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Management, Challenges and Prospects of Drinking Water Resources in India: A Study of Aligarh and Bulandshahr in Western Uttar Pradesh

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Abstract

Water is an important source for sustaining life and livestock, which requires being properly used, developed and managed. India is not a water-deficient country, but its growing demand for water makes it vulnerable, and by 2050 it will become the highest water-demanding country with a daily demand of 2413 billion litres per capita at the global level. In 1951, India's water per capita availability was 5177 cm per year, decreasing to 1820 cm in 2001. India's water per capita availability will be 1341 cm per year in 2025 and 1140 cm per year in 2050. In India, 43.5 percent of drinking water requirement is being fulfilled by tap water, 42 percent by handpump/tubewell sources, 11 percent by well and 3.5 percent by other sources. Inadequate use of water resources is an important feature of Uttar Pradesh which pushed many regions in the state into dry and rain-fed zones. The state is also the largest extractor of groundwater, accounting for 18.4 percent of the country's groundwater and 5.4 percent of the world's groundwater. The per capita groundwater extraction is 225.0 cm per capita which are more than the national average of 182.9 cm per capita and the world average of 125.9 cm per capita. In Uttar Pradesh, 67.9 percent of water drinking requirements are fulfilled by handpumps or tubewells, 27.3 percent by tap water, 4 percent by well and 0.9 percent by other sources. It has also been observed that the majority of the development blocks have overexploited the groundwater resources in which some development blocks become more critical while some other blocks come under the semi-critical zones. This may be due to rapid population growth, urbanization, higher dependency on groundwater for agriculture, fast-growing manufacturing units, and a change in temporal and spatial variation due to climate change and ineffective management of water resources.

Keyword: Water; Population growth; Urbanisation; Sustainable development; Environment and Climate change; Uttar Pradesh.

Jel Classification: Q25, Q56, 018, Q01, Q5, Q54

I. Introduction:

Water is essential to human life and plays a crucial role in the country's socio-economic development. The availability of water is fundamental to an economy and ecology. It has become more critical due to the changing climatic and environmental issues. The growth of the economy and the development of smart cities also depend on how much we manage our natural resources. The modernization of India cannot be left alone without the modernization of the country's water management. This is not surprising because India has 17 percent of the global population but has only 4 percent of the world's water resources. India is not a water-deficient country, but its growing demand for water makes it vulnerable, and by 2050 it may become the highest water-consuming country with a daily water requirement of 2413 billion litres per capita as against the 1866 billion litres per capita in the year 2000. In India, agriculture consumes 83 percent of water, and the industrial sector consumes 12 percent, whereas the domestic use of water is only 5 percent. In 1951, India's water per capita availability was 5177 cm per year, decreasing to 1820 cm in 2001. India's water per capita availability will be 1341 cm per year in 2025 and 1140 cm per year in 2050. In India, 43.5 percent of drinking water requirement is being fulfilled by tap water, 42 percent by handpump/tubewell sources, 11 percent by well and 3.5 percent by other sources.

Better and more efficient water use is a challenge for Indian agriculture and industry. It requires proper water management both at the village level and at the city level. In order to make agriculture more remunerative and improve the prosperity of farming, the Indian government has introduced many schemes, namely Her Chet Kop Panni Paani' (Water for Every Farm), 'Per Drop, More Crop.' The government's intention to double the farmer's income by 2022 will further increase the pressure on groundwater resources already fulfilling more than the 83 percent irrigation requirement. The growth of the industrial sector, the make in India campaign, skill India and the promotion of MSMEs will demand more and more water which is already using 12 percent of water resources. The efficiency of water use and reuse, water harvesting, increasing the reservoir's capacity, groundwater recharge and the availability of clean and safe drinking water is the need of the hour. In this concern, the growing need by agriculture, business and industry cannot be ignored as an important cause responsible for the growing water scarcity. World Health Organization reports continuously raising concerns that there is a growing problem with water resources across the globe. The report further estimated that around 1 billion people could not get safe and clean drinking water. Millennium Development Goal of the U.N. (2000) seeks to half the number of people for safe drinking water over the years. The various studies in India have found that 85 percent of persons in urban India can get water availability on their premises, in only 20 percent of them have an excess of safe drinking water.

The growing population has increased the diverse need for water. The growing population, urbanization, deforestation, rising environmental degradation, and increasing multiple water uses have aggravated the problem. It would also be able to account for ground and surface water resources in water resources management. Uttar Pradesh is the largest extractor of groundwater and accounts for 18.4 percent of the country's groundwater resources and 5.4 percent of the world's groundwater resources. The per capita groundwater extraction in the state is 225.0 cm which is more than the national average of 182.9 cm per capita and the world average of 125.9 cm per capita. In Uttar Pradesh, 67.9 percent of drinking water requirements are being fulfilled by handpumps/tubewells, 27.3 percent by tap water, 4 percent by well and 0.9 percent by other sources. It has also been observed that the majority of the development blocks have overexploited the groundwater resources, which make some development blocks critical, and some are under the semi-critical zones.

The degrading quality of water and its bad impact on agriculture production and human health is a cause of major concern. The Western region of Uttar Pradesh is rich in agricultural productivity and has become the growing source of groundwater extraction. The region is also realizing a rise in the spatial temperature, variability in rainfall, environmental pollution and growing population is also a cause of concern for the region. The growing population, deforestation and increasing demand for water for different uses are the major issues that need to be addressed.

