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1 Introduction

The Sustainable Development Goals (SDGs), were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. 17 interlinked objectives were defined and designed to serve as a "shared blueprint for peace and prosperity for people and the planet." The SDGs emphasize the interconnected environmental, social and economic aspects of sustainable development by putting sustainability at their center. [1].

NITI Aayog, the Government of India's premier think tank, has been entrusted with the task of coordinating the SDGs, mapping schemes related to the SDGs and their targets, and identifying lead and supporting ministries for each target. In addition, the Ministry of Statistics and Programme Implementation (MoSPI) has been leading discussions for developing national indicators for the SDGs. State governments are key to India's progress on the SDGs as they are best placed to 'put people first' and to ensuring that 'no one is left behind.' [2]

Water and sanitation are at the core of sustainable development. SDG 6 provides the blueprint for ensuring availability and sustainable management of water and sanitation for all.

India ranks 112th of 166 countries on the SDG index rank [3] with a score of 63.5. Limited progress has been made on the overall SDG targets in India. However, SDG 6 for India indicates that the population using at least basic drinking water services¹ (90%) shows moderate improvement with "some challenges remaining."

The health burden of poor water quality is enormous. It is estimated that around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are estimated to die of diarrhea and 73 million working days are lost due to waterborne disease each year. The resulting economic burden is estimated at \$600 million a year [4].

The major challenges around water security in India revolve around availability, accessibility and quality of water resources. A survey by India water portal revealed that as high as 48.6 percent rural households and 28 percent urban households survive without access to an improved source (devoid of contamination/safe) of drinking water throughout the year [5].

A survey by a prominent community social media platform called "local circles." which included over 22,000 responses from households located across 311 districts of India says that Only 2% Indian households get drinkable quality water from their local body and 65% are using some kind of modern filtration mechanism.

¹ The percentage of the population using at least a basic drinking water service, such as drinking water from an improved source, provided that the collection time is not more than 30 minutes for a round trip, including queuing.

2 Water Shortage in India

Water security refers in particular to the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies [6]. Ensuring water security, vital for people wellbeing, agriculture, energy and other sectors, is therefore one of the major challenges of the 21st Century for the scientific community, society, and policy.

Water security in India faces several issues and challenges that threaten the sustainability and development of the country. These include over-extraction of groundwater, water pollution, inadequate distribution, lack of proper water management, climate change, and conflicts over water. India relies heavily on groundwater, which is being depleted at an alarming rate due to over-extraction for irrigation, industrial, and domestic use. The increasing industrialization and urbanization have led to widespread water pollution, contaminating rivers and groundwater, and making it unsafe for consumption [7].

India is suffering from one of the worst water crises in its history and millions of lives and livelihoods are under threat. Currently, 600 million Indians face high to extreme water stress and about two lakh people die every year due to inadequate access to safe water [8]. Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, and Madhya Pradesh are the worst affected States so far. In Karnataka, 138 out of 176 taluks have very low groundwater levels and the government has declared over 3000 regions as severely affected by drinking water shortage [9].

63 percent of India's districts are threatened by falling groundwater levels. In many cases, this water is becoming contaminated. Worryingly, poverty rates are 9-10 percent higher in districts where groundwater tables have fallen below 8 meters, leaving small farmers particularly vulnerable [10].

Nearly 70 percent [11] of India's water is contaminated, impacting three in four people. This leads to a high disease burden with like of four major water borne diseases — cholera, acute diarrhea, typhoid, and viral hepatitis. In fact, some estimates determine that the health costs to treat waterborne diseases are almost \$9 billion per year [12].

Most states have achieved less than 50% of the total score in the augmentation of groundwater resources, highlighting the growing national crisis—54% of India's groundwater wells are declining [13].

