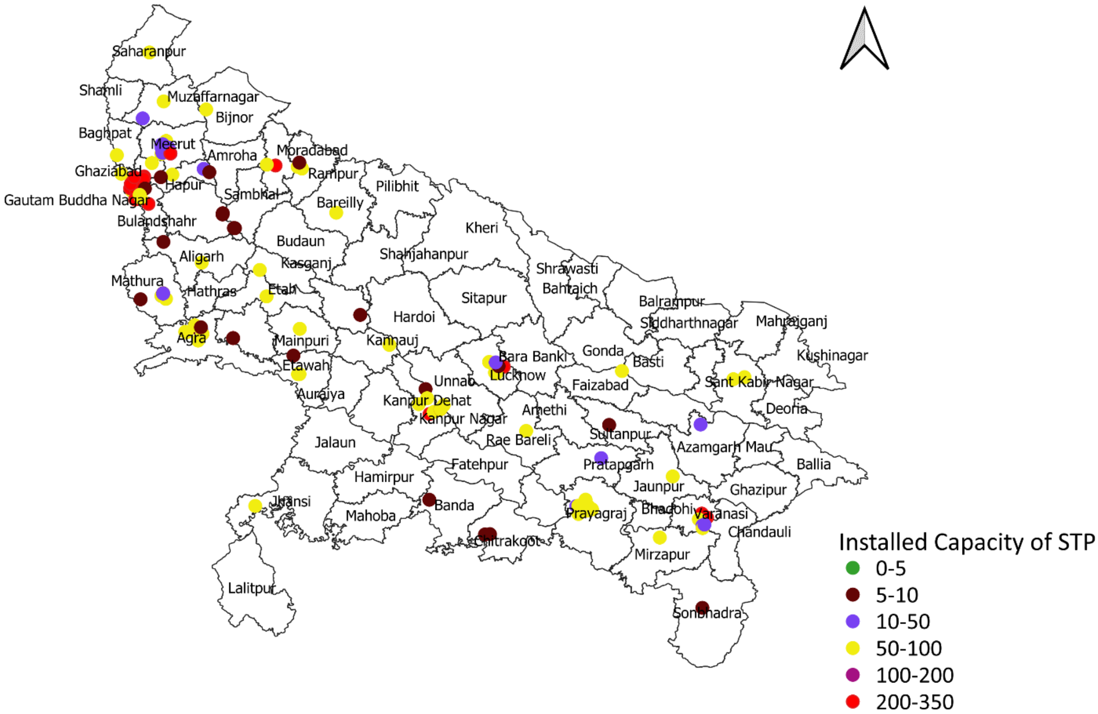
1. Sewage treatment plant: Capacity, location, functionality, installed capacity, technology and compliance

There can be reuse of treated wastewater only in districts where a reasonable amount of treated wastewater is available, i.e. where there are existing STPs that generate enough wastewater that can be diverted to some use.

STP status: Uttar Pradesh has 139 STPs distributed across 38 districts. The concentration of STPs in districts such as Agra, Gautam Buddh Nagar and Lucknow highlights regional disparities. Notably, 37 districts lack any STP, indicating a significant infrastructural gap in sewage management. *Map 1* shows that the concentration of STPs is high in Agra, Gautam Buddh Nagar, Meerut, Lucknow, Prayagraj, Ghaziabad, Varanasi, Bulandshahr and Kanpur district.

Capacities of STPs: 139 STPs of Uttar Pradesh have installed capacity ranging from 0.8 MLD to 345 MLD (see *Map 1: Installed capacity of STPs in Uttar Pradesh*). The STP with lowest capacity of 0.8 MLD lies in Bulandshahr district while the highest capacity STP of 345 MLD lies in Lucknow district (see *Map 1: Installed treatment capacity of different STPs in Uttar Pradesh*).

Map 1: Installed treatment capacity of different STPs in Uttar Pradesh (in MLD)



Source: Created by CSE from CPCB and NMCG data

Most STPs (72) fall into the 10–50 MLD capacity range, indicating a moderate to high level of treatment capacity in many areas. Only a few (7) STPs have capacities exceeding 50 MLD, with only two districts (Lucknow and Kanpur) having capacities of 200–350 MLD. Districts such as Kanpur, Gautam Buddh Nagar and Varanasi have higher capacities, reflecting their larger urban centres or significant population density. STPs with capacity in the 0–5 MLD range are likely smaller or less developed, with fewer STPs or less demand for higher treatment capacity.

2. Operational status: Out of 140 STPs, seven are not operational, one is partially operational (Rampur: 5 MLD), and one is under trial (Gorakhpur zone C: 10 MLD)

Operational	130
Not operational	7
Partially operational	2
Under trial	1

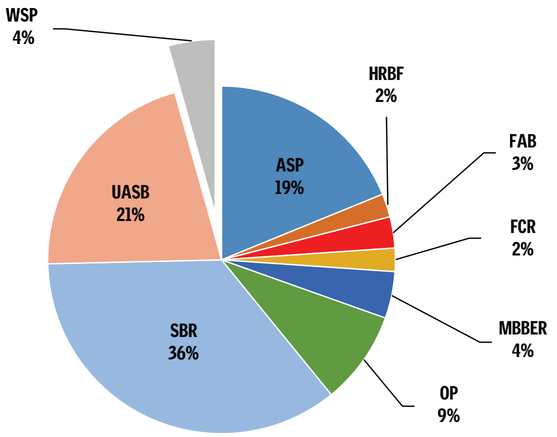
Treatment technology: The technologies used in the STPs of Uttar Pradesh shown in table 1 are activated sludge process (ASP); high rate bio filter (HRBF); fluidized aerobic bio-reactor (FAB), food chain reactor (FCR); moving bed bio-film reactor (MBBR); oxidation pond (OP); sequencing batch reactor (SBR); up-flow anaerobic sludge blanket (UASB); waste stabilization pond (WSP) etc. (see *Table 1: Treatment technology used in STPs in different cities of Uttar Pradesh*). The major technologies used in Uttar Pradesh are sequencing batch reactor (SBR); up-flow anaerobic sludge blanket (UASB) and activated sludge process (ASP).

Table 1: Treatment technologies used in STPs in different cities of Uttar Pradesh

Technology used	Number of STPs	City
SBR	49	Agra, Aligarh, Baghpat, Kannauj, Gautam Buddh Nagar, Meerut, Muzaffarnagar, Lucknow, Prayagraj, Ghaziabad, Hapur, Jaunpur, Sultanpur, Varanasi, Moradabad, Rampur, Jhansi, Bulandshahr, Gorakhpur, Kanpur, Etah, Mathura, Kasganj, Rae Bareli, Shahjahanpur, Budhana
UASB	29	Agra, Bijnor, Shaharanpur, Meerut, Lucknow, Prayagraj, Ghaziabad, Ayodhya, Sonbhadra, Moradabad, Rampur, Bulandshahr, Gorakhpur, Kanpur, Mainpuri, Firozabad, Mathura
ASP	26	Bareli, Meerut, Prayagraj, Varanasi, Ayodhya, Bulandshahr, Kanpur, Firozabad, Vrindavan, Pilkhua
OP	12	Agra, Muzaffarnagar, Sultanpur, Sonbhadra, Banda, Chitrakoot, Bulanshahr, Etawah, Mathura
WSP	6	Kanpur, Fatehgarh, Etawah, Mathura
MBBR	6	Meerut, Lucknow, Bulandshahr, Ghaziabad
FAB	4	Lucknow, Prayagraj, Pratapgarh
Bio-tower (HRBF)	3	Prayagraj
FCR	3	Prayagraj

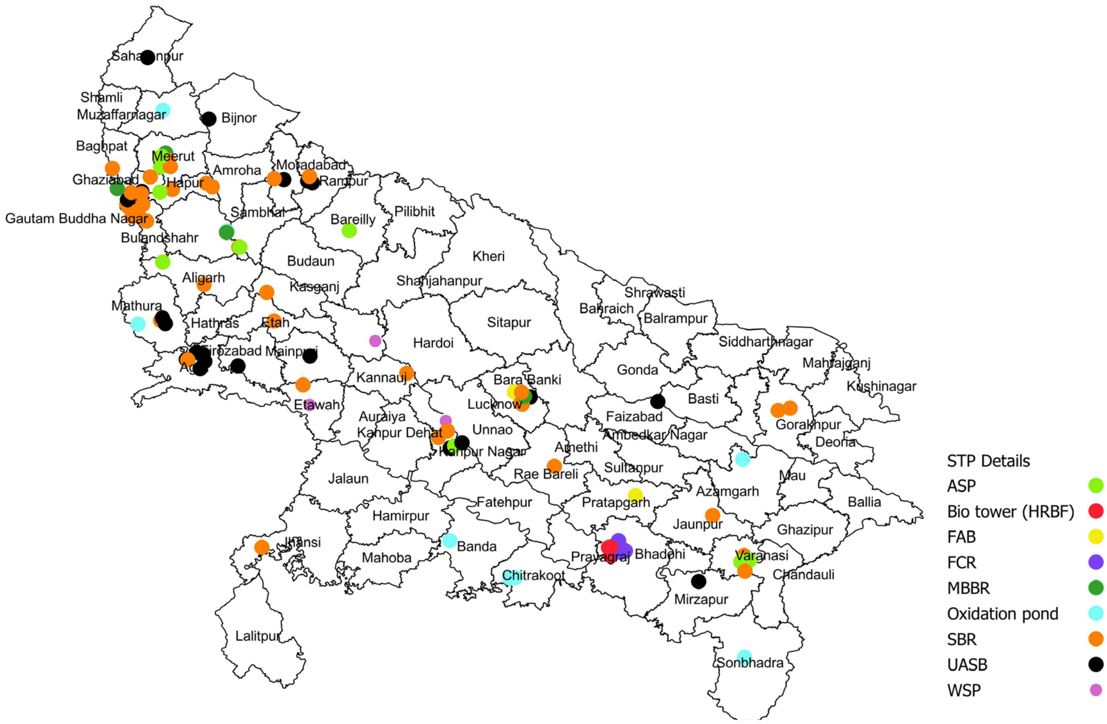
The distribution of STP technologies varies significantly across districts. Urban districts like Lucknow, Prayagraj and Agra show a higher diversity in technology use, reflecting their larger sewage treatment needs and varying urban challenges. Less urbanized districts tend to rely on simpler technologies such as oxidation ponds (OP) and waste stabilization ponds (WSP), suitable for lower population densities and less stringent effluent requirements (see *Figure 2: Percentage of different technologies in STPs of Uttar Pradesh, Table 1: Treatment technologies used in STPs in different cities of Uttar Pradesh* and *Map 2: Different wastewater treatment technologies in Uttar Pradesh*).

Figure 2: Percentage of different technologies in STPs of Uttar Pradesh



Source: Created by CSE from CPCB and NMCG data

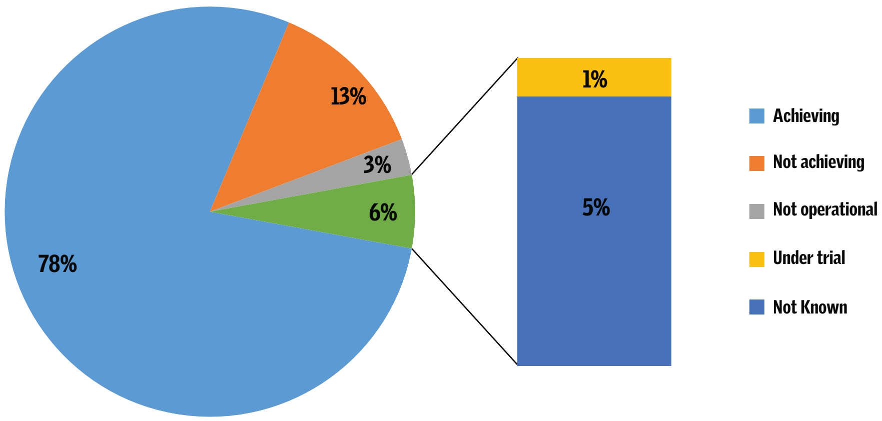
Map 2: Different wastewater treatment technologies in Uttar Pradesh



Source: Created by CSE from CPCB and NMCG data

Compliance status: Out of 140 STPs of Uttar Pradesh, 109 are achieving and 18 are not achieving the compliance status as per MoEFCC notification dated October 13, 2017. STPs whose compliance status is not given in the NGT monthly report include Sultanpur (10 MLD), Sonbhadra (4 MLD), Banda (3 and 4 MLD), Jhansi (26 MLD), Kanpur (5 MLD), and Unnao (15 MLD) (see *Figure 3: Compliance status of STPs in Uttar Pradesh*). Remaining 7 STPs are non-operational hence there compliance status is not known.

Figure 3: Compliance status of STPs in Uttar Pradesh



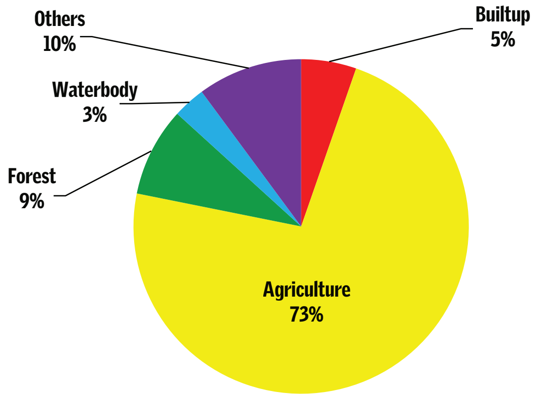
Source: Created by CSE from NMCG data

2. Land use land cover

The land use land cover (2017–18) data on the India Water Resource Information System (WRIS) site categorizes land use into 18 distinct classes. To simplify the categories, we have consolidated them into five main categories: Built-up, Agriculture, Forest, Waterbodies, and Other (see *Figure 4: Land use land cover classification in Uttar Pradesh [2017–18]*).