The growing requirements of water call for adopting measures for reuse of water, wastewater management and better sanitation, infrastructural development and its proper management will be very beneficial for the development the smart cities. There is a need to adopt measures to reuse the 40 billion litres of wastewater produced every day in urban India. This paper presents an overview of relevant issues about the development and management of water resources, including the stakeholders of water resources, challenges and prospects. The first section discusses the introduction, while the second part discusses the literature review. The third section discusses water resources in India. The fourth section discusses the water availability in Uttar Pradesh. The fifth sections discuss the management and challenges of water resources. Last section; sum-up the study with important findings and valuable suggestions.

II. **Literature Review:**

There is a growing amount of literature on water resource management, challenges and prospects. There also exist various models which describe the various aspects of water resources. One such model is the water resource management model, which describes the management of water in such a way as to optimize the available water resources and make them more beneficial. Such models aim to optimize water use with the minimization of a cost. The water resource model establishes interrelation between water resources, water requirements, and economic benefits of water to provide useful information to policymakers for resource allocation. McKinney et al. (1999) have provided a detailed study of the modelling of water resources management at the basin level. Mayer and Muñoz-Hernandez (2009) have carried out a study on the integrated water optimization model. Hajkowicz and Collins (2007) have pointed out detailed water resource and management factors. Schoups et al.

(2006) have developed a model for managing groundwater and surface water and studied the various effects on the profitability and sustainability of irrigated agriculture. Elmahdi et al. (2007) have conducted a study on water allocation and its use in irrigation.

Hunh, et al. (2010) studied the correlation between the growing population and water resources and observed a positive correlation. Chau et al. (1997) observed that the growing water problem had made the water resources at the regional and national issues the helm of risk. Molen and Hildering (2005) pointed out that water resources are an integral part of the eco-system, wetland, coastal areas and mangroves. Singh (2000) observed that 85.5 percent of urban India have access to drinking water, but only 20 percent have access to safe drinking water. Prasad (2000) has observed that ground and surface water availability at the market level has helped increase agricultural productivity. Pant (2005) observed that marginal farmers largely benefited from the groundwater. Nelliat (2007) observed that the private water supply fulfils 85 percent of the industrial water supply need. Deng's (1982) water management models and Simonov (2002) System dynamic approaches focused on formulating water optimization models and stresses needed to make the sustainable development of the water resources.

Haq et al. (2007), in their study, observed that clean and safe drinking water is very important for one health. He further argued that inadequate and poor quality water results in more sickness and death increased health costs, and lower worker productivity and school enrolment. Kanmony (2003), Kundu and Thakur (2006) and Zerah (2006), in their studies, observed that there is a disparity between urban and rural India in the provision of drinking water. They further observed that rural people are discriminated against in the provision of water, and there is a positive relationship between economic development and drinking water availability.

Singh D (2009) observed a disparity between the scheduled castes and other castes regarding access to drinking water sources, distance, and sanitation availability. In a study, Tiwari and Pandey (2011) observed that if the present trend and pattern of demand and supply of water will continue, half of the water demand will be unmet shortly. Loucks (2000) argued that sustainable water resource systems are designed and managed to contribute to society's objectives, now fully and in the future, while maintaining ecological, environmental and hydrological integrity.

III. Water Resources in India:

India has 4 percent of water resources but has 17 percent of the world's population and 2.5 percent of the world's geographical area. It is estimated that India has around 4000 cm of water through precipitation, in which nearly 1869 cm of water is available through the surface and replenishable groundwater sources. Globally, 2.5 percent of water is fresh, whereas 97.5 of the water is saline which is not safe for drinking. India has only 0.3 percent of the world's freshwater, although have 4 percent of the world's water resources. The various studies in India observed that only 20 percent of people in urban India have an excess of safe and clean drinking water on their premises. Although having good surface water availability, the country has an uneven distribution of rainfall and severe flood problems in some regions and drought in some other regions.

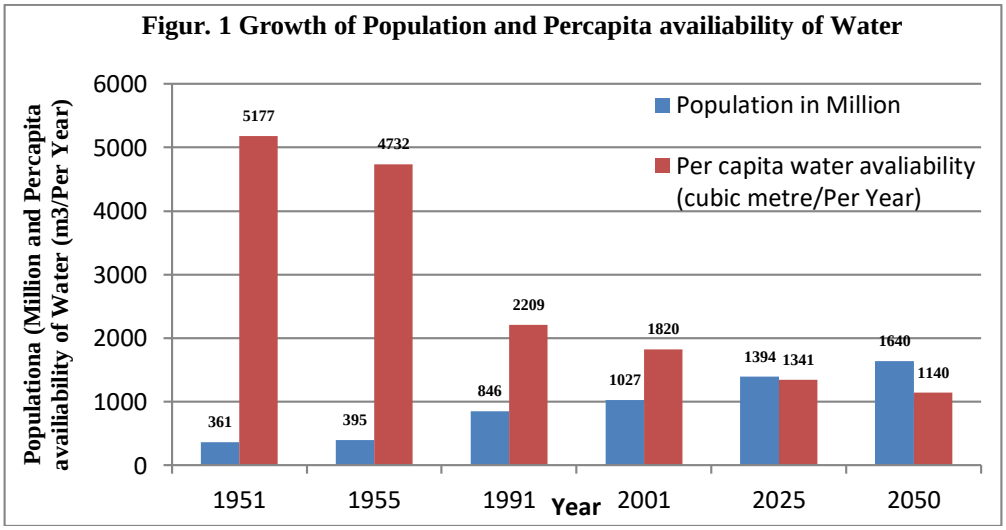
The growing population, urbanization, deforestation, rising environmental degradation, and diverse water needs have aggravated the problem of the country's ground and surface water resources. The changing climatic

conditions have resulted in water scarcity and the poor quality of water, which negatively impacts agricultural production and human health. It has also resulted in a rise in the spatial temperature, variability in the rainfall and environmental pollution. By the year 1950, except for three water basins, namely Brahamani-Bitarani, Mahanadi and Narmada, all the remaining water basins will experience severe water scarcity situations.

