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Availability of Water Resources in India

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ABSTRACT
Water is dire essential for the sustenance of life. Water is used for domestic, agricultural and industrial purposes. Availability of water is an immensely important aspect of water resources management. Water availability fluctuates throughout the year with periods of high flow (e.g. monsoons) and low flow (e.g. dry seasons). Water availability is seasonally and regionally variable and is amply influenced by the intensity, timing, and duration of summer and winter monsoons. The uneven distribution of rainfall and water resources leads to regional disparities in water availability. There are significant regional differences in water availability due to rainfall patterns and other factors. The present paper appraises of available surface and groundwater resources, analysis of surface and groundwater availability and the water-related dimensions of climate change, and water governance and also provides an overview of the most critical water resources challenges and stress factors.

Key Words: Water Resources, Availability, Water Stress, India

1. INTRODUCTION

Water availability refers to how much water is physically available or accessible (water quantity) and whether that water is safe to use (water quality). The difference in water quantity and quality across the India and how they change through tine, determine whether there is enough water for human ecosystem needs. In a nutshell, the water availability refers to the quantity and quality of water accessible for human and ecosystem needs, considering spatial and temporal variations. It is a crucial factor for sustainable development, impacting everything from agriculture and industry to human health and ecosystem's stability. Water availability is influenced by various factors, including hydro-meteorological conditions, geological formations and population density.

With 97% of the Earth's water resources in the form of saltwater and only 3% as freshwater of which 70% is in the form of glacier ice, water is a limited resource. Water is required to support both ecological systems and serve human needs for economic and social development. Besides meeting basic human needs, it is a major source of energy in some parts of the world, while in others its potential as an energy source remains largely untapped. Water is dire essential for agriculture and for many industrial processes. In India, there is intense competition for water resources from all interstate rivers, except the Brahmaputra River, among the riparian states. Moreover, water-sharing disputes extend to neighbouring countries, including Nepal, China, Pakistan, Bhutan, and Bangladesh.

Although the overall water resources in the subcontinent are sufficient for meeting its needs, gaps in water supply persist owing to the temporal as well as spatial variability of water distribution among states and neighbouring countries. Bridging these gaps is crucial for ensuring equitable water access and sustainable water resources management. There is intense competition for the water from interstate rivers such as the Cauvery Krishna, Godavari, Vamsadhara, Mandovi, Ravi-Beas-Sutlej, Narmada, Tapti, and Mahanadi among the riparian states of India. This competition is primarily due to the lack of water augmentation from surplus rivers such as the Brahmaputra, the Himalayan tributaries of the Ganga, and the west-flowing coastal rivers of the Western Ghats (**World Bank Report, 2015).**

Water availability in India is seasonally and regionally variable, and is influenced by the intensity, timing, and duration of summer and winter monsoons. Climate change will lead to higher total precipitation and increased rainfall intensity, but the frequency and spatial extent of droughts will increase, particularly in north-western and southern India. Flood risks will increase due to heavy rainfall and melting glaciers, threatening highland populations with natural disaster. Coastal cities, particularly in the Bay of Bengal, are threatened by rising sea levels and more frequent cyclones.

Water occurs in nature in all its three forms, the solid, liquid and gaseous, and in various degrees of motions. Formation and movement of clouds, rain, snow fall, stream and groundwater flow are some of the instances of dynamic movement of water. India receives an average annual precipitation of 1,170 millimeters (46 in), amounting to approximately 4,000 cubic kilometers (960 cu mi) of rainfall or about 1,720 cubic meters (61,000 cu ft) of freshwater per person each year. The country accounts for 18% of the world's population but has an access to only about 4% of the world's water resources (**India - Rivers Catchment, 2016)**.

Per capita water availability is declining due to population growth. The average annual per capita water availability was assessed as 1,816 cubic meters in 2001, decreasing to 1,545 cubic meters in 2011 and further decreased to 1,486 cubic meters in 2021 and projected to be 1,367 cubic meters in 2031(**CGW, 2023**).

WATER RESOURCES OF INDIA

The origin of all sources of water is rainfall. Monsoon precipitation is the lifeline of India. India has an average annual precipitation of around 3880 billion cubic meters (BCM) and boasts a vast river system and snow-capped mountains. The annual water resources availability in India is 1869 BCB. Nevertheless, owing to the vagaries of monsoons and uneven distribution of rainfall and high evaporation rates, the net available water resources for use are estimated to be around 1,126 BCM. This figure includes water from various sources, such as precipitation (rainfall and snow), surface water in rivers, lakes, and reservoirs, and replenishable groundwater. Out of the total available water resources, approximately 690 BCM is surface water, while the remaining 436 BCM is groundwater. Out of the total available water resources, around 690 BCM is surface water, and the remaining 436 BCM is groundwater (**Central Water Commission, 2023**) (Table 1).