- **Agriculture:** Includes kharif crops, rabi crops, zaid crops, double and triple crops, and shifting cultivation. This category covers 73 per cent of the total state area.
- **Forest:** Encompasses plantation, evergreen forest, deciduous forest and degraded/scrub forest, accounting for 9 per cent of the state area.
- **Waterbodies:** Includes all types of waterbodies, representing 3 per cent of the total area.
- **Built-up:** Covers developed areas and constitutes 5 per cent of the state area.
- **Other:** Includes current fallow, littoral swamp, grassland, wasteland, Rann, and snow cover, making up 10 per cent of the state area.

Figure 4: Land use land cover classification in Uttar Pradesh (2017-18)



Source: Created by CSE from National Water Informatics Centre, WRIS data

Given that agriculture constitutes 73 per cent of the state's land area, it presents the most significant opportunity for treated water reuse. With built-up areas comprising 5 per cent of the state, there is potential for reusing treated water in urban settings, such as for landscaping, parks and non-potable purposes. Waterbodies cover only 3 per cent of the total area, and can be a potential source for treated water recharge or to support aquatic ecosystems. Overall, the data suggests that Uttar Pradesh has significant potential for treated water reuse, particularly in the agricultural sector.

3. Rainfall

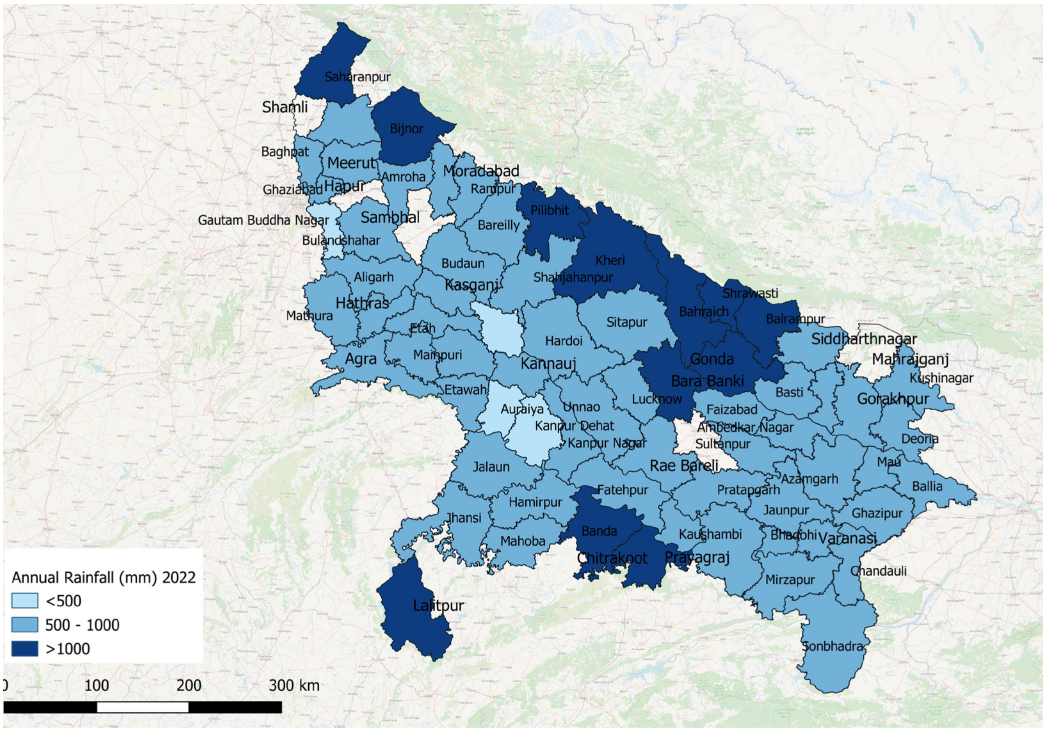
Rainfall is unevenly distributed across Uttar Pradesh, affecting water availability. The following is the distribution of rainfall:

- Low rainfall areas: Less than 500 mm annually, where water scarcity is most acute;
- Medium rainfall areas: 500–1,000 mm annually, where water resources are moderately stressed.
- High rainfall areas: More than 1,000 mm annually, with relatively abundant water resources.

The state saw a range in annual rainfall, with the highest recorded in Maharajganj at 1,436.90 mm and the lowest in Mathura at 595.60 mm. For 2022, the state's normal rainfall remained 955 mm, while the average annual rainfall was 812.22 mm.

Several districts, including Saharanpur, Muzaffarnagar, Bijnor, Meerut, Amroha, Aligarh, Hathras, Etah, Bareilly, Pilibhit, Kheri, Sitapur, Bahraich, Barabanki, Lucknow, Shravasti, Balrampur, Gonda, Faizabad, Siddharthnagar, Sant Kabir Nagar, Deoria, Gorakhpur, Varanasi, Chitrakoot, Fatehpur, Banda, Hamirpur, Jalaun, Jhansi and Lalitpur, recorded annual rainfall exceeding the state's average annual rainfall (see *Map 3: Annual rainfall distribution in different parts of Uttar Pradesh in 2022*).

Map 3: Annual rainfall distribution in different parts of Uttar Pradesh in 2022



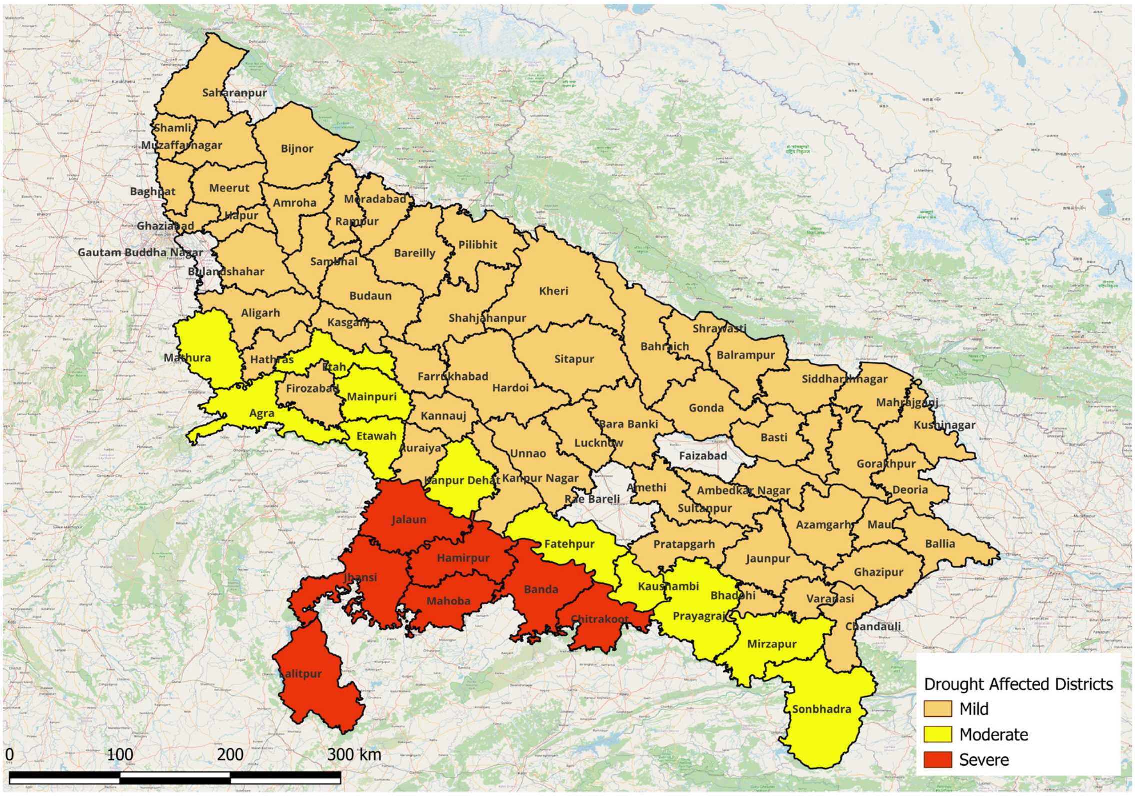
Source: Created by CSE from CGWB Report 2022–23

4. Drought-prone areas

According to the State Disaster Management Plan 2023 for Uttar Pradesh, several districts have experienced drought in 1979, 2002, 2004, 2007, 2009, 2014, 2015, 2016 and 2018. The severity of drought in these districts is illustrated in *Map 4*. Districts affected seven to eight times during 2002–18 are classified as Severe; those affected five times are categorized as Moderate; and those affected fewer than five times are considered Mild.[9]

The districts identified as prone to severe drought, according to the State Disaster Management Plan 2023, include Lalitpur, Jhansi, Jalaun, Hamirpur, Mahoba, Banda and Chitrakoot (see *Map 4: Drought-affected districts of Uttar Pradesh during 2002–18*).

Map 4: Drought-affected districts of Uttar Pradesh during 2002–18



Source: Created by CSE from State Disaster Management Plan 2023 data

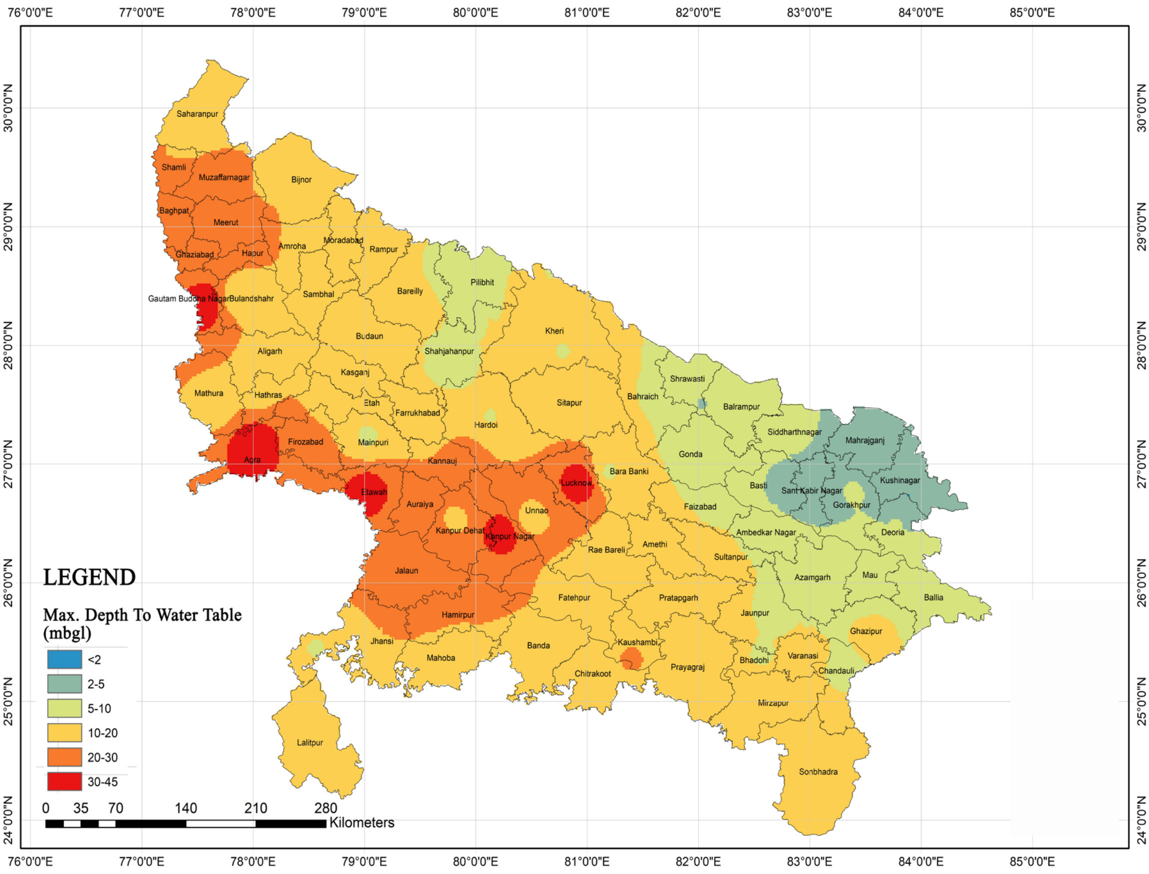
5. Groundwater levels

Groundwater is a critical resource in Uttar Pradesh, but it is under significant stress in many parts of the state. Districts are categorized based on the depth of groundwater levels, which is a key indicator of stress:

- **Less than 2 metres**: Indicates minimal stress, usually in areas with abundant groundwater.
- **2–5 metres**: Moderate stress, requiring careful management.
- **5–10 metres**: Significant stress, where alternative water sources should be considered.
- **10–20 metres**: High stress, necessitating urgent measures for groundwater conservation and the introduction of treated wastewater.
- **Greater than 20 metres**: Extreme stress, where groundwater is severely depleted, and immediate action is required.

The depth to groundwater levels in Uttar Pradesh exhibited significant variability throughout 2021–22. According to the Central Ground Water Board (CGWB), groundwater levels generally rise from the northeast to the southwest, following the state's northern limit. Shallow water levels are typically found in the northern, northeastern and central regions of the state, while moderate levels are observed in the central, southwestern and southern border areas. Water levels are deeper in the western regions, along the Yamuna River, parts of southern Uttar Pradesh, and in urban areas (see *Map 5: Depth of groundwater in different districts of Uttar Pradesh*).

Map 5: Depth of groundwater in different districts of Uttar Pradesh



Source: Created by CSE from CGWB data

The month of May—part of the pre-monsoon period—often shows the deepest water levels of the year, following a full cycle of inputs and outputs. This month signifies the beginning of the dry season and is used as a key reference for groundwater estimates. The CGWB's analysis of 661 wells reveals that water levels are generally in the range of 2–20 metres below ground level (mbgl), though variations exceeding 20 mbgl can occur in certain areas of Uttar Pradesh.

Districts with the highest maximum depth of groundwater (30–45 mbgl) include Gautam Buddh Nagar, Agra, Etawah, Kanpur Nagar and Lucknow. In contrast, districts with the lowest maximum depth to groundwater (2–5 mbgl) include Maharajganj, Kushinagar, Sant Kabir Nagar and parts of Gorakhpur.

