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A Critical Study of the Kaliaghai-Kapaleshwari-Bagui Project and Its Consequences for Water Management in the Moyna Basin, West Bengal, India

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Abstract: *The Moyna basin of East Midnapore, located in the lower deltaic plain of coastal West Bengal, has historically been prone to prolonged floods and prolonged inundation. Prior to 2010, a combination of low channel capacity, heavy sedimentation, structural barriers and tidal backwash caused annual or near-annual floods lasting 15-40 days. The Kaliaghai-Kapaleshwari-Bagui (KKB) project (2010) was initiated in collaboration with the West Bengal government and the central government as a major basin-scale intervention that included river dredging, embankment strengthening, channel widening and rehabilitation of tributary networks. This study critically examines the hydrological, geomorphological and socio-economic consequences of the project using household surveys, flood records, rainfall statistics, satellite observations and secondary data from the state irrigation department, comparing the pre- and post-2010 situations. The findings show a significant reduction in flood duration and water stagnation-typically 15-30 days before 2010 to 3-7 days after 2011, and a significant reduction in flood frequency. Despite these achievements, new challenges are emerging: rapid sediment deposition in low-lying areas, tidal barriers, persistent man-made barriers (bamboo bridges, fishing nets), and reduced transport capacity in distributary rivers. The paper argues that the KKB project has successfully reduced the risk of major floods, but its long-term sustainability depends on continued dredging, improved sediment management, catchment-wide planning, and community-cantered water management strategies. The study provides policy recommendations to ensure a resilient hydrological management in the Moyna basin.*

Keywords: *Moyna Basin, flood management, water stagnation, deltaic rivers, KKB Project, West Bengal.*

1. Introduction

The Moyna basin, located between the Kaliaghai, Chandia and Kangsabati rivers, is one of the most geomorphologically sensitive and hydrologically complex (Nasrabad et al. 2025; Cacciuttolo et al. 2025; Biswas and Mondal, 2024; Mondal et al., 2025a, 2025b, 2025c 2025d) floodplains in coastal West Bengal. Historically, it has been susceptible to prolonged flooding due to its bowl-shaped topography, very gentle gradients and the interaction between seasonal flows and tidal backwaters (Dwivedi and Sreenivas, 2002; Amarasinghe, 2009; Rudra, 2002; Sahu, 2014; Gayen, 2022; Mondal and Biswas, 2022; Majumdar et al., 2022; Wang et al. 2025; Sahoo et al. 2025; Fadiel et al. 2025). Before 2010, intense rainfall in the upper catchment regularly exceeded the drainage capacity of the basin, leading to breaching of embankments (Acharya et al., 2010; Sahu, 2014; Bandyopadhyay, 2015; Biswas and Mondal, 2024), subsidence of water tables, destruction of crops and displacement of rural households in low-lying areas. The rivers draining the basin have suffered severe morphological degradation, characterized by: rapid siltation and bed degradation, narrowing due to encroachment, inefficient drainage during spring tides, structural barriers such as low-lying road and rail bridges, artificial barriers from culverts, bamboo bridges, fishing nets and sluice gates. These factors collectively create permanent water logging (Dwivedi and Sreenivas, 2002; Amarasinghe, 2009; Acharya et al., 2010; Sahu, 2014; Samanta et al., 2018; Mondal and Biswas, 2022; Majumdar et al., 2022; Gayen, 2022; Mondal, 2025; Wang et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Sahoo et al. 2025; Fadiel et al. 2025) of 15-40 days annually, which affects the agricultural calendar, rural livelihoods, infrastructure and market connectivity. Realizing the seriousness of the situation, the Government of West Bengal and the Ministry of Water Resources launched the KKB Flood Management Project in 2010 under the Centrally Assisted Flood Management Programme. The project included large-scale river restoration work, which mainly involved dredging (Dwivedi and Sreenivas, 2002; Bandyopadhyay, 2015; Nasrabad et al. 2025; Fadiel et al. 2025; Cacciuttolo et al. 2025) of major rivers Kaliaghai, Kharika, Kapaleswari, Bagui and Chandia. Besides, desilting of tributaries like Deuli, Sundarpur, Shiulipur, Amrakhali, Kalimondap, Katakhali, Ganapath, Uttarbarh, Panchali, Chabukia, Madhabchak, Debikhali-Khidirpur, Denredighi, Golapata and Shilakhali and re-alignment of embankments (Sahu, 2014; Biswas and Mondal, 2024) in Sabang, Moyna and adjoining blocks. Since the completion of major dredging phases in 2011-2013, local reports indicate a dramatic improvement in drainage efficiency. However, recent evidence indicates a gradual return of sedimentation, changes in hydrodynamics and water stagnation (Plan, 2004; Molle, 2005; Huang et al. 2008; Hailin et al. 2009; Acharya et al., 2010; Pandey et al. 2010; Suriya and Mudgal 2012; Wang et al. 2011; Kienberger 2012; Roy and Dhar, 2024; Mondal, 2025; Nasrabad et al. 2025; Cacciuttolo et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d) in some parts of the basin. Therefore, this study critically assesses the hydrological and management implications of the KKB project to determine its long-term viability, constraints and sustainability.

