IJRAR.ORG E-ISSN: 2348-1269, P-ISSN: 2349-5138

INTERNATIONAL JOURNAL OF RESEARCH AND ANALYTICAL REVIEWS (IJRAR) | IJRAR.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Geographical Assessment of Water Resources in Muzaffarpur District of Bihar: Availability, Utilisation and Challenges

Dr. Sita Ram Pandit

Assistant Professor (Guest)

Department of Geography

Sardar Ballabhbhai Patel College Bhabua (Kaimur)

(V.K.S.University Ara)

Abstract

This paper provides a geographical assessment of water resources in Muzaffarpur District (Bihar), focusing on the availability of surface and groundwater, the ways in which these resources are utilised (agriculture, domestic, industrial), and the challenges (flooding, water-logging, contamination, over-exploitation) the district faces. Maps and schematic diagrams illustrate spatial patterns and key issues. Although the district has significant water resource endowments (rivers, aquifers, ponds), there are critical constraints in distribution, quality, and sustainable management.

Keywords: Water resource management, Sustainable development, Surface and groundwater, Aquifer, Water utilization pattern

1. Introduction

Muzaffarpur District lies in the northern Indian state of Bihar, north of the Ganga. It covers an area of about 3,132 km². (IJRAR)

Given its alluvial plains, the district is endowed with rivers and groundwater aquifers, which provide the basis for agriculture and livelihoods. At the same time, the region experiences both floods (during monsoons) and water-logging, and issues such as quality deterioration of groundwater. This paper examines the water resource geography of the district along three axes: (i) Availability, (ii) Utilisation, and (iii) Challenges.

2. Study Area

2.1 Location and Topography

Muzaffarpur District is located between approximately 25°54′N to 26°23′N latitude and 84°53′E to 85°45′E longitude. (Central Ground Water Board) The topography is generally flat, being part of the Gangetic alluvial plain, with gentle undulations and very little relief. (DCMSME)

2.2 Drainage and River Systems

The district is drained by several rivers including the Burhi Gandak River, Bagmati River, among others. (DCMSME) These rivers, being part of the larger basin network of north Bihar, play a major role in water availability, irrigation and flooding. The drainage network is relatively dense but the flat terrain means slow drainage and greater potential for water-logging during high flows.

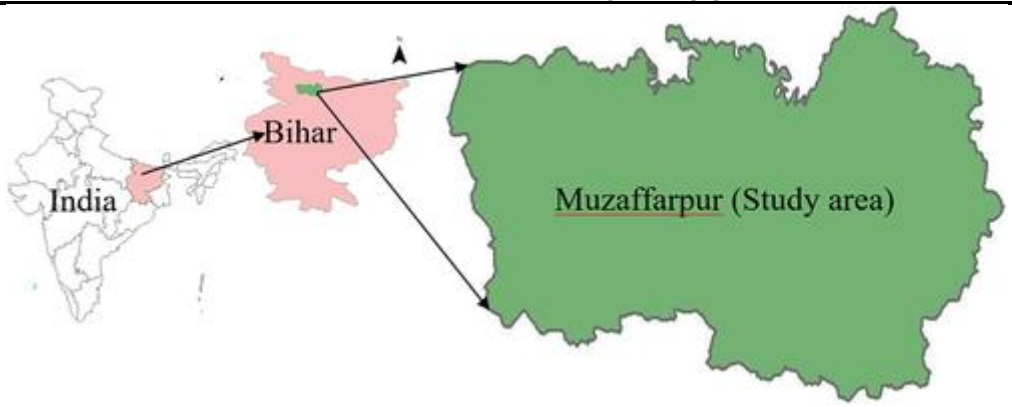


Figure-1: Base map of Muzaffarpur District (2025)

