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Impact of bargi dam on groundwater recharge and agricultural productivity in Jabalpur, Madhya Pradesh: A comprehensive review

¹Aditya Dwivedi ²Stuti Sharma ³Prashant Namdeo ⁴Ekansh Raghuvanshi

¹M.Tech in Soil and Water Conservation, Mahakaushal University, Jabalpur, Madhya Pradesh, India

²Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Madhya Pradesh, India

³Senior Research Fellow (SRF), Seed Technology Research Centre, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Madhya Pradesh, India

⁴Junior Research Fellow (JRF), Department of Genetics and Plant Breeding, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Madhya Pradesh, India

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Corresponding Author: Aditya Dwivedi

Abstract

Large dams play a pivotal role in India's water resource management, influencing irrigation, hydropower, and socio economic development. The Bargi Dam, built on the Narmada River in Jabalpur district, Madhya Pradesh, is one of the earliest projects completed under the Narmada Valley Development Authority. Its impacts on groundwater recharge and agricultural productivity have been profound, with both positive and negative outcomes. Enhanced infiltration from canal irrigation has raised groundwater tables, supporting wells and tube wells in command areas. At the same time, waterlogging and soil salinity have emerged as challenges, affecting crop yields and long term sustainability. This review synthesises available literature on hydrological changes, agricultural productivity, socio economic transformations, and environmental concerns associated with Bargi Dam, while highlighting policy and management strategies for sustainable water use in the region.

Keywords: Bargi dam; groundwater recharge; agricultural productivity; irrigation; narmada river; jabalpur; waterlogging; soil salinity; hydrology; sustainability.

Introduction

Water resource development through large dams has been central to India's agricultural modernisation since independence. With nearly 5,000 large dams across the country, irrigation expansion has transformed rural economies, particularly in semi-arid regions. The Bargi Dam, in Jabalpur district, Madhya Pradesh, was commissioned in the early 1990s as part of the Narmada Valley Development Project. It was designed to provide irrigation to approximately 2.45 lakh hectares across 1,450 villages, alongside hydropower generation and flood control. The projected expenditure for the Bargi Project has been estimated at Rs. 5,127.22 crores. ^[1]

The Bargi project has had a dual impact: while it has increased water availability and enabled multi-cropping, it has also introduced ecological and hydrological challenges. Groundwater recharge has improved in canal command areas due to seepage and infiltration, but excessive recharge has led to waterlogging and soil salinity in certain zones. Agricultural productivity has risen through crop diversification and higher yields, yet sustainability concerns persist because of uneven water distribution and aquifer imbalance. ^[2]

This review article aims to provide a comprehensive synthesis of Bargi Dam's impact on groundwater recharge and agricultural productivity in Jabalpur, Madhya Pradesh. It examines hydrological processes, agricultural outcomes, socio-economic consequences, and environmental concerns, and suggests policy interventions for sustainable management.

Background on Bargi dam

The Bargi Dam is one of the major multipurpose projects constructed on the Narmada River in Madhya Pradesh. It is located approximately 40 km south of Jabalpur city and was among the first dams completed under the Narmada Valley Development Authority (NVDA) initiative. ^[3] Commissioned in the early 1990s, the dam was designed to serve multiple objectives: irrigation, hydropower generation, flood control, and domestic and industrial water supply.

3.1 Structural features

- **Type of dam:** Earth-cum-rockfill dam with a concrete spillway.
- **Height and length:** Approximately 69.80 m high and 5.4 km long.

- **Reservoir capacity:** Gross storage capacity of 3,180 million cubic meters.
- **Catchment area:** Nearly 14,556 km^[2].
- **Power generation:** Hydropower station with an installed capacity of 90 MW.^[4]

3.2 Irrigation potential

The Bargi project was initially planned to irrigate 2.45 lakh hectares across 1,450 villages in Jabalpur, Mandla, and Seoni districts. However, actual irrigation coverage has varied due to canal construction delays, seepage losses, and operational constraints. The Left Bank Canal (LBC) and Right Bank Canal (RBC) are the two major distributaries, with the LBC serving large parts of Jabalpur district.

3.3 Socio-economic context

The dam's construction submerged approximately 162 villages, displacing nearly 27,000 people. While resettlement programs were initiated, challenges in compensation and rehabilitation have been documented. On the positive side, the project has created opportunities for enhanced agricultural productivity, fisheries development, and rural employment.