Flooding in the coastal region of West Bengal has received considerable academic attention due to its association with deltaic geomorphology, high population density and climate variability (Rudra, 2002; Acharya et al., 2010; Mondal and Biswas, 2022; Nasrabad et al. 2025; Cacciuttolo et al. 2025). The Moyna basin has been studied specifically for its chronic flooding and waterlogging challenges (Dwivedi and Sreenivas, 2002). Sahu, (2014) and Gayen, (2022) and Wang et al. (2025) and Sahoo et al. (2025) identified that the basin's low-lying, bowl-shaped morphology and tidal influence create inherent drainage constraints (Mondal and Biswas, 2022; Mondal, 2025). Using GIS-based flood mapping (Plan, 2004; Molle, 2005; Amarasinghe, 2009; Wang et al. 2011; Acharya et al., 2010; Sahu, 2014; Samanta et al., 2018;

Majumdar et al., 2022; Gayen, 2022; Roy and Dhar, 2024; Islam, K., et al., 2024; Mondal et al., 2025a, 2025b, 2025c 2025d; Nasrabad et al. 2025; Cacciuttolo et al. 2025), he showed how rainfall accumulation in concave depressions, independent of external overbank flooding, leads to persistent waterlogging (Dwivedi and Sreenivas, 2002). Samanta et al. (2018) constructed flood susceptibility maps using geospatial frequency ratio models, highlighting how DEM-derived geomorphological indicators indicate flood propagation in a deltaic environment. Such an approach has been applied to the Moyna basin to identify pre- and post-project waterlogging zones (Dwivedi and Sreenivas, 2002). Research by Acharya et al. (2010) and Banerjee, (2015) emphasizes the role of geoinformatics and community preparedness in improving flood management outcomes in rural Bengal. Their work emphasizes the importance of integrating structural and non-structural measures. (Plan, 2004; Molle, 2005; Acharya et al., 2010; Barman, 2021; Majumdar et al., 2022; Mondal and Biswas, 2022; Mondal, 2025; Wang et al. 2025; Sahoo et al. 2025) observed that no major flood events occurred in the Kaliaghai-Kapaleshwari-Bagui basin after 2008, indicating the initial effectiveness of the KKB project. However, (Majumdar et al., 2022; Nasrabad et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Cacciuttolo et al. 2025), studying the adjacent blocks, reported that vulnerabilities remain due to sediment mobility, dam failure, and land use change. Although separate studies discuss waterlogging, disaster management, and basin hydrology, there is no comprehensive assessment explicitly focusing on the long-term hydrological impact of the 2010 KKB project, particularly on comparative pre- and post-project flood regimes (Bandyopadhyay, 2015; Samanta et al., 2018; Biswas and Mondal, 2024; Mondal, 2025; Fadiel et al. 2025), sediment trends, and community-perceived effectiveness. The present study fills this gap by integrating hydrological data, field surveys, rainfall records, and geomorphological analysis to critically assess the consequences of the KKB project on water management in the Moyna Basin.

2. Study Area

The Moyna basin, located in Purba Medinipur district, extends from about 22°40' N to 87°50' E (Figure 1). The basin is mainly drained by the Kaliaghai River in the south, the Chandia River in the north-central and the Kangsabati River in the east. These rivers exhibit a mixed flow-tidal nature, with the upstream monsoon flow interacting with the diurnal tidal oscillations of the Bay of Bengal.

The elevation is 3-10 m above mean sea level, the topography is a saucer-shaped basin with an internal depression, the climate is mainly tropical monsoon, the average annual rainfall is 1,400-1,600 mm, alluvial soil, fine silt soil prone to water stagnation (Plan, 2004; Molle, 2005; Huang et al. 2008; Hailin et al. 2009; Pandey et al. 2010; Suriya and Mudgal 2012; Wang et al. 2011; Kienberger 2012; Bandyopadhyay, 2015; Samanta et al., 2018; Majumdar et al., 2022; Biswas and Mondal, 2024; Roy and Dhar, 2024; Mondal et al., 2025a, 2025b, 2025c 2025d; Mondal, 2025; Nasrabad et al. 2025; Cacciuttolo et al. 2025; Wang et al. 2025; Sahoo et al. 2025), land use is mainly agriculture (paddy, betel, vegetables, fisheries), scattered settlements, hydrology is highly sensitive to rainfall variations and tidal backwash. The basin contains 84 villages, which are heavily dependent on agriculture, fishing, and seasonal labour. Historically, annual floods have caused crop losses, migration, infrastructure disruption, and significant economic hardship. This geographic and socio-economic structure makes this region an ideal example for studying the long-term effects of large-scale flood management interventions.