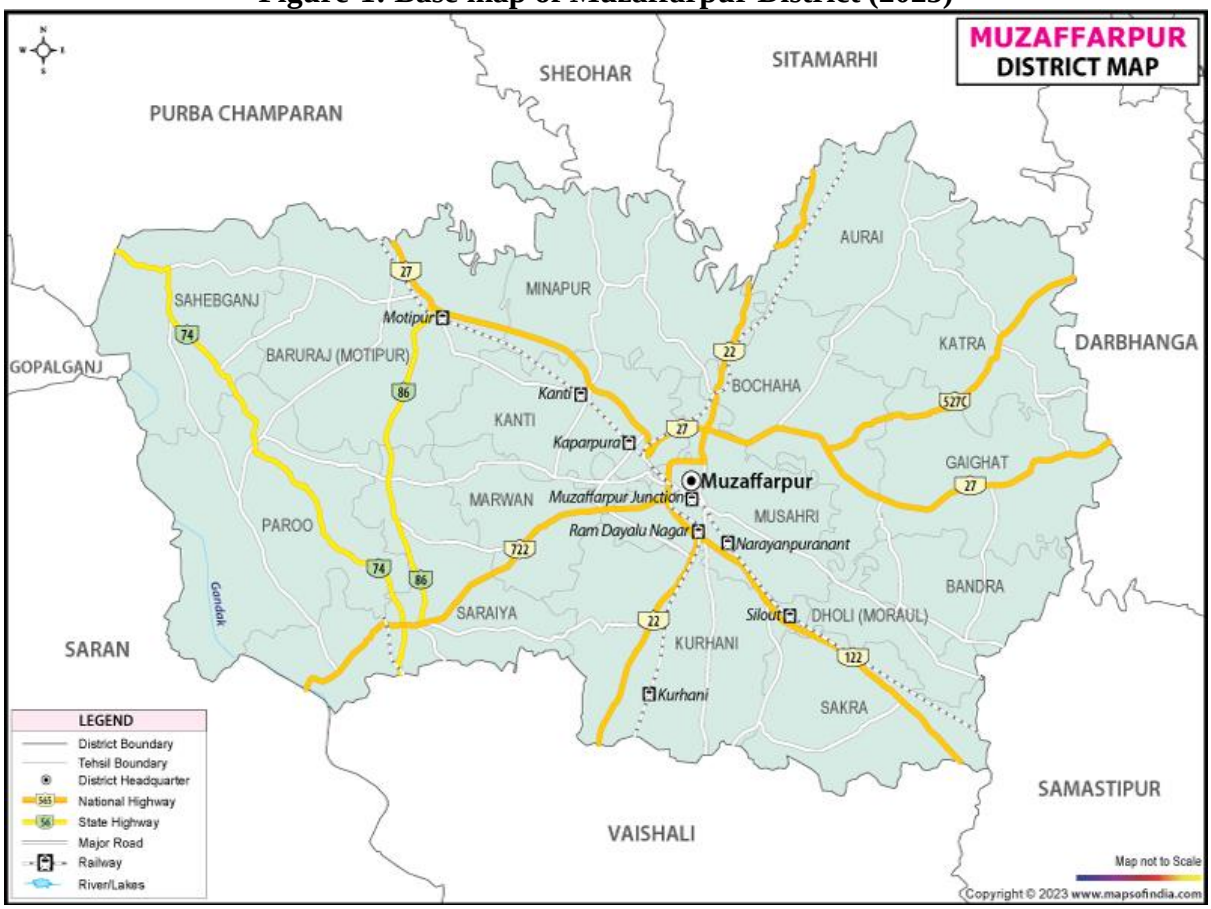


Figure-2: Muzaffarpur District map with blocks

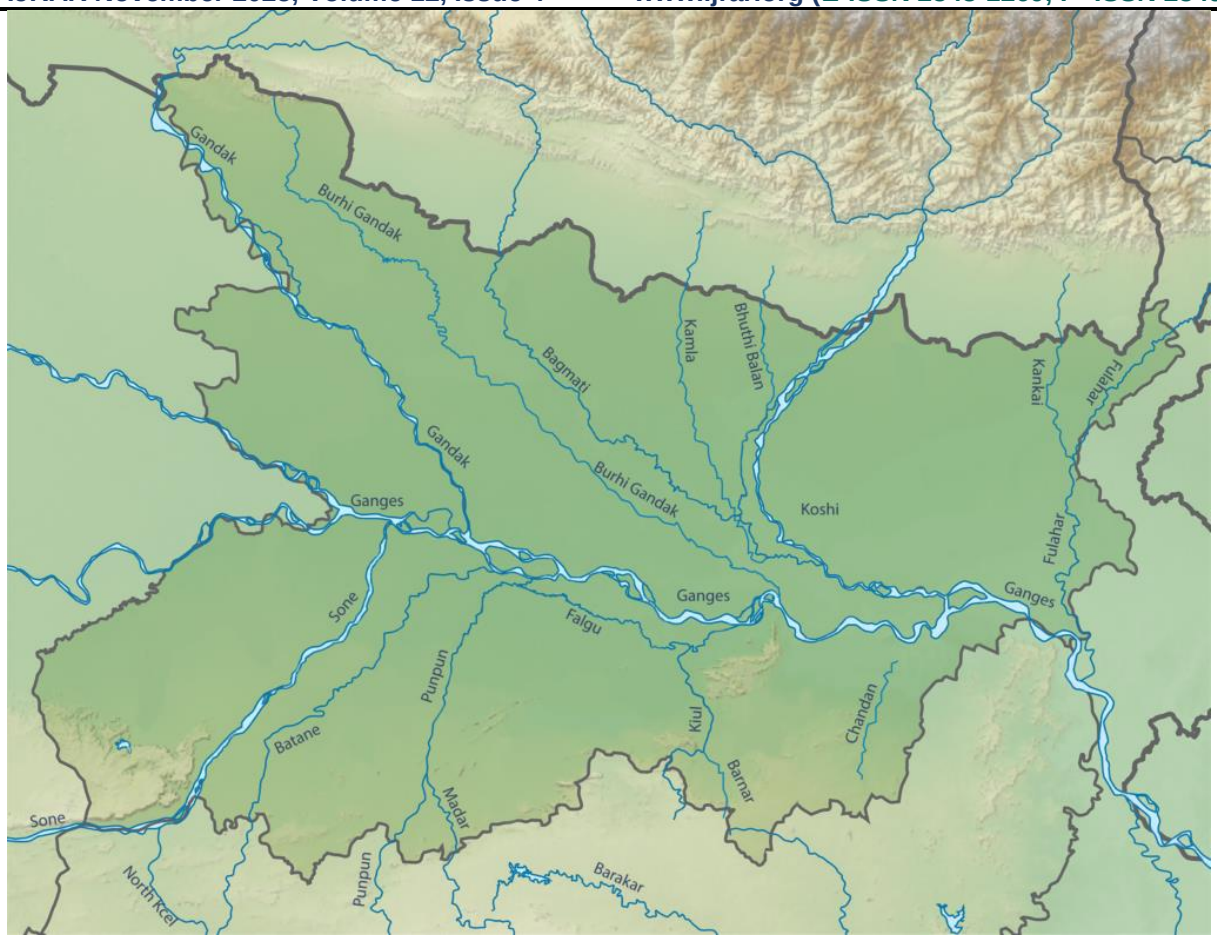


Figure-3: Major rivers of Bihar

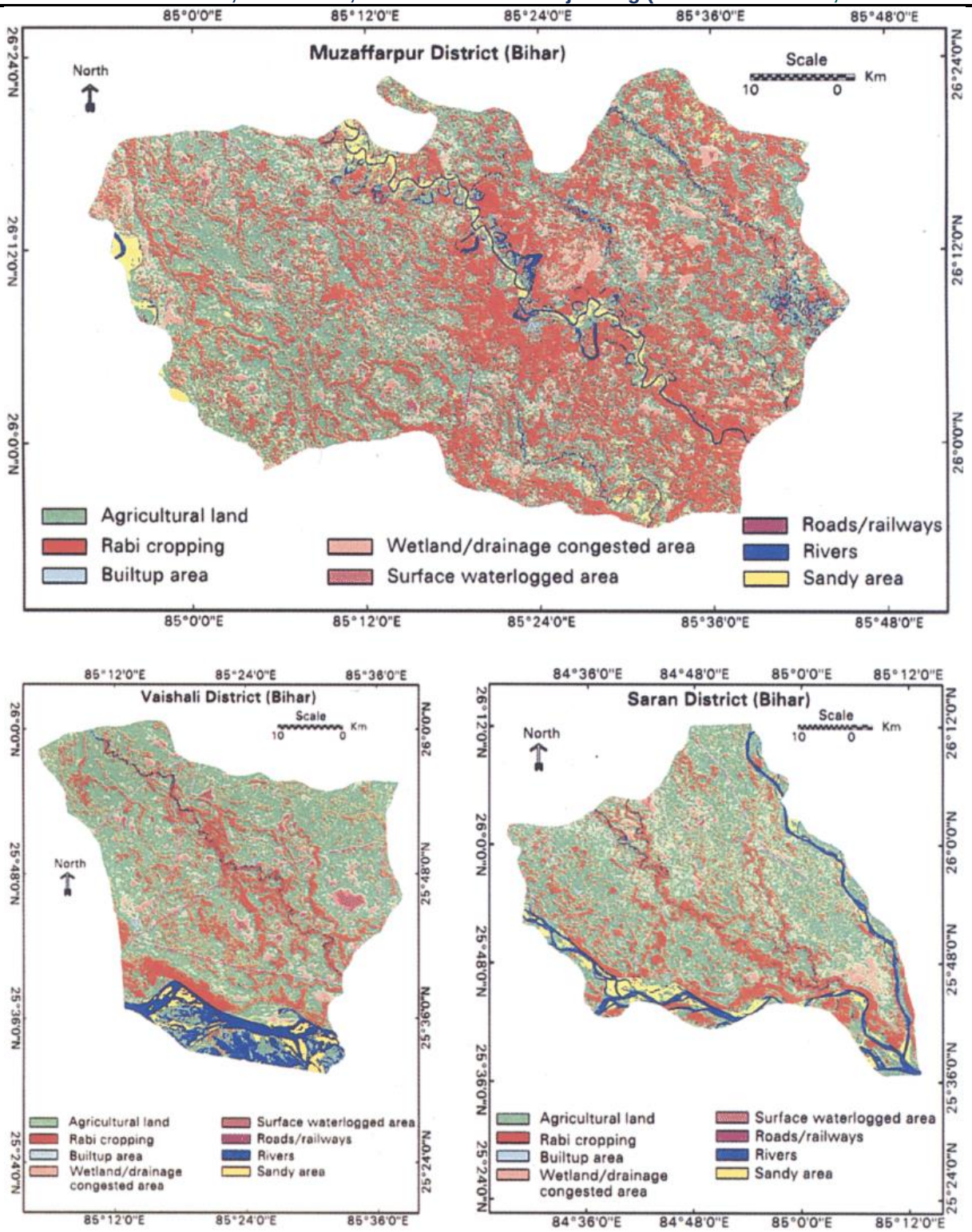


Figure-4: GIS mapping of availability water resource of Muzaffarpur district

2.3 Hydrogeology

The district's aquifers mainly consist of alluvial sands of varying grades. Groundwater occurs under confined to semi-confined conditions with deeper aquifers. Recharge of groundwater is primarily by rainfall infiltration, seepage from rivers, ponds and tanks, return flow from irrigation.

3. Water Resource Availability

3.1 Surface Water Availability

The presence of major rivers and an alluvial plain ensures surface water availability. The map below shows the river network and water bodies in the district.