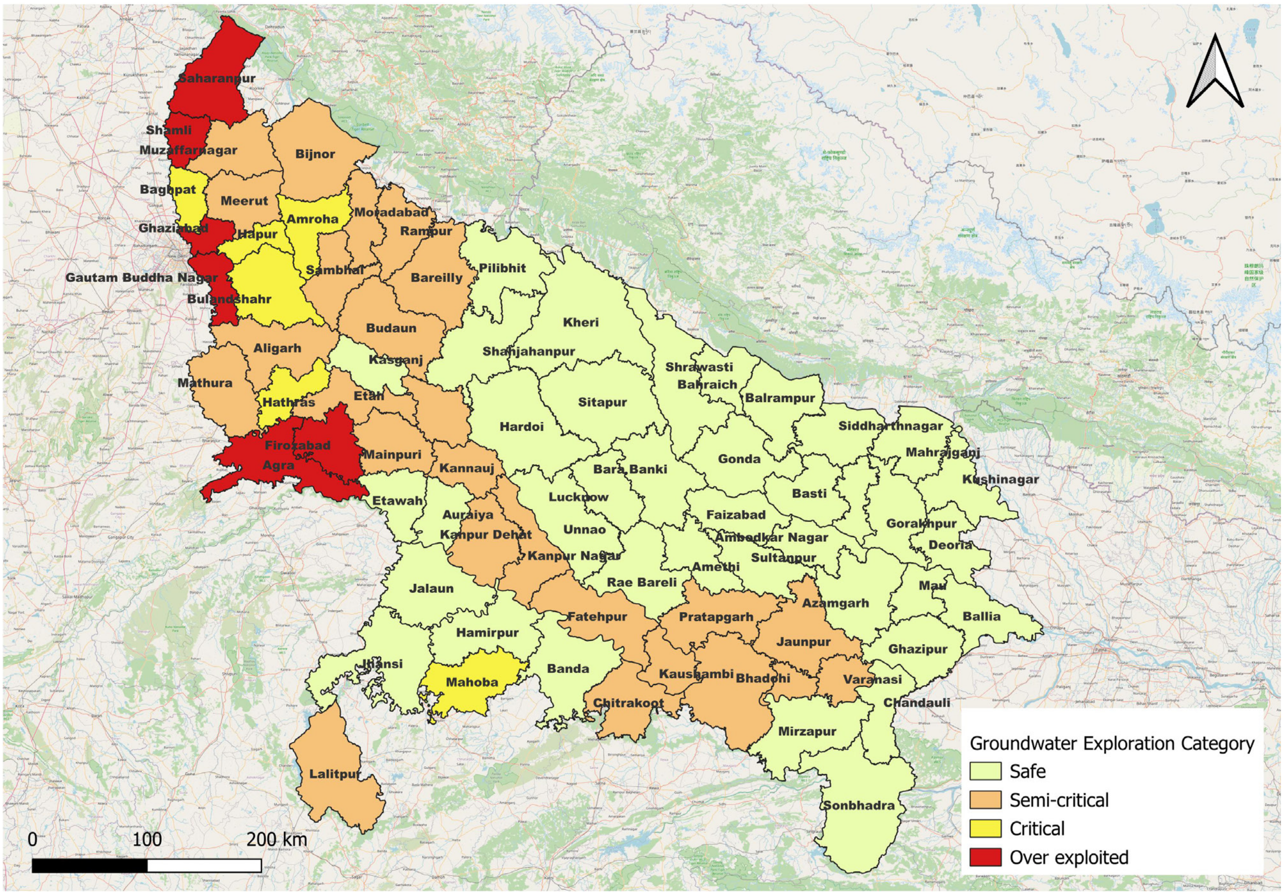
6. Groundwater exploitation

The Central Ground Water Board's (CGWB's) *Dynamic Ground Water Resources of India Report, 2023* categorizes districts in Uttar Pradesh based on their groundwater extraction levels. The districts are classified into four categories: safe zone, semi-critical zone, critical zone, and over-exploited zone (see *Map 6: Status of groundwater exploitation in districts of Uttar Pradesh, 2023*).

Groundwater exploitation zones

- **Safe zone (0–70 per cent extraction)**: These districts have a lower risk of groundwater depletion. They are generally not facing immediate concerns related to water scarcity.
- **Semi-critical zone (70–90 per cent extraction)**: These areas are experiencing moderate stress on groundwater resources. Continued high rates of extraction can lead to future problems if not managed carefully.
    - *Muzaffarnagar, Bijnor, Meerut, Moradabad, Rampur, Sambhal, Badaun, Bareilly, Aligarh, Mathura, Farrukhabad, Etah, Mainpuri, Kannauj, Kanpur Nagar, Kanpur Dehat, Fatehpur, Chitrakoot, Kaushambi, Pratapgarh, Prayagraj, Jaunpur, Bhadohi and Varanasi.*
- **Critical zone (90–100 per cent extraction)**: These areas are at a high risk of groundwater depletion. Immediate measures are necessary to reduce extraction and enhance recharge to prevent a water crisis.
    - *Baghpat, Amroha, Bulandshahr, Hathras and Hapur*
- **Over-exploited zone (>100 per cent extraction)**: These districts face critical water shortages and are experiencing significant environmental and socioeconomic impacts due to the overuse of groundwater. Urgent and substantial interventions are required to address the over-extraction and to restore groundwater levels.
    - *Saharanpur, Shamli, Ghaziabad, Gautam Buddh Nagar, Agra and Firozabad*

Map 6: Status of groundwater exploitation in districts of Uttar Pradesh, 2023

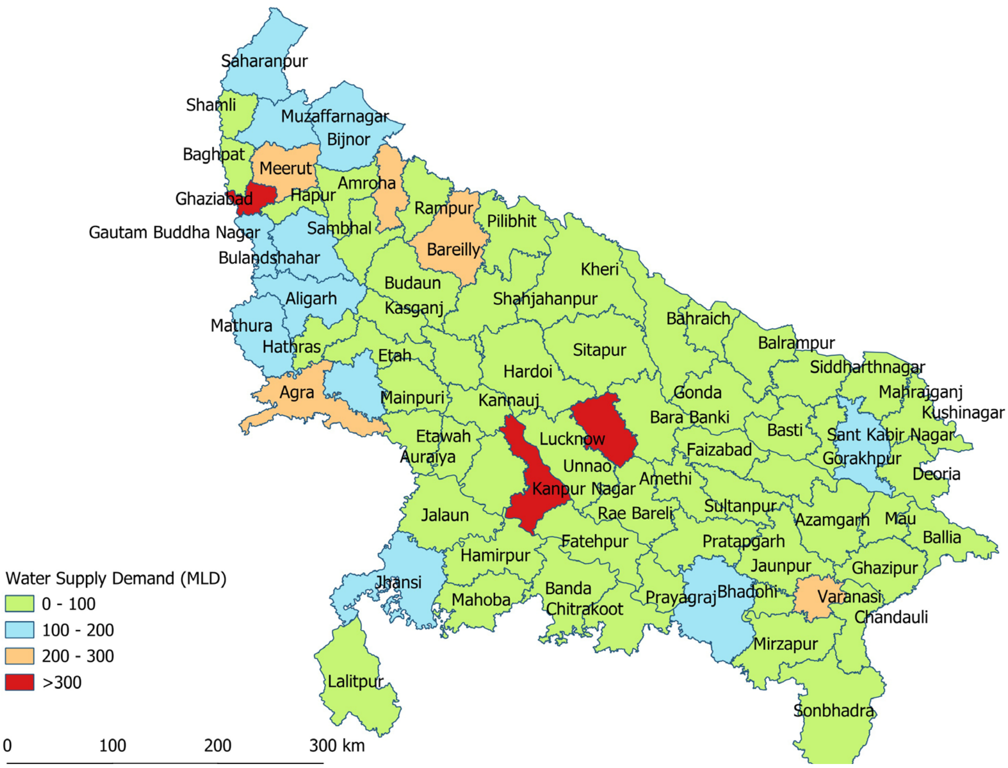


Source: Created by CSE from CGWB data

3. Assessment of key demand centres

This section assesses the state's water needs to identify the most critical areas where treated water reuse can have the greatest impact. The assessment of the demand centres ensures that treated wastewater is directed to sectors and places where it is most required, minimizing the burden on freshwater supplies by optimizing the distribution of important resources. Finding these hubs also makes it easier to create customized infrastructure and legal frameworks that guarantee effective and secure water reuse. This assessment will help in prioritization of treated water, with focus on the most critical areas of need, and resources can be allocated effectively to maximize the benefits of treated water reuse.

Map 7: Domestic demand for urban water supply (in MLD) in Uttar Pradesh



Source: Created by CSE

Domestic water demand (urban)

As noted in the introduction, 22.27 per cent of Uttar Pradesh's total population—i.e. 45,429,363 people—is urban. Based on the Central Public Health and Environmental Engineering Organisation (CPHEEO) guideline of 135 litres per capita per day (LPCD) for domestic water supply, we have calculated the demand for urban domestic water supply for each district (see *Map 7: Domestic demand for urban water supply [in MLD] in Uttar Pradesh*).

Districts such as Kanpur Nagar, Lucknow and Ghaziabad have high domestic water supply demand, exceeding 300 million litres per day (MLD). Moradabad, Meerut, Bareilly, Agra and Varanasi have demands in the range of 200–300 MLD. Saharanpur, Muzaffarnagar, Bijnor, Gautam Buddh Nagar, Bulandshahr, Aligarh, Mathura, Firozabad, Jhansi, Prayagraj and Gorakhpur have demands in the range of 100–200 MLD. The remaining districts have an urban domestic water supply demand of less than 100 MLD.

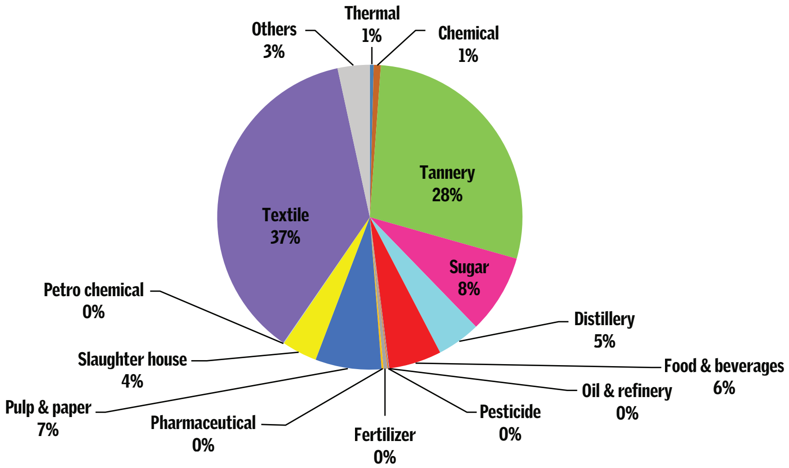
Industrial water demand in Uttar Pradesh

According to the Central Pollution Control Board (CPCB) report for 2020–21, Uttar Pradesh hosts a total of 1,464 industries across various sectors, including thermal, chemical, tannery, sugar, distillery, food and beverage, oil and refinery, pesticide, fertilizer, pharmaceutical, paper and pulp, slaughterhouse, petrochemical, textile, and others. Kanpur Nagar district has the highest concentration, with 414 industries. In contrast, ten districts—Banda, Chitrakoot, Hamirpur, Kannauj, Kaushambi, Lalitpur, Mahoba, Pratapgarh, Shravasti and Siddharthnagar—report no industries (see *Figure 5: Percentage of different types of Industries in Uttar Pradesh*, *Map 8: Distribution of industries in different districts of Uttar Pradesh* and *Table 2: Industry-intensive districts of UP and their STPs*).

The report details the following distribution of industry types:
- Thermal plants: 6
- Chemical industries: 11
- Tannery industries: 415
- Sugar industries: 123
- Distillery industries: 68
- Food and beverage industries: 82
- Oil and refinery industry: 1
- Pesticide industries: 2
- Fertilizer industries: 6

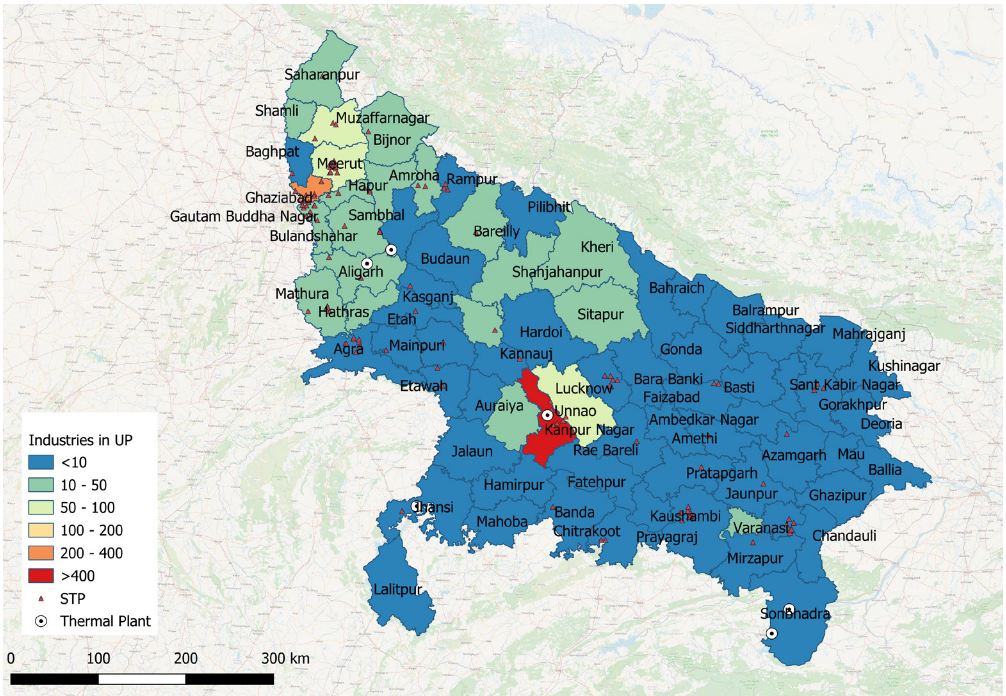
- Pharmaceutical industries: 3
- Paper and pulp industries: 103
- Slaughterhouse industries: 55
- Petrochemical industry: 1
- Textile industries: 544
- Other industries: 50

