IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Water Economy In India: A Case Study Of Sustainable Management And Economic Valuation

Nitika

M.Sc student

GCW, GOHANA

Dept. of Geography

Abstract

The field of the "water economy"—which focuses on the complex economic assessment of water resources—has become a crucial area of academic and applied research. This field goes beyond only acknowledging the inherent importance of water and explores how much it contributes economically to a variety of industries, including energy generation, industry, and agriculture. It carefully looks at the processes that control the distribution of water, evaluating the effectiveness of current pricing schemes and investigating substitute financial tools that encourage effective distribution. Additionally, it examines the legal frameworks intended to guarantee the sustainable use of this essential resource, recognizing the necessity of strong governance systems that strike a balance between conflicting demands and safeguard long-term availability. Water management must alter to meet the growing global water shortage, which is caused by a combination of causes such as unsustainable farming practices, inefficient consumption habits, and the worsening effects of climate change. This calls for a thorough and planned strategy that goes beyond disjointed and reactive reactions to proactive and integrated solutions. Given that this essential resource is essential to sustaining ecological health, economic growth, and human well-being, it is necessary that it be distributed fairly and allocated effectively. This study does a thorough investigation of the various facets of the water economy. It explores the complex economic value of water, not only as a commodity but also as a vital component of many economic endeavour and a supplier of vital ecological services. By highlighting the necessity of a comprehensive and inclusive approach that takes into account the inter-dependencies of water resources and the various demands of stakeholders, it clarifies the fundamentals of integrated water resource management, or IWRM. Additionally, it thoroughly examines the complex effects of water scarcity on a range of industrial sectors, including the possibility of higher operating costs, supply chain vulnerabilities, and production disruptions. In order to solve these issues and guarantee water security for both the current and future generations, it simultaneously develops and suggests workable, long-term solutions that include behavioral adjustments, legislative changes, and technology advancements. This entails supporting water conservation through intelligent technology and education, as well as circular water economies.

Keywords: Water economy, sustainable management, Economic valuation.

1.Introduction

The worldwide need to ensure sustainable water supplies demands a thorough analysis of the water economy, a field that incorporates economic, social, and environmental factors into the management of this limited and vital resource (Gleick, 2018). Water is strategically important because it is essential to life and economic activity, including food production, energy production, industrial processes, and human consumption. But increasing water scarcity, which is made worse by unsustainable consumption habits, widespread pollution, and the worsening effects of climate change, is a serious threat to world peace and prosperity. Deficits in water governance and the presence of ineffective pricing mechanisms, which worsen waste and lead to unequal access, compound these difficulties (Biswas, 2008). Understanding water as a precious and limited resource requires a paradigm change from conventional, disjointed methods to an all-encompassing, integrated framework (UNESCO, 2019). The objective of this analysis is to ascertain the economic worth of water, analyze the intricacies of its pricing systems, assess the difficulties in water governance, and suggest long-term solutions that guarantee resource viability and encourage fair access. In order to support the development of a resilient and sustainable water economy, this study uses a strong analytical framework to guide policymaking and encourage prudent water management.

2. Objectives

1.To analyse the economic value of water and promote sustainable management
2. To examine water scarcity, its impacts and climate adaptation strategies.
3. To analyse India's water resources basin wise, year wise and industry wise.

3. Methodology

This paper is based on secondary sources. To make this paper, help has been taken from different newspapers, websites, research papers, books etc. In preparing this research paper, an attempt has been made to understand water economy in a different and simple way by deeply studying many report, research papers, books, etc.

4.The Economic Value of Water

Water has a variety of economic uses. It entails measuring the contribution of water to business (energy, manufacturing), agriculture (crop yields), and household use (public health). Importantly, it encompasses environmental services like climate regulation and biodiversity. Sustainable development, effective allocation, and well-informed water management all depend on a thorough economic cost analysis that takes supply, opportunity, and externality costs into account.