India has 10360 rivers and possesses 1869 cm of water available in rivers, lakes, ponds, tanks, etc. Due to numerous reasons, namely topographical, hydrological and other problems, only 690 cm (32 percent) of water is utilized. In the river, water availability also depends upon the river's catchment areas and the precipitation. Ganga, Brahmaputra, Barak and Indus have a large catchment area and water from precipitation. Over the years, changes in climatic conditions, rise in temperature, spatial variation of rain, and multiple water uses have hindered water flow. It is estimated that 432 cm of groundwater resources are available. It meets 83 percent of the irrigation needs and 85 percent of the drinking needs of the rural population and around 40 percent of the urban drinking requirements in the country.

Below, Figure.1 depicted the per capita availability of water resources and projected water availability by 2050. It can be observed from the figure that in 1951 population of the country was 361 million, but water per capita availability was 5177 cm per year. In 2001, the country's population increased to 1027 million, but water per capita availability decreased to 1820 cm per year. It is estimated that in 2025, the country's population will increase to 1394 million, but the water per capita water availability will decrease to 1341 cm per year. By 2050, the country's population will increase to 1640 million, whereas water per capita availability will decrease to 1140 cm per capita per year, showing that a large number of the population will be unable to access the water if the suitable measures have not been adopted.

Figur. 1 Growth of Population and Percapita availiability of Water



Sources: Government of India, 2009.

The large-scale use of groundwater resources has led to the depletion in the groundwater level and deterioration in the quality of the groundwater resources. This may be accorded to the over-exploitation of groundwater for agriculture, industrial and drinking purposes, change in the cropping pattern, low and spatial variation in rainfall, subsidized electricity, sewage and waste disposal, urbanization and a decline in the natural recharge to the groundwater aquifers. The groundwater extraction is very high in Uttar Pradesh, Punjab, Haryana, and Rajasthan, whereas it is moderate in Gujarat, Bihar, Tripura and Haryana, whereas low in the states of

Chhattisgarh, Odisha and Kerala etc. Various studies have observed that if the overexploitation of water will not be managed, it will put a serious threat to the sustainability of water resources.

Table 1 shows the different drinking water sources, namely tap water, well water, handpump, tube-well water, and other sources, according to the census in 2001 and 2011. It can be observed from the table that at the national level, tap water drinking sources increased from 36.7 percent in 2001 to 43.5 percent in 2011. Likewise, the handpump and tubewell source of drinking water has very minimally increased from 41.2 percent in 2001 to 42 percent in 2011. The share of a good source of drinking water has decreased from 18.2 percent in 2001 to 11 percent in 2011. According to Census 2011, tap water sources of drinking water are largest in the states of Chandigarh, 96.7 percent, Pondicherry, 95.3 percent, Himachal Pradesh, 89.9 percent and Goa, 85.4 percent, whereas other states, namely Bihar, 4.4 percent, Assam 10.5 percent, Jharkhand 12.9 percent, Odissa 13.8 percent and Uttar Pradesh 27.3 percent. Likewise, although well sources fulfil 11 percent of drinking water requirements, Lakshadweep accounted for 71.7 percent, Kerala 62 percent, Jharkhand 36 percent and UP only 4 percent. At the national level, the handpump and tube-well drinking water sources are 42 percent, but Bihar 89.6 percent, UP 67.9 percent, Punjab 46.6 percent and Rajasthan 37.5 percent, whereas some states, namely Sikkim 0.1 percent, Mizoram 1.7 percent and Goa 0.3 percent. This shows the divergent source of drinking water across the different states where some states, namely Chandigarh, Pondicherry, Himachal Pradesh and Goa, have proper management for drinking water resources while some other states, Bihar, Assam, Jharkhand, Odissa, and Uttar Pradesh have not the proper and effective management for tap drinking water sources.

Table 1: Sources of Drinking water in different states of India according to the census, 2001 and 2011.

Sl no	States/U.T.	Percentage of households							
		Tap water		Well Water		Handpump/Tube-well water		Other sources of Water	
		2001	2011	2001	2011	2001	2011	2001	2011
1	JK	52.5	63.9	5.6	6.5	12.7	12.8	29.2	16.7
2	Himachal Pradesh	84.1	89.9	4.8	2.9	4.5	4.2	6.6	3.4
3	Punjab	33.6	51	0.8	0.4	64	46.6	1.6	2
4	Chandigarh	91.9	96.7	0	0.1	8	2.6	0.2	0.6
5	Uttrakhand	65.9	68.2	1.2	1.1	20.8	24	12.1	6.7
6	Haryana	48.1	68.8	11.7	3	37.9	25	2.2	3.2
7	NCT of Delhi	75.3	81.3	0.0.	0.1	21.9	13.7	2.7	4.9
8	Rajashthan	35.3	40.6	24	10.8	32.9	37.5	7.9	11.1
9	UP	23.7	27.3	11.6	4	64.1	67.9	0.6	0.9
10	Bihar	3.7	4.4	12.6	4.3	82.9	89.6	0.8	1.7
11	Sikkim	70.3	85.3	0.1	0.6	0.4	0.1	29.1	14.1