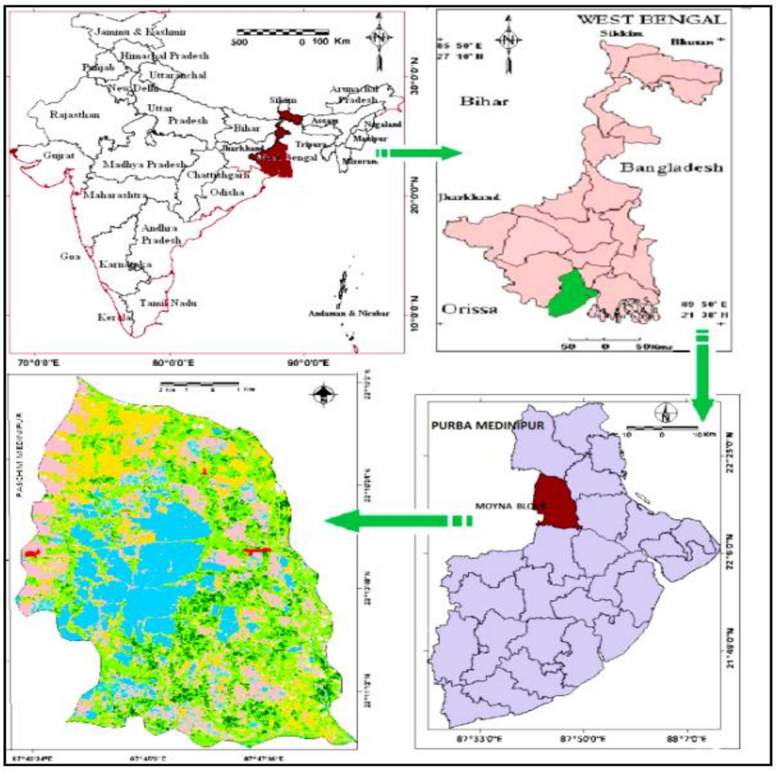

Fig. 2: The Location Map of the Moyna Basin

3. Data Source and Methodology

This study used a mixed methodology to integrate primary and secondary data using both quantitative and qualitative tools.

3.1 **Primary Data**: A total of 17 representative villages of the Moyna basin were surveyed in a household survey. BDMO (Moyna, Block Disaster Management Officer), Irrigation Officer, Embankment Supervisor, Panchayat member, farmer and jailer were used to interview key informants. Canal depth measurements, sedimentation patterns, condition of embankments (Sahu, 2014) and man-made obstacles were observed.

3.2 **Secondary Data**: Flood records of Irrigation and Waterways Department of Kaliaghai-Kapaleshwari-Baghai (KKB) Project Division (2000-2020), River level records from Temathani (Table 1) Rainfall data from IMD Observatory, SOI Topographic Sheet (73N/11, 73N/12, 73N/15, and 73N/16 R.F. = 1 : 50,000; year: 1970, 1972, 1973 and 1976) and Cadastral Map, the Comptroller and Auditor General's (CAG, 2020; Nasrabad et al. 2025; Cacciuttolo et al. 2025) performance audit on flood control projects in West Bengal, Satellite Imagery (Landsat, Sentinel-2, Google Earth), Project Report (2010-2018) and Government Annual Report, Academic literature on basin hydrology and flood management. Calculation of flood frequency, duration and magnitude. Regression analysis between rainfall intensity and flood occurrence. Temporal framework the analysis was divided into the following three phases, namely- (a) pre-project period: 2001-2009, (b) Implementation phase: 2010-2013 and (c) post-project stabilization period: 2014-2020.

Table 1: Secondary Data and their Source

Data collected	Description of the data	Year	Source
Water Velocity Data	Digital Current Meter (Revolutions/40 Sec.)	2022, 2023	Field Survey
Household data	Flood Impact and Flood adaptation	2022, 2023	Field Survey
Topographical Map	73N/11, 73N/12, 73N/15, and 73N/16 R.F. = 1: 50,000	1970, 1972, 1973 and 1976	Survey of India
Flood data	Frequency of flood, Level of flood water, Causes of flood etc	2000 to 2022	Kaliaghai Kapaleswari Baghai Project Division Office (https://wbiwd.gov.in/uploads/tender/ten)
Satellite images	Landsat 7, ASTER GDEM V 3.0 data	2008, 2011 and 2021	United States Geological Survey (USGS) (https://www.usgs.gov)
Satellite images	Remote sensing data, IIRS P6/sensor LISS-III	2008, 2011 and 2021	Bhuvan Indian Geo-platform of ISRO (www.bhuvan.nrsc.gov.in)
Rainfall data	Purba Medinipur District and Paschim Medinipur District	2008-2021	Internet (https://wbiwd.gov.in)
Census report	Purba Medinipur District and Paschim Medinipur District	2011	Census of India (https://censusindia.gov.in)
District Disaster Management Plan	Purba and Paschim Medinipur District, Rainfall, Flood Data	2017 to 2022	Internet (http://wbdmd.gov.in)
Flood Inundation Map	Annual flood layers	2008, 2011 and 2021	Bhuvan Indian Geo-platform of ISRO (www.bhuvan.nrsc.gov.in)

3.3 Methodology: This study uses a mixed methodology based on document review, geospatial analysis, and field-based assessment to assess the hydrological and institutional impacts of the 2010 KKB project in the Moyna basin. Specifically, we first conducted a forensic review of the Detailed Project Report (DPR), construction and payment records, and the Comptroller and Auditor General's (CAG, 2020) performance audit on flood control projects in West Bengal to reconstruct design objectives, deviations, and maintenance plans. Then, using multi-temporal remote sensing (Landsat/Sentinel) and GIS (Plan, 2004; Molle, 2005; Amarasinghe, 2009; Acharya et al., 2010; Wang et al. 2011; Sahu, 2014; Bandyopadhyay, 2015; Majumdar et al., 2022; Gayen, 2022; Mondal and Biswas, 2022; Roy and Dhar, 2024; Islam, et al., 2024; Biswas and Mondal, 2024; Mondal, 2025; Nasrabad et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Cacciuttolo et al. 2025; Wang et al. 2025; Sahoo et al. 2025), we generated flood-sensitivity and flood-risk maps for the Kaliaghai and Moyna systems, applying bi-geographic statistical models-frequency ratios, Shannon entropy, and information value-according to established methods in the literature. Predictor variables include elevation, slope, geomorphic moisture, drainage density, NDVI, land use, rainfall, and stream power. A flood-point list (from BHUVAN) was used in validation along with ROC curve analysis. We performed analytical-hierarchy-process (AHP) based multi-criteria decision making (using elevation, slope, and use etc.) to identify long-term flood footprints (Dwivedi and Sreenivas, 2002; Plan, 2004; Molle, 2005; Amarasinghe, 2009; Sahu, 2014; Samanta et al., 2018; Roy and Dhar, 2024; Islam, et al., 2024; Mondal, 2025; Wang et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Sahoo et al. 2025; Nasrabad et al. 2025; Cacciuttolo et al. 2025). Finally, field-level cross-sections, bathymetry, and hydraulic measurements were combined with the above to explain whether the observed morphological and flood-spread changes were consistent with documented project implementation errors.