Figure 5: Percentage of different types of industries in Uttar Pradesh



Source: CPCB (2020–21)

Map 8: Distribution of industries in different districts of Uttar Pradesh



Source: Created by CSE from NMCG data

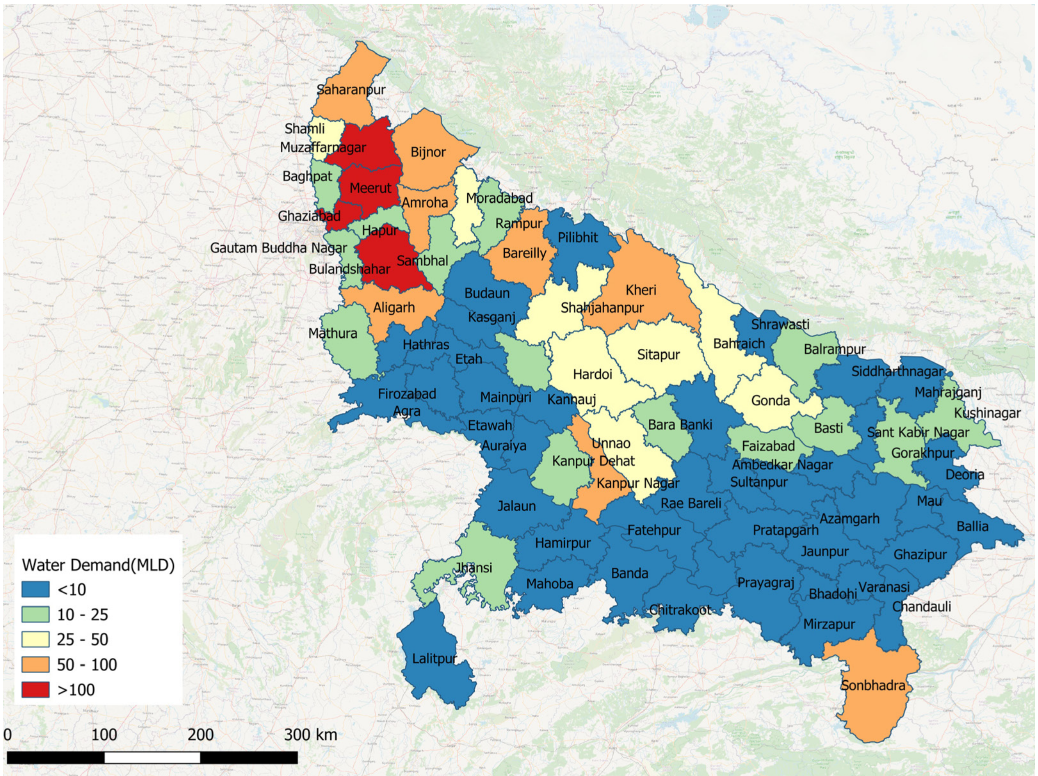
Table 2: Industry-intensive districts of UP and their STPs

S. no.	District	Number of industries	Major industry	Number of STPs	Total installed STP capacity (in MLD)
1.	Kanpur Nagar	414	Tannery and thermal plants	7	475
2.	Ghaziabad	276	Textile	8	480
3.	Unnao	76	Tannery	1	15
4.	Meerut	61	Textile	14	179
5.	Muzaffarnagar	53	Pulp and paper	2	54.5

Source: CPCB (2020–21) and NGT report 2024

From the analysis it is evident that Kanpur Nagar district has more than 400 industries, Ghaziabad district has 200–400 industries, and Unnao, Meerut and Muzaffarnagar district have 100–200 industries. These five districts are industry-intensive zones of Uttar Pradesh, so these zones are high priority for reuse of treated water in industries. Treated wastewater can be used from the STPs of these districts (see *Table 2: Industry-intensive districts of UP and their STPs*).

Map 9: Industrial water demand in different districts of Uttar Pradesh



Source: Created by CSE

Based on the water consumption data for various industries provided in the NMCG 2013 Report, water demand was estimated (in MLD) for the following industry types: chemical; tannery; sugar; distillery; food and beverage; paper and pulp; and textile, bleaching and dyeing. We used these estimates to calculate the water demand for each district's industries. For oil and refinery, pesticide, fertilizer, pharmaceutical, slaughterhouse and petrochemical industries, we used the water consumption rates from the 'Others' category in the NMCG report (see *Map 9: Industrial water demand in different districts of Uttar Pradesh*).

The estimates indicate that Muzaffarnagar, Meerut, Ghaziabad and Bulandshahr have the highest industrial water supply demand, exceeding 100 MLD. Saharanpur, Bijnor, Aligarh, Amroha, Raebareli, Kheri, Kanpur Nagar and Sonbhadra have industrial water supply demands in the range of 50–100 MLD.

Districts such as Banda, Chitrakoot, Hamirpur, Kannauj, Kaushambi, Lalitpur, Mahoba, Pratapgarh, Shravasti and Siddharth Nagar have zero demand for industrial water supply due to the absence of industries in these areas.

Water demand from thermal power plants

According to the 2020–21 CPCB list of grossly polluting industries (GPIs), there are six thermal power plants in Uttar Pradesh.[11] These six thermal plants lie in Sonbhadra, Kanpur Nagar, Jhansi, Aligarh and Bulandshahr districts of Uttar Pradesh. All of the plants are coal based except for Narora Atomic Power Station, which lies in Bulandshahr district and is nuclear power based.[12]

According to Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited (UPRVUNL)[13] Obra Thermal Power Station was running in compliance till July 1982 and 1,600 MW capacity is proposed for 2023. As per a Central Electricity Authority of India (CEA) report (STATIONS, 2021), Anpara Thermal Power Station was running in compliance till June 2015, but subsequently due to an accident it went out of generation; after 2016 there is no data available regarding its working and generation. According to a recent notification from MoEF&CC, all thermal power plants currently in operation must lower their specific water use to 3.5 m^3 per megawatt-hour (MWh).[14] All new power plants constructed after January 1, 2017 must achieve zero liquid discharge (ZLD) and utilize no more than 2.5 m^3 of water per MWh. Based on this notification, water demand has been calculated for Panki, Parichha and Harduaganj Thermal Power Plants as some installed capacity has been running after 2017. The water demand for Obra and Anpara plants has also been calculated in case they start working in the future. Based on figures given in the *Smart Water Magazine*, water demand for Narora Atomic Nuclear Power Station Narora, Bulandshahr is estimated to be 0.036–0.65 MLD (see *Table 3: Thermal power plants in Uttar Pradesh*).

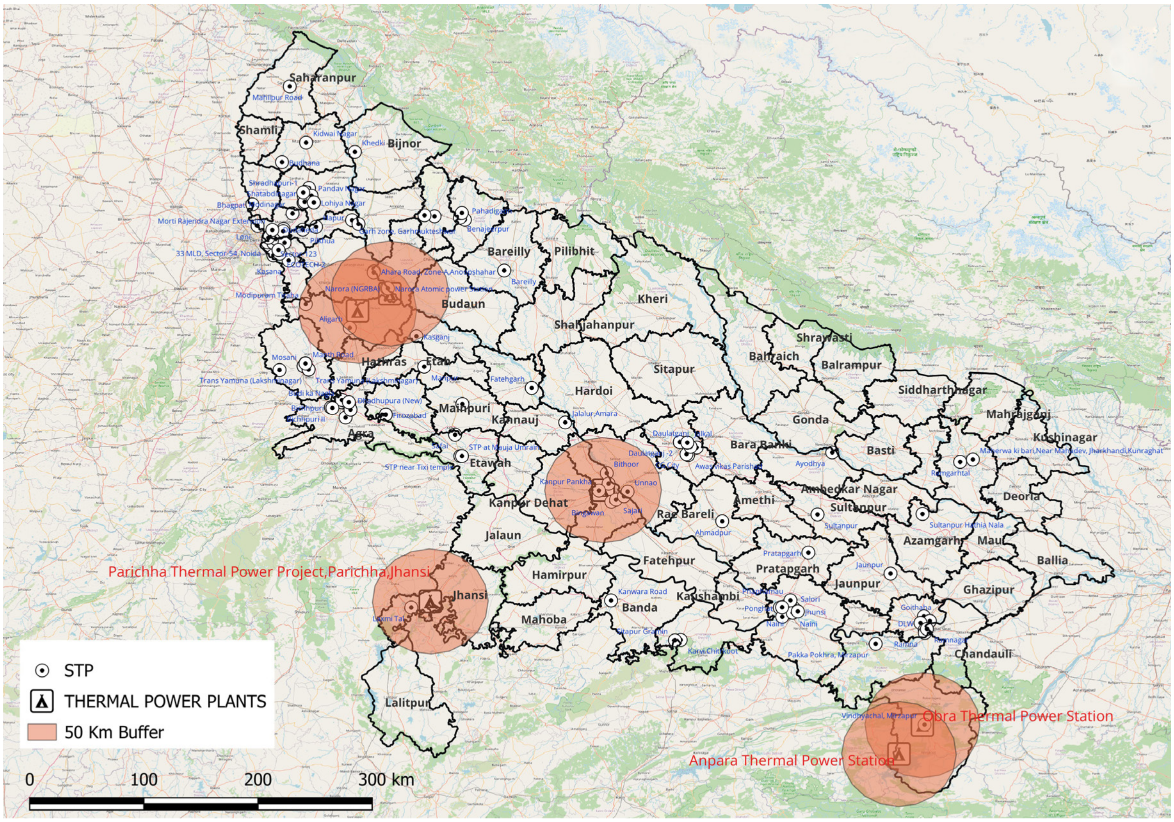
Table 3: Thermal power plants in Uttar Pradesh

S. no.	Industry	District	Power generation capacity (MW)	Fuel used	Year of commissioning	Acc. To MoEF&CC water consumption (m3/ MWH)	Water demand (m3/ hour)	Water demand (MLD)
1	Obra Thermal Power Station	Sonbhadra	1,442	Coal	1974–1982	3.5	5047	121
2	Anpara Thermal Power Station	Sonbhadra	1,630	Coal	1986–2016	2.5	4075	97.8
3	Panki Thermal Power House, Panki	Kanpur	210	Coal	1984–2023	2.5	525	12.6
4	Parichha Thermal Power Project, Parichha, Jhansi	Jhansi	220	Coal	1984–2013	2.5	550	13.2
5	Harduaganj Thermal Power Station, Kasimpur, District Aligarh	Aligarh	375	Coal	1978–2022	2.5	937.5	22.5
6	Narora Atomic Power Station Narora, Bulandshahr	Bulandshahr	440	Nuclear			1.514–2.725	0.036–0.65

Source: Thermal plant (CPCB List of GPIs 2020–2021); Plant details (Uttar Pradesh Rajya Vidyut Utpadan Nugam Limited.); Year of Comissioning and Installed capacity (Central Electricity Authority); Nuclear plant water consumption (Smart Water Magazine), Nuclear plant details (Nuclear Power Corporation of India Ltd.); Water consumption (MoEF&CC notification).

One of the provisions in the 2016 updated energy price policy mandates that thermal power plants situated within a radius of 50 kilometres of an STP must use the treated wastewater generated by the facility. On the basis of the policy we conclude that thermal plants in Uttar Pradesh can take treated water from the STPs as mentioned in *Table 4* (see *Map 10: STPs falling within a 50-km radius of thermal power plants in UP and Table 4: STPs falling within a 50-km radius of thermal power plants in UP*).

Map 10: STPs falling within a 50-km radius of thermal power plants in UP



Source: Created by CSE

Table 4: STPs falling within a 50-km radius of thermal power plants in UP

S. no.	Industry	District in which thermal power plant lies	STP within 50-km radius	District in which STP lies	STP capacity (in MLD)
1	Obra Thermal Power Station	Sonbhadra	Vidhyanchal, Mirzapur	Sonbhadra	4
2	Anpara Thermal Power Station	Sonbhadra	Vidhyanchal, Mirzapur	Sonbhadra	4
3	Panki Thermal Power House, Panki	Kanpur	Bithoor	Bithoor	1.3
			Unnao	Unnao	15
			Baniyapur Jajmau-3 Sajari Bingawan Kanpur Pankha	Kanpur Nagar	15 5 42 210 30
4	Parichha Thermal Power Project, Parichha, Jhansi	Jhansi	Laxmi Tal	Jhansi	26

S. no.	Industry	District in which thermal power plant lies	STP within 50-km radius	District in which STP lies	STP capacity (in MLD)
5	Harduaganj Thermal Power Station, Kasimpur, District Aligarh	Aligarh	Aligarh	Aligarh	45
			Modipurma Tirah	Meerut	5
			Narora (NGRBA) Narora Atomic power Station Ahara Road, Zone A, Anoopshahr Ahara Road, Zone B, Anoopshahr Anoopshahr Zone A (NGRBA) Zone B Anoopshahr	Bulandshahr	4 2.25 0.8 1.75 1.5 1
6	Narora Atomic Power Station Narora, Bulandshahr	Bulandshahar	Aligarh	Aligarh	45
			Kasganj	Kasganj	15
			Narora (NGRBA) Narora Atomic power Station Ahara Road, Zone A, Anoopshahr Ahara Road, Zone B, Anoopshahr Anoopshahr Zone A (NGRBA) Zone B Anoopshahr	Bulandshahr	4 2.25 0.8 1.75 1.5 1