12	**Arunachal Pradesh**	67.8	65.5	4.7	5.7	9.7	13.1	17.8	15.7
13	**Nagaland**	42	47.2	34.9	25.7	4.5	6.7	18.6	20.5
14	**Manipur**	29.3	38.6	6.4	7.5	7.7	6.8	56.6	47.1
15	**Mizoram**	31.9	58.7	2	4.7	4	1.7	62	34.9
16	**Tripura**	24.6	33.2	38.3	27.4	27.9	34.3	9.1	5.1
17	**Meghalaya**	34.5	39.3	27.4	25.4	4.4	5.4	33.7	29.9
18	**Assam**	9.2	10.5	26.7	18.9	49.6	59.4	14.6	11.3
19	**West Bengal**	21.4	25.4	10	6	67.1	66.8	1.5	1.7
20	**Jharkhand**	12.6	12.9	51.8	36.5	30.1	47.3	5.6	3.4
21	**Odessa**	8.7	13.8	28.6	19.5	55.5	61.4	7.3	5.2
22	**Chhatisgarh**	15.5	20.7	24.6	11.4	55	65.6	4.9	2.3
23	**MP**	25.3	23.4	29	20	43.1	54.6	2.6	2
24	**Gujarat**	62.3	69	11.7	7.1	21.8	21.2	4.2	2.7
25	**Daman Diu**	72.9	75.2	3.4	0.7	23.4	23.5	0.2	0.5
26	**DNH**	28.2	46.5	19.4	7.2	48.8	45	3.6	1.3
27	**Maharashtra**	64	67.9	17.8	14.4	15.8	15.5	2.4	2.1
28	**Andhra Pradesh**	48.1	69.9	16.5	6.4	32	20.6	3.4	3.1
29	**Karnataka**	58.9	66.1	12.4	9	25.7	21.5	3	3.5
30	**Goa**	69	85.4	26.1	11.1	1.1	0.3	3.8	3.2
31	**Lakshadeep**	3.1	20.3	93	71.7	1.6	2.5	2.4	5.5
32	**Kerala**	20.4	29.3	71.9	62	3	4.2	4.8	4.4
33	**TN**	62.5	79.8	10.6	5.1	23	12.8	3.8	2.4
34	**Pondicherry**	89.3	95.3	2.7	1.9	6.6	2.5	1.4	0.3
35	**A&N islands**	76.2	85	16	7.3	0.5	0.5	7.3	7.1
	India	**36.7**	**43.5**	**18.2**	**11**	**41.2**	**42**	**3.9**	**3.5**

Source: Census 2001& 2011.

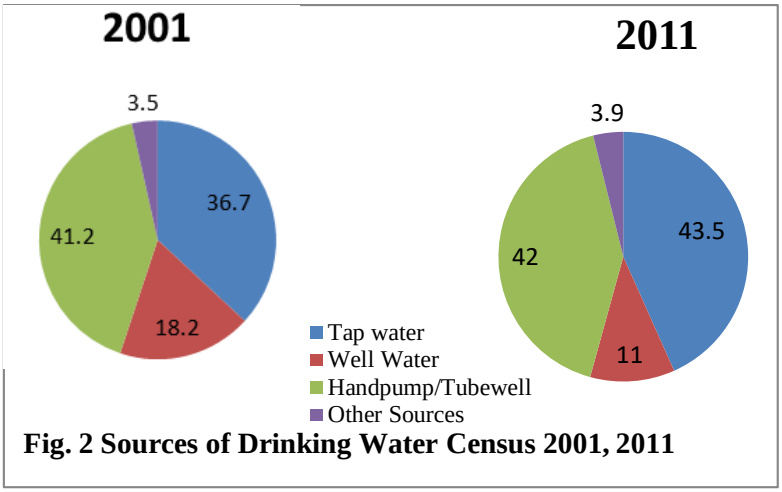


Fig. 2 Sources of Drinking Water Census 2001, 2011

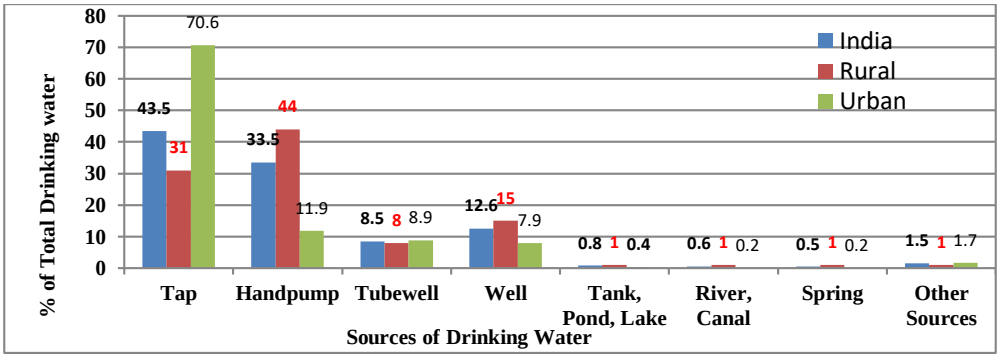
Table 2 (Fig.3) below depicts the drinking water sources in rural and urban India according to the census, 2001 and 2011. The tap water source of drinking water in rural India increased from 24.3 percent in 2001 to 31 percent in 2011, whereas, in urban India, it increased from 68.7 percent in 2001 to 70.6 percent. The second-largest source of drinking water at the national level is handpump, 33.5 percent in 2011, which was 35.7 percent in 2001. The handpump is the largest source of rural household drinking water, increasing from 43.2 percent in 2001 to 44 percent in 2011, whereas in urban India, it has decreased from 16.2 percent in 2001 to 11.9 percent in 2011. The share of well as a source of drinking water in rural India decreased from 22.2 percent in 2001 to 15 percent in 2011, whereas in urban areas, it increased from 7.7 percent in 2001 to 7.9 percent in 2011. The share of the tank, pond, and lake accounted for 0.8 percent, river and canal 0.6 percent and spring 0.5 percent, according to the census, 2011. The share of tanks, ponds, lakes, rivers, and canals varies between 0.2 to 0.4 percent in rural and urban India.