Table 1
Water Resources of India

Sl. No.	Parameter	Unit (Billion Cubic Meter/Year)
1	Annual Water Availability	1869
2	Usable Water	1126
3	Surface Water	690
4	Ground Water	436

Source: Central Water Commission, 2023

According to the most recent estimate, India's annual groundwater recharge is s 437.60 BCM. When accounting for natural discharge, the yearly extractable groundwater resource is projected to be 398.08 BCM. In 2022, the annual groundwater extraction was 239.16 BCM **(CGWB 2022).** Thus, with the extraction of 239 billion cubic meters groundwater per year, India stands as the largest groundwater extractor in the world. Nevertheless, over the last few decades, population explosion, changes in agricultural practices, food consumption patterns, lifestyle shifts, and alterations in land use patterns have placed simmering pressure on water resources. Albeit India is receiving sufficient rainwater during the monsoon season, only a small percentage of it contributes to water reserves due to a lack of storage capacity. Notably, rivers in India receive 80 per cent of their annual flow during the four months of the southwest monsoon season **(Kaul, 1999).**

WATER RESOURCES AVAILABILITY IN INDIA

The water resources availability in India is presented in table 2

Table 2
Water Resources Availability in India

Sl. No.	Items	Quantity
1	Annual Precipitation (including snowfall)	4000 BCM
2	Average Annual Availability	1869 BCM
3	A .Per Capita Availability (2001) in cubic metres B. Per Capita Availability (2011) in cubic metres C. Per Capita Availability (2015) in cubic metres	1816 Cu. M. 1545 Cu. M. 1474 Cu. M.
4	Estimated Utilisable Water Resources A. Surface Water Resources B. Ground Water Resources	1123 BCM 690 BCM 433 BCM

Source: Central Water Commission (2015)

India receives about 4000 billion cubic metre (BCM) of precipitation in a year, but 80−95% of this is received during three to four months of monsoon season. Spatial distribution of water is also highly uneven. Annually, arid and semi-arid regions of western India receive 300−500 mm rainfall, while humid regions of eastern India receive about 3000 mm rainfall (**Central Water Commission, India, 2023**).

With the current technological and infrastructural development, less than one-third of this precipitation can be utilized. Annual utilizable surface and ground water resources in the country are estimated to be 690 BCM and 431 BCM. With rapidly increasing urbanization and water demand, the per capita water availability in the country has declined by almost 20 per cent in the last two decades and is likely to decline by another 20 per cent by 2050, making India a water-scarce country (**https://pib.gov.in/PressReleasePage.aspx? PRID=1604871#).** Global warming and climate change are expected to further influence the water availability as well as its immense spatial variability in the country. Since the 1950s, the Indian Meteorological Department has reported a decline in annual rainfall in at least 14 states covering more than 50 per cent area of the country. Seasonally, monsoon rainfall is reported to be decreasing in more than 20 states, with maximum decline in Uttar Pradesh.

Groundwater is the main source of domestic water supply for rural and urban India as more than 80% of it is supply sourced through it, making the country the largest user of groundwater in the world (**https://www.worldbank.org, 2020**). The agriculture sector uses 89% of the groundwater for irrigation while 11% is used in the domestic and industrial sectors. This excessive extraction of groundwater has made almost 22% of assessed blocks as critical or overexploited. At the state level, Punjab, Haryana, Rajasthan, and Delhi are states where Stage of Groundwater Extraction is more than 100% and hence the groundwater is overexploited. Decadal Growth Rate has been assumed as 12 per cent and therefore population growth from 2011 to 2015 has been assumed as 4.8 per cent (**Central Ground Water Board, 2019-20**).