4. Results and Discussion

4.1 Duration of Water Stagnation

Table 2: Year wise Water Stagnation Duration in Moyna Basin (2001-2020)

Year	Stagnation Days	Average Days	Year	Stagnation Days	Average Days
2001	25-29	27	2011	10-14	12
2002	28-32	30	2012	5-9	7
2003	15-19	17	2013	11-15	13
2004	40-44	42	2014	2-6	4
2005	27-31	29	2015	1-2	1
2006	35-39	37	2016	0	0
2007	33-37	35	2017	0	0
2008	43-47	45	2018	0	0
2009	19-23	21	2019	7-11	9
2010	18-22	20	2020	0	0

An assessment of historical flood records shows a clear change in flood patterns in the Moyna basin before and after the implementation of the KKB project in 2010 (Table 2). Prior to this intervention, prolonged flooding was a recurring hazard (Plan, 2004; Molle, 2005; Huang et al. 2008; Hailin et al. 2009; Pandey et al. 2010; Suriya and Mudgal 2012; Wang et al. 2011; Kienberger 2012; Roy and Dhar, 2024; Mondal et al., 2025a, 2025b, 2025c 2025d; Nasrabad et al. 2025; Cacciuttolo et al. 2025; Mondal, 2025). The floods of 2004 and 2008 caused water stagnation for 40 days or more, whereas the severe floods of 2001, 2002, 2005, 2006 and 2007 caused continuous water stagnation for more than 30 days (Figure 2). This long duration reflects the highly silted river system with insufficient river transport capacity and inadequate drainage.

According to government project records, the average flood duration before 2011 was 30 days or more, indicating chronic drainage inefficiency. However, after the large-scale dredging and channel rehabilitation began, there was a sharp decline: after 2011, the average flood duration decreased to about 7 to 8 days. This improvement is further supported by the technical observations of the Executive Engineer of the KKB Project Department (CAG, 2020; Nasrabad et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Cacciuttolo et al. 2025). During the 2013 monsoon, there was 35% more rainfall than normal, which was 46% more than the 2011 rainfall-yet the water level was 1 meter lower than the peak level of the 2011 flood. Most notably, before 2011, the flood water was above the danger level for an average of 261 hours, but after dredging, it exceeded the danger level for only 4 hours in 2013. This trend continued in subsequent years: no water stagnation (Dwivedi and Sreenivas, 2002; Plan, 2004; Molle, 2005; Huang et al. 2008; Amarasinghe, 2009; Hailin et al. 2009; Pandey et al. 2010; Suriya and Mudgal 2012; Wang et al. 2011; Kienberger 2012; Bandyopadhyay, 2015; Majumdar et al., 2022; Biswas and Mondal, 2024; Roy and Dhar, 2024; Nasrabad et al. 2025; Cacciuttolo et al. 2025) events were observed in 2015, 2016, 2017, 2018 or 2020. However, minor water logging was observed in 2011, 2013 and 2019. These results collectively indicate a significant improvement in the drainage efficiency and hydrological responsiveness of the basin after the project (KKB, 2010). A complete analysis and chart of waterlogging (2001-2020) in the Moyna basin is presented. The graph clearly shows a strong decreasing trend after the KKB project of 2010, which is consistent with the research argument as a right step towards improved drainage and flood management (Abulgaziev et al. 2024; Biswas and Mondal, 2024). Thus, the project reduced the water stagnation (Plan, 2004; Molle, 2005; Huang et al. 2008; Hailin et al. 2009; Suriya and Mudgal 2012; Kienberger 2012; Wang et al. 2011; Pandey et al. 2010; Samanta et al., 2018; Majumdar et al., 2022; Mondal, 2025; Nasrabad et al. 2025; Cacciuttolo et al. 2025) duration by 60-80%, indicating major improvement in channel conveyance capacity.