Table 2: Sources of Drinking water in Rural and Urban India according to the census, 2001 and 2011

Source	India		Rural		Urban	
	2001	2011	2001	2011	2001	2011
Tap	36.7	43.5	24.3	31	68.7	70.6
Handpump	35.7	33.5	43.2	44	16.2	11.9
Tubewell	5.6	8.5	5.7	8.0	5.1	8.9
Well	18.2	12.6	22.2	15.0	7.7	7.9
Tank, Pond, Lake	1.0	0.8	1.3	1.0	0.3	0.4
River, Canal	1.0	0.6	1.3	1.0	0.2	0.2
Spring	0.7	0.5	0.9	1.0	0.2	0.2
Other sources	1.2	1.5	1.0	1.0	1.5	1.7

Source: Census 2001 and 2011.

Figure 3, Different Sources of Drinking water in Rural and Urban India Census, 2011.



IV. Water Resources in Uttar Pradesh

Uttar Pradesh is the most populous state having 16.2 percent of India's population with 7.3 percent of the geographical areas in the country. Its climate is tropical, having warm weather. It has 648 statutory towns with 106774 villages with a 199,812,341 population according to the census of 2011. It has 822 development blocks and 226 municipal boards, with 22.3 percent of the urban population in the state. It has numerous agro-climatic zones, making it vulnerable to various water-related issues. The state is primarily an agrarian-based economy and is regarded as India's food basket, accounting for 8 percent of the country's national manufacturing output. The service sector is growing fast in the state and contributes around 49 percent of the state's gross domestic product. The state is the largest groundwater user, accounting for 18.4 percent of the country and 4.5 percent of the global groundwater extraction. It is also the largest per capita extractor of groundwater, 225.0 cm, against the national per capita groundwater extraction of 182.9 cm and global per capita ground extraction of 125.9 cm (World Bank, 2022).

This depicts the overexploitation, critical and semi-critical situation in many parts of the state, which can be accorded to the high population growth, urbanization, and temporal and spatial variations due to climate change leading to severe floodwater erosion and droughts. The central government sets the standards for maintaining water quality, but state governments are responsible for the supply of water and management of water for domestic and other purposes in rural and urban areas. Composite Water Management Index (2019), which measures the performance of states on a comprehensive set of water indicators, put the state on 15 ranks with an index weightage of 39 as against the index weightage of 75 for Gujarat which is at the first rank. The index also reported that the state is negatively performing on all the major performance indicators for water sector development, including Groundwater Source Augmentation (-1.51); Watershed Development – Supply Side Management (-3.21); Demand Side Management Participatory Irrigation Practices (-0.01); Demand Side Management Sustainable on-farm Water Use Practices (-0.88); Rural Drinking Water (-0.53); Urban Water Supply and Sanitation (-0.70).

Table 3 provides a comparative analysis of the drinking water sources in Uttar Pradesh and at the Indian level, both in rural and urban areas, according to the census 2011. At the national level, the major source of drinking water is tap water which accounts for 43.5 percent in urban India, accounting for 70.6 percent and in rural areas, 30.8 percent. In Uttar Pradesh, 27.3 percent use a tap source of drinking water in urban areas, which accounted for 51.5 percent, whereas rural areas account for 20.2 percent.

Table 3: Household by main Source of Drinking Water Census, 2011

Sl No	Items	India			U.P		
		Total	Rural	Urban	Total	Rural	Urban
1	**Tap Water**	43.5	30.8	70.6	27.3	20.2	51.5
2	**Tap water from the Treated source**	32.0	17.9	62.0	20.2	13.1	44.7
3	**Tap water from an untreated source**	11.6	13.0	8.6	7.1	7.1	6.9
4	**Well covered well**	11.0	13.3	6.2	4.0	4.9	0.8
5	**Uncovered well**	1.6	1.5	1.7	0.6	0.6	0.4
6	**Handpump**	33.5	43.6	11.9	64.9	73.2	36.8
7	**Tubewell/borehole**	8.5	8.3	8.9	2.9	1.0	9.6
8	**Spring**	0.5	0.7	0.2	0.0	0.0	0.0
9	**River/canal**	0.6	0.8	0.2	0.1	0.1	0.1
10	**Tank/Ponds/Lake**	0.8	1.1	0.4	0.1	0.1	0.2
11	**Other sources**	1.5	1.4	1.7	0.7	0.1	0.6
Households by the availability of drinking water (Location)							
	Within the premises	46.6	35.0	71.2	51.9	44.1	78.8
	Near the Premises	35.8	42.9	20.7	36.0	41.9	16.0
	Away from the premises	17.6	22.1	8.1	12.1	14.1	5.2

Source: Census, 2011

The second-largest source of drinking water at the national level is the handpump which accounts for 33.5 percent of all the drinking water sources, in rural India accounts for 43.6 percent, and urban India accounts for only 11.9 percent. In Uttar Pradesh, handpump is 64.9 percent as the largest source of drinking water, in which rural areas are 73.2 percent and urban areas 36.8 percent. The third-largest source of drinking water at the national level is tubewell/borehole, which accounts for 8.5 percent in rural India and 8.9 percent in urban India, whereas, in UP, it is 2.9 percent, which is in rural areas 1.0 percent and urban areas 9.6 percent. In Uttar Pradesh, well-drinking water sources account for 4.6 percent, rural areas for 4.9 percent, whereas urban areas account for only 0.8 percent. Likewise, different drinking water sources at the national level are tanks/ponds/lakes (0.8 percent), river canals (0.6 percent), springs 0.5 percent, and other sources account for 1.5 percent. In the state of Uttar Pradesh, the significance of other drinking water sources are tube-well/borehole (2.9 percent), river/canal 0.1 percent, river/lake 0.1 percent and other sources account for 0.7 percent.