BASIN-WISE PER-CAPITA WATER RESOURCE AVAILABILITY

Water availability varies across regions, with some areas experiencing water scarcity while others have abundant resources. There is significant regional variation in water availability due to differences in rainfall patterns, geographical features, and hydrological factors. India boasts an extensive surface water network, including major rivers like the Ganges, Yamuna, Brahmaputra, and Godavari, among others. India divides its surface water into 22 basins. The Ganges, Indus, Godavari and Brahmaputra Basins cover more than half the country (**WRIS, 2020**). The Ganges and Brahmaputra Basins have headwaters in the Himalayas and is part of the trans-boundary Ganges-Brahmaputra-Meghna Basin which outlet through the Ganges Delta **(FAO, 2020)**

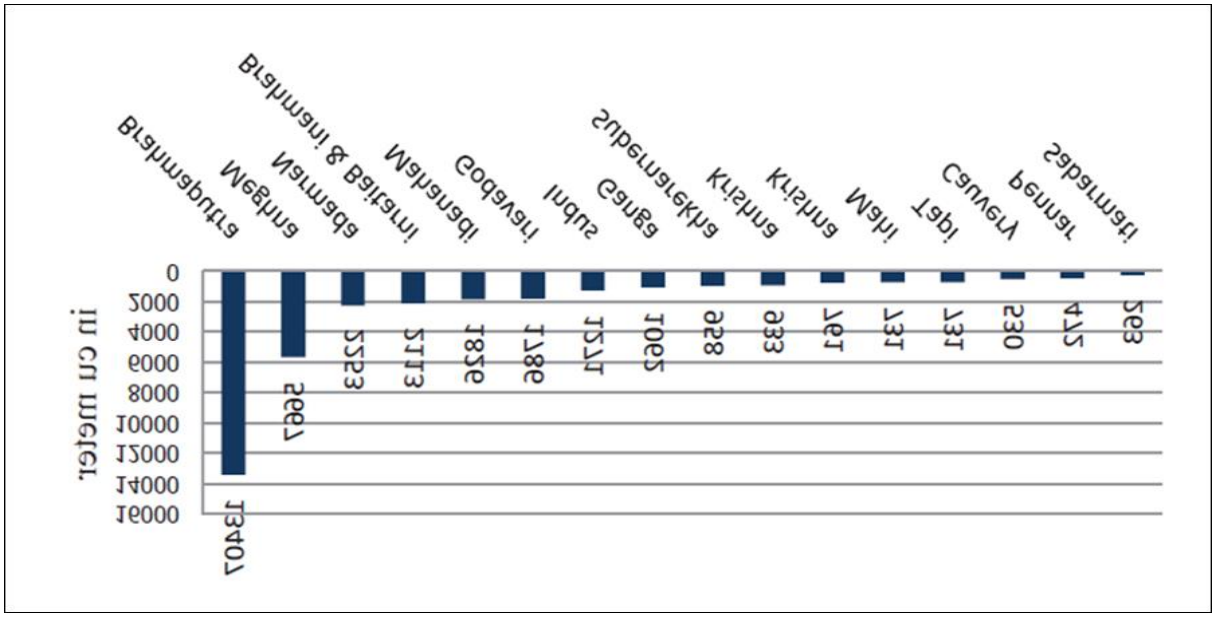
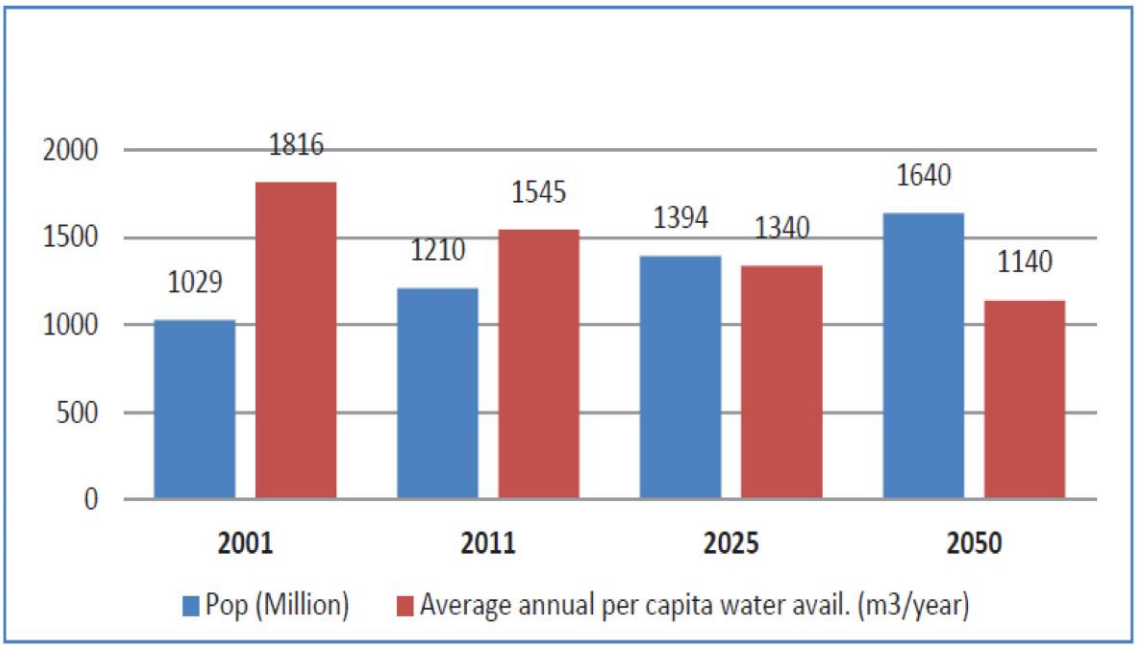