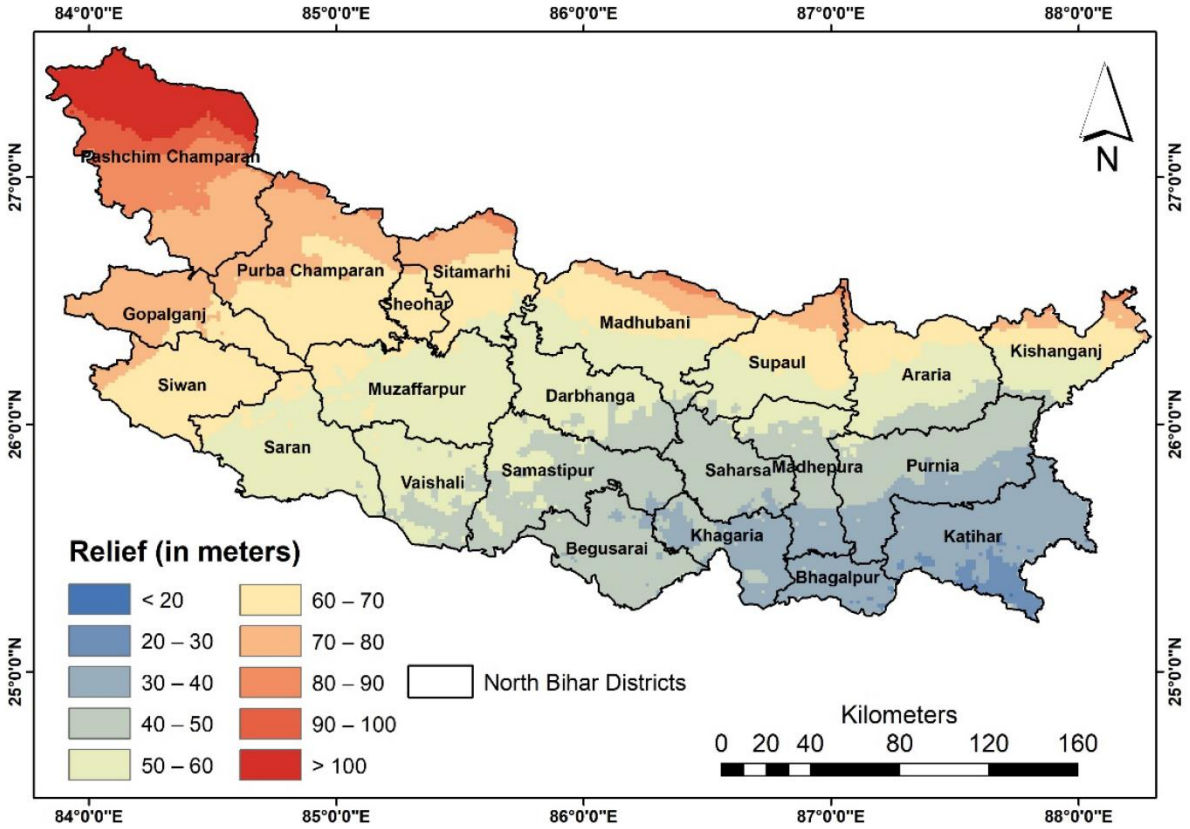


Figure-5: Relief of North Bihar with district boundary

According to district planning documents, a number of ponds, tanks and wetlands exist (government sector ~220 ha; private sector ~100 ha) in the district. However, given the large area of the district and the number of users, surface water alone is not sufficient to meet all demands.

3.2 Groundwater Availability

As per the estimates by the Central Ground Water Board (CGWB) for Muzaffarpur District (as on 31.3.2009):

- Total ground water resource: ~1,070.52 million m^3.
- Allocation for irrigation: ~501.52 million m^3.
- Gross annual groundwater draft: ~572.77 million m^3.
- Balance: ~497.75 million m^3 (i.e., about 46 % of the total).
- Level of groundwater development: about 53.5%.

These numbers indicate a moderately developed groundwater system, with headroom for further development—but with caution. The aquifer mapping has been done recently (2023) for Muzaffarpur. (Central Ground Water Board)

3.3 Land Use and Water-logging

Land use / land cover data show the extent of agriculture, built-up areas, wetlands and water-logging zones. (ResearchGate) The presence of "chaurs" (low lying wetlands) and seasonal water-logging in certain parts of the district are significant for water availability and drainage. (IJRAR)