According to the census 2011, 46.6 percent of people have a drinking water facility within their premises, in the urban area accounts for 71.2 percent, while rural India accounted for 35.0 percent. In UP, 51.9 percent of people have drinking facilities within their premises in urban areas account for 78.8 percent, and in rural areas, 44.1 percent. The table also depicts that 35.8 percent of people have drinking water sources near their premises at the national level, whereas urban areas have 20.7 percent and rural areas have 42.9 percent. In Uttar Pradesh, 36.1 percent of people have drinking water near their premises, in which urban areas 16.1 percent and rural areas 41.9 percent. The table also shows that 17.6 percent of the people at the national level have drinking water sources away from their premises, whereas it is 12.1 percent in UP.

Western Uttar Pradesh is one of the growing regions of water consumption due to agricultural, industrial, and household requirements. The region also realizes the growing water scarcity and water degraded quality, and water level depletion over the years. The region is rich in agricultural productivity, which is an important source of livelihood for the majority of the people. The growing population, deforestation, and increasing water demand for different uses cause big concern and require a strategy to provide the water availability for farming, drinking, livestock, and other developmental needs in the region.

Table 4 depicts the main drinking water sources, namely tap water, handpump and tubewell in Western and other parts of UP according to the census in 2001 and 2011. The table depicts that the households using tap water resources increased from 23.7 percent in 2001 to 27.3 percent in 2011. In the state, the tap source of drinking water in different districts is Gautam Budha Nagar, 54.2 percent; Lucknow, 52.0 percent and Maharajganj, 46.6 percent. The table also shows Lalitpur at 9.5 percent, Kaushambi at 9.5 percent and Mahoba at 11.1 percent. Aligarh had 28.4 percent of households using tap water in 2001 and 27.8 percent in 2011, whereas for Bulandshahar, it was 26.2 percent in 2011.

Table 4: Main source of Drinking water in Western and some other parts of Uttar Pradesh Census, 2001 and 2011.

Sl No.	Districts	The main source of drinking water (%)				Location (%)	
		Tap Water		Handpumps and Tube-well		Within the premises	
		2001	2011	2001	2011	2001	2011
1.	**Saharanpur**	35.5	32.4	62.3	65.9	71.4	69.4
2.	**Muzaffar Naga**	30.6	29.8	68.3	68.4	75.0	70.2
3.	**Bijnor**	29.7	36.1	68.4	62.5	68.8	70.4
4.	**Moradabad**	30.3	34.0	68.6	64.9	80.7	83.0
5.	**Rampur**	39.0	37.1	60.1	61.7	84.2	86.7
6.	**Meerut**	37.5	43.7	60.9	54.8	80.9	82.7
7.	**Baghpat**	22.7	24.8	75.2	72.7	61.3	46.7
8.	**Ghaziabad**	42.8	41.9	56.0	55.6	81.2	81.9
9.	**Gautam Budha Nagar**	47.6	54.2	51.1	43.4	74.8	84.4
10.	**Bulandshahar**	26.2	26.2	72.2	72.4	68.8	77.4
11.	**Aligarh**	28.4	27.8	68.2	70.5	54,43	61.9
12.	**Mathura**	27.4	29.1	48.9	60.1	38.3	47.2
13.	**Agra**	30.8	33.3	59.9	62.1	38.7	45.7
14.	**Firozabad**	19.9	24.9	75.3	72.7	29.5	33.4
15.	**Mainpuri**	19.5	20.3	73.7	78.1	37.0	41.3

16.	**Badaun**	27.6	20.2	70.4	78.7	69.3	71.0
17.	**Bareilly**	40.5	43.4	58.1	55.5	83.1	86.6
18.	**Pillibhit**	30.5	7.1	67.7	71.9	79.6	82.6
19.	**Shahjahanpur**	13.0	28.6	81.1	69.9	61.6	71.1
20.	**Farukhabad**	17.8	15.9	78.3	83.0	27.7	35.2
21.	**Kannauj**	12.5	16.9	83.1	81.2	20.9	25.9
22.	**Utah**	21.7	22.8	71.8	76.0	36.9	41.4
23.	**Allahabad**	28.1	28.1	39.0	55.5	31.9	35.9
24.	**Jhansi**	25.4	26.1	43.1	62.4	34.4	37.8
25.	**Lucknow**	50.5	52.0	44.0	46.3	56.1	61.2
	UP	**23.7**	**27.3**	**64.1**	**67.9**	**46.0**	**51.9**

Source: Census, 2001 and 2011.

In the state, households using handpumps and tube-wells/boreholes as the main source of drinking water increased from 64.1 percent in 2001 to 67.9 percent in 2011. The use of handpump and tube-wells sources of drinking water for different districts are Mau 85.2 percent, Kaushambi 84.0 percent, Farrukhabad 83.0 percent, Gautam Buddha Nagar 43.4 percent, Lucknow 46.3 percent and Maharajganj 51.9 percent. The use of handpumps and tube-well/boreholes in Aligarh increased from 68.2 percent in 2001 to 70.5 percent in 2011, 72.2 percent and 72.40 percent, respectively, in Bulandshahar during the period above.

