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Revitalizing Bihar's Agriculture: A Comprehensive Analysis of Water Resource Dynamics, Climate Resilience, and the Role of Traditional Irrigation Systems

Editorial
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Editorial

Bihar is one of India's most historically rich and culturally diverse states, with a heritage dating back thousands of years, contributing significantly to India's cultural landscape. Agriculture plays a crucial role in Bihar's economy, with the sector and its allied activities growing at a rate of about 5 percent in the last five years (2017-18 to 2021-22).

Bihar, being the second most populous state in India after Uttar Pradesh, is home to over 125 million (MoHFW 2011) people, constituting around 9% of India's population. Bihar covers only 2.86% of the country's total area (FSI 2011). This takes the state's population density to approximately 1106 persons per sq. km - almost three times India's population density of 424 people per sq. km. between, 2001 and 2011, Bihar witnessed a population growth of 25.42%, as against the national growth of 17.70%. The contribution of the primary sector i.e., agriculture, forestry, fishing, fishing, and mining contributed 21.2% to the GSDP in 2021-2022, slightly lower than in 2020-21. Among agriculture and allied sub-sectors, the share of crops in the GSVA has been the largest (9.3%) followed by livestock (6.6%) (2020- 21).

Agriculture as the bedrock of the primary sector, is immensely sensitive. The state has 97% of small and marginal farmers accounting for 75% of operational holdings and centered around two key staple cereals i.e., rice and wheat. The heavy reliance on the primary sector (~80%) for employment and livelihood is compounded by limited opportunities in other sectors. The disproportionate engagement of the population in this sector leaves them exceptionally vulnerable to the state's climate extremes. Lean periods drive large numbers of people to migrate.

Water resources are vital for sustaining agriculture and domestic needs in Bihar. Efficiently managing water resources is crucial in the state to ensure long-term water availability in southern Bihar, facilitate flood mitigation or drainage of excess rainwater in northern Bihar, and minimize the impacts of seasonal variations. Rainfall recharge plays a pivotal role in replenishing a significant portion of usable groundwater.

In Bihar, rainfall, both monsoon and non-monsoon, stands as the primary source of recharge, contributing 63.61% to the total annual groundwater recharge. The remaining 36.39% of the total annual groundwater recharge comes from various sources, including canal seepage, return flow from irrigation, and recharge from tanks, ponds, and water conservation structures.

Notably, the state experienced approximately 40% less rainfall in 2022 and 23% less in 2023 compared to the total rainfall. Moreover, climate projections indicate worsening conditions for the state. These projections highlight a sharp increase in summer maximum temperatures, along with winter minimum temperatures, across most districts. In contrast, the average annual rainfall, especially during the monsoon and winter, shows a declining pattern for 2030 and 2050. The variability in monsoon rainfall not only affects recharge but also amplifies groundwater withdrawal.

About 74.15 % of total annual groundwater extraction i.e., 10.01 BCM is used for irrigation. Only 3.49 BCM is for

Domestic and industrial use, which is about 25.85 % of the total extraction. Alarming findings from the Bihar Economic Survey (2022-23) reveal severe groundwater depletion in districts such as Aurangabad, Nawada, Kaimur, and Jamui witnessed water levels plummeting over 10 meters below normal during the summer of 2021. A declining trend in groundwater levels across the state from 2005 to the present, with an average decrease of 2.5 meters. Areas facing medium to high water stress have increased substantially in the state. According to Dynamic Ground Water Resources of Bihar (2022), 08 blocks fall in the over-exploited category with a stage of groundwater abstraction of more than 100%. Moreover, 12 blocks are in critical, 46 in semi-critical and the remaining are safe category. Last year around 7841 Villages in 11 Districts of Bihar plunged into the clutches of drought. The state heavily relies on groundwater for agriculture.

These compelling numbers underscore the urgent need to address discrepancies in irrigation infrastructure and prioritize water resource development in districts. Anticipating potential risks, impacts, and vulnerabilities in a timely manner, the government of Bihar initiated the Jal-Jeevan- Hariyali Mission, spearheaded by the Hon'ble Chief Minister of Bihar. Furthermore, the state has a tradition of conserving surface water and utilizing it for irrigation and other purposes.

Nearly 5000 years ago, during the Magadh dynasty, the aahar-pyne irrigation system was developed to harness surface run-offs. Managed by Zamindar families, the system played a crucial role in irrigation and sustaining the water table. Unfortunately, during the British era, both the management and use of this irrigation system were severely neglected. This negligence exacerbated the use of tube wells to extract groundwater for irrigation, with no effort made to preserve, maintain, and keep the traditional system alive. Consequently, it had a detrimental impact on the groundwater table and shifted preferences of both farmers and the government away from traditional irrigation systems, prompting the collapse of a valuable community-managed irrigation system.