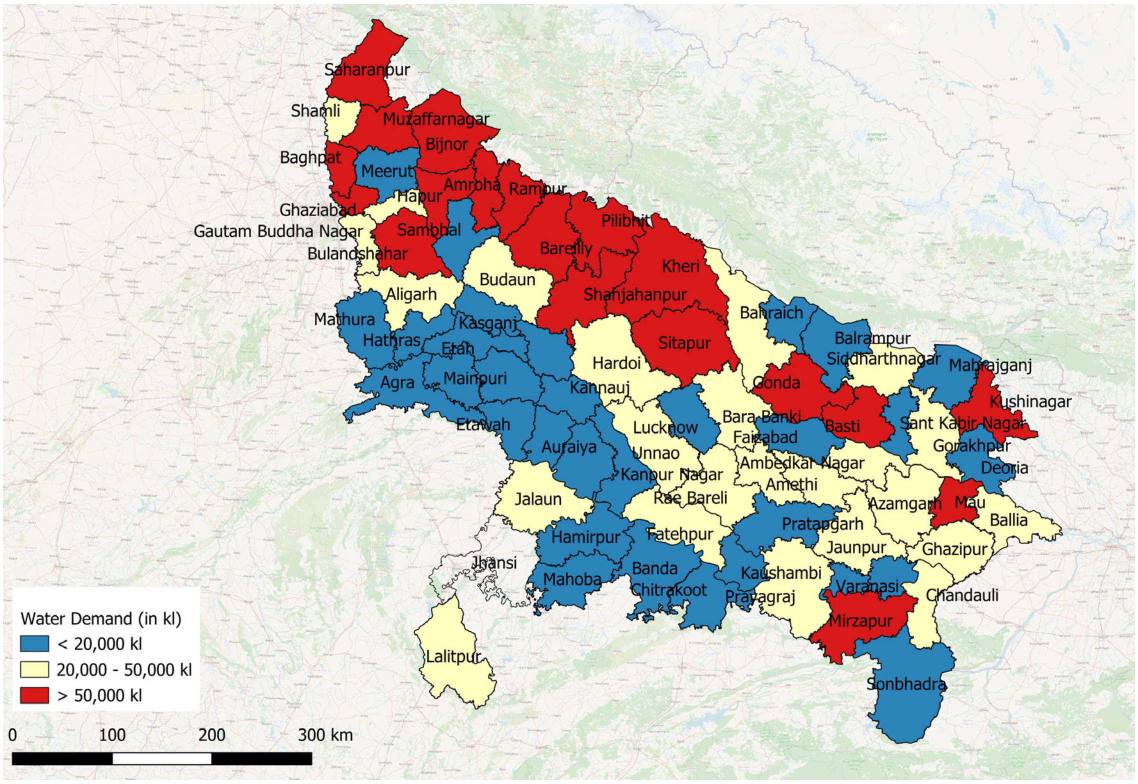
Water demand from agriculture

According to the 2019 Agricultural Contingency Plan report, wheat, millets, rice, pulses, lentils, chickpea, pigeon pea, potato, maize and sugarcane are the major crops grown in Uttar Pradesh.[15]

According to the 2023 State Disaster Management Plan, the major crops grown in drought-prone districts are wheat and pulses (in Lalitpur, Jhansi, Jalaun and Hamirpur), wheat and pigeon pea (in Mahoba), wheat and rice (in Banda), and wheat and pigeon pea (in Chitrakoot).[16]

Using water consumption data for crops from sources such as the UN's Food and Agriculture Organization, Map My Crop, and Agriculture Contingency Reports, we calculated the water demand for the two major crops in each district throughout their growing periods. Districts were then categorized based on this water demand (see *Map 11: Agricultural water demand per season for two major crops throughout their growing period for each district in Uttar Pradesh*).

Map 11: Agricultural water demand per season for two major crops throughout their growing period for each district in Uttar Pradesh



Source: Created by CSE

The following districts have high, medium and low water demand respectively:

- High water demand (> 50,000 KL per season): Bareilly, Bijnor, Bulandshahr, Gonda, Kheri, Mau, Moradabad, Muzaffarnagar, Saharanpur, Shahjahanpur, Sitapur, Amroha, Baghpat, Basti, Ghaziabad, Kushinagar, Mirzapur and Pilibhit
- Medium water demand (20,000–50,000 KL per season): Aligarh, Ambedkar Nagar, Amethi, Azamgarh, Budaun, Bahraich, Ballia, Barabanki, Chandauli, Fatehpur, Gautam Buddh Nagar, Ghazipur, Gorakhpur, Hapur, Hardoi, Jalaun, Jaunpur, Lalitpur, Raibareli, Shamli, Siddharthnagar, Unnao and Prayagraj
- Low water demand (< 20,000 KL per season): Agra, Auraiya, Balrampur, Banda, Bhadohi, Deoria, Faziabad, Etah, Etawah, Farrukhabad, Firozabad, Hamirpur, Hathras, Kannauj, Kanpur Nagar, Kanpur Dehat, Kaushambi, Lucknow, Mahoba, Mainpuri, Mathura, Meerut, Pratapgarh, Sambhal, Sant Kabir Nagar, Shahjahanpur, Shravasti, Sonbhadra, Sultanpur, Varanasi and Maharajganj

Summary of assessment findings

Our analysis of the baseline status with respect to resource, climatic conditions, treatment infrastructure and key demand centres across various districts reveals significant patterns and pressing concerns related to groundwater stress, development stages, drought proneness and water demand (see Table 5: *Summary of assessment findings*).

Table 5: Summary of the assessment findings

Sewage treatment capacity (MLD)	0–5	Agra, Kanpur, Meerut, Lucknow, Hapur, Sonbhadra, Banda, Chitrakoot, Bulandshahr, Fatehgarh, Etawah, Firozabad, Gautam Buddh Nagar, Mathura
	5–10	Meerut, Lucknow, Hapur, Sultanpur, Pratapgarh, Varanasi, Rampur, Kanpur, Mathura, Ghaziabad
	10–50	Agra, Aligarh, Baghpat, Bareilly, Bijnor, Kannauj, Saharanpur, Gautam Buddh Nagar, Meerut, Muzzafar Nagar, Lucknow, Prayagraj, Ghaziabad, Hapur, Jaunpur, Sultanpur, Varanasi, Ayodhya, Sonbhadra, Moradabad, Rampur, Jhansi, Bulandshahr, Gorakhpur, Kanpur, Etah, Etawah, Mainpuri, Mathura, Kasganj, Rae Bareilly, Shahjahanpur, Unnao, Budhana
	50–100	Agra, Gautam Buddh Nagar, Meerut, Prayagraj, Ghaziabad, Varanasi, Moradabad, Firozabad
	100–200	Gautam Buddh Nagar, Varanasi, Kanpur
	200–350	Lucknow, Kanpur
Groundwater stress zone (m below groundwater level)	Less than 2 (very low)	Nil
	2–5 (low)	Basti, Kushinagar, Sant Kabir Nagar, Shravasti, Mahrajganj
	5–10 (medium)	Ambedkar Nagar, Azamgarh, Bahraich, Ballia, Balrampur, Barabanki, Bhadohi, Chandauli, Deoria, Faizabad, Gonda, Gorakhpur, Hardoi, Jaunpur, Jhansi, Kheri, Mainpuri, Mau, Pilibhit, Siddharthnagar
	10–20 (high)	Aligarh, Amroha, Banda, Bareilly, Bijnor, Budaun, Bulandshahr, Chitrakoot, Etah, Farrukhabad, Fatehpur, Ghazipur, Hathras, Kanpur Dehat, Lalitpur, Mahoba, Mathura, Mirzapur, Moradabad, Pratapgarh, Rae Bareli, Rampur, Saharanpur, Sitapur, Sonbhadra, Sultanpur, Unnao, Varanasi, Prayagraj
	20–30 (very high)	Auraiya, Baghpat, Firozabad, Ghaziabad, Hamirpur, Jalaun, Kannauj, Kaushambi, Meerut, Muzaffarnagar
	30–45 (extremely high)	Agra, Etawah, Kanpur Nagar, Lucknow

Groundwater development stage	Safe zone: 0–70%	Ambedkar Nagar, Amethi, Auraiya, Azamgarh, Bahraich, Ballia, Balrampur, Banda, Barabanki, Basti, Chandauli, Deoria, Faizabad, Etawah, Ghazipur, Gonda, Gorakhpur, Hamirpur, Hardoi, Jalaun, Jhansi, Kasganj, Kheri, Kushinagar, Lucknow, Mau, Mirzapur, Pilibhit, Rae Bareli, Sant Kabir Nagar, Shahjahanpur, Shravasti, Siddharthnagar, Sitapur, Sonbhadra, Sultanpur, Unnao, Mahrajganj
	Semi-critical zone: 70- 90%	Chitrakoot, Etah, Farrukhabad, Fatehpur, Jaunpur, Kannauj, Kanpur Nagar, Kanpur Dehat, Kaushambi Lalitpur, Mainpuri, Mathura, Meerut, Moradabad Muzaffarnagar, Pratapgarh, Rampur, Sambhal, Varanasi, Prayagraj
	Critical zone: 90–100%	Amroha, Baghpat, Bulandshahr, Hapur, Hathras, Mahoba
	Over-exploited zone: >100%	Agra, Firozabad, Gautam Buddh Nagar, Ghaziabad ,Saharanpur, Shamli
Drought-prone areas	Mild	Aligarh, Ambedkar Nagar, Amethi, Amroha, Auraiya, Azamgarh, Budaun, Baghpat, Bahraich, Ballia, Balrampur, Barabanki, Bareilly, Basti, Bhadohi, Bijnor, Bulandshahr, Chandauli, Deoria, Faziabad, Farrukhabad, Firozabad, Gautam Buddh Nagar, Ghazipur, Ghaziabad, Gonda, Gorakhpur, Hapur, Hardoi, Hathras, Jaunpur, Kannauj, Kanpur Nagar, Kasganj, Kheri, Kushinagar, Lucknow, Mau, Meerut, Moradabad, Muzaffarnagar, Pilibhit, Pratapgarh, Rai Bareli, Rampur, Saharanpur, Sambhal, Sant Kabir Nagar, Shahjahanpur, Shamli, Shravasti, Siddharthnagar, Sitapur, Sultanpur, Unnao, Varanasi, Mahrajganj
	Moderate	Agra, Etah, Etawah, Fatehpur, Kanpur Dehat, Kaushambi, Mainpuri, Mathura, Mirzapur, Sonbhadra, Prayagraj
	Severe	Banda, Chitrakoot, Hamirpur, Jalaun, Jhansi, Lalitpur, Mahoba
Rainfall	Low rainfall areas	Amethi, Auraiya, Farrukhabad, Gautam Buddh Nagar, Hapur, Kanpur Dehat, Sambhal, Shamli, Mahrajganj
	Medium rainfall areas	Agra, Aligarh, Ambedkar Nagar, Amroha, Azamgarh, Budaun, Baghpat Ballia, Bareilly, Basti, Bhadohi, Bulandshahar, Chandauli, Deoria, Faizabad, Etah, Etawah, Fatehpur, Firozabad, Ghazipur, Ghaziabad, Gorakhpur, Hamirpur, Hardoi, Hathras, Jalaun, Jaunpur, Jhansi, Kannauj, Kanpur Nagar, Kasganj, Kaushambi, Kushinagar, Lucknow, Mahoba, Mainpuri, Mathura, Mau, Meerut, Mirzapur, Moradabad Muzaffarnagar, Pratapgarh, Rai Bareli, Rampur, Sant Kabir Nagar Shahjahanpur, Siddharthnagar, Sitapur, Sonbhadra, Sultanpur, Unnao, Varanasi, Prayagraj
	High rainfall areas	Bahraich, Balrampur, Banda, Barabanki, Bijnor, Chitrakoot, Gonda, Kheri, Lalitpur, Pilibhit, Saharanpur, Shravasti

Domestic water supply (MLD)	Low: 0–100	Ambedkar Nagar, Amethi, Amroha, Auraiya, Azamgarh, Budaun, Baghpat, Bahraich, Ballia, Balrampur, Banda, Barabanki, Basti, Bhadohi, Chandauli, Chitrakoot, Deoria, Faizabad, Etah, Etawah, Farrukhabad, Fatehpur, Ghazipur, Gonda, Hamirpur, Hapur, Hardoi, Hathras, Jalaun, Jaunpur, Kannauj, Kanpur Dehat, Kasganj, Kaushambi, Kheri, Kushinagar, Lalitpur, Mahoba, Mainpuri, Mau, Mirzapur, Pilibhit, Pratapgarh, Rae Bareli, Rampur, Sambhal, Sant Kabir Nagar, Shahjahanpur, Shamli, Shravasti, Siddharthnagar, Sitapur, Sonbhadra, Sultanpur, Unnao, Mahrajganj
	Medium: 100–200	Aligarh, Bijnor, Bulandshahr, Firozabad, Gautam Buddh Nagar, Gorakhpur, Jhansi Mathura, Muzaffarnagar, Saharanpur, Prayagraj
	High: 200–300	Agra, Bareilly, Meerut, Moradabad, Varanasi
	Very high: >300	Ghaziabad, Kanpur Nagar, Lucknow
Shallow aquifer recharge	Over-exploited zone: >100%	Agra, Firozabad, Gautam Buddh Nagar, Ghaziabad, Saharanpur, Shamli
	More than 20 MBGL water level	Auraiya, Baghpat, Firozabad, Ghaziabad, Hamirpur, Jalaun, Kannauj, Kaushambi, Meerut, Muzaffarnagar, Agra, Etawah, Kanpur Nagar, Lucknow.
Industrial Water demand (MLD)	Very low: <10	Agra, Ambedkar Nagar, Amethi, Auraiya, Azamgarh, Budaun, Ballia, Banda, Barabanki, Bhadohi, Chandauli, Chitrakoot, Deoria, Etah, Etawah, Fatehpur, Firozabad, Ghazipur, Hamirpur, Hathras, Jalaun, Jaunpur, Kannauj, Kasganj, Kaushambi, Lalitpur, Mahoba, Mainpuri, Mau, Mirzapur, Pilibhit, Pratapgarh, Rai Bareli, Sant Kabir Nagar, Shrawasti, Siddharthnagar, Sultanpur, Varanasi, Prayagraj, Mahrajganj
	Low: 10–25	Baghpat, Balrampur, Basti, Faziabad, Farrukhabad, Gautam Buddh Nagar, Gorakhpur, Hapur, Jhansi, Kanpur Dehat, Kushinagar, Lucknow, Mathura, Rampur, Sambhal
	Medium: 25–50	Bahraich, Gonda, Hardoi, Jhansi, Moradabad, Shahjahanpur, Shamli, Sitapur, Unnao
	High: 50–100	Aligarh, Amroha, Bareilly, Bijnor, Kanpur Nagar, Kheri, Saharanpur, Sonbhadra
Agricultural water demand (KL)	Low: <20,000	Agra, Auraiya, Balrampur, Banda, Bhadohi, Chitrakoot, Deoria, Faziabad, Etah, Etawah, Farrukhabad, Firozabad, Hamirpur, Hathras, Jhansi, Kannauj, Kanpur Nagar, Kanpur Dehat, Kasganj, Kaushambi, Lucknow, Mahoba, Mainpuri, Mathura, Meerut, Pratapgarh, Sambhal, Sant Kabir Nagar, Shrawasti, Sonbhadra, Varanasi, Mahrajganj
	Medium: 20,000–50,000	Aligarh, Ambedkar Nagar, Amethi, Azamgarh, Budaun, Bahraich, Ballia, Barabanki, Chandauli, Fatehpur, Gautam Buddh Nagar, Ghazipur, Gorakhpur, Hapur, Hardoi, Jalaun, Jaunpur, Lalitpur, Rai Bareli, Shamli, Siddharthnagar, Sultanpur, Unnao, Prayagraj.
	High: >50,000	Amroha, Baghpat, Bareilly, Basti, Bijnor, Bulandshahr, Ghaziabad, Gonda, Kheri, Kushinagar, Mau, Mirzapur, Moradabad, Muzaffarnagar, Pilibhit, Rampur, Saharanpur, Shahjahanpur, Sitapur

4. Prioritization of treated wastewater reuse

Why prioritize reuse of treated wastewater?