4.1 Water as an Economic Good

The traditional paradigm of water as a freely available and limitless resource has been superseded by a more sophisticated economic perspective (Young & Loomis, 2014). Contemporary economic theory acknowledges water as a scarce and intrinsically valuable commodity, displaying hybrid characteristics of both a public and private good, determined by its source and utilization. While market-driven approaches advocate for the implementation of rational water pricing strategies to promote resource conservation, curtail wastage, and facilitate equitable allocation, the fundamental importance of water as a requisite for human existence and societal stability necessitates governmental intervention. This often manifests in regulatory frameworks governing water distribution and the provision of targeted subsidies to ensure accessibility for marginalized populations, thereby mitigating potential market inefficiencies and upholding principles of social equity.

4.2 Water Pricing Mechanisms

Pricing water strategically is crucial for controlling demand and making effective use of available resources. Models can be market-based (adapting to supply and demand) or cost-based (covering supply costs). Tariffs and subsidies guarantee affordability, but they need to be properly crafted to avoid abuse. Effective implementations show notable improvements in water conservation and efficiency, such as those in Singapore and Denmark. This emphasizes the necessity of data-driven, sophisticated pricing methods that strike a balance between social, economic, and environmental objectives (Global Water Intelligence, 2020).

4.3 Water Scarcity and Economic Implications

A thorough examination of the complex effects of water scarcity is necessary due to its widespread influence on international economic systems, especially in the vital sectors of industry and agriculture. Agriculture is particularly vulnerable to insufficient water supplies because of its high freshwater resource demand. Reduced crop yields, increased food insecurity, and inflationary pressures in global commodity markets are all consequences of this shortage (FAO, 2017). At the same time, industrial activities in a variety of industries, such as manufacturing, energy, and textiles, which are inherently dependent on water for production processes, are vulnerable to downtime, increased operating costs, and a resulting decline in economic output. Furthermore, there are serious systemic economic concerns associated with the escalating impacts of anthropogenic climate change, which are causing extreme hydrological events like droughts and floods to occur more frequently and with greater intensity. These occurrences cause significant harm to vital infrastructure, interfere with complex supply chain systems, and clearly slow GDP growth in the impacted areas. In order to reduce these economic vulnerabilities and guarantee long-term economic stability and resilience in the face of changing environmental problems, it is crucial to develop and implement strong, sustainable, and adaptable water management plans.

5. India's scenario

The water economy in India is struggling. While climate change affects the supply of water, growing populations and industrialization create unsustainable demand. Scarcity is made worse by ineffective management, which includes losses and infrastructural problems. Fragmented governance makes it more difficult to implement policies effectively. The productivity of agriculture, industrial output, and ecological health are all at risk due to this problem. India has a 4% of the world's freshwater resources but supports 18% of the global population (NITI Aayog, 2018; World Bank, 2020). Urbanization, industries, and agriculture demands are driving up water consumption. Depletion results from one of the highest rates of groundwater exploitation in world. Over 600 million people face to extreme water stress(NITI Aayog 2018).

5.1 Availability of water in India

Table No. 1.1: water resources of India

Sr. No	Criterion	Unit in BCM
1	Subsurface water	436
2	Superficial water	690
3	Potable water	1126
4	Yearly water availability	1869

Source: Central water commission (CWC,2015)

The provided data outlines India's annual water resource distribution. The total annual water availability is quantified at 1869 billion cubic meters. However, the volume of technically and economically usable water is significantly lower, at 1126 billion cubic meters. This usable portion is further disaggregated into surface water resources, accounting for 690 billion cubic meters, and groundwater resources, contributing 436 billion cubic meters. This breakdown underscores the nation's reliance on both surface and subsurface water sources, while also highlighting the substantial disparity between total water availability and the fraction that is readily accessible for utilization.

Table No. 1.2 Basin wise yearly per capita water availability in cubic meters

Basin	Yearly per capita water in cubic meters
Brahmputra	13407
Meghna	5667
Narmada	2253
Brahmani & Baitarni	2113
Mahanadi	1826
Godavari	1786
Indus	1217
Ganga	1062
Subernarekha	958
Krishna	933
Mahi	731
Tapi	731
Kaveri	530
Pennar	472
Sabarmati	263

Source: Central water commission (CWC,2015)