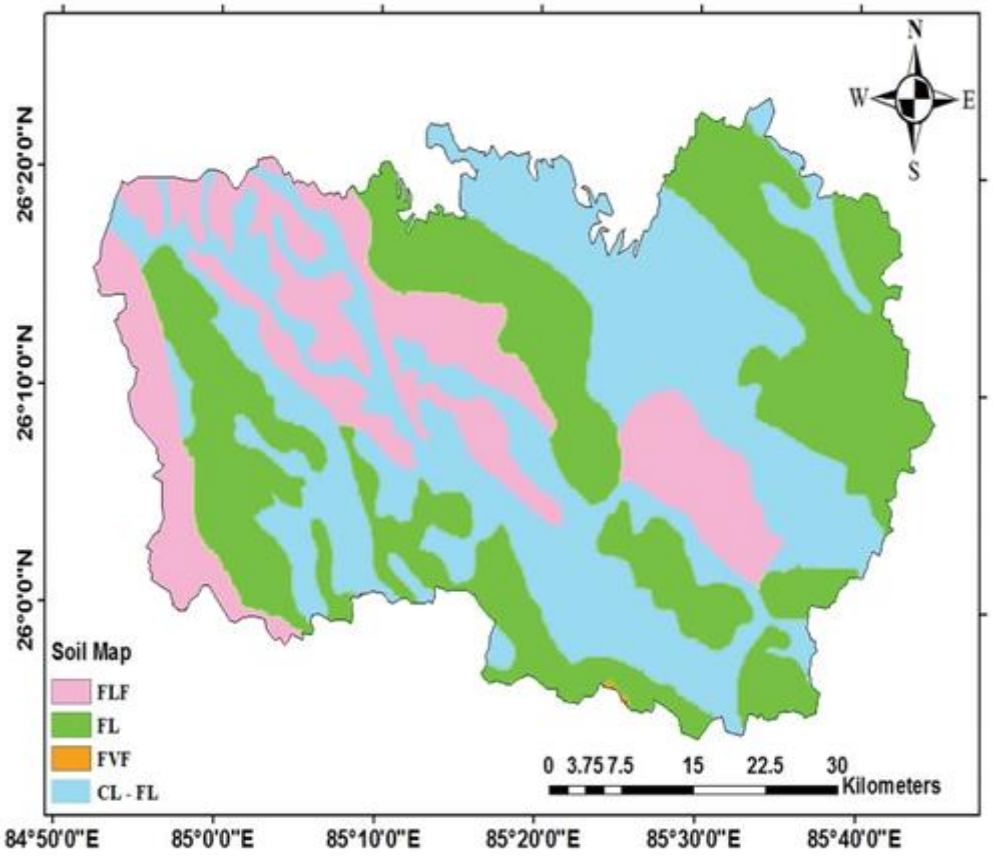


Figure-6: Water logging parts of Muzaffarpur districtin 2022

4. Utilisation of Water Resources

4.1 Agricultural Irrigation

Agriculture is the primary occupation in Muzaffarpur District. The alluvial soils, flat terrain, and availability of water enable multiple crops annually. (DCMSME) The irrigation potential is largely met by groundwater (~90% of irrigation potential) in the district. (DCMSME)

4.2 Domestic and Industrial Use

Domestic water supply is largely drawn from groundwater (tube wells, hand pumps), as well as surface sources for urban supply. However, issues of treatment and coverage persist. For example, one report indicates the city's water supply was only covering ~30% of required area; no treatment plant for the water supply; about 13 tube wells functioning. (nwm.gov.in) Industrial use is smaller in volume compared to agriculture but concentrated in urban zones and requires quality water.

4.3 Fisheries, Ponds and Wetlands The district has pond and tank resources (government 220 ha; private ~100 ha) which support fisheries and ancillary livelihoods. Wetlands also act as seasonal water storage, flood buffers, recharge zones.

5. Challenges in Water Resource Management

5.1 Floods, Drainage and Water-logging

Being part of the Ganga plain and with major rivers, Muzaffarpur experiences flooding during monsoon. Poor drainage due to flat terrain aggravates water-logging. The city's drainage capacity was inadequate (storm-water drains covering only ~59% area) and open drains discharge into rivers untreated. (nwm.gov.in)

5.2 Groundwater Over-exploitation and Quality Issues

Although groundwater development is at ~53.5% (as per 2009 data) which is moderate, block-wise some blocks have higher levels (for example Mushahari block ~89%) leading to stress. Quality issues include saline/alkaline soils, water-logging, potential contamination. A 2024 thesis indicates mapping of groundwater quality/salinity in Motipur & Kanti blocks of Muzaffarpur. (krishikosh.egranth.ac.in)

5.3 Water Quality and Pollution

Surface water quality is impacted by untreated sewage and storm-water discharge. The city water supply lacked a treatment plant as of one report. (nwm.gov.in) Groundwater can also suffer from chemical contamination (though specific district-wide arsenic/uranium data for Muzaffarpur is less detailed in this review).

5.4 Institutional, Monitoring and Infrastructure Issues

While mapping efforts (such as aquifer mapping) are underway, effective monitoring, treatment infrastructure, drainage management and water-body conservation are lagging. Weak drainage networks and inadequate storm water systems increase vulnerability. (nwm.gov.in)

5.5 Climate Change and Variability

Changes in rainfall patterns, extreme precipitation events, and fluctuating river flows will affect both availability and management of water resources. The district's flat terrain and alluvial setting make it sensitive to both excess water (flood-waterlogging) and seasonal dry spells.