The Multi Criteria Decision Analysis (MCDA) framework presented in the following section helps states determine which districts to prioritize for treated wastewater reuse interventions and then identify the most suitable sectors (domestic, industrial, agriculture or any other) within those districts.

It requires evaluating different potential applications—such as agricultural irrigation, industrial processes, groundwater recharge and domestic usage—and ranking them according to their feasibility, benefits, and alignment with local needs. This process ensures that treated wastewater is allocated to the most suitable and high-impact uses, which need to be defined based on a transparent consultative process of all stakeholders, especially the most vulnerable sections and those who can speak for biodiversity and nature uses.

Reuse of treated water prioritization requires that:

- Wastewater treatment is happening as per standards.
- A new source of water supply that can substitute or reduce demand for freshwater is created. The longer-term aim should be reducing freshwater and groundwater withdrawals, not increasing them along with this new water option.
- Different reuse options are identified, and prioritization options evaluated to ensure that equity and justice in reuse of treated wastewater is not sacrificed.
- The trade-off between reuse after secondary or tertiary treatment is addressed. Secondary treatment makes water fit for reuse in waterbodies and groundwater recharge, while tertiary treatment is required for making water fit for industrial use or domestic water consumption. The costs of both are very different.

Method used for prioritization

Multi-criteria decision analysis (MCDA)

MCDA is a decision-making framework that allows for the evaluation of complex scenarios where multiple, often conflicting, criteria need to be considered simultaneously. MCDA is a well-established scientific method used to evaluate and prioritize different options based on multiple criteria.

THE MAIN STEPS IN MCDA

Identification of options: Before creating a weighted decision matrix, all the possible options available must first be identified and listed. This step ensures that all relevant alternatives are considered and overlooking of potential solutions is avoided.

Determination of criteria: Next, the specific criteria that will be used to evaluate the options needs to be determined. These criteria should be relevant, measurable and aligned with the objectives. For instance, if you are choosing a new car, criteria such as fuel efficiency, safety features and price may be important to you.

Assignment of weights: Once you have your criteria, weights need to be assigned to each of them. These weights reflect the relative importance of each criterion in the decision-making process. The sum of all weights should be equal to 1 or 100 per cent, ensuring that the criteria are properly balanced.

Evaluation of options: With the criteria and weights in place, you can now evaluate each option against the established criteria. This involves assigning scores or ratings to each option based on how well they meet each criterion. The scores are then multiplied by the corresponding weights to calculate a weighted score for each option. These weights and scores are subjective and should be decided through relevant stakeholders consultation before applying it for the decision analysis.

Comparison and decision making: Finally, you compare the weighted scores of each option and identify the one with the highest score. This option is considered the most favourable choice based on the established criteria and their assigned weights.

By following these principles, a weighted decision matrix provides a structured and objective approach to decision making. It helps to make informed choices by considering multiple factors and their relative importance.

In the context of wastewater reuse prioritization, MCDA helps in assessing various districts based on factors such as groundwater stress, groundwater development stage, drought-prone areas, rainfall, and demand centres e.g., domestic, industrial and agricultural.

KEY POINTS TO BE CONSIDERED FOR PRIORITIZATION (EXAMPLE FROM AGRA DISTRICT)

The following are some important points to consider regarding the priority-level matrix for districts and the ranking of demands for each district:

The priority-level matrix and ranking of demands provides a structured approach to addressing Uttar Pradesh's water challenges, but they should be viewed as a flexible framework. The state is encouraged to customize and refine this tool to fit its specific needs and conditions, ensuring that the final strategies for wastewater reuse are both practical and impactful.

- The matrix of priority levels and the ranking of demands for each district is developed by CSE based on a comprehensive analysis of available data and assessments. It is essential, however, to recognize that this matrix is a guiding tool. It may not encompass all practical factors present on the ground, such as local socioeconomic conditions, existing infrastructure, and the varying levels of technical feasibility across districts.
- The state should use the matrix as a foundational guide to initiate planning and decision-making. Before implementation, however, it is recommended that the state validates the findings from the matrix by conducting ground-level surveys, stakeholder consultations and technical assessments. This validation will help ensure that the matrix aligns with the real-world conditions of each district.
- The state may need to adjust the weightings and scores of each criterion within the matrix to better reflect the local context. Factors such as the availability of funding, current state of infrastructure, social acceptance, and technical feasibility can significantly influence the prioritization of wastewater reuse projects.
- Social acceptance of wastewater reuse varies across regions, influenced by cultural beliefs, public perceptions and local practices. The state should assess the social implications of the matrix recommendations and make adjustments where necessary to ensure community buy-in and successful adoption of reuse practices.
- The state should revisit and revise the matrix as new data becomes available or as conditions on the ground change so the matrix remains relevant and effective in guiding sustainable water management.

Step 1: Prioritization of districts for treated wastewater reuse interventions

1. **Criteria for weighting and scoring:**
    - The report evaluates each district on the basis of different criteria and assigns scores for factors such as groundwater stress zones, drought-proneness, rainfall patterns, and sector-specific water demands.
    - These scores are weighted according to their relative importance to determine a composite score for each district. The weighting system reflects the priority given to different criteria based on their impact on sustainable water management.

2. **Prioritization based on composite scores:**
   - Districts are ranked on the basis of their composite scores, which helps in identifying high-priority areas for treated wastewater reuse interventions.
   - For example, districts with high water demand and severe groundwater stress might be ranked higher for receiving targeted investments in sewage treatment plants (STPs) and reuse infrastructure.

Steps for prioritization

1. Define the parameters: We need to start with identifying parameters that will be assessed for prioritization, which in this case is groundwater stress zone (water level and exploitation level), drought-prone areas, rainfall, domestic water demand, industrial water demand and agriculture water demand.
2. Assign weights to each parameters: Assign weights to each parameter based on its relative importance. Groundwater, which is heavily relied upon statewide, should receive a higher weight. Agriculture, as a key economic sector, should also be given significant weight. Domestic use, being a fundamental need, should be equally prioritized.
3. Assign weights to each parameters: Assign weights to each parameter based on its importance. For instance:

- Groundwater stress zone: 20 per cent
- Groundwater development stage: 15 per cent
- Drought-prone areas: 15 per cent
- Rainfall levels: 10 per cent
- Domestic water supply: 15 per cent
- Industrial water demand: 10 per cent
- Agricultural water demand: 15 per cent

4. Create a scoring system: For each parameter, create a scoring system (see *Table 6: Scoring system for the parameters*).

Table 6: Scoring system for the parameters

Parameters	Criteria	Score
Groundwater stress zone (based on water level metre below ground level)	Less than 2	1
	2–5	2
	5–10	3
	10–20	4
	20–30	5
	30–45	6
Groundwater development stage	Safe zone	1
	Semi-critical zone	2
	Critical zone	3
	Over-exploited zone	4
Drought-prone areas	Mild	1
	Moderate	2
	Severe	3
Rainfall	High	1
	Medium	2
	Low	3
Domestic water supply	Low	1
	Medium	2
	High	3
	Very high	4
Industrial water demand	Very low	1
	Low	2
	Medium	3
	High	4
Agricultural water demand	Low	1
	Medium	2
	High	3

Calculate the weighted score for each district:
The weighted score for each parameter was calculated using the formula:

Weighted score = Score x (Weight/100)

- For each city, multiply the score of each parameter by its respective weight to get the weighted score (see *Table 7: Calculation of weighted score*).

Table 7: Calculation of weighted score

Parameters after assessment	Weightage (in per cent)	Score	Weighted score
Groundwater stress zone: Extremely high	20	6	1.2
Groundwater development stage: Over-exploited zone	15	4	0.6
Drought-prone areas: Moderate	15	2	0.3
Rainfall: Medium	10	2	0.2
Domestic water supply: High	15	3	0.45
Industrial water demand: Low	10	2	0.20
Agricultural water demand: Low	15	1	0.15
Total weighted score			3.10

5. Aggregation and classification

The weighted scores are aggregated to provide a total priority score for each city. Based on the total score, districts are classified into high-, medium-, or low-priority levels:

Example from Table 7:
Total weighted score for Agra:
Total score = **0.6** + **0.9** + **0.6** + **0.2** + **0.2** + **0.6** + **0.4** + **0.15** = **3.10**

Classify districts into priority levels:
Based on the total weighted scores, districts were classified into three priority levels:

a. **High priority**: Total score > 2.5
b. **Medium priority**: Total score 1.5–2.5
c. **Low priority**: Total score < 1.5

Priority level for Agra: High (since the total score is > 2.5).

- **High priority**: Districts that have over-exploited groundwater resources, high demand for domestic and industrial water, and are in drought-prone or low-rainfall areas. These districts require immediate attention for the reuse of treated wastewater.
- **Medium priority**: Districts that are in critical or semi-critical groundwater zones with moderate water demand. These districts should be targeted for treated wastewater reuse to prevent further groundwater depletion.
- **Low priority**: Districts in safe zones with adequate rainfall and moderate or low water demand. These districts may not require immediate action but should be monitored for future needs.

(See *Table 8: Classification of districts to identify where government should focus on reuse of treated wastewater on priority* and *Map 12: District-wise priority-level matrix for reuse of treated wastewater*.)

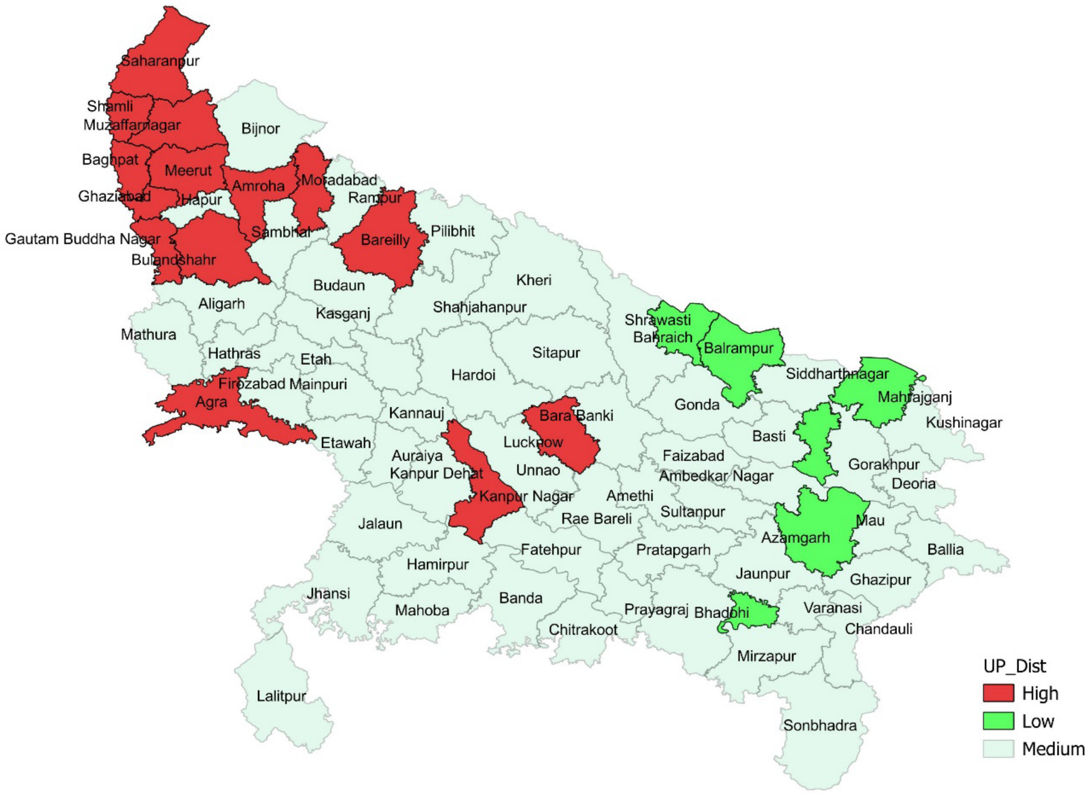
Table 8: Classification of district to identify where government should focus on reuse of treated wastewater on priority