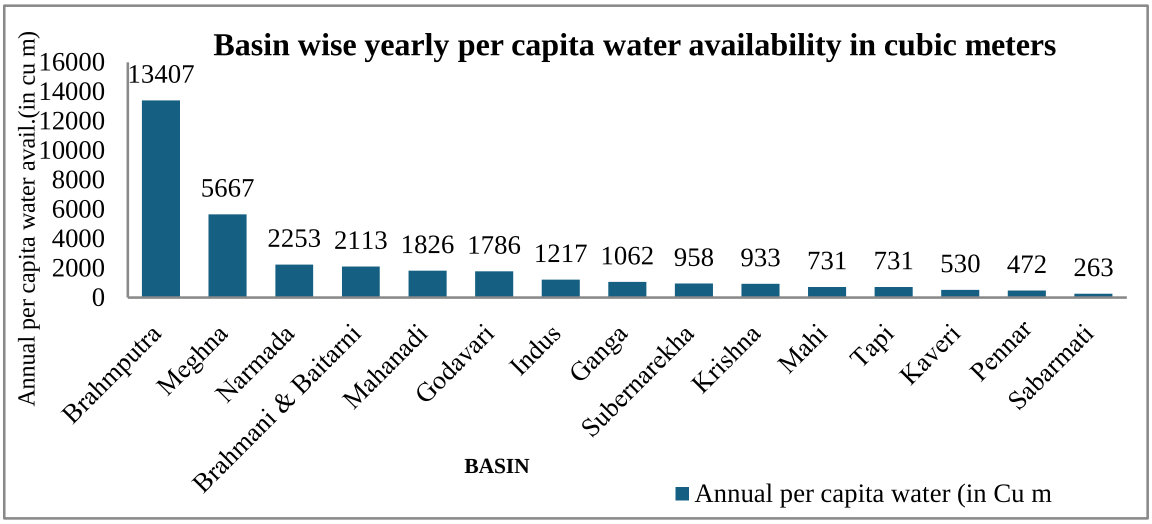
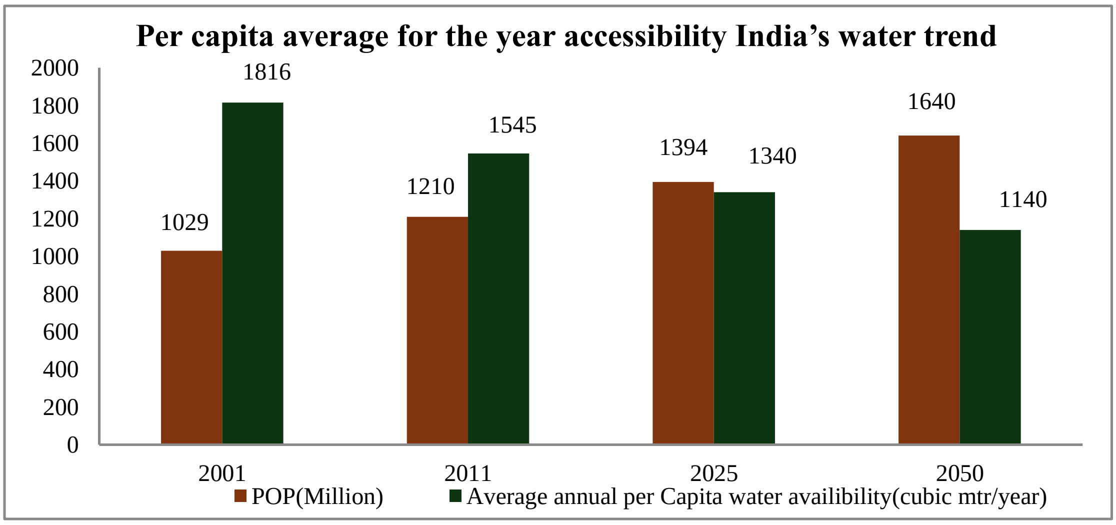