3.4 Environmental setting

The Bargi reservoir has altered the local ecology, submerging forests and agricultural land. It has also created new aquatic habitats that support inland fisheries. However, reports have noted soil salinity, waterlogging, and biodiversity loss in submerged areas.

This background provides the foundation for understanding how Bargi Dam has influenced groundwater recharge and agricultural productivity in Jabalpur. The next section will analyse hydrological impacts on groundwater recharge, focusing on infiltration, aquifer dynamics, and waterlogging.^[5]

Groundwater recharge impacts

The Bargi Dam has profoundly influenced groundwater recharge in Jabalpur district. Canal irrigation and reservoir seepage have altered the hydrological balance, producing both beneficial and adverse outcomes.

4.1 Positive impacts on groundwater recharge

- **Enhanced infiltration:** Seepage from canals and irrigated fields has increased percolation into aquifers, raising groundwater tables in command areas.
- **Support for wells and tube wells:** Farmers in the Left Bank Canal (LBC) command area report improved well yields, enabling supplementary irrigation during dry spells.
- **Stabilisation of groundwater levels:** Seasonal fluctuations have reduced, ensuring more reliable water availability for agriculture.
- **Expansion of irrigated area:** Recharge has facilitated the use of groundwater in regions beyond direct canal command, extending irrigation benefits.^[6]

4.2 Negative impacts

- **Waterlogging:** Excessive seepage has led to waterlogging in low-lying fields, reducing soil aeration and crop productivity.

- **Soil salinity and alkalinity:** Prolonged waterlogging has caused salt accumulation, particularly in clay-rich soils, affecting long-term fertility.
- **Aquifer imbalance:** Uneven recharge has created disparities, with some areas experiencing rising water tables while others remain deficient.
- **Infrastructure damage:** Waterlogging has weakened the foundations of rural roads and buildings in certain canal command villages.^[7]

4.3 Case studies

- **Left Bank Canal Command:** Studies show groundwater levels rose by 1-2 meters within five years of canal operation, but 15-20% of fields experienced waterlogging.
- **Right Bank Canal Command:** Recharge was less pronounced due to sandy soils, but aquifer sustainability improved, supporting horticultural expansion.
- **Bio-drainage interventions:** Plantations of Eucalyptus and Pongamia have been tested to mitigate waterlogging, showing promising results in reducing excess soil moisture.

4.4 Long-term implications

While Bargi Dam has improved groundwater availability, salinity, waterlogging, and uneven distribution threaten recharge sustainability. Effective management strategies, such as canal lining, controlled irrigation, and bio-drainage, are essential to balance recharge benefits with ecological stability.

Agricultural productivity impacts

The Bargi Dam has transformed agricultural productivity in Jabalpur district by expanding irrigation coverage, stabilising water supply, and enabling crop diversification. However, these gains have come with challenges such as waterlogging, soil degradation, and uneven distribution of benefits.

5.1 Cropping patterns

- **Shift from rainfed to irrigated agriculture:** Prior to Bargi Dam, agriculture in Jabalpur was largely dependent on monsoon rainfall. Canal irrigation has enabled year-round cultivation.
- **Introduction of multi-cropping:** Farmers in the Left Bank Canal (LBC) command area have adopted double and triple cropping systems, cultivating wheat, rice, pulses, and oilseeds in rotation.
- **Expansion of horticulture:** Reliable water supply has encouraged cultivation of vegetables, fruits, and cash crops such as sugarcane and soybean.^[8]

5.2 Yield improvements

- **Cereal crops:** Wheat and rice yields have increased significantly due to assured irrigation, with productivity rising by 25-40% compared to pre-dam levels.
- **Pulses and oilseeds:** Improved water availability has supported higher yields of soybean, gram, and mustard, strengthening crop diversification.
- **Vegetables and fruits:** Irrigation has facilitated

intensive cultivation of tomato, brinjal, and mango orchards, contributing to nutritional security and market expansion.

5.3 Socio-economic outcomes

- **Income growth:** Farmers in canal command areas report higher incomes due to increased yields and diversified cropping.
- **Employment generation:** Agricultural intensification has created seasonal employment opportunities in farming, agro-processing, and marketing.
- **Market integration:** Surplus production has strengthened linkages with urban markets in Jabalpur and neighbouring districts, enhancing rural-urban economic ties.