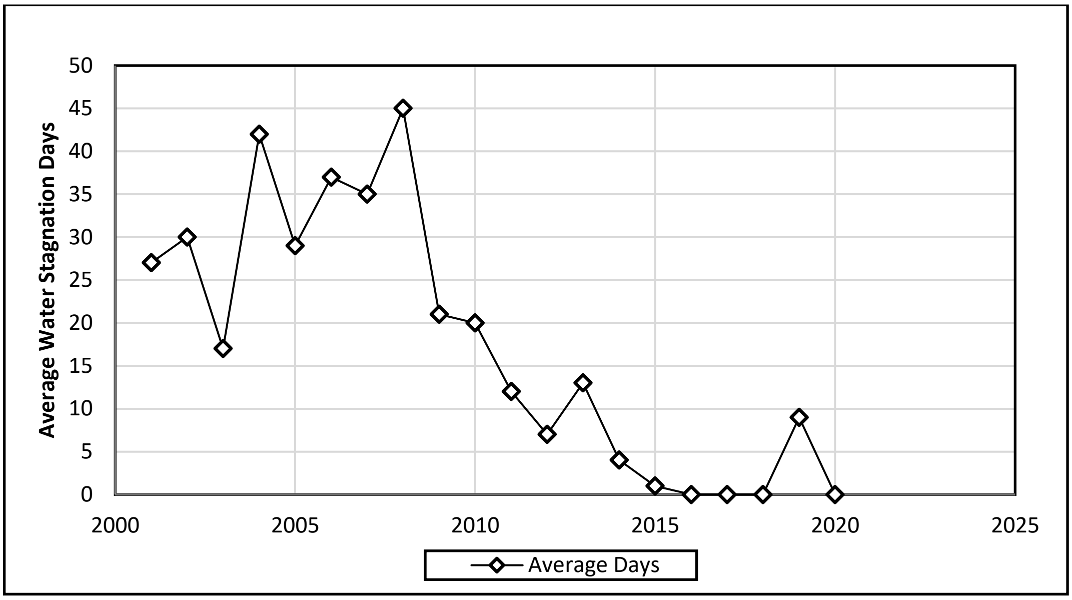

Fig. 2: Water Stagnation Duration in Moyna Basin (2001-2020)

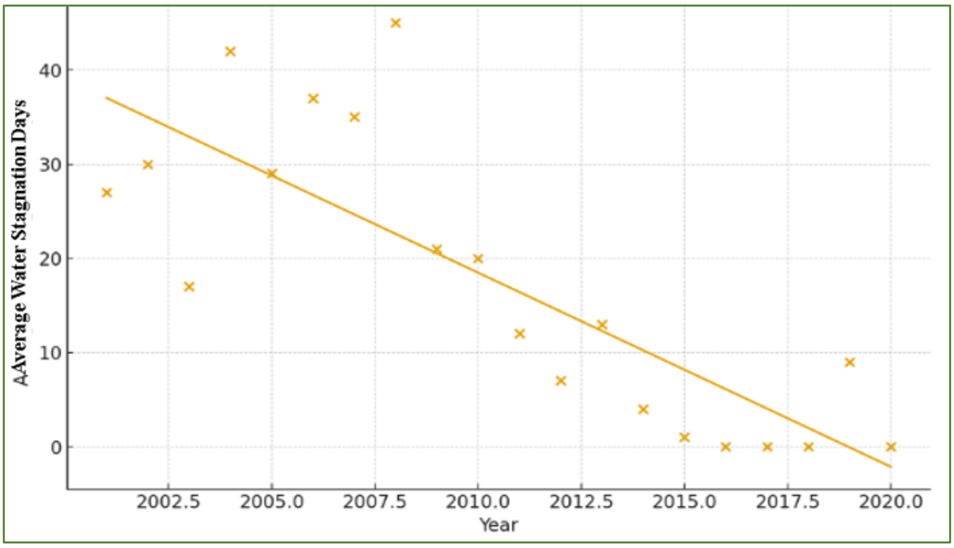

Fig. 3: Trend Line for Water Stagnation in Moyna Basin (2001-2020)

4.2 Flood frequency in the study area

A long-term review of flood events since 2001 further reinforces the significant changes in the flood regime (Sahu, 2014; Fadiel et al. 2025; Nasrabad et al. 2025; Cacciuttolo et al. 2025) of the basin. Before 2010, the Moyna basin experienced almost annual floods or prolonged inundation lasting more than 30 days on average. Recorded floods occurred in 2001, 2002, 2004, 2005, 2006, 2007 and 2008, with particularly severe floods in 2004 and 2008. Floods were also recorded in 2009 and 2010, affecting the Kaliaghai and Chandia rivers adjacent to the basin In 2008, a dam breach on the right bank of the Kaliaghai river caused severe flooding in a large part of the districts of Patashpur-1, Patashpur-2, Bhagwanpur-1, Bhagwanpur-2, Deshpraan, Chandipur, Egra-1. Floods also occurred in the entire Sabang block and the Moyna basin on the left bank of the Kaliaghai river. This incident highlights the urgent need for structural mitigation measures (Amarasinghe, 2009; Sahu, 2014; Mondal and Biswas, 2022; Gayen, 2022; Abulgaziev et al. 2024; Mondal et al., 2025a, 2025b, 2025c 2025d; Fadiel et al. 2025). As a result, in 2010, the central and state governments jointly undertook a comprehensive flood management initiative at a cost of Rs 633 crore, which included the re-drainage of the Kaliaghai, Kapaleshwari, Bagui and Chandia rivers and several tributaries including Deuli, Sundarpur, Shiulipur, Amrakhali, Kalimondap, Katakhali, Ganapath, Uttarbarh, Panchali, Chabukia, Madhabchak, Debikhali-Khidirpur, Denredighi, Golapata and Shilakhali. Significant improvements have been seen since the intervention. After the 2008 disaster, the basin has not seen any major floods. Although some local, short-term floods still occur, they do not escalate into large-scale floods. The comprehensive rehabilitation programme carried out between 2010 and 2020 under the government's flood management programme has significantly increased the channel capacity and reduced the intensity of floods (Dwivedi and Sreenivas, 2002; Biswas and Mondal, 2024; Abulgaziev et al. 2024). As observed by Acharya et al. (2010) and Barman (2021), the restored Kaliaghai river now plays a central role in regional flood control. The basin has shifted from a high-frequency flood regime (Mondal, 2025; Fadiel et al. 2025) to a low-frequency, low-intensity regime (Acharya et al., 2010; Samanta et al., 2018; Majumdar et al., 2022; Mondal et al., 2025a, 2025b, 2025c 2025d; Nasrabad et al. 2025; Cacciuttolo et al. 2025).

