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The Impact of Kaliaghai River Flood (2021): A Detailed Study of Socio-Economic and Environmental Consequences in West Bengal

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ABSTRACT

The frequency and intensity of floods in the Kaliaghai River Basin of West Bengal, India, have increased significantly over the past two decades, resulting in severe socio-economic and environmental consequences. This study provides a comprehensive assessment of the impact of recurrent floods across Sabang (LVI-0.322), Patashpur-I (LVI-0.278), Bhagwanpur-I (LVI-0.064), Narayangarh (LVI-0.050) and Patashpur-II (LVI-0.039) blocks. Using a mixed-methods approach, it integrates household surveys (400 samples), key informant interviews, focus group discussions and geospatial analysis (2000-2022) to analyse rainfall-water table patterns, land use changes and community vulnerability. The study identified a strong relationship between a 3-day cumulative rainfall of more than 250 mm and a rise in river water level of more than 6 m, which triggers flood conditions. For example, on 19 September 2021, 382 mm of rainfall resulted in a rise in water level of 8.9 m, exceeding the flood threshold. About 51% of households surveyed faced displacement due to floods, with an average loss of ₹12,000-25,000 per incident. Agricultural losses were extensive, with crop losses estimated at ₹14,200 per hectare, affecting over 3,800 hectares of paddy and 1,200 hectares of vegetables. Relief reach was limited—only 38% of respondents reported receiving timely assistance. Health impacts were significant, as 43% of households reported post-flood illnesses such as diarrhoea and skin infections. Ecological analysis showed that vegetation cover in wetlands and lowlands had decreased by 21%, mainly due to siltation, encroachment, and the expansion of uncontrolled fishing structures (e.g., "patas"), which obstructed river flow and worsened waterlogging. The study emphasizes the combined impact of natural factors (short-term heavy rainfall, sediment accumulation) and human activities (drainage obstruction, broken embankments, land use conversion) in intensifying flood risk. In conclusion, the paper recommends integrated flood management strategies including river dewatering, embankment strengthening, drainage restoration, floodplain zoning and development of resilient livelihoods. These interventions are crucial for reducing risk and enhancing long-term resilience in the flood-prone Kaliaghai River Basin.

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***KEYWORDS:** Kaliaghai River, Flood Impact, Livelihood, Environment, Agriculture, Infrastructure, West Bengal, Disaster Management.*

1. INTRODUCTION

Floods are one of the most frequent and destructive natural disasters in India (Wang et al. 2011; Sharma et al. 2011; Sharifi et al. 2012), annually affecting approximately 32 million of people. This number has varied from 3.61 million in 1965 to 70 million in 1978 (Central Water commission Publication, 1996; Dilley et al. 2005; Adhikari et al. 2010; Singh et al. 2013 and Tripathi. 2015). The most flood-prone area in India is 40 million hectares (mha), with floods affecting an average of about 7.6 million hectares (mha) annually. This area has varied significantly in the last five decades, from low as 1.46 mha in 1965 to as high 17.5 mha in 1978 (Central Water commission Publication, 1996). In 2021, India's second-highest flood-affected area was 16.8 mha, the second highest after 17.5 mha in 1978 (Central Water commission Publication, 2024).

Land-use changes play a significant role in shaping flood impacts in many regions. The conversion of natural landscapes such as wetlands, forests, and grasslands into built-up and agricultural areas reduces the land's natural ability to absorb excess water. Encroachment along riverbanks disrupts natural flow patterns, increasing erosion and flood intensity. Intensive farming practices and unplanned urban growth also contribute to higher run-off and sedimentation. Overall, these land-use transformations amplify both the frequency and severity of floods, affecting ecosystems and human livelihoods alike(Waza, 2023; Waza et al., 2023; Waza, Pednekar, et al., 2025).

Changing cropping patterns also influence flood impacts and landscape stability. The shift from traditional, water-absorbing crops to high-input or water-intensive varieties alters soil structure and reduces its infiltration capacity. Seasonal monocropping weakens soil resilience, making fields more prone to erosion and run-off during floods. The replacement of deep-rooted crops with shallow-rooted ones further destabilises the topsoil. Overall, these shifts in cropping practices can intensify flood damage, reduce soil fertility, and increase long-term environmental vulnerability(Din Waza et al., 2025; Waza, Ikram, et al., 2025).

Due to the geographical location of the Kaliaghai River basin, flat terrain and dense river system, the eastern state of West Bengal is particularly vulnerable to both riverine and flash floods (NDMA, 2017; Barman, 2021; Mondal, 2022). Among its many rivers, the Kaliaghai River, which flows through West and East Medinipur districts, poses a recurring threat to life, livelihoods and infrastructure due to seasonal flooding during the monsoon season (Archarya et al., 2008). These floods are often exacerbated by human activities, heavy rainfall in short periods, rainfall during high tide condition and climate change, causing widespread socio-economic disruption and environmental degradation in the region (Sahu, 2007; Barman, 2021; Mondal, 2022).