5.4 Challenges

- **Waterlogging and salinity:** In certain villages, excessive irrigation has reduced yields due to soil degradation.
- **Unequal distribution:** Farmers located at the tail end of canals often face water shortages, leading to disparities in productivity.
- **Dependence on canal schedules:** Rigid irrigation schedules sometimes fail to align with crop water requirements, affecting yield optimisation. ^[5]

5.5 Long-term implications

While Bargi Dam has boosted agricultural productivity, sustainability depends on improved water management. Crop diversification, soil health monitoring, and equitable water distribution are essential to maintain long-term gains.

Socio-economic impacts

The Bargi Dam has reshaped the socio-economic landscape of Jabalpur district and surrounding regions. While irrigation expansion and agricultural intensification have improved livelihoods, the project also brought challenges related to displacement, resettlement, and equitable benefit distribution.

6.1 Livelihood enhancement

- **Agricultural prosperity:** Farmers in canal command areas report higher incomes due to increased yields and diversified cropping systems.
- **Employment generation:** Irrigation expansion has created seasonal employment in farming, agro-processing, and marketing, reducing rural underemployment.
- **Fisheries development:** The Bargi reservoir has become a hub for inland fisheries, supporting thousands of fishers and contributing to local food security.

6.2 Displacement and resettlement

- **Village submergence:** Approximately 162 villages were submerged, displacing nearly 27,000 people during dam construction. ^[9]
- **Resettlement challenges:** Compensation and rehabilitation programs faced delays, with many families reporting inadequate land allotment and livelihood support.

- **Social disruption:** Displacement led to fragmentation of communities and loss of traditional livelihoods, particularly among tribal populations.

6.3 Equity and distribution of benefits

- **Regional disparities:** Farmers at the head of canals benefit more from irrigation, while those at the tail often face water shortages.
- **Socio-economic inequality:** Larger landholders have gained disproportionately from irrigation expansion, while marginal farmers struggle with access and affordability.
- **Gender dimensions:** Women's participation in agriculture has increased due to irrigation, but access to land and credit remains limited.

6.4 Rural development outcomes

- **Market integration:** Surplus agricultural production has strengthened rural-urban linkages, with Jabalpur city serving as a major market hub.
- **Infrastructure growth:** Irrigation expansion has stimulated rural infrastructure development, including roads, storage facilities, and agro-processing units.
- **Educational and health improvements:** Rising incomes have indirectly supported better access to education and healthcare in canal command villages.

6.5 Long-term implications

The socio-economic impacts of Bargi Dam highlight the dual nature of large irrigation projects: while they can enhance livelihoods and rural development, they also risk creating inequities and displacement challenges. Sustainable management requires inclusive policies that balance productivity gains with social justice.

Environmental concerns

The Bargi Dam has generated significant environmental consequences in Jabalpur and surrounding districts. While the reservoir and canal system have improved water availability, they have also altered soil properties, biodiversity, and ecological balance.

7.1 Soil salinity and waterlogging

- **Excessive seepage** from canals has led to waterlogging in low-lying fields, reducing soil aeration and crop productivity.
- **Salt accumulation:** Prolonged waterlogging has caused salinity and alkalinity in clay-rich soils, particularly in the Left Bank Canal command area.
- **Impact on fertility:** Saline soils reduce nutrient uptake, leading to declining yields of sensitive crops such as pulses and vegetables. ^[10]

7.2 Biodiversity loss

- **Submergence of forests:** Reservoir creation submerged large tracts of forest land, leading to habitat loss for wildlife species.
- **Aquatic ecosystem changes:** The reservoir has altered fish diversity, favouring certain species while reducing native populations.
- **Decline in terrestrial biodiversity:** Displacement of

flora and fauna has been reported in submerged villages and forest zones. ^[11, 12]

7.3 Ecological imbalance

- **Altered hydrology:** Continuous seepage and recharge have changed aquifer dynamics, affecting natural groundwater flow.
- **Vegetation stress:** Waterlogging has damaged traditional crops, while bio-drainage plantations (Eucalyptus, Pongamia) have been introduced to restore balance.
- **Climate implications:** Large reservoirs contribute to localised humidity changes, influencing microclimates in canal command areas. ^[13]

7.4 Mitigation measures

- **Canal lining:** Reduces seepage losses and minimises waterlogging.
- **Bio-drainage plantations:** Trees with high transpiration rates help lower water tables in waterlogged soils.
- **Soil management practices:** Gypsum application and crop rotation with salt-tolerant species have been recommended to restore fertility.

7.5 Long-term implications

Environmental concerns highlight the need for integrated water resource management. Without corrective measures, soil degradation and biodiversity loss could undermine Bargi Dam's long-term benefits. Sustainable practices such as controlled irrigation, bio-drainage, and ecological monitoring are essential to balance development with conservation.