Table 3: Year wise Flood Frequency in Moyna Basin

Year	Flood	Frequency/year	Year	Flood	Frequency/year
2001	Flood	1	2011	No flood	0
2002	Flood	1	2012	No flood	0
2003	No flood	0	2013	Flood	1
2004	Devastating flood	2	2014	No flood	0
2005	Flood	1	2015	No flood	0
2006	Flood	2	2016	No flood	0
2007	Flood	1	2017	No flood	0
2008	Devastating flood	1	2018	No flood	0
2009	Flood	1	2019	Flood	1
2010	Flood	1	2020	No flood	0

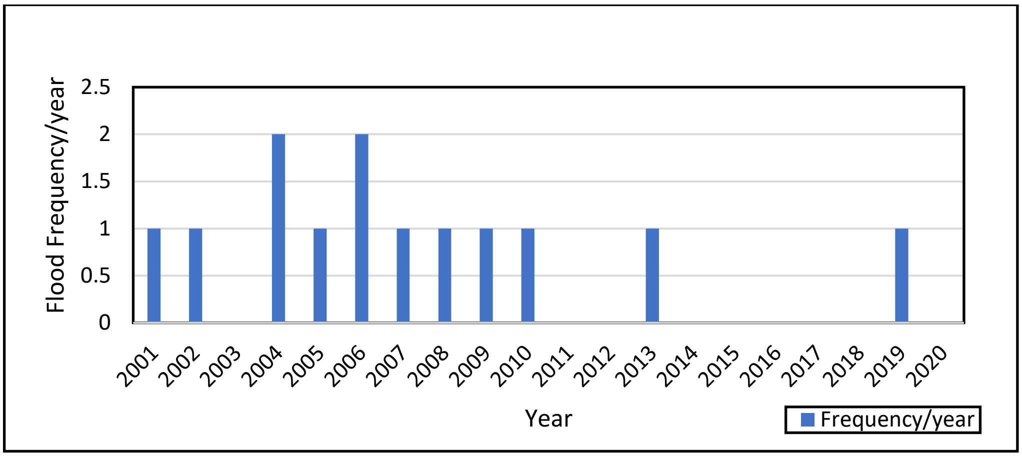

Fig. 4: Flood Frequency/year in Moyna Basin (2001-2020)

4.3 Hydrological Improvements After Dredging:

Dredging of Kaliaghai and Kapaleshwari-Bagui rivers under KKB project- increased canal depth by 2-4 meters at many places, widening of canals in the blocked areas, improved drainage in Chandia and lower floodplains (Abulgaziev et al. 2024), reduced upstream flow during peak discharge, increased efficiency of tidal water drainage (Rudra, 2002; Plan, 2004; Molle, 2005; Amarasinghe, 2009; Acharya et al., 2010; Majumdar et al., 2022; Mondal, 2025; Wang et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Sahoo et al. 2025; Nasrabad et al. 2025; Cacciuttolo et al. 2025). These changes significantly reduced (Bandyopadhyay, 2015; Abulgaziev et al. 2024; Mondal, 2025) the accumulation of stormwater during monsoons.

4.4 Sedimentation-the New Emerging Problem:

Despite initial success, sedimentation has started to accumulate again, low banks are located near the intersection of the tides, rapid sedimentation is occurring in areas blocked by bamboo bridges and nets, the distributary channel has started to narrow (Acharya et al., 2010; Sahu, 2014), upstream banks are affected due to uncontrolled land use practices. Field observations have shown that the level has risen by 0.25-0.80 meters in some parts between 2016 and 2020. This poses a threat to the long-term sustainability of the project.

4.5 Role of Anthropogenic Obstructions

More than 23 bamboo culverts, fishing nets, temporary check dams and informal river crossings by boats obstruct sediment movement and reduce flow velocity (Abulgaziev et al. 2024; Mondal, 2025). These structures encourage local sediment deposition, create artificial backwater effects, obstruct debris movement (Acharya et al., 2010; Barman, 2021; Mondal, 2025), and impede navigation and water transport. Without community awareness and enforcement, these obstructions will compromise the benefits of the KKB project.

4.6 Interaction with Tidal Dynamics

The lower Moyna basin interacts with the Kaliaghai-Haldi-Bay of Bengal tidal system. During spring tides, water cannot effectively exit the basin, the tidal backwash slows the river's drainage, and the silt carried from upstream deposits in the lower reaches is a major hydrogeological challenge (Sahu, 2014; Samanta et al., 2018; Majumdar et al., 2022; Biswas and Mondal, 2024; Abulgaziev et al. 2024; Mondal, 2025; Mondal et al., 2025a, 2025b, 2025c 2025d) that simple dredging cannot fully address.