The state availability of drinking water within their premises increased from 46.0 percent in 2001 to 51.9 percent in 2011. According to the census 2011, 36.01 percent of households had a source of drinking water near their premises, whereas 12.1 percent of them were away from their premises. The district-wise availability of water resources within the premises shows Rampur district 86.7 percent, Bareilly 86.6 percent, Gautam Budha Nagar 84.4 percent, whereas Kaushambi 12.2, Mahoba 12.2 percent and Chitrakoot 15.6 percent. The households having drinking water within their premises in Aligarh increased from 54.4 percent in 2001 to 61.9 percent in 2011, whereas in district Bulandshahar, it increased from 68.8 percent in 2001 to 77.4 percent in the 2011 census. Census 2011 also revealed that the majority of the households in the Southern part of the state have drinking water away from their premises. The tehsil Marian of Mirzapur recorded the highest 36.8 percent of households having water away from their premises whereas tehsil Rampur of district Rampur has the lowest 1.2 percent source of drinking water away from their premises.

Table 5 depicts the drinking water sources in different areas of Aligarh according to the census of 2011. The table reveals that Aligarh's drinking water sources are handpumps 62.3 percent, tube-well/borehole 8.2 percent, tank/pond/lake 0.01 percent, river/canal 0.02 percent, tank/tank/pond/lake 0.09 percent, while other sources accounted for 1.07 percent.

Table 5: Main Source of Drinking Water in Aligarh according to the census, 2011

Sl. N0	Name of the Sub-district	Handpumps	Tubewell/ borehole	Spring	River/ Canal	Tank/Pond/Lake	Other Sources
1.	**Khair**	54,097 (76.4%)	1,765 (2.5%)	4 (0.01%)	12 (0.02%)	11 (0.02%)	-1.41%
2.	**Ghabana**	41,258 (80.8%)	732 (1.4%)	0 (0%)	9 (0.02%)	11 (0.02%)	499 (1.0 %)
3.	**Atrauli**	86,101 (71.7%)	818 (0.7%)	11 (0.01%)	20 (0.02%)	115 (0.1%)	984 (0.8%)
4.	**Koil**	144,505 (48.6%)	45,078 (15.2%)	45 (0.02%)	84 (0.03%)	424 (0.14%)	3,400 (1.1%)
5.	**Iglas**	50,821 (78.1%)	1,205 (1.9%)	3 (0.0%)	14 (0.02%)	6 (0.01%)	571 (0.9%)
Rural		**309,111 (76.1%)**	**6,460 (1.6%)**	**26 (0.01%)**	**70 (0.02%)**	**57 (0.01%)**	**3,710 (0.9%)**
Urban		**67,671 (34.2%)**	**43,138 (21.7%)**	**37 (0.02%)**	**69 (0.03%)**	**510 (0.26%)**	**2,744 (1.4%)**
Total		**376,782 (62.3%)**	**49,598 (8.2%)**	**63 (0.01%)**	**139 (0.02%)**	**567 (0.1%)**	**6,454 (1.1%)**

Source: Census, 2011

In all the available sources in rural areas, handpumps accounted for 76.1 percent, whereas it is 34.2 percent in urban areas. It can also be observed from the table that handpumps sources of drinking water in different areas are Iglas 78.1 percent, Khair 76.4 percent, Ghana 80.8 percent, Atrauli 71.4 percent and Koil 48.9 percent. In the district, tubewell/borewell sources accounted for 8.2 percent of urban areas accounted for 21.7 percent, whereas rural areas accounted for 1.6 percent.

Table 6 depicts the drinking water sources in different areas of Bulandshahr according to the census 2011. The table depicts that the different drinking water in Bulandshahr is handpumps 70.6 percent, tubewell/boreholes 1.83 percent, tank/pond/lake 0.09 percent, river/canal 0.02, whereas in rural areas, 77.1 percent and urban areas 50.5 percent.

Table 6: Main Source of Drinking Water in district Bulandshahr according to Census, 2011

Sl.N	Name of the Sub-district	Handpumps	Tubewell/ borehole	Spring	River/ Canal	Tank/ Pond/Lake	Other Sources
1	**Sikandrabad**	43,712 (69.4%)	1,626 (2.6%)	5 (0.01%)	7 (0.01%)	41 (0.1%)	606 (1.0%)
2	**Bulandshahr**	91,434 (64.7%)	3,735 (2.6%)	9 (0.01%)	23 (0.02%)	10 (0.01%)	1,472 (1.04%)
3	**Siana**	64,151 (75.3%)	407 (0.5%)	2 (0%)	13 (0.02%)	9 (0.01%)	826 (1.0%)
4	**Anupshahr**	45,300 (78.2%)	601 (1.04%)	2 (0%)	38 (0.1%)	20 (0.03%)	558 (1.0%)
5	**Debai**	52,338 (71.4%)	617 (0.84%)	3 (0%)	19 (0.03%)	173 (0.2%)	795 (1.1%)
6	**Shikarpur**	50,814 (69.2%)	400 (0.6%)	2 (0%)	7 (0.01%)	9 (0.01%)	871 (1.19%)
7	**Khurja**	63,434 (71.7%)	3,273 (3.7%)	6 (0.01%)	9 (0.01%)	262 (0.3%)	1,192 (1.4%)
8	**Rural**	**338,451 (77.1%)**	**2,537 (0.6%)**	**23 (0.01%)**	**65 (0.01%)**	**28 (0.01%)**	**4,701 (1.1%)**
9	**Urban**	**72,732 (50.5%)**	**8,122 (5.6%)**	**6 (0%)**	**51 (0.04%)**	**496 (0.34%)**	**1,619 (1.1%)**
	Total	**411,183 (70.6%)**	**10,659 (1.8%)**	**29 (0%)**	**116 (0.02%)**	**524 (0.1%)**	**6,320 (1.1%)**

Source: Census, 2011

It can also be observed from the table that handpumps account for 78.2 percent of drinking water requirements in Anupshahr, Siana 75.3 percent, Khurja 71.7 percent, Dubai 71.4 percent and Sikandrabad 69.4

percent. In the district, tubewell/borewell sources accounted for 1.83 percent, which is 5.6 percent in urban areas and 0.6 percent in rural areas of Bulandshahr.