Policy and management perspectives

The long-term sustainability of Bargi Dam's benefits depends on effective policy interventions and management strategies. While the project has enhanced irrigation and agricultural productivity, challenges such as waterlogging, salinity, and inequitable distribution require systematic governance.

8.1 Irrigation scheduling and efficiency

- **Canal operation policies:** Current irrigation schedules often fail to align with crop water requirements, leading to inefficiencies.
- **Micro-irrigation promotion:** Adoption of drip and sprinkler systems can reduce water losses and improve crop water use efficiency.
- **Canal lining:** Lining distributaries and minors reduces seepage, thereby minimising waterlogging and salinity.

8.2 Groundwater monitoring

- **Aquifer mapping:** Regular monitoring of groundwater levels in canal command areas is essential to detect imbalances.
- **Recharge regulation:** Controlled irrigation practices can prevent excessive recharge and waterlogging.
- **Community participation:** Farmer groups can be involved in monitoring and reporting groundwater conditions to local authorities.

8.3 Sustainable agricultural practices

- **Crop diversification:** Encouraging salt-tolerant and less water-intensive crops reduces stress on soil and water resources.
- **Soil health management:** Gypsum application, organic amendments, and crop rotation help restore fertility in saline soils.
- **Agro-forestry and bio-drainage:** Planting high-transpiration species such as Eucalyptus and Pongamia mitigates waterlogging. ^[14]

8.4 Institutional and policy framework

- **Integrated Water Resource Management (IWRM):** Coordination between NVDA, farmers, and local institutions ensures balanced water use.
- **Equity in distribution:** Policies must address disparities between head-end and tail-end farmers to ensure fair access.
- **Capacity building:** Training programs for farmers on efficient irrigation and soil management enhance adoption of sustainable practices.

Policy frameworks should emphasise adaptive irrigation management, community-based monitoring, and ecological restoration. Without these measures, environmental degradation and social inequities may undermine Bargi Dam's long-term productivity gains.

Conclusion and future directions

The Bargi Dam has emerged as a transformative water resource project in Jabalpur district, Madhya Pradesh. Its impacts on groundwater recharge and agricultural productivity show the dual nature of large irrigation schemes: while they provide substantial benefits in water availability, crop diversification, and socio-economic development, they also create environmental and equity challenges.

9.1 Key Findings

- **Groundwater recharge:** Canal seepage and reservoir infiltration have raised groundwater tables, supporting wells and stabilising aquifers. However, excessive recharge has caused waterlogging and salinity in certain areas.
- **Agricultural productivity:** Irrigation expansion has enabled multi-cropping, improved yields of cereals, pulses, and horticultural crops, and strengthened rural incomes. Yet, disparities persist between head-end and tail-end farmers.
- **Socio-economic impacts:** Enhanced livelihoods, employment, and fisheries development contrast with displacement challenges and inequitable distribution of benefits.
- **Environmental concerns:** Soil degradation, biodiversity loss, and ecological imbalance highlight the need for corrective measures.

9.2 Policy implications

- **Integrated water management:** Policies must balance irrigation expansion with groundwater sustainability through canal lining, micro-irrigation, and controlled

water release.

- **Equity in distribution:** Tail-end farmers require targeted interventions to ensure fair access to irrigation benefits.
- **Soil and crop management:** Adoption of salt-tolerant crops, gypsum application, and crop diversification can mitigate soil degradation.
- **Community participation:** Farmer cooperatives and local institutions should be empowered to monitor groundwater and manage irrigation schedules.

9.3 Future directions

- **Long-term aquifer monitoring:** Continuous hydrological studies are needed to track groundwater dynamics and prevent imbalance.
- **Ecological restoration:** Bio-drainage plantations, afforestation, and biodiversity conservation programs should be expanded.
- **Adaptive irrigation strategies:** Flexible canal operation policies aligned with crop water requirements can enhance efficiency.
- **Socio-economic inclusivity:** Rehabilitation programs for displaced communities must be strengthened, ensuring livelihood security and social justice.

9.4 Final remarks

The Bargi Dam exemplifies the opportunities and challenges of large irrigation projects in India. Its success lies not only in engineering achievements but also in sustainable management and inclusive policies. By integrating hydrological science, agricultural innovation, and socio-economic equity, Bargi Dam can continue to serve as a model for balanced development in Madhya Pradesh and beyond.

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