In India, drinking water comes under the control of the State and Union Territories (S&UTs). S&UTs get schematic and financial support from the Central Ministry of Drinking Water and Sanitation (now called the Ministry of Jal Shakti). The Government of India has launched several schemes that are being implemented by the S&UTs to enhance the quality of drinking water, such as the Jal Jeevan Mission (to provide piped water to all rural households)

3 Integrated solutions to balance water resources -

Water being a state subject, steps for augmentation, conservation and efficient management of water resources are primarily undertaken by the respective State Governments. The recently released NFHS-5 (2019-2020) data also shows that while access to drinking water from improved sources has increased in the 22 states surveyed as compared to NFHS (2015-2016), rural areas continue to lag behind as compared to urban in terms of access to safe drinking water. In order to supplement the efforts of the State Governments, Central Government provides technical and financial assistance to them through various schemes and programmes. Government of India, in partnership with States, is implementing Jal Jeevan Mission (JJM)-Har Ghar Jal which aims at providing potable water in adequate quantity of prescribed quality on regular and long-term basis to every rural household through tap water connection by 2024. [14]

The major challenges for Goal 6 include issues of water scarcity, access to safe drinking water, sanitation, water quality, flood risks, and transboundary water. In order to achieve Goal 6 and monitoring the targets, a comprehensive assessment of global water resources considering multiple challenges in an integrated manner is required.

First, we should emphasize whether enough water resources are available or not. Second, we need to focus whether available water resources are accessible or affordable to society and ecosystem. Third, we need to consider whether available and accessible water is of good quality [15].

3.1 Measures to increase the availability of water:

To increase water availability, we need to improve agricultural water productivity, irrigation efficiency, and domestic and industrial water-use intensity, increase water storage in reservoirs and, increase the use of desalination technologies [16].

Stemming groundwater depletion: Groundwater is one of the most important sources for irrigation as well as domestic water supply. It is the most reliable source of drinking water for nearly 43 percent of the rural population in the country [17]. However, overexploitation has led to its depletion and state governments will be required incentivize farmers to reduce groundwater usage through cash benefits and subsidies. A pilot of such a scheme was launched in Punjab and resulted in water savings of between 6 and 25 percent without any adverse effect on the yield [18]. Promoting and adopting water-saving technologies like drip irrigation, micro-irrigation, and water-efficient appliances can also significantly reduce water consumption and improve productivity. Existing schemes like the Mukhya Mantri Jal Swavlamban Abhiyan' launched in Rajasthan can be replicated across states to ensure water conservation and harvesting.

Rainwater Harvesting and Storage Infrastructure: Large scale implementation of rainwater harvesting systems in urban and rural areas can be achieved through incentivizing the construction of structures on rooftops, public buildings, and open areas. The state governments should look to

provide subsidies for the installation of rainwater storage tanks, particularly in rural areas with high possibilities of rainwater harvesting. Further, the central government should increase the investment in promoting nationwide campaigns, like “Jal Shakti Abhiyan: Catch the Rain” that promote the conservation of rainwater.

Green water filtration corridors: Phytoremediation is the engineered use of green plants to remove, contain, stabilize or destroy contaminants in the soil and groundwater. The uptake of groundwater by the plants can achieve containment of the groundwater and contamination [19]. Given the low-cost of phytoremediation compared to conventional technology and sustainability associated with plants, phytoremediation can be a reliable solution for a sustainable and economical remediation of soil and water from the organic and inorganic pollutants. This is also a viable and practical solution for India, given that many native varieties of plant species can be used in building such projects like Indian gooseberry, Jamuna, water hyacinth etc [20].

Solar powered water desalination units: India is surrounded by sea water on three sides, which is a huge geographic advantage for the country. Central government should invest in setting up desalination plants at strategic points in and around the country and promote the use of such installations at public places such as seaports, beaches, etc. Such schemes have already been successfully implemented in island countries like Haiti [21], and other water adjacent countries like Saudi Arabia [22].

Adaptive and flexible governance models: Institute an independent agency to allocate water sources across various competing uses and state governments in every river basin.

3.2 Measures to improve the accessibility of water:

We need to promote the treatment of home water, improvement of hygiene behaviors, increase the use of affordable, effective and environmentally friendly of drinking water and sanitation.

Water ATMs: Implement a network of water ATMs across urban areas. These ATMs would dispense clean drinking water at a nominal cost, making it affordable for all socio-economic groups. Subsidies could be provided to ensure affordability for marginalized communities. These units are currently placed in and around public places in urban cities and larger railway stations. A program with large scale implementation in rural areas and remote places is required by state governments in conjunction with NGOs and the private sector. Proper network planning and organization of the machines can help increase the scope and generate greater impact for the program.