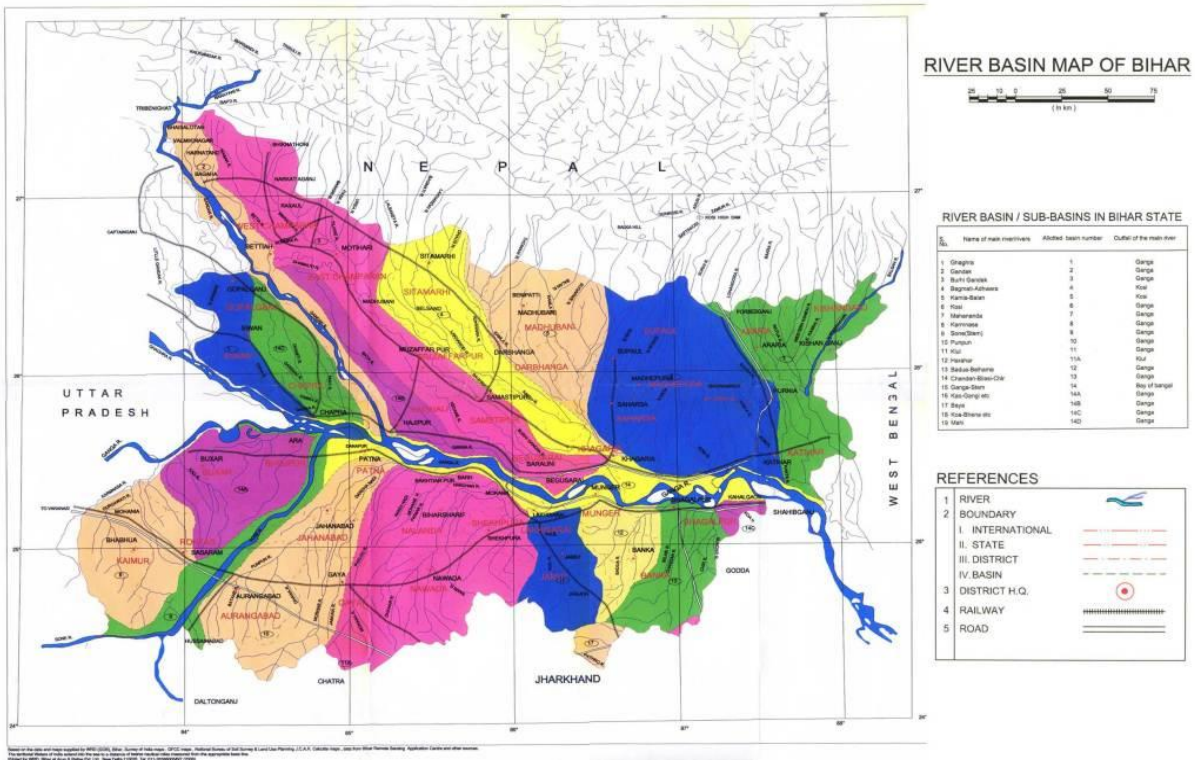
6. Spatial Patterns and Map-Based Insights

6.1 Groundwater Potential Zones

Mapping of aquifer potential shows spatial variation: some zones of high potential, others of moderate/low. Efficient planning should target recharge in weaker zones. (See figure)

6.2 Water-logging & Wet-land Zones

Land use maps identify wetland/water-logging patches (chaurs) especially in low lying parts. These zones are important for drainage planning, flood risk mitigation, and as recharge zones.



Fifure-7: River Basin map of Bihar

7. Recommendations (Strategic Framework)

Towards Sustainable Water Resource Management in Muzaffarpur District, Bihar

The sustainable management of water resources in Muzaffarpur District requires an integrated geographical, ecological, and socio-institutional approach. Based on the analysis of availability, utilisation, and challenges, the following multi-dimensional recommendations are proposed.

7.1 Hydrological and Drainage Management Strategies

Objective: Reduce flood and water-logging vulnerability, improve drainage efficiency, and enhance stormwater management.

1. Integrated Drainage Master Plan

Prepare a Drainage Atlas of Muzaffarpur District using GIS and remote sensing to map natural drainage lines, depressions, and chaurs.

Redesign existing drainage systems in the city and peri-urban areas (Kanti, Mushahari, Kurhani) to ensure slope-based flow and avoid backflow during monsoon.

Introduce bio-drainage systems (tree plantation along drains) in water-logged zones to absorb excess soil moisture.

2. Floodplain Zoning and Management

Demarcate flood-prone areas along the Burhi Gandak, Bagmati, and Kadane rivers through satellite-based flood inundation mapping (using Sentinel-1 data).

Regulate construction in floodplains and restore natural flood buffers (wetlands, chaurs). Establish flood-control reservoirs and diversion channels in northwestern low-lying regions to store floodwaters for later irrigation.