District	Groundwater stress zone	Groundwater development stage	Drought-prone areas	Rainfall	Demand for domestic water supply	Demand for Industrial water	Demand for agriculture water	Priority level
Agra	Extremely high	Over-exploited zone	Moderate	Medium	High	Low	Low	High
Aligarh	High	Semi-critical zone	Mild	Medium	Medium	High	Medium	Medium
Ambedkar Nagar	Medium	Safe zone	Mild	Medium	Low	Low	Medium	Medium
Amethi	Medium	Safe zone	Mild	Low	Low	Very low	Medium	Medium
Amroha	High	Critical zone	Mild	Medium	Low	High	High	High
Auraiya	Very high	Safe zone	Mild	Low	Low	Very low	Low	Medium
Azamgarh	Medium	Safe zone	Mild	Medium	Low	Very low	Medium	Low
Budaun	Medium	Semi-critical zone	Mild	Medium	Low	Very low	Medium	Medium
Baghpat	Very high	Critical zone	Mild	Medium	Low	Low	High	High
Bahraich	Medium	Semi-critical zone	Mild	High	Low	Medium	Medium	Medium
Ballia	Medium	Safe zone	Mild	Medium	Low	Very low	Medium	Medium
Balrampur	Medium	Safe zone	Mild	High	Low	Low	Low	Low
Bareilly	High	Semi-critical zone	Mild	Medium	High	High	High	High
Basti	Low	Safe zone	Mild	Medium	Low	Low	High	Medium
Bhadohi	Medium	Safe zone	Mild	Medium	Low	Very low	Low	Low
Bijnor	High	Safe zone	Mild	High	Medium	High	High	Medium
Bulandshahar	High	Critical zone	Mild	Medium	Medium	Medium	High	High
Chandauli	Medium	Safe zone	Mild	Medium	Low	Very low	Medium	Medium
Deoria	Medium	Safe zone	Mild	Medium	Low	Very low	Low	Medium
Firozabad	Very high	Over-exploited zone	Mild	Medium	Medium	Very low	Low	Medium
Gautam Buddh Nagar	Very high	Over-exploited zone	Mild	Low	Medium	Low	Medium	High

District	Groundwater stress zone	Groundwater development stage	Drought-prone areas	Rainfall	Demand for domestic water supply	Demand for Industrial water	Demand for agriculture water	Priority level
Ghaziabad	Very high	Over-exploited zone	Mild	Medium	Very high	High	High	High
Gorakhpur	Medium	Safe zone	Mild	Medium	Medium	Low	Medium	Medium
Hapur	Very high	Critical	Mild	Low	Low	Very low	Medium	Medium
Hardoi	Medium	Safe	Mild	Medium	Low	Medium	Medium	Medium
Hathras	High	Critical zone	Mild	Medium	Low	Very low	Low	Medium
Jaunpur	Medium	Semi-critical zone	Mild	Medium	Low	Very low	Medium	Medium
Kanpur Nagar	Extremely high	Semi-critical zone	Mild	Medium	Very high	High	Low	High
Kasganj	High	Safe zone	Mild	Medium	Low	Very low	Low	Medium
Kheri	Medium	Safe zone	Mild	High	Low	High	High	Medium
Kushinagar	Low	Safe zone	Mild	Medium	Low	Low	High	Medium
Lucknow	Extremely high	Safe zone	Mild	Medium	Very high	Low	Low	High
Mau	Medium	Safe zone	Mild	Medium	Low	Very low	High	Medium
Meerut	Very high	Semi-critical zone	Mild	Medium	High	High	Low	High
Moradabad	High	Semi-critical zone	Mild	Medium	High	Medium	High	High
Muzaffarnagar	Very high	Semi-critical zone	Mild	Medium	Medium	High	High	High
Pilibhit	Medium	Safe zone	Mild	High	Low	Very low	High	Medium
Pratapgarh	High	Semi-critical zone	Mild	Medium	Low	Very low	Low	Medium
Rai Bareli	High	Safe zone	Mild	Medium	Low	Very low	Medium	Medium
Rampur	High	Semi-critical zone	Mild	Medium	Low	Low	High	Medium
Saharanpur	High	Over-exploited zone	Mild	High	Medium	High	High	High
Sambhal	High	Semi-critical zone	Mild	Low	Low	Low	Low	Medium
Sant Kabir Nagar	Low	Safe zone	Mild	Medium	Low	Very low	Low	Low
Shahjahanpur	Medium	Safe zone	Mild	Medium	Low	Medium	High	Medium
Shamli	Very high	Over-exploited zone	Mild	Low	Low	Medium	Medium	High
Shrawasti	Low	Safe zone	Mild	High	Low	Very low	Low	Low
Siddharthnagar	Medium	Safe zone	Mild	Medium	Low	Very low	Medium	Medium
Sitapur	High	Safe zone	Mild	Medium	Low	Medium	High	Medium

District	Groundwater stress zone	Groundwater development stage	Drought-prone areas	Rainfall	Demand for domestic water supply	Demand for Industrial water	Demand for agriculture water	Priority level
Sultanpur	High	Safe zone	Mild	Medium	Low	Very low	Medium	Medium
Unnao	High	Safe zone	Mild	Medium	Low	Medium	Medium	Medium
Varanasi	High	Semi-critical zone	Mild	Medium	High	Very Low	Low	Medium
Mahrajganj	Low	Safe	Mild	Low	Low	Very Low	Low	Low
Etah	High	Semi-critical zone	Moderate	Medium	Low	Very Low	Low	Medium
Etawah	Extremely high	Safe zone	Moderate	Medium	Low	Very Low	Low	Medium
Fatehpur	High	Semi-critical zone	Moderate	Medium	Low	Very low	Medium	Medium
Kanpur Dehat	High	Semi-critical zone	Moderate	Low	Low	Low	Low	Medium
Kaushambi	Very high	Semi-critical zone	Moderate	Medium	Low	Very low	Low	Medium
Mainpuri	Medium	Semi-critical zone	Moderate	Medium	Low	Very low	Low	Medium
Mathura	High	Semi-critical zone	Moderate	Medium	Medium	Low	Low	Medium
Mirzapur	High	Safe zone	Moderate	Medium	Low	Very low	High	Medium
Sonbhadra	High	Safe zone	Moderate	Medium	Low	High	Low	Medium
Prayagraj	High	Semi-critical zone	Moderate	Medium	Medium	Very low	Medium	Medium
Banda	High	Safe zone	Severe	High	Low	Very low	Low	Medium
Chitrakoot	High	Semi-critical zone	Severe	High	Low	Very low	Low	Medium
Hamirpur	Very high	Safe zone	Severe	Medium	Low	Very low	Low	Medium
Jalaun	Very high	Safe zone	Severe	Medium	Low	Very low	Medium	Medium
Jhansi	Medium	Safe zone	Severe	Medium	Medium	Low	Low	Medium
Lalitpur	High	Semi-critical zone	Severe	High	Low	Very low	Medium	Medium
Mahoba	High	Critical zone	Severe	Medium	Low	Very low	Low	Medium
Faizabad	Medium	Safe	Mild	Medium	Low	Low	Low	Medium
Farrukhabad	High	Semi- critical zone	Mild	Low	Low	Low	Low	Medium
Ghazipur	High	Safe zone	Mild	Medium	Low	Very low	Medium	Medium
Gonda	Medium	Safe zone	Mild	High	Low	Medium	High	Medium
Kannauj	Very high	Semi- critical zone	Mild	Medium	Low	Very low	Low	Medium

Map 12: District-wise priority-level matrix for reuse of treated wastewater



Source: CSE

The matrix categorizes the districts in Uttar Pradesh into **high-**, **medium-** and **low**-priority levels based on multiple factors, including city type, groundwater stress zone, groundwater development stage, drought-prone areas, rainfall levels, and water demand across domestic, industrial and agricultural sectors. This categorization helps identify where to focus efforts for maximizing the reuse of treated wastewater, offering strategic insights into water resource management.

High-priority districts

- Districts in this category generally have a combination of with **extremely high or very high groundwater stress zones** and are in **over-exploited or semi-critical groundwater development stages**.
- They also have a **high** or **very high domestic and industrial water demand** but limited water availability due to **low rainfall** or **drought-prone areas**. **Examples:** Agra, Ghaziabad, Bareilly, Kanpur Nagar, Meerut, Saharanpur, Lucknow

Recommendations:

- Immediate action is required to set up or upgrade wastewater treatment infrastructure and enforce regulations to promote treated wastewater reuse.

Medium-priority districts

- These districts are typically at the **high** or **medium groundwater stress** and **semi-critical or safe groundwater development stages**.
- Water demand in these districts is moderate across domestic, industrial and agricultural sectors, and rainfall conditions are typically moderate.
  - **Examples:** Ali**garh, Firozabad, Varanasi, Gorakhpur**
  - **Implications:**
- A phased approach is recommended for medium-priority districts. Initial investments in awareness campaigns, capacity building and moderate infrastructure development can gradually introduce wastewater reuse in these areas.

Low-priority districts

- Districts in this category are often at the **low to medium groundwater stress** and **safe groundwater development stages**.
- These districts typically have **low to very low water demand** across all sectors, with adequate rainfall and relatively lower drought risk.
  - **Examples:** Bhadohi, Balrampur, Shravasti, Azamgarh

Recommendations: Focus on sustainability and monitoring with selective pilot projects to explore the benefits of treated wastewater reuse.

This structured approach ensures efficient resource allocation, focusing efforts where they are needed most while laying the groundwork for sustainable water management practices across the state.

Step 2: Identifying priority sectors within districts

To identify the priority sectors within the districts in Uttar Pradesh, the following steps and mechanisms were applied (see *Table 8: Classification of district to identify where government should focus on reuse of treated wastewater on priority* for detailed matrix):

Steps to calculate the ranking

Demand and weightage for different uses may vary from state to state. For Uttar Pradesh, which is still primarily rural, where domestic and agriculture water use is a priority, we have given more weightage to these two. In other states, this may change.

1. **Identify key demand centres:**

For each district, the major demand centers identified in this study are:

- o Domestic water demand
- o Industrial water demand
- o Groundwater recharge (will cover lake recharge and wetlands)
- o Agricultural water demand

2. **Assign weights to each demand centre:**

The weights provided are:

- o Domestic water supply: 25 per cent
- o Industrial water demand: 20 per cent
- o Groundwater recharge: 25 per cent
- o Agricultural water demand: 30 per cent

3. **Determine scores for each demand centre**:

Assign a score (1–5) to each demand centre in each district based on its importance or intensity according to the assessment carried out (see *Table 5: Summary of the assessment findings*).

For example:

- ▪ Very high demand: 5
- ▪ High demand: 4
- ▪ Medium demand: 3
- ▪ Low demand: 2
- ▪ Very low demand: 1
- ▪ Over-exploited zone and area with more than 20 metres water level: 5

4. **Calculate weighted scores**:

Multiply the score of each demand centre by its respective weight.

5. **Aggregate the scores**

Add the weighted scores for each demand centre.

6. **Rank the demand centres**:

Rank the demands in descending order of their weighted scores for each city.

EXAMPLE CALCULATION FOR DISTRICT: AGRA

LET'S ASSUME THE FOLLOWING SCORES FOR AGRA:

- Domestic water supply: 4 points
- Industrial water demand: 1 points
- Shallow acquifer recharge: 4 points
- Agricultural water demand: 1 points

NOW, CALCULATE THE WEIGHTED SCORES:

- Domestic water supply: 4 points x 0.25 = 1
- Industrial water demand: 1 points x 0.20 = 0.20
- Shallow aquifer recharge: 4 points x 0.25 = 1
- Agricultural water demand: 1 points × 0.30 = 0.3

TOTAL WEIGHTED SCORES:

- Domestic water supply: 1
- Industrial water demand: 0.2
- Shallow aquifer recharge: 1
- Agricultural water demand: 0.3

RANKING:

Priority 1: Shallow aquifer recharge
Priority 2: Domestic water supply
Priority 3: Agriculture
Priority 4: Industry

Table 9: Sector prioritization within districts for reuse of treated wastewater for UP

Applying the framework of prioritization we get the following:

City	Priority 1	Priority 2	Priority 3	Priority 4
Agra	Shallow aquifer recharge	Domestic water supply	Agriculture	Industry
Aligarh	Shallow aquifer recharge	Agriculture	Industry	Domestic water supply
Baghpat	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry
Bareilly	Agriculture	Domestic water supply	Shallow aquifer recharge	Industry
Bijnor	Agriculture	Industry	Domestic water supply	Shallow aquifer recharge
Kannauj	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry
Saharanpur	Shallow aquifer recharge	Agriculture	Industry	Domestic water supply
Gautam Buddh Nagar	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry

City	Priority 1	Priority 2	Priority 3	Priority 4
Meerut	Domestic water supply	Shallow aquifer recharge	Industry	Agriculture
Muzaffarnagar	Agriculture	Shallow aquifer recharge	Industry	Domestic water supply
Lucknow	Domestic water supply	Shallow aquifer recharge	Agriculture	Industry
Prayagraj	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry
Ghaziabad	Domestic water supply	Shallow aquifer recharge	Agriculture	Industry
Hapur	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry
Jaunpur	Agriculture	Domestic water supply	Shallow aquifer recharge	Industry
Sultanpur	Agriculture	Domestic water supply	Shallow aquifer recharge	Industry
Varanasi	Domestic water supply	Shallow aquifer recharge	Agriculture	Industry
Sonbhadra	Industry	Agriculture	Domestic water supply	Shallow aquifer recharge
Moradabad	Agriculture	Domestic water supply	Shallow aquifer recharge	Industry
Rampur	Agriculture	Shallow aquifer recharge	Domestic water supply	Industry
Jhansi	Domestic water supply	Agriculture	Industry	Shallow aquifer recharge
Bulandshahr	Agriculture	Shallow aquifer recharge	Domestic water supply	Industry
Gorakhpur	Agriculture	Domestic water supply	Industry	Shallow aquifer recharge
Kanpur	Domestic water supply	Shallow aquifer recharge	Industry	Agriculture
Etah	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry
Etawah	Agriculture	Domestic water supply	Shallow aquifer recharge	Industry
Mainpuri	Shallow aquifer recharge	Agriculture	Domestic water supply	Industry
Mathura	Shallow aquifer recharge	Domestic water supply	Agriculture	Industry
Kasganj	Agriculture	Domestic water supply	Shallow aquifer recharge	Industry
Rae Bareli	Agriculture	Shallow aquifer recharge	Domestic water supply	Industry
Shahjahanpur	Agriculture	Industry	Domestic water supply	Shallow aquifer recharge
Unnao	Agriculture	Industry	Domestic water supply	Shallow aquifer recharge
Firozabad	Shallow aquifer recharge	Domestic water supply	Agriculture	Industry

Key findings

Table 9 provides a detailed overview of priority sectors for treated wastewater reuse across **33 cities in Uttar Pradesh** (**where the STP installed treatment capacity is more than 5 MLD**) reflecting regional variations and sectoral water demands. Key insights are:

1. Agriculture dominance

Agriculture is the top priority for wastewater reuse in **14 cities,** indicating the sector's heavy reliance on water for irrigation in the agrarian state. Cities such as **Bulandshahr, Bareilly, Bijnor, Rampur and Gorakhpur** prioritize agriculture due to extensive agricultural activities. This highlights the need to meet irrigation demands amidst depleting freshwater resources, particularly in rural and semi-urban areas.