Emergency Mobile Water Purification Units: Disaster Management Units in each state should create response teams equipped with mobile water purification units that can be deployed to areas with limited access to clean water in case of emergencies.

Piped water systems: Improve efforts of the HarGharJal Mission to providing potable water to every rural household by 2024. Currently, 68% of households have tap water connections as of September 2023 [23].

3.3 Measures to enhance the quality of water:

Online Portal: Central government can create a portal to that would allow citizens to report water quality issues and track the resolution process. Simultaneously, the state government would then collaborate with local health authorities to ensure regular testing of water sources.

Information Management: Guidelines should be implemented, to standardize a holistic list of indicators and frequency of reporting, that assess the progress on safely managed drinking water services. Mechanisms that collect and share information between state and center and amongst state should be implemented at a Central level. This can be done by scaling up the progress made by India's Jal Jeevan Mission.

Investment in technology: To encourage water quality testing to ensure potable drinking water supply, States/UTs have been advised to open water quality testing laboratories to general public at a nominal rate for testing of their water samples. Further, usage of smart sensors to monitor water quality and usage in real-time can detect changes in water quality, identify leaks, and provide data to help improve water management and conservation. Experiences from other Asian and African countries can guide the way.

4 Collaborative Water Management Strategies

It is evident water management requires collective effort and collaborative water management strategies that engage a spectrum of stakeholders, from government bodies to non-governmental organizations (NGOs), private entities, and communities. The objective is not merely to address the immediate water shortage crisis but to lay down the foundations for a sustainable and equitable water future for the nation.

NGOs play a pivotal role in bridging the gap between government initiatives and grassroots action.

NGOs have a deep understanding of local communities and can effectively raise awareness, conduct outreach, and implement water conservation and education programs. The government should actively collaborate with and support NGOs in water conservation and education efforts. This can include providing funding, technical assistance, and resources for community-based projects.

Substantial financial resources must be allocated to water management efforts. A comprehensive evaluation of current water project funding is essential to identify gaps and prioritize areas in need of increased investment.

Public-Private Partnerships (PPPs) represent a potent avenue for leveraging private sector expertise and resources in the pursuit of effective water resource management. Successful PPPs require a supportive regulatory and legal framework, simple approval processes, and dispute resolution mechanisms. To attract private sector investments, incentives such as tax breaks, subsidies, and guaranteed returns should be explored.

Effective regulation and governance structures are indispensable for ensuring equitable and sustainable water resource management. Regulations can help balance competing interests, safeguard water quality, and allocate resources fairly. More stringent penalties can be introduced for polluters to promote responsible industrial practices to prevent water contamination.

5 Conclusion

The past few years have seen greater emphasis on water quality monitoring and surveillance with specific allocation being made under Central grants. There has been great focus on setting up and upgrading laboratories at the state and district levels, and on water monitoring through field testing kits. However, awareness, surveillance, monitoring and testing, mitigation measures, availability of alternate water sources and adoption of hygienic practices continues to remain roadblocks.

There is a need to invest further in water infrastructure to improve water availability, storage capacity, distribution, and mitigate the impacts of water-related disasters. Promoting the adoption of water-saving technologies like drip irrigation, micro-irrigation, and water-efficient appliances can significantly reduce water consumption and improve productivity. Additionally, the government should implement and enforce regulations to prevent water pollution and ensure access to safe drinking water, especially in rural and urban areas. Collaboration and active engagement of various stakeholders including the government, civil society, private sector, and communities are essential to addressing these challenges. [7]

One of the greatest challenges has been the convergence of various departments associated with water. The Union ministry of Jal Shakti launched the Jal Jeevan Mission, aiming to expand the piped water network to all households in India by 2024. However, success depends on the states, as water is a state subject. The National Institute for Transforming India (NITI) Aayog has developed the Composite Water Management Index (CWMI) [24] to enable effective water management in Indian states in the face of this growing crisis. The index is a novel, data-backed approach to water management that can promote governance, and inter-state collaboration and coordination [25].

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