3. Wetland Rejuvenation and Water Storage Enhancement
Reclaim and revive traditional wetlands (e.g., Paighambarpur Chaur, Jhapaha Chaur) through desiltation and vegetation management. Promote community wetland management committees for maintenance, fisheries, and eco-tourism. Integrate wetlands into urban green-blue infrastructure for both flood mitigation and groundwater recharge.
7.2 Groundwater Management and Recharge Enhancement
Objective: Ensure sustainable extraction, prevent over-exploitation, and augment recharge.
1. Artificial Recharge Structures
Construct percolation tanks, recharge shafts, and recharge trenches in villages with declining groundwater levels (Mushahari, Motipur, Sakra). Encourage rooftop rainwater harvesting in government buildings, educational institutions, and urban colonies. Introduce Recharge Zonation Mapping for prioritising recharge projects using aquifer mapping (CGWB, 2023).
2. Groundwater Regulation and Monitoring
Implement Block-level Water Budgeting to match groundwater draft and recharge capacity. Declare high-extraction blocks (where >80% development) as "Groundwater Sensitive Zones" and regulate new borewell drilling. Install piezometers in each block to monitor water table fluctuation and quality. Create a Muzaffarpur Groundwater Portal (digital dashboard) for monthly reporting and transparency.
3. Promotion of Efficient Water Use in Agriculture
Encourage micro-irrigation systems (drip, sprinkler) through subsidies and farmer training. Replace water-intensive crops (e.g., summer paddy) with less demanding alternatives (maize, pulses, oilseeds). Establish Water User Associations (WUAs) to manage irrigation schedules and collective borewells.
7.3 Water Quality Improvement and Pollution Control
Objective: Achieve safe, clean, and sustainable water for all uses.
1. Urban and Industrial Wastewater Treatment. Construct decentralized sewage treatment plants (STPs) at ward or cluster level in Muzaffarpur city. Introduce Constructed Wetlands Technology for low-cost natural treatment of domestic wastewater. Mandate pre-treatment for industrial effluents before discharge into rivers or drains.
2. Rural Drinking Water Quality Monitoring
Conduct periodic water testing (arsenic, fluoride, nitrate, iron) in hand pumps and wells. Provide iron removal plants and fluoride-safe filters in affected panchayats. Use GIS-based Water Quality Index Mapping to identify contamination hotspots.
3. River Pollution Control and Eco-Restoration
Stop direct discharge of urban drains into Burhi Gandak and Kadane rivers; construct intercepting drains. Implement Riverfront Development Plans with green buffer zones, plantations, and walkways to protect banks. Promote community river watch groups (Nadi Rakshak Samiti) to monitor pollution sources and encroachments.
7.4 Institutional Strengthening and Governance
Objective: Build robust administrative, legal, and community frameworks for water governance.
1. Integrated District Water Resource Authority (IDWRA)Establish a coordinating body comprising representatives from CGWB, PHED, Agriculture, Municipal Corporation, and NGOs. This authority will plan, monitor, and enforce policies on groundwater use, drainage, and pollution control.
2. Policy and Legal Reforms
Enforce Groundwater Extraction Permits and regulate private borewells in urban and peri-urban areas. Make rainwater harvesting mandatory in new construction projects. Include water audit and reporting as part of district development planning.
3. Capacity Building and Data Integration
Train local officials and panchayat members in water budgeting, GIS monitoring, and aquifer management. Integrate datasets from CGWB, Remote Sensing Centre, and IMD for holistic planning. Promote academic collaboration with R.B. College and L.N. Mithila University for research-based monitoring.
7.5 Climate-Resilient and Future-Oriented Planning
Objective: Build adaptive water management systems to face climatic variability.
1. Climate Scenario Modelling
Use rainfall-runoff models and IMD projections to anticipate extreme flood or drought events.
Develop contingency plans for both surplus and deficit years.
2. Sustainable Agriculture and Water Nexus
Promote zero-budget natural farming (ZBNF) and organic methods to reduce chemical infiltration into water.
Encourage crop diversification with water-resilient species.

3. Green Infrastructure Integration
Develop urban green corridors connecting parks, ponds, and drains to enhance infiltration and reduce heat islands. Encourage household-level rain gardens and soak pits in colonies.
7.6 Community Participation and Awareness
Objective: Involve citizens as stakeholders in water management and conservation.
1. Community-Led Water Conservation
Organise Jal Chaupal (village water meetings) for participatory planning.
Train local youth as Jal Sainiks (water volunteers) to monitor rainwater harvesting and pond cleaning. Establish Village Water Committees under the Gram Panchayat Development Plan (GPDP).
2. Education and Awareness Campaigns
Introduce "Water Literacy" programs in schools and colleges. Launch district-wide awareness drives on saving water, waste segregation, and pollution prevention.
3. Revival of Traditional Knowledge Systems
Document indigenous practices of flood management, pond construction, and seasonal cropping used by local communities. Integrate traditional "ahars and pynes" (ancient irrigation channels) into modern water management schemes.
7.7 Technological and Mapping Innovations
Objective: Leverage modern technology for real-time monitoring, mapping, and management.
1. GIS-Based Water Resource Inventory
Develop district-level Geo-Portal showing rivers, aquifers, wetlands, borewell density, and land use. Use high-resolution Sentinel-2 or Landsat data for mapping waterlogged areas and seasonal changes.
2. Remote Sensing for Flood Early Warning
Install Automatic Weather Stations (AWS) and rainfall gauges at block level. Integrate IMD and ISRO data to issue early flood alerts to vulnerable villages.
3. Digital Water Governance. Use mobile apps for citizen reporting of water pollution, drainage issues, and illegal extraction. Encourage open data sharing among institutions and research bodies.
7.8 Economic and Policy Incentives
Objective: Encourage efficient water use through financial, technical, and policy instruments.
1. Incentivise Water-Efficient Technologies
Provide subsidies for drip/sprinkler systems and solar-powered irrigation pumps. Offer tax rebates for industries adopting zero-liquid-discharge (ZLD) systems.
2. Water Pricing and Rationalisation
Introduce volumetric pricing for groundwater-based urban water supply to promote conservation. Impose penalties on illegal borewells and wastage.
3. Public–Private–Community Partnerships (PPCP)
Engage local industries, NGOs, and academic institutions in CSR-driven water management projects. Encourage private investment in wastewater recycling and wetland conservation.
7.9 Research, Documentation and Continuous Assessment
Objective: Promote continuous research-based evaluation of water resources.1. Periodic Water Resource Assessment (every 5 years). Conduct district-level hydrogeological and water quality surveys at regular intervals. Use satellite imagery to track surface water shrinkage or expansion. 2. Documentation and Knowledge Repository. Develop an Open Water Data Archive of Muzaffarpur District containing all maps, research, and survey data. Encourage publication of annual "State of Water Resources in Muzaffarpur" reports.
Conclusion to Recommendations
The above framework aims at transforming Muzaffarpur into a "Water-Resilient District" through integration of scientific mapping, institutional capacity, traditional wisdom, and community participation. The implementation of these recommendations requires inter-departmental coordination, consistent monitoring, and active involvement of local stakeholders. Only through such an integrated geographical approach can the district ensure long-term water security, ecological stability, and socio-economic sustainability.
8. Conclusion
Muzaffarpur District enjoys relatively good water resource endowments (surface and groundwater) due to its alluvial terrain and river network. However, utilisation and sustainability remain challenged by flooding, drainage issues, groundwater quality and over-abstraction, and infrastructure deficits. A geographically informed, map-based planning approach along with institutional strengthening and community action will be essential to manage water resources sustainably in the coming decades.