The Kaliaghai River originates from the village of "Dudhkundu" in Jhargram district, located on the eastern side of the Choto Nagpur Plateau, and is part of a complex river network flowing southwest. (Mondal, 2022). During heavy monsoons, the river often overflows its banks, inundating low-lying villages, agricultural fields, and transport networks in the blocks on both banks of the river (Narayangarh, Sabang, Patashpur -I & II, Bhagwanpur-I, and Moyna). The situation has been further worsened by human interventions such as encroachment on the river banks, unscientific construction of embankments, and installation of fishing nets and *'pata'* structures, which obstruct the natural flow of water (Archarya et al, 2008; Bhattacharya, 2020; Mondal, 2022). As a result, the frequency and intensity of floods have increased in recent decades, further impacting rural livelihoods and local ecosystems.

The socio-economic impact of the Kaliaghai River floods is profound. The mainstay of the region's economy, agriculture, suffers significant losses due to crop damage, soil erosion and prolonged waterlogging (Archarya et al., 2008; Laha et al, 2014). Small and marginal farmers, sharecroppers and daily wage labourers are particularly vulnerable, often losing both production and income during the flood season (Bordoloi and Mujaddadi, 2018; Jana and Roy, 2018; Gayen, 2022). In addition, floods damage homes, livestock, roads, bamboo poles and concrete bridges, human lives and livelihoods, the economy, property and infrastructure, and critical infrastructure such as schools, college laboratories and health centres, further isolating affected communities (Das et al, 2014; Ferdaush, 2015; Islam et al, 2017; Das et al, 2017). The displacement of families, the spread of water-borne diseases and disruption of education and healthcare further exacerbate the plight of the population (Bordoloi and Mujaddadi, 2018; Majumder, 2020; Majumdar et al, 2022; Gayen, 2022).

Several administrative blocks in the Kaliaghai River Basin – namely Sabang, Narayangarh, Patashpur-I, Patashpur-II and Bhagwanpur-I– experience repeated and severe floods almost every year. These flood events are mainly attributed to the low elevation of the region, inadequate drainage infrastructure, high seasonal rainfall and moderately permeable soil, which contribute to persistent waterlogging (Sahu, 2014; Barman, 2021). Such conditions have a direct and detrimental impact on the socio-economic development of the basin. Every year, floods cause significant economic losses amounting to crores of rupees. In particular, the Sabang block suffers extensive damage to a wide range of agricultural and allied activities, including seasonal paddy, monsoon and winter crops, vegetables, betel cultivation, fisheries, mat-stick production and floriculture (Laha et al., 2014; Mondal, 2022). In addition to agricultural losses, floods cause significant disruption to daily life – damaging infrastructure such as roads and houses, affecting educational facilities, deteriorating public health conditions and resulting in loss of livestock and private property. The extent of agricultural destruction across this basin became very clear in the 2005 floods. About 14,000 hectares of cropland were damaged in Narayangarh block, 12,480 hectares in Bhagwanpur-1 block, 12,460 hectares and 13,184 hectares in Patashpur-1 and Patashpur-2 blocks respectively, and 2,500 hectares in Maina block (Laha et al., 2014). Such extensive damage significantly hampers the economic development and livelihood security of the people living in the basin.

Ecologically, floods alter the landscape of floodplains. Sedimentation, riverbank erosion, and habitat destruction affect biodiversity and water quality (Archarya et al., 2008; Barman, 2021; Mondal, 2022). The frequent submergence of agricultural lands and settlements has led to a much higher use of chemical inputs after floods, which has further stressed the local environment (Sahu, 2014; Das and Sinha, 2019). These changes highlight the interconnectedness of human and ecological systems in the flood-prone areas of the Kaliaghai River Basin. Despite the recurrent nature of floods in the region, there is a dearth of integrated flood management plans tailored to the unique characteristics of the basin (Archarya et al., 2008; Laha et al, 2014, Barman, 2021). Local administrations often implement short-term relief measures, while long-term strategies for resilience-building, sustainable land-use planning, and adaptive livelihoods are largely absent (Sahu, 2007 and Mondal, 2022). This study aims to fill a critical gap in understanding the multidimensional impacts of floods in the Kaliaghai River Basin, with an emphasis on livelihood disruption, infrastructural vulnerability, and ecological consequences.

Using remote sensing data, Flood impact data, field surveys, questionnaire surveys, group discussions and secondary literature review, the study provides a comprehensive assessment of the impact of floods and explores potential policy and community-based solutions (Archarya et al., 2008; Sharma et al. 2011; Laha et al, 2014; Bordoloi and Mujaddadi, 2018; Jana and Roy, 2018; Das and Sinha, 2019; Gayen, 2022; Mondal, 2022). The findings of this study are expected to contribute to more effective flood mitigation strategies and encourage sustainable development practices in the region.