2. Shallow aquifer recharge

Shallow aquifer recharge emerges as a strategic priority in **12 cities, including Agra, Firozabad, Saharanpur and Gautam Buddh Nagar**. These regions face significant groundwater depletion, necessitating efforts to replenish aquifers using treated wastewater. This is particularly vital in water-stressed areas of **western Uttar Pradesh**, where groundwater over-extraction is a critical concern.

3. Domestic water supply

In **6 cities, including Lucknow, Varanasi, Ghaziabad, Jhansi and Kanpur**, domestic water supply is the primary focus. This reflects the growing need for urban centres to address potable water scarcity driven by rapid urbanization, population growth and stress on traditional water sources. Cities such as **Meerut and Ghaziabad** also prioritize groundwater recharge alongside domestic use, indicating integrated approaches to urban water security.

4. Industrial reuse

Industry, while not a primary focus in most cities, is consistently prioritized as a secondary or tertiary option. In **Sonbhadra**, however, industrial reuse is the top priority. Other cities such as **Meerut, Bulandshahr and Ghaziabad** also emphasize industrial reuse to balance freshwater availability with economic growth.

5. Regional trends

Western Uttar Pradesh: Cities such as Agra, Gautam Buddh Nagar, Aligarh, Etah, Mathura and Firozabad prioritize a combination of shallow aquifer recharge, domestic water supply and agriculture. This region faces high groundwater exploitation and industrial activity.

- Central Uttar Pradesh: Cities such as Lucknow, Kanpur and Prayagraj focus on domestic supply and agriculture, indicating a balance between urban water security and irrigation needs.
- Eastern Uttar Pradesh: Cities such as Gorakhpur, Jaunpur and Sultanpur primarily focus on agriculture, with limited emphasis on industrial reuse or aquifer recharge due to lower industrialization levels.
- Bundelkhand region: Cities such as Jhansi and Etah emphasize domestic supply and **shallow aquifer recharge**, given the region's history of water scarcity and droughts.

6. Balancing competing demands

Table 9 highlights Uttar Pradesh's multifaceted approach to wastewater reuse, with the following aspects balanced:

- **Agriculture water needs** in rural and peri-urban areas;
- **Urban water security** in rapidly growing cities;
- **Groundwater management** to combat over-extraction; and
- **Industrial water demand** in select regions like Sonbhadra.

The prioritization ranking provides valuable insights into the unique water demands of districts across Uttar Pradesh. By understanding these priorities, policymakers can develop targeted strategies that address the most critical water needs in each city.

Stakeholder mapping—roles and responsibilities

To effectively implement the plan for the reuse of treated wastewater (TWW) in Uttar Pradesh, various stakeholders must play coordinated and defined roles (see *Table 10: Stakeholders roles and responsibilities for formulating and implementing strategies on reuse of treated wastewater).*

Table 10: Stakeholders roles and responsibilities for formulating and implementing strategies on reuse of treated wastewater

Stakeholder	Role
State government (Urban Development and Water Resources Departments)	Formulate comprehensive policies for TWW reuse; allocate funds for infrastructure; ensure inter-departmental coordination for water management strategies.
Uttar Pradesh Jal Nigam	Oversee the construction, operation, and maintenance of sewage treatment plants (STPs); ensure treated water meets quality standards suitable for reuse.
Uttar Pradesh Pollution Control Board (UPPCB)	Monitor effluent quality from STPs; enforce compliance with environmental and health standards; regulate industrial wastewater treatment and reuse.
Urban local bodies (ULBs)	Implement local-level reuse strategies based on city-specific needs; manage and operate STPs; facilitate urban reuse for landscaping and street cleaning.
Irrigation Department	Facilitate the use of treated wastewater for agricultural irrigation in water-scarce regions; support water-efficient practices among farmers.
Industries (including textile, leather and power sectors)	Adopt treated wastewater for industrial processes like cooling and washing; invest in dedicated treatment infrastructure; adhere to state reuse policies.
Agricultural sector (farmers and agricultural cooperatives)	Utilize treated wastewater for irrigation; adopt practices to ensure crop safety and soil health; collaborate with government agencies for safe reuse.
Public Health and Engineering Department (PHED)	Ensure that TWW reuse complies with health standards for non-potable uses; provide guidelines on safe usage of treated wastewater.
Private sector and public–private partnerships (PPPs)	Invest in TWW infrastructure development; engage in operation and management of STPs through PPP models; innovate in treatment technologies.
Non-governmental organizations (NGOs) and community-based organizations (CBOs)	Conduct awareness campaigns on the benefits and safety of TWW reuse; train communities and farmers on best practices.
Research institutions and academia	Conduct research on innovative reuse technologies; provide scientific data to support policy development; evaluate the impact of TWW practices.
Local communities (urban and rural residents)	Participate in local water management planning; adopt safe reuse practices; provide feedback on policy effectiveness and areas of improvement.

Time frame for planning scaling up of reuse of treated wastewater in Uttar Pradesh

Defining an action plan for implementing the reuse of treated wastewater is crucial because it provides a clear roadmap with specific steps, responsibilities and timelines, ensuring that all stakeholders understand their roles and the project's progress (see *Table 11: Roadmap for scaling up reuse of treated wastewater in Uttar Pradesh*).

Table 11: Roadmap for scaling up reuse of treated wastewater in Uttar Pradesh

Phase	Time frame	Action	Details
Short term	0–3 years	Finalize state policy on treated wastewater reuse	Align with national guidelines and city-level priorities.
		Establish a dedicated state-level body	Coordinate across departments and ensure effective implementation and monitoring (see *Table 10: Stakeholder roles and responsibilities for formulatinge and implementing strategies on reuse of treated watsewater*).
		Capacity building and training programmes	Conduct workshops for ULBs, industries and farmers on best practices for treated wastewater reuse.
		Prioritize districts as pilot projects	Prioritize districts with high demand like Ghaziabad, Agra, Kanpur, Lucknow and Meerut.
		Promote decentralized treatment solutions	Encourage small districts to adopt decentralized treatment to cut costs and logistical challenges.
		Launch public awareness campaigns	Educate communities, industries, and farmers on the benefits and safety of treated wastewater reuse.
		Develop incentives for early adopters	Introduce subsidies, rebates, and tax benefits for stakeholders who adopt treated wastewater reuse.
		Develop sector-specific reuse strategies	Prioritize reuse in recharge, agricultural, industrial and urban water supply reuse based on city-specific needs.
		Strengthen governance and monitoring	Implement robust monitoring, compliance mechanisms, and third-party audits.
		Develop a Management Information System (MIS)	Track progress, monitor water quality and evaluate socioeconomic impacts.
		Encourage public–private partnerships (PPPs)	Promote PPP models for building and operating infrastructure in high-potential districts.
		Create business models for reuse	Develop economically viable models that benefit both private players and end-users.
Long term	3–5 years	Plan at city level for the reuse of treated water	Cities should prepare their plans by using city level toolkit for reuse of treated water.
		Integrate treated wastewater reuse in urban and regional planning	Ensure all new developments which includes infrastructure for wastewater reuse.
		Regular policy review and updates	Continuously revise policies and standards based on feedback, technological advancements and evolving needs.
		Promote community-led initiatives	Engage community organizations and NGOs to promote local reuse practices and sustainability.
		Build a circular economy of water	Integrate treated wastewater reuse into broader sustainability frameworks to achieve a circular water economy.

Data sources

Topic	Sources	Year	Department	Link
Groundwater exploitation	Dynamic Ground Water Resources of India	2023	Central Ground Water Board	https://cgwa-noc.gov.in/LandingPage/LatestUpdate/NCDGWR2023.pdf
Groundwater table level	Ground Water Year Book Uttar Pradesh	2021 -2022	Central Ground Water Board	https://www.cgwb.gov.in/old_website/Regions/NR/Reports/UP_24.10.22.pdf
Land cover	WMS Server Landuse Landcover	2017-2018	India Water Resources Information System	https://arc.indiawris.gov.in/server/services/NWIC/LULC_2005_2018/MapServer/WMSServer
STPs	NGT Monthly progress report	Apr-24	National mission for clean Ganga	NGT Monthly Progress Report (nmcg.nic.in)
Lakes and ponds	Mission Amrit Sarovar	2022 ownwards		https://amritsarovar.gov.in/ComprehensiveReportPagination
	Jal Shakti census Vol. 1		Department of Water Resources, River Development and Ganga Rejuvenation	https://cdnbbsr.s3waas.gov.in/s3a70dc40477bc2adceef4d2c90f47eb82/uploads/2023/04/2023040672.pdf
	Jal Shakti Census Vol. 2			https://cdnbbsr.s3waas.gov.in/s3a70dc40477bc2adceef4d2c90f47eb82/uploads/2023/05/20240110191671260.pdf
Industries	Central Pollution Control Board	2020–21	National Ganga River Basin Authority	https://www.cpcb.nic.in/ngrba/GPI_UP.pdf
	Status of Grossly Populating Industries, Chapter8	2013	NMCG	https://nmcg.nic.in/pdf/pollution per cent20assessment.pdf
	National Mission for Clean Ganga	April 2024	Ministry of Jal Shakti	https://nmcg.nic.in/ngtprogressreport.aspx
				https://nmcg.nic.in/writereaddata/fileupload/ngtmpr/41_Uttar per cent20Pradesh per cent20- per cent20MPR per cent20April per cent202024.pdf
Thermal Power Plant	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd			https://web.archive.org/web/20081113110616/http://www.uprvunl.org/anpara.htm
	Nuclear Power Corporation of India Ltd			https://web.archive.org/web/20141026194220/http://www.npcil.nic.in/main/ProjectOperationDisplay.aspx?ReactorID=85
	Central Electricity Authority	March 2021	Ministry of Power	https://cea.nic.in/wp-content/uploads/pdm/2021/06/list_power_stations_2021.pdf
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	Centre for Science and Environment			https://cdn.cseindia.org/attachments/0.71571700_1629984459_cse-coal-power-water.pdf

Topic	Sources	Year	Department	Link
Agricultural crops	Agricultural Contingency Plan	2019	Department of Agriculture & Farmers Welfare	https://agriwelfare.gov.in/en/AgricultureContigencyPlan/UTTAR per cent20PRADESH?page=4
	Irrigation Water Management: Irrigation Water Needs	1987	UN's Food and Agriculture Organization	https://www.fao.org/4/s2022e/s2022e07.htm#TopOfPage
	Map my Crop		Cutting-edge AgTech startup	https://mapmycrop.com/gram-chickpea-crop-guideindia/#:~:text=Suitable per cent20for per cent20cultivation per cent20in per cent20rainfed,yield per cent20of per cent209 per cent20qtl per cent2Facre.
	Development of e-course for BSc. Agriculture		Tamil Nadu Agriculture University	http://eagri.org/eagri50/AGRO103/lec07.pdf
	Water productivity of major pulses—A review	2023	ELSEVIER	https://doi.org/10.1016/j.agwat.2023.108249
	Water productivity mapping of major Indian crops	2018	NABARD	https://www.nabard.org/auth/writereaddata/tender/1806181128Water per cent20Productivity per cent20Mapping per cent20of per cent20Major per cent20Indian per cent20Crops, per cent20Web per cent20Version per cent20(Low per cent20Resolution per cent20PDF).pdf
Drought	Agricultural Contingency Plan	2019	Department of Agriculture & Farmers Welfare	https://agriwelfare.gov.in/en/AgricultureContigencyPlan/UTTAR per cent20PRADESH?page=4
	Uttar Pradesh State Disaster Management Plan	2023	State Disaster Management Authority	https://upsdma.up.nic.in/2023/SDMP-Plan-Part-1.pdf
	Uttar Pradesh Drought Management Plan	2022	State Disaster Management Authority	https://upsdma.up.nic.in/Aapda per cent20Drought per cent20Guideline.pdf
Agriculture	Agricultural Contingency Plan	2019	Department of Agriculture & Farmers Welfare	https://agriwelfare.gov.in/en/AgricultureContigencyPlan/UTTAR per cent20PRADESH?page=4
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The state of Uttar Pradesh generates 5,500 million litres per day (MLD), of which only 3,296 MLD is treated. With reuse concentrated in major cities, much of UP's reuse potential is left untapped.

This report proposes a two-step prioritization framework—geographical and sectoral—to identify high-demand districts and key areas for intervention, such as domestic supply, industrial demand and agricultural support. With a matrix-driven decision model—which ensures that all relevant alternatives are considered and potential solutions not overlooked—it underscores the critical role of wastewater reuse to reduce groundwater dependence; address water scarcity; and promote sustainable, long-term water resilience in Uttar Pradesh. It can serve as a guidance framework for policymakers to optimize the reuse of treated wastewater, while addressing the state's substantial water demand across domestic, industrial and agricultural sectors.

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