Table 2 presents a critical overview of India's basin-wise annual per capita water availability, measured in cubic meters (cu m), revealing significant regional disparities. The Brahmaputra basin exhibits the highest availability at 13,407 cu m, followed by the Meghna basin at 5,667 cu m, primarily due to high rainfall and lower population density. Basins like Narmada, Brahmani & Baitarni, Mahanadi, and Godavari also demonstrate relatively higher per capita availability, ranging from 1,786 to 2,253 cu m. Conversely, basins such as Sabarmati (263 cu m), Pennar (472 cu m), Kaveri (530 cu m), Tapi (731 cu m), and Mahi (731 cu m) face acute water stress, reflecting higher population densities and lower rainfall. The Indus and Ganga basins, vital for agriculture and densely populated, show moderate availability at 1,217 cu m and 1,062 cu m, respectively. This data underscores the uneven distribution of water resources across India, highlighting the urgent need for efficient water management strategies, inter-basin transfers, and sustainable water usage practices to mitigate regional water scarcity and ensure equitable access.

Table 1.3: Per Capita Average For The Year Accessibility India's Water Trend

Year	Population (M)	Average yearly per Capita water availability(cubic mtr./year)
2001	1029	1816
2011	1210	1545
2025	1394	1340
2050	1640	1140

Source: Press Information Bureau (PIB), 2 mar 2020

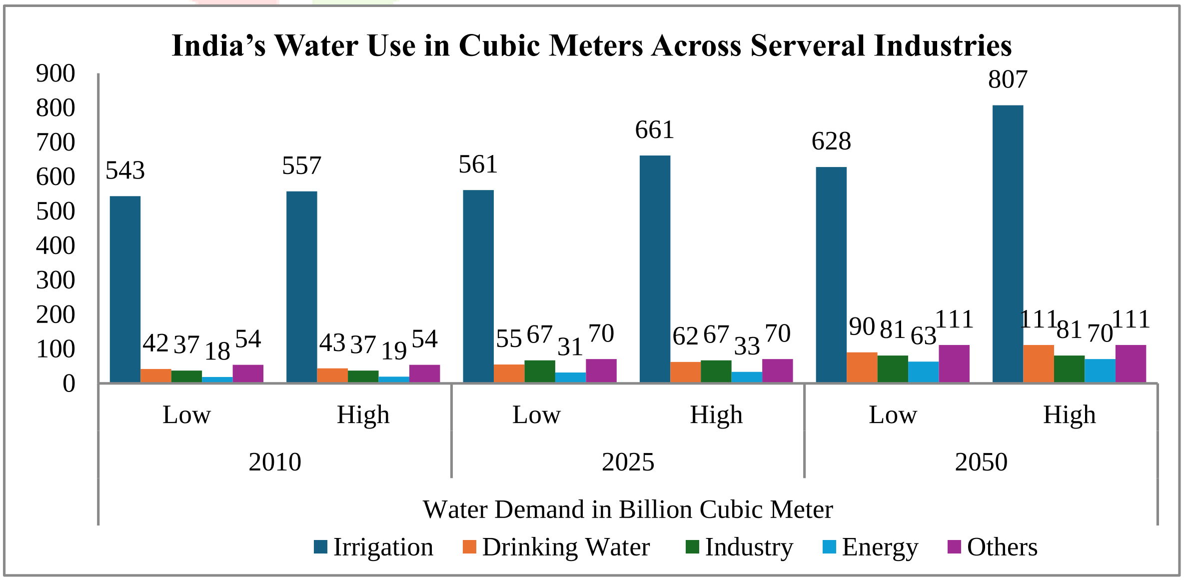


The provided data presents a compelling narrative of escalating water resource scarcity in India, directly correlated with burgeoning population growth. In 2001, a population of 1.029 billion individuals corresponded with an average annual per capita water availability of 1,816 cubic meters. A decade later, in 2011, the population increased to 1.210 billion, resulting in a reduction of per capita water availability to 1,545 cubic meters. Projected figures indicate a continued decline: by 2025, with a population of 1.394 billion, per capita availability is anticipated to reach 1,340 cubic meters, and by 2050, with a projected population of 1.640 billion, this figure is expected to further decrease to 1,140 cubic meters. This trend underscores the critical imperative for strategic water resource management, encompassing enhanced irrigation efficiency, robust conservation policies, and sustainable utilization practices. The diminishing per capita water availability poses significant systemic risks to agricultural productivity, industrial output, and domestic water security, necessitating immediate and comprehensive policy interventions to mitigate future water stress.