Till independence, the irrigated land in the state was limited to 4.04 lakh hectares, however, the irrigation potential (major & minor) was 66.295 lakh hectares. After decades of struggle, the significance of traditional irrigation systems for Bihar has again been recognized, and the Bihar Government is making concerted efforts to revitalize, rejuvenate, and restore the Ahar Pynes system. This resulted in a huge increase in irrigation potential (created) in the state and the overall water use efficiency (major and medium) of irrigation schemes in 2020-2021 was increased to 75.40 %. This indicates that the available water could be utilized more efficiently by optimizing its use in the crop cycle and introducing modern technology.

Currently, the Government of Bihar manages the irrigation system efficiently under different program heads. To start with a community-centric approach the Government has provided a special initiative under Jal Jiwan Hariliyali Mission for ensuring adequate year-round distribution of irrigation. The aahar-pyne system with 05 acres or less is managed by the Rural Development Department with the support of BRLPS. At the same, the large irrigation systems are managed by the 'Soil Conservation Works' of the Agriculture Directorate. The Government undertakes routine maintenance and repair of the aahar pyne. The systems provide reliable water supply through reservoirs, canals, and pumping stations. Tailor-made for local conditions, Aahar Pyne systems suit the state's agro-climatic conditions and topography.

Farmers, especially in Southern districts of Bihar, get a greater proportion of Kharif irrigation from aahar-pyne system with lesser or no effort. Most of the farmer has some land in the head, middle, and tail of the aahar-pyne system, thus they participate actively in protecting and optimizing their irrigation. Further, farmers synchronized the crop cycle according to the water availability in the command area, uniform cropping system facilitates collective action for the maintenance and conservation of the local commons. Many times, farmers stand for collective action irrespective of their village, caste, communities, etc. whenever aahar-pyne gets affected. They are also involved in minor repairs and maintenance to get an uninterrupted and equitable supply of irrigation.

The need for reverting to traditional irrigation systems in certain contexts stems from several compelling reasons. Firstly, the state has hectares of rainfed agriculture, traditional systems promote sustainability

by utilizing local water sources and minimizing energy consumption, easing the strain on water resources. Their adaptability to local climate patterns makes them resilient to changing weather conditions, enhancing climate resilience. Moreover, the community-led management of these systems fosters cooperation, knowledge sharing, and ownership, empowering local communities. The lower construction and maintenance costs of traditional systems enable their accessibility to small-scale farmers and resource-limited communities. By preserving traditional irrigation practices, communities can safeguard cultural heritage and transmit valuable knowledge. Additionally, these systems have a smaller ecological footprint, promoting environmental preservation and biodiversity. Their inherent resilience to disruptions and natural disasters ensures stable agricultural production and livelihoods. However, it is essential to

consider the appropriateness of adopting such systems based on specific local conditions, available resources, and water management needs, as a combination of traditional and modern approaches might offer the most sustainable and effective solution.

The agrarian economy of the state is significantly affected by climate change. The increase in temperate especially in the southern districts of the state is likely to accelerate the water demand for agricultural crops and augment the moisture loss. With changing rainfall patterns, increased frequency of droughts, and subsequently the dependency on water would be more. Under the climate change scenario, aahar- pyne system has the potential to address these challenges and minimize the adverse effects of climate change on agriculture.

In the current scenario, the aahar-pyne irrigation system needs to be strengthened. Further, scientific studies on natural conditions and physical configurations are required to optimize the aahar-pyne irrigation system. Identifying and mitigating hotspots that restrict water flow, optimizing the use of available resources, and ensuring the sustainability of the system are important considerations for future strategies. Additionally, the construction of reservoirs as water storage junctions and long-term planning based on altitude and slope are crucial for effective irrigation management. It is also necessary to investigate cost-effective efficient technology for irrigation in the state.

Furthermore, the surface water harvesting or recharge structures such as percolation tanks, ponds, reservoirs, etc. could be more efficient by studying the geo-morphological features and aquafers of the region. For example, structures that contribute to groundwater are considered on a priority basis. By recognizing the importance of traditional irrigation systems, implementing appropriate strategies, and addressing institutional challenges, Bihar can build a sustainable and resilient irrigation infrastructure. This, in turn, will contribute to the economic development, agricultural prosperity, and overall well- being of the state.