V. Management and Challenges of Water Resources

India has 4 percent of global water resources but has only 0.3 percent of world freshwater resources. India is not a water-deficient country, but the large-scale use and extraction of water make it very vulnerable and threaten the sustainability of water resources in India. Suppose the continuous use of water resources will move further along with increasing population, urbanization, deforestation, multiple cropping patterns, and excess use of groundwater for agriculture in changing climatic conditions. In that case, the water demand will be unmet in the coming decades. In India, we realize a severe change in climatic conditions, erratic rain, uncertain rain, and water erosion, leading to surface water unavailability. It has also placed a huge burden on the groundwater sources of water, which are already facing an inefficient groundwater recharge. At present, groundwater serves the 83 percent irrigation requirement, 12 percent industry requirement and 5 percent domestic water requirement. Uttar Pradesh's groundwater extraction surpasses the national average of 18.4 percent, a global average of the country's water resources, and 5.4 percent of the global water resources. This depicts that we are very ignorant about the sustainability of water resources, and its irresponsible use will put hindrances on the sustainability of the ecological system. It can be further said that inefficient water use and inappropriate water management are putting us at risk of water security and sustainability. We have a finite and uneven distribution of water resources that need to be appropriately managed, developed and utilized for the welfare of the people. We are also witnessing an earlier indication of a future water crisis in the temporal and spatial change in climate, acid rain, uncertain rain, seasonal variation, water erosion, deforestation, water level depletion, floods, increased droughts, etc.

The inadequate management of water resources and its overexploitation has put many regions in critical and semi-critical zones like the Bundelkhand and Vindhya regions. There is a growing water problem for drinking and other purposes in many areas of the region. The state also ranks negatively in all major domains concerning performance indicators for water sector development developed by NITI Ayog. The state's situation has also worsened due to the inefficient management of irrigation, which consumes more than 83 percent of the water resources. The situation is also worsening due to the disappearance of ponds, lakes, water storage facilities, and administrative failure to revive the old ponds and dig the new ponds and other water bodies to harvest the rainwater. It also calls for increasing forestation and saving water from pollution generated by industries or manufactured sources. This may improve the health of water resources and put hindrances on the factors that are causing health hazards. This also calls for making people aware of the economic use of water, sanitation and health hygiene. The use of trained staff and other persons having scientific information for the efficient use of water and its proper management may overcome the severe water crisis. The district Aligarh is also severely hit by the water crisis where there is a spatial variation in water availability, and Nagar Nigam Aligarh can provide a per capita water supply of 88.1 litres per day as against the demand of 135 litres per day. In Aligarh, adequate efforts are being made to regain the flow of water in the river of Karvan, Neem, Veer, Kali, Ganga, Yamuna,

Sanger, Chuyia, Rutba, Sirsa and Rad, which except Ganga, Yamuna and Kali are all the other rivers have lost their importance or at the helm of losing their existence. Efforts are also made to revive old ponds and lakes to harvest more rainwater to recharge the groundwater aquifers. The district Bulandshar is better managed in the management of water. In the Bulandshahr, almost all the villages have drinking water availability which may be accorded due to the measures adopted to misuse water and overexploitation of water.

VI. Conclusions & Valuable Suggestions.

Water is an important source of socio-economic life. Its sustainability much depends upon how it is used, developed and managed. India is a water-efficient country but facing a fast consumption of water resources and moving towards water insecurity and unsustainability. It is estimated that India's water resources are at risk, and by 2050, it will become the highest water-demanding country with 2413 billion liters of water per year against the availability of 1140 cm per year. Inadequate use of water resources is an important feature of the Uttar Pradesh, leading to an increase in the dry and rain-fed areas. The state is also the largest extractor of groundwater at the national level. In Uttar Pradesh, 67.9 percent of water drinking requirement is being fulfilled by handpumps/tubewells against the national average of 42 percent. In Uttar Pradesh, 27.3 percent of drinking water requirement is being fulfilled by tap water against the national average of 43.5 percent. Likewise, the state well fulfils the drinking water requirement of 4 percent against the national average of 11 percent. In the state, overexploitation of groundwater resources has made it more critical. This may be due to rapid population growth, urbanization, higher dependency on groundwater for agriculture, fast-growing manufacturing units, and a change in temporal and spatial variation due to climate change and ineffective management of water resources. It requires appropriate management for developing and utilizing water for the welfare of the people. The state needs to do more work to provide safe and clean drinking water. The efforts are required to revive old ponds, water tanks, lakes and water storage bodies for rainwater harvesting. It also calls for increasing the forestation, saving water from pollution generated by industries or other manufactured sources. This may improve the health of water resources and put hindrances on the factors that are causing health hazards. This also calls for making people aware of the economic use of water and sanitation and maintaining health hygiene. The use of trained staff and other persons having scientific information for the efficient use of water and its proper management may overcome the severe water crisis.

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