Fig.1 Basin-wise Annual per Capita Water Availability (in cubic meters)

The availability of water per person in India is declining over time. However, the availability of surface water varies across different regions and seasons. Some areas face water scarcity, especially during dry seasons, while others experience seasonal flooding. For instance, India's hydrological area can be divided into 19 major river basins. The per-capita water resource availability varies from a low of 263 m3 in the Sabarmati basin to a high of 13407 m3 in the Brahmaputra basin (Fig.1).

Thus, as per international standards, the per capita water availability in India is relatively low at around 1,545 cubic meters per person per year in 2011. This is expected to decrease further to 1340 m3 in 2025 and 1140 m3 2050 with rapidly increasing population growth and urbanization (Fig.2). In fact, over the last few decades, high population growth, changes in food consumption, lifestyle, and land use patterns have exerted tremendous pressure on our water resources. Although India receives ample rainfall during the monsoon season, only a small percentage of that water is actually stored due to a lack of storage capacity. There is a significant mismatch between the spatial distribution of available water and the population, the situation becomes alarming. Ironically, less water is available where more people live.



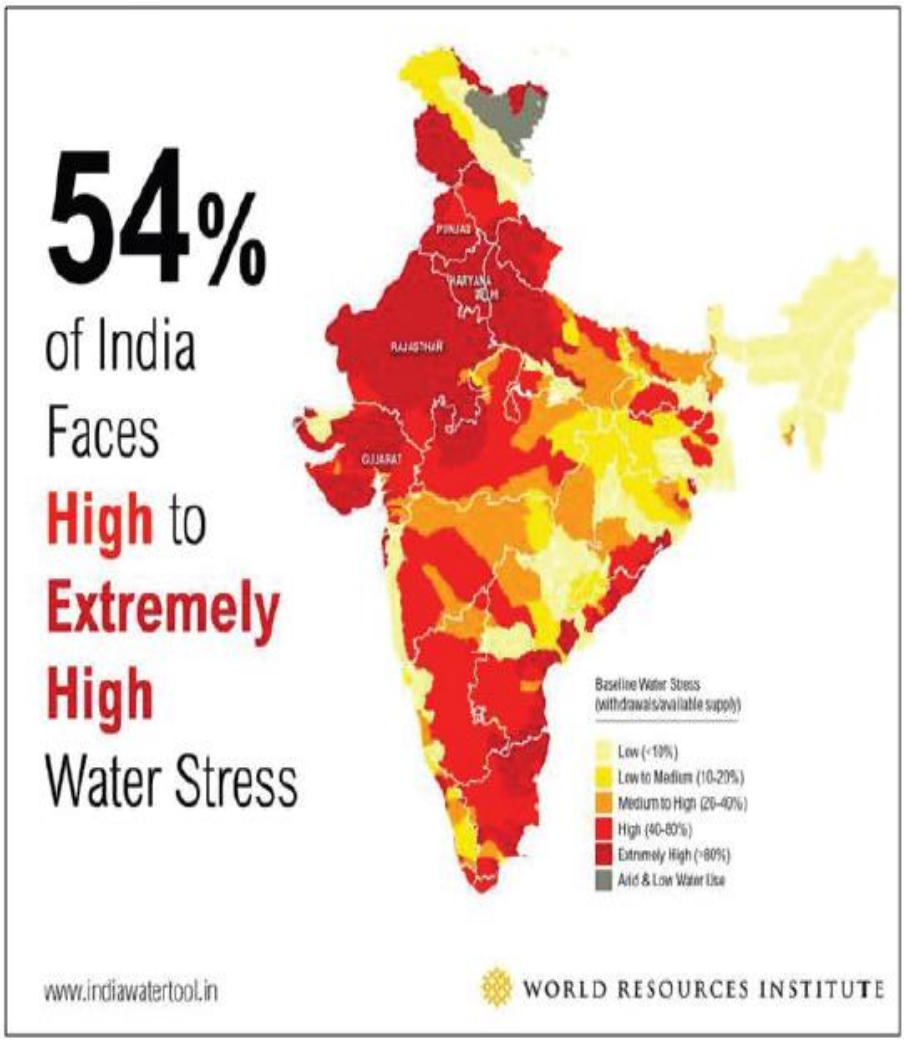
Source: PIB, 2nd March, 2020

Fig.2. Average Annual Per Capita Availability Trend of Water in India

WATER STRESS IN INDIA

Water Stress, refers to the lack of ability to meet human and ecological demand for fresh water (**CEO Water Mandate Secretariat, 2014**). It is a broader concept and is more inclusive. It considers not only the physical abundance of freshwater but also includes aspects of water availability, quality and accessibility to water which is a function of infrastructure and affordability. Moreover, it includes the requirement for environmental flows. Water stress is calculated as ratio of the total water withdrawal to the total available renewable supply. Environmental water stress is an indicator of the proportion of utilizable water in the world river basins being withdrawn for direct human use and where it conflicts with Environmental Water Requirement (EWR).

As per United Nations criteria, a region with an annual water supply of less than 1700 m3 per an individual is categorized as being under 'water stress'. When annual water supplies drop below 1,000 m3 per person, the population faces 'water scarcity', and below 500 cubic meters, it's considered 'absolute scarcity'. Looking at this standard in the Indian context, we find that in the year 1951, the per capita water availability was 5100 m3, which has decreased to 1816 m3 in 2001. India is one of the most water stressed countries in the world. Per capita annual freshwater availability (1,427 m3) is lower than the Falkenmarki threshold for water stress and 66 per cent of water resources are abstracted. Approximately 31 per cent of India’s water resources originate in neighbouring countries. Water is abundant in the lower reaches of the Ganges River Delta in the east but deficits are common in the northwest, west and south depending on timing and course of summer and winter monsoons. Poor management, high demand, and drought threaten groundwater availability in urban areas throughout India.