4.7 Socio-Economic Effects of the Project

(a) Positive Outcomes:

- Restoration of timely agricultural cycles.
- Reduced risk of crop damage.
- Improved access to markets and services.
- Increased household resilience.
- Reduced need for temporary migration.
- Higher agricultural productivity due to reduced waterlogging.

(b) Remaining Concerns:

- Localized waterlogging of low-lying rice fields continues.
- Sedimentation poses a threat to long-term flood protection.
- Embankment encroachment continues.
- Fisheries-related disruptions remain widespread.

5. Findings

- Flood duration has decreased from an average of 30-35 days (before 2010) to an average of
- 7-8 days (after 2011).
- Flood frequency has decreased dramatically, with no major floods occurring between 2010 and 2020.
- Dredging has significantly increased water carrying capacity, but without maintenance this benefit may decline.
- Sedimentation is rapidly accumulating, especially in the riverbed.
- Human encroachment remains a serious problem.
- The project, while successful, is not structurally self-sustaining; it requires institutional and community oversight.

6. Policy Recommendations

- Regular dredging cycle: A 5-year rolling dredging policy should be introduced.
- Sediment governance framework: Soil conservation upstream should be implemented.
- Barrier removal: The number of bamboo bridges should be reduced; fishing nets and illegal encroachment should be controlled.
- Improved embankment management: Strong monitoring and maintenance of embankment lines is required.
- Water-monitoring stations: Real-time water-level sensors and rainfall-flow monitoring systems should be installed.
- Community-based flood management: Village committees should monitor minor channels and barriers.
- Integration with tidal river management (TRM): To address tidal backflow-induced siltation.

- Flood-resilient agriculture: Short-duration rice varieties and integrated farming systems should be introduced.

7. Limitations

7.1 Limited Availability and Reliability of Hydrological Data

A major limitation of the study is the inadequate availability of long-term, high-resolution hydrological and geomorphological data for the Moyna Basin. Many government records are either fragmented, outdated, or not publicly accessible, which constrains precise assessment of pre- and post-project changes in river discharge, sediment load, and drainage efficiency. This data gap may lead to partial interpretation of the actual impacts of the Kaliaghai-Kapaleshwari-Bagui Project on flood dynamics and water management.

7.2 Insufficient Consideration of Local Socio-Environmental Variability

The study area exhibits significant spatial heterogeneity in terms of land use, elevation, drainage congestion, and community adaptation practices. However, capturing this micro-level variability across the entire Moyna Basin is challenging within a limited research framework. As a result, the findings may not fully represent localized experiences of waterlogging, flood vulnerability, and livelihood impacts, thereby affecting the generalization of conclusions regarding the project’s effectiveness.

8. Conclusion

The Kaliaghai-Kapaleshwari-Bagui project (2010) is one of the most effective flood mitigation measures (Sahu, 2014; Samanta et al., 2018; Mondal and Biswas, 2022; Majumdar et al., 2022; Gayen, 2022; Mondal et al., 2025a, 2025b, 2025c 2025d; Mondal, 2025; Fadiel et al. 2025) undertaken in coastal West Bengal. Its immediate results were transformative: the frequency and duration of floods have been dramatically reduced (Dwivedi and Sreenivas, 2002; Biswas and Mondal, 2024; Abulgaziev et al., 2024), agricultural stability has improved, and community resilience has increased. However, the long-term hydrological behaviour of the delta system suggests that the project’s benefits may create adverse effects if not continuously maintained. Sedimentation, tidal barriers, and human-induced disturbances are re-emerging threats that, if neglected, could restore the pre-2010 flood regime (Dwivedi and Sreenivas, 2002; Bandyopadhyay, 2015; Samanta et al., 2018; Majumdar et al., 2022; Biswas and Mondal, 2024; Abulgaziev et al. 2024; Mondal, 2025; Fadiel et al. 2025; Mondal et al., 2025a, 2025b, 2025c 2025d; Nasrabad et al. 2025; Cacciuttolo et al. 2025). Therefore, the future of water security in the Moyna basin depends on sustainable investment, integrated reservoir management, modern monitoring systems, and active community participation. One-time interventions cannot guarantee permanent flood control in a dynamic deltaic environment; only continuous scientific management can do so.

References

Abulgaziev, A., Zhumagaziev, A., Kurbaniyazov, S., & Saburova, N. (n.d.). *Geomorphological analysis of river systems in the Sauran district under arid climate conditions*.

Acharyya, N., Maiti, S., & Bandyopadhyay, J. (2010). Modelling flood of Patashpur-I Block in Purba Medinipur, West Bengal using geoinformatics. *Indian National Cartographic Association*.

Amarasinghe, U. A. (2009). *Strategic analysis of India's river linking project*. International Water Management Institute (IWMI).

Bandyopadhyay, J. (2015). *Environmental hydrology in deltaic rivers of eastern India*. Atlantic Publishers.

Barman, R. (2021). *Impact assessment of the Kaliaghai River dredging programme*. Retrieved from http://www.keleghai.in

Biswas, B., & Mondal, N. (2024). *Impact of Kaliaghai, Kapaleshwari and Bagui Project-2010 over Moyna Basin*.

Comptroller and Auditor General of India. (2020). *Performance audit: Flood management programme / flood control measures in West Bengal*.