Table no. 1.4: India's Water Use in Cubic Meters Across Serveral Industries

SECTOR	Demand of Water in BCM					
	2010(Past)		2025(Present)		2050(Future)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Irrigation	543	557	561	661	628	807
Drinking Water	42	43	55	62	90	111
Industry	37	37	67	67	81	81
Energy	18	19	31	33	63	70
Others	54	54	70	70	111	111

Source: Basin planning director, (CWC 9th plan document)



This analysis examines projected water demand in India, presented in billion cubic meters (BCM), across key sectors for the years 2010, 2025, and 2050. The data incorporates both low and high demand scenarios to reflect inherent uncertainties in long-term forecasting.

Irrigation, constituting the largest segment, exhibited a demand of 543-557 BCM in 2010. Projections indicate a progressive increase, reaching 561-661 BCM by 2025 and 628-807 BCM by 2050. This trajectory underscores the critical nexus between agricultural productivity and water resource management, highlighting the potential impacts of evolving irrigation technologies and agricultural policies. The range between low and high projections demonstrates the sensitivity of irrigation demand to variables such as water efficiency and shifts in crop patterns.

Domestic water consumption, encompassing drinking water, is projected to rise from 42-43 BCM in 2010 to 55-62 BCM by 2025 and 90-111 BCM by 2050. This growth correlates with demographic expansion, urbanization, and improvements in living standards, emphasizing the need for robust urban water infrastructure and efficient distribution systems.

Industrial water demand is anticipated to experience a significant increase, from 37 BCM in 2010 to 67 BCM by 2025 and 81 BCM by 2050. The consistent values between low and high scenarios suggest a relatively high degree of confidence in these projections, reflecting the predictable water requirements of industrial processes. This growth necessitates the implementation of water-efficient technologies and closed-loop systems within industrial facilities.

Energy sector water demand, primarily for thermal power plant cooling, is projected to increase from 18-19 BCM in 2010 to 31-33 BCM by 2025 and 63-70 BCM by 2050. This trajectory is driven by the escalating demand for electricity and the continued reliance on thermal power generation. The implementation of advanced cooling technologies and the diversification of energy sources are crucial for mitigating the water footprint of the energy sector.

The "Others" category, likely encompassing livestock and environmental water needs, demonstrates a consistent growth pattern, rising from 54 BCM in 2010 to 70 BCM by 2025 and 111 BCM by 2050. The consistency between low and high demand values indicates a higher degree of certainty in the estimation of this category.

In summary, the data reveals a substantial increase in India's aggregate water demand, rising from 694-710 BCM in 2010 to 784-843 BCM by 2025 and 973-1180 BCM by 2050. The significant divergence between the low and high demand scenarios in 2050 underscores the critical importance of proactive water resource management strategies to ensure long-term water security and mitigate the potential for water stress. This analysis highlights the need for integrated water resource planning, technological innovation, and policy interventions to address the escalating water demands across all sectors.

6. Resource Management

A comprehensive strategy is necessary for effective water resource management, giving sustainable distribution and economical utilization first priority. Engagement of stakeholders and adherence to the principles of Integrated Water Resources Management (IWRM) are essential. It is crucial to encourage conservation through technology and conscientious consumption, in addition to strict restrictions and open government. Resilient infrastructure, such as sophisticated monitoring and storage, helps to lessen the effects of climate change. Water quality is protected when pollution is reduced by stringent laws and treatment methods. Long-term resilience is guaranteed by proactive climate adaptation, which includes flood and drought control.

6.1 Integrated Water Resource Management (IWRM)

The need to balance water supply and demand has spurred the broad use of Integrated Water Resources Management (IWRM), a strategic framework that integrates social, economic, and environmental factors to maximize sustainable water use (GWP, 2000). The effectiveness of IWRM is based on the complementary ideas of inclusive stakeholder involvement, cross-sectoral cooperation, and the successful integration of water management policies into larger developmental frameworks. Interestingly, the Netherlands is a prime example of IWRM implementation done right, showcasing its ability to control water distribution, reduce flood risks, and guarantee the sustainability of water resources over the long term(OECD, 2021).