Source: World Water Resources Institute (2023)
Fig.3 Levels of Water Stress in India

Regarding groundwater resources, they have steadily emerged as the backbone of India's agricultural and drinking water security. Groundwater contributes nearly 62% to irrigation, 85% to rural water supply and 50 per cent to urban water supply. The situation is particularly worrying in India, where a significant mismatch exists between available water and the spatial distribution of the population. Surprisingly, regions and states in India with higher populations tend to have less accessible water (**Figure 3**). The number of rainy days varies from about 5 in Rajasthan to around 150 in north-eastern India (**Rao, 1976**). With 2.3 billion people residing in water-stressed countries (**UN-Water, 2021**) and 100 cities are facing the greatest rise in water risks by 2050 house 350 million people (**WWF, 2020).** As per the WWF Water Risk Filter which lists cities with overall water risk for the current and future, India dominates with 30 of 100 cities listed.

CONCLUSION

Water availability is a complex issue influenced by numerous interconnected factors. Understanding these factors and implementing appropriate management strategies is crucial for ensuring sustainable water resources for both human and ecological needs. Water is a renewable resource and all of Earth's

water is naturally recycled through the water cycle or hydrologic cycle. Water is dire essential for drinking, agriculture and industrial purposes. Water resources availability in India is seasonally and regionally variable, and is influenced by the intensity, timing, and duration of summer and winter monsoons. Owing to the uneven distribution of rainfall and high evaporation rates, the net available water resources for use are estimated to be around 1,123 BCM.

Poor management, high demand, and drought threaten groundwater availability in urban areas throughout India. The paper focused on stock of current water availability. The situation is particularly worrying in India, where a significant mismatch exists between available water and the spatial distribution of the population. Per capita water availability below 1,700 cubic meters is considered water-stressed, and below 1,000 cubic meters is considered water-scarce. India faces a complex water availability situation characterized by regional variations, increasing demand, and the impacts of climate change. Addressing these challenges requires a multi-thronged approach involving water resource management, demand-side management, and technological solutions

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