Consequences of the 2021 Floods in the Kaliaghai River Basin, West Bengal. Mondal, N., Kar, S., Hussain, I., Farooq, A., & Ahmed, P. (2025c). The Impact of Kaliaghai River Flood (2021): A Detailed Study of Socio-Economic and Environmental Consequences in West Bengal

Dwivedi, R. S., & Sreenivas, K. (2002). Vegetation and waterlogging dynamics derived from spaceborne multispectral and multitemporal data. *International Journal of Remote Sensing, 23*(14), 2729–2740. https://doi.org/10.1080/01431160110076234

Fadiel, A. F. A., Elmnifi, M., Aleksandrovna, D. T., Nassar, Y. F., & El-Khozondar, H. (2025). Desalination in Libya (2000-2025): A strategic review of technological evolution, institutional challenges and pathways toward water security.

Gayen, S. (2022). Flood risk assessment and its mapping in Purba Medinipur (Moyna block). *Water*.

Hailin, Z., Yi, J., Xuesong, Z., Gaoliao, J., Yi, Y., & Baoyin, H. (2009). GIS-based risk assessment for regional flood disaster. In *Proceedings of the International Conference on Environmental Science and Information Application Technology* (pp. 564–567).

Huang, D., Liu, C., Fang, H., & Peng, S. (2008). Assessment of waterlogging risk in Lixiahe region of Jiangsu province based on AVHRR and MODIS image. *Chinese Geographical Science, 18*(2), 178–183. https://doi.org/10.1007/s11769-008-0178-2

Irrigation and Waterways Department, Government of West Bengal. (2008–2020). *Annual reports*.

Irrigation and Waterways Department, Government of West Bengal. (2010). *Annual flood report 2010*.

Kaliaghai-Kapaleshwari-Bagui Project Division. (2010-2018). *Technical reports*.

Kienberger, S. (2012). Spatial modelling of social and economic vulnerability to floods at the district level in Buzi, Mozambique. *Natural Hazards, 64*(3), 2001–2019.

Majumdar, S., Das, A., & Mandal, S. (2022). River bank erosion and livelihood vulnerability of the local population at Manikchak block in West Bengal, India. *Environment, Development and Sustainability*, 1–38.

Molle, F. (2005). *Historical transformations of the Lower Jordan River Basin in Jordan: Changes in water use and projections (1950–2025)*. IWMI.

Mondal, N. (2025). *Coping with recurrent flood hazards: Human adjustment strategies in the Kaliaghai River Basin, West Bengal*. In *37th Annual Conference of the Indian Institute of Geomorphologists (IGI): Abstract volume*. University of Kashmir, Srinagar, India.

Mondal, N. (2025d). *Assessing the impact of fishing nets and 'patas' on flood dynamics in the Kaliaghai River, West Bengal*.

Mondal, N., & Biswas, B. (2022). *Human adjustments to flood hazards in the Kaliaghai River Basin, West Bengal, India* (M.Phil. thesis). University of Burdwan.

Mondal, N., & Biswas, B. (2022). *Human adjustments to flood hazards in the Kaliaghai River Basin* (MPhil thesis). University of Burdwan.

Mondal, N., Kumar, D., & Nazir, O. (2025b) Spatial Assessment of Rural Socio-Economic Development: A Study of Purba Medinipur District, West Bengal.

Mondal, N., Kumar, D., & Wasit, M. (2025a). Assessing the Socio-economic and Environmental

Nasrabad, M. F., Neyshabouri, S. Z., & Khozeymahnezhad, H. (n.d.). *Journal of Hydraulic and Water Engineering (JHWE), 2*(2), 145–164.

Pandey, A. C., Singh, S. K., & Nathawat, M. S. (2010). Waterlogging and flood hazards vulnerability and risk assessment in Indo-Gangetic Plain. *Natural Hazards, 55*(2), 273–289. https://doi.org/10.1007/s11069-010-9525-6

Rudra, K. (2002). Floods in West Bengal, 2000: Causes and consequences in changing environmental scenario of the Indian subcontinent. In S. Basu (Ed.), *Changing environmental scenario of the Indian subcontinent* (pp. 326–347). ACB Publications.

Sahoo, A. K., Biswal, N. C., & Panda, R. P. (2025). A comprehensive assessment of the Daya River: Pollution dynamics and the post-pandemic trajectory (2000–2025). *FishTaxa*, 36(1s), 178–191.

Sahu, A. S. (2014). A study on Moyna basin water-logged areas (India) using remote sensing and GIS methods and their contemporary economic significance. *Geography Journal*, 2014, 1–9. http://www.hindawi.com/journals/geography/2014/401324/

Samanta, R. K., Bhunia, G. S., Shit, P. K., & Pourghasemi, H. R. (2018). Flood susceptibility mapping using geospatial frequency ratio technique: A case study of Subarnarekha River Basin, India. *Modeling Earth Systems and Environment, 4*(1), 395–408.

Suriya, S., & Mudgal, B. V. (2012). Impact of urbanization on flooding: The Thirusoolam sub-watershed case study. *Journal of Hydrology, 412–413*, 210–219.

Wang, Y., Li, Z., Tang, Z., & Zeng, G. (2011). A GIS-based spatial multi-criteria approach for flood risk assessment in the Dongting Lake region, Hunan, China. *Water Resources Management, 25*(13), 3465–3484. https://doi.org/10.1007/s11269-011-9866-2

Wang, Y., Yuan, L., Zhou, Y., & Qin, X. (2025). Dynamic spatiotemporal evolution of ecological environment in the Yellow River Basin (2000–2024) and its driving mechanisms. *Land, 14*(10), 1958.