6.2 Water Conservation and Efficiency Measures

For the development of strong water conservation paradigms, technical innovation must be applied strategically (Gleick, 2003).. By treating salty water, desalination plants—which are especially important in water-limited areas like the Middle East—allow for the expansion of drinkable freshwater supplies and reduce dependency on traditional, limited supplies? Similarly, the construction of sustainable water resource management methods is greatly aided by the application of rainwater gathering and wastewater reclamation techniques. The implementation of advanced leak detection technologies and smart metering systems in urban environments maximizes the effectiveness of water distribution and encourages conscientious consumption practices. Additionally, encouraging the use of water-efficient appliances and precision irrigation methods through government laws is crucial to developing a water-stewardship culture and optimizing the effectiveness of conservation measures.

6.3 Water Governance and Policy Frameworks

The establishment of a resilient and equitable water governance framework necessitates the promulgation of transparent and enforceable policies, the development of robust regulatory mechanisms, and the cultivation of well-defined institutional architectures designed to optimize water resource allocation and utilization. International initiatives, notably the **United Nations' Sustainable Development Goal 6**, articulate the global imperative to secure universal access to potable water and sanitation. At the national level, a spectrum of countries has implemented comprehensive water management strategies, exemplified by **India's National Water Policy** and **South Africa's Water Act**, which serve to regulate water distribution, quality assurance, and conservation practices (Government of India, 2012). However, the inherent complexities associated with the management of transboundary water resources, as exemplified by the ongoing geopolitical dynamics surrounding the **Nile River**, underscore the persistent challenges in achieving collaborative and equitable governance within shared hydrological systems.

7. Challenges and Future Perspectives:

7.1 Climate Change and Water Security

The rising effects of anthropogenic climate change are the biggest and most pressing threat to global water security. High ambient temperatures cause a marked increase in evaporation, which in turn causes a measurable decrease in the amount of freshwater that is accessible. At the same time, the increased occurrence and severity of extreme weather events, such as but not limited to devastating floods, protracted droughts, and cyclonic storms, cause major disruptions to vital water supply infrastructure, cause major damage to vital infrastructure, and seriously jeopardize agricultural productivity and food security.

7.2 Economic and Political Challenges

High water losses and restricted access are caused by corruption, ineffective management, and deficiencies in water infrastructure in many developing countries (Biswas, 2008). Some countries' privatization of water utilities has resulted in affordability problems, which have sparked disputes and protests. Additionally, as seen by the Israel-Palestine water conflict and the Grand Ethiopian Renaissance Dam (GERD) dispute between Ethiopia, Sudan, and Egypt, geopolitical issues over shared water resources lead to tensions between nations.

7.3 Innovations in Water Management

The integration of cutting-edge technological advancements is fundamentally reshaping the landscape of contemporary water resource management. Specifically, the deployment of artificial intelligence (AI) and big data analytics facilitates the precise modeling and forecasting of water demand fluctuations, optimizes the efficiency of water distribution networks, and enables the real-time detection and mitigation of infrastructure vulnerabilities, such as leaks. Concurrently, the potential application of blockchain technology is being rigorously investigated to enhance transparency and accountability in water governance, as well as to establish secure and auditable platforms for the exchange of water rights. In parallel, a strategic emphasis is being placed on the implementation of nature-based solutions. National governments and international organizations are increasingly allocating resources to watershed conservation and wetland restoration initiatives, recognizing their pivotal role in augmenting natural water filtration processes and fortifying ecosystem resilience, thereby contributing to the development of robust and sustainable water management strategies.