References

1. Agarwal, A., & Narain, S. (1997). Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems. Centre for Science and Environment.
2. Ahmad, E. (1971). Geomorphology of the Ganga Plain. Indian Journal of Geomorphology, 2(1), 1–12.
3. Bhattacharya, A. K. (2010). Groundwater Quality in the Ganga Alluvial Plain of Bihar, India. Environmental Monitoring and Assessment, 166(1–4), 251–262.
4. Central Ground Water Board (CGWB). (2023). Ground Water Year Book – Bihar. Ministry of Jal Shakti, Government of India.
5. Central Water Commission (CWC). (2022). Water and Related Statistics. Government of India.
6. Census of India. (2011). District Census Handbook: Muzaffarpur. Registrar General and *Census Commissioner, India.
7. Chakraborty, S., & Das, P. (2019). Assessment of Groundwater Quality Using GIS Techniques: A Case Study from North Bihar Plains. Journal of Water and Land Development, 43(1), 45–53.
8. Das, N. (2017). Hydrological and Geographical Study of River Baya in North Bihar. Indian Geographical Journal, 92(2), 87–102.
9. Ghosh, A., & Singh, R. B. (2020). GIS-Based Evaluation of Water Resource Vulnerability in Flood-Prone Regions of Bihar, India. Geographical Review of India, 82(1), 65–79.
10. Government of Bihar. (2022). Bihar Economic Survey 2021–22. Finance Department, Govt. of Bihar.
11. Jha, M. K., & Sinha, R. (2008). Natural and Anthropogenic Factors Affecting Groundwater Quality in the Middle Ganga Plain, India. Hydrological Processes, 22(14), 2073–2087.
12. Joshi, A. (2015). Water Resources Management in Bihar: Challenges and Opportunities. Indian Journal of Regional Science, 47(2), 101–113.
13. Khatun, F., & Kumar, R. (2018). Impact of Urbanization on Surface and Ground Water Quality in Muzaffarpur District, Bihar. Journal of Environmental Research and Development, 12(4), 953–959.
14. Kumar, D., & Sharma, S. (2020). Spatial Assessment of Groundwater Quality Using GIS in North Bihar. Sustainable Water Resources Management, 6(2), 27–38.
15. Kumar, R. (2016). Water Resources and Flood Hazard in North Bihar. Indian Journal of Geography and Environment, 13(2), 233–245.
16. Kumar, S., & Singh, J. (2021). A Study on River Pollution and Its Impact on Local Livelihoods: A Case of Muzaffarpur District, Bihar. International Journal of Environmental Sciences, 10(3), 199–212.
17. Mishra, S. (2022). Hydrological Behavior of River Kadane and Its Socio-Economic Significance. Bihar Geographical Review, 14(1), 45–60.
18. Mukherjee, S., & Bandyopadhyay, J. (2019). Water Crisis in India: Challenges and Policy Perspectives. Routledge.
19. National Water Mission. (2023). State Water Resources Report: Bihar. Ministry of Jal Shakti, Govt. of India.
20. NDMA. (2021). Bihar Flood Management Plan. National Disaster Management Authority, Govt. of India.
21. Pandey, A., & Singh, V. P. (2018). Hydrological Modeling of the Ganga Basin Using Remote Sensing and GIS. Springer.
22. Planning Commission. (2011). Report on Water Resources of Eastern India. Government of India.
23. Saha, S., & Roy, P. (2017). Water Quality Assessment and Management in Flood-Prone Regions of Bihar Using GIS and Remote Sensing. Applied Water Science, 7(6), 3221–3232.
24. Sinha, R., & Jain, V. (2013). Flood Hazards of North Bihar Rivers, India: Frequency and Magnitude Analysis. Natural Hazards, 68(2), 621–639.
25. Singh, A. K. (2017). Hydrogeochemical Evaluation of Groundwater Quality in Ganga–Ghaghara Doab, Bihar. Environmental Earth Sciences, 76(3), 142–156.
26. Singh, R. B. (2001). Environmental Consequences of Agricultural Development: A Case Study from the Green Revolution State of Haryana, India. Agriculture, Ecosystems & Environment, 82(1–3), 97–103.
27. Singh, S. (2018). Geographical Perspective of Water Resource Utilization in North Bihar Plains. The Geographer, 65(2), 75–88.
28. UNDP. (2020). Water Resource Management and SDGs in India. United Nations Development Programme.
29. UNESCO. (2021). World Water Development Report: Valuing Water. UNESCO Publishing.
30. World Bank. (2023). Bihar: Water Resource Development and Management Strategies. World Bank Publications.