8. Conclusion and Recommendations

A fundamental tenet of global sustainability, the water economy has a significant impact on public health, food security, and economic stability. Developing effective and transparent governance structures, establishing fair pricing systems that represent the true cost of water, and putting strong valuation procedures into practice are all necessary for the prudent management of this limited resource. As the stewards of public resources, governments must implement integrated and comprehensive water management plans that cut across sectoral boundaries and promote a holistic approach to the distribution and use of water resources. In addition, consistent investment in contemporary water infrastructure—which includes sophisticated treatment plants, effective distribution systems, and intelligent metering systems—is essential for reducing water loss and maximizing resource use. At the same time, it is essential to promote conservation technology like rainwater collecting projects, water-efficient appliances, and precision irrigation systems in order to foster a culture of water stewardship and lower overall usage. International collaboration is crucial for resolving possible conflicts and guaranteeing the fair distribution of water among riparian governments because many water resources are transboundary. In order to promote peaceful and sustainable water governance, it is imperative that shared water management frameworks be developed collaboratively, that strong conflict resolution procedures be established, and that open lines of communication be fostered. Future research initiatives should focus on creating creative financing models that encourage sustainable water management techniques, creating climate adaptation plans that improve water resilience against growing environmental stresses, and creating legislative frameworks that successfully strike a balance between the need for long-term water sustainability and economic growth goals. Research should specifically examine how impact investing, green bonds, and public-private partnerships may be used to raise money for water infrastructure projects. It should also look into the creation of predictive modeling tools that can help guide decisions on climate-resilient water management. Furthermore, exploring policy tools that support water demand management—like incentive-based laws and water trading schemes is essential to striking a long-term balance between supply and demand. India has a 4% of the world's freshwater resources but supports 18% of the global population (NITI Aayog, 2018; World Bank, 2020). Urbanization, industries, and agriculture demands are driving up water consumption. Depletion results from one of the highest rates of groundwater exploitation in world. Over 600 million people face to extreme water stress(NITI Aayog 2018). The Brahmaputra basin exhibits the highest availability at 13,407 cu m, followed by the Meghna basin at 5,667 cu m, primarily due to high rainfall and lower population density. Irrigation, constituting the largest segment, exhibited a demand of 543-557 BCM in 2010. Projections indicate a progressive increase, reaching 561-661 BCM by 2025 and 628-807 BCM by 2050. Domestic water consumption, encompassing drinking water, is projected to rise from 42-43 BCM in 2010 to 55-62 BCM by 2025 and 90-111 BCM by 2050. Industrial water demand is anticipated to experience a significant increase, from 37 BCM in 2010 to 67 BCM by 2025 and 81 BCM by 2050. Energy sector water demand, primarily for thermal power plant cooling, is projected to increase from 18-19 BCM in 2010 to 31-33 BCM by 2025 and 63-70 BCM by 2050. The diminishing per capita water availability poses significant systemic risks to agricultural productivity, industrial output, and domestic water security, necessitating immediate and comprehensive policy interventions to mitigate future water stress.

9. References

1. Biswas, A. K. (2008). Integrated water resources management: Is it working? International Journal of Water Resources Development, 24(1), 5-22.
2. Food and Agriculture Organization of the United Nations. (2017). the future of food and agriculture: Trends and challenges. FAO.
3. Gleick, P. H. (2003). Water use. Annual Review of Environment and Resources, 28(1), 275-314.
4. Gleick, P. H. (2018). The world's water volume 9: The biennial report on freshwater resources. Island Press.
5. Global Water Intelligence. (2020). Global water market 2020: Meeting the world's water and wastewater needs until 2020. Media Analytics Ltd.
6. Global Water Partnership. (2000). Integrated water resources management. TAC Background Papers, No. 4.
7. Molden, D. (Ed.). (2007). Water for food, water for life: A comprehensive assessment of water management in agriculture. Earth scan and International Water Management Institute.
8. Organisation for Economic Co-operation and Development. (2021). Measuring progress in agricultural water management. OECD Publishing.
9. Rogers, P., de Silva, R., & Bhatia, R. (2002). Water is an economic good: How to use prices to promote equity, efficiency, and sustainability. Water Policy, 4(1), 1-17.
10. United Nations Educational, Scientific and Cultural Organization. (2020). UNESCO Science Report: The race against time for smarter development. UNESCO Publishing.
11. United Nations Educational, Scientific and Cultural Organization. (2019). UNESCO Science Report: Towards 2030. UNESCO Publishing.
12. UN-Water. (2021). Summary Progress Update 2021: SDG 6—water and sanitation for all. United Nations.
13. Young, R. A., & Loomis, J. B. (2014). Determining the economic value of water: Concepts and methods (2nd ed.). RFF Press.