1.1. Study Area

The Kaliaghai River Basin is located (***Figure 1***) in South West Bengal, extending through parts of the districts of Paschim Medinipur, Purba Medinipur and Jhargram. The basin is characterized by alluvial soil, rain-fed agriculture, fish farming and low-lying plains, which make it highly susceptible to flooding (Archarya et al., 2008; Laha et al, 2014; Barman, 2021; Mondal, 2022). The region covers an area of 1801.4 sq. km and consists of low-lying areas and is known to be flood-prone. The Kaliaghai River Basin extends from 22° 01' 11" N to 22° 24' 10" N latitude and from 87° 07' 11" E to 87° 51' 07" E longitude. The elevation of the river basin area ranges from 4 m to 102 m and the topography slopes from 1.2°–23.7°. The average seasonal rainfall is more than 1576.47 mm. The major towns affected include Narayangarh, Sabang, Pataspur-I, Pataspur-II and Bhagwanpur-I.

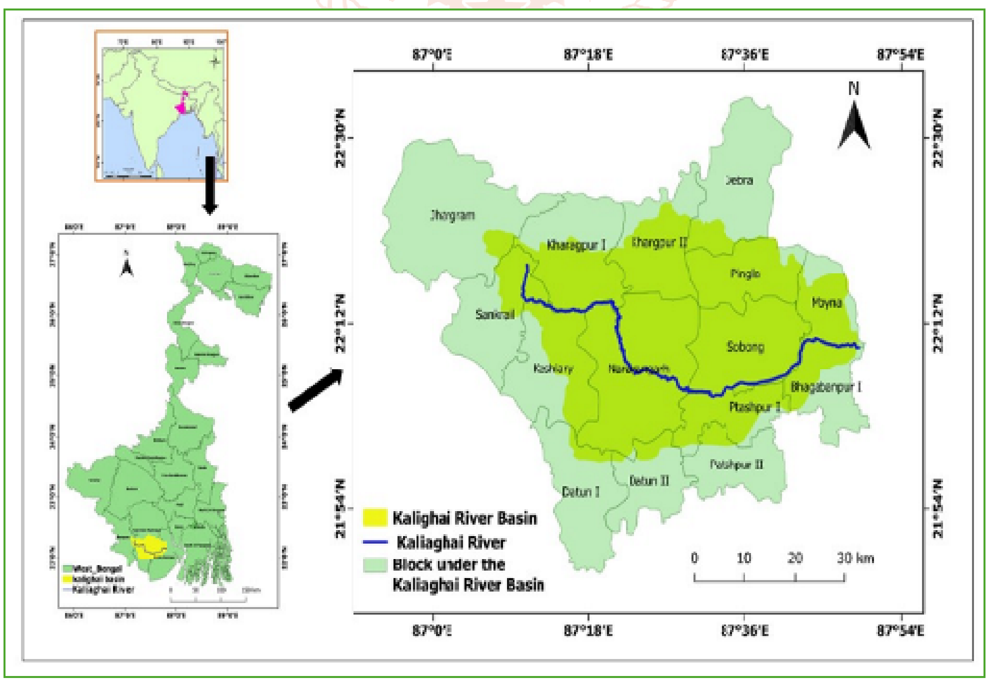

Figure 1: Location map of the Kaliaghai River Basin

Source: Prepared by the researcher

1.2. Objectives

A. To examine the socio-economic consequences on local communities.
B. To assess the environmental impact of floods in the Kaliaghai River Basin.
C. To propose policy measures for flood risk reduction.

2. Methodology

This study uses a mixed methodology to comprehensively assess the socio-economic and environmental impacts of floods in the Kaliaghai River, mainly located in the Paschim Medinipur and Purba Medinipur districts of West Bengal. The methodology combines quantitative data analysis, geospatial techniques, and qualitative field research to gain insights into both macro- and micro-level flood dynamics and consequences.

2.1. Study Area Selection

The Kaliaghai river basin was selected as the study area due to its frequent flood hazard and diverse land use characteristics. The most affected areas of the selected blocks are - Sabang, Narayangarh, Patashpur-I, Patashpur-II and Bhagwanpur-I, which experience both annual monsoon floods and occasional flash floods. Geographical coordinates, landform features and river morphology were mapped using Survey of India Topographical Maps and Bhuvan (ISRO) data platform.

2.2. Research Design

A descriptive and analytical research design was used: the occurrence and impact of the flood were described, causal factors (natural and anthropogenic) were analysed, social, economic and environmental impacts were assessed, and effective recommendations were proposed. The methodology was divided into the following components:

2.3. Data Collection Techniques

A. Secondary Data Collection

Secondary data was collected from multiple reliable sources – **Meteorological data:** Rainfall records for the years 2000-2023 were collected from the India Meteorological Department (IMD). **Flood records:** River gauge data, information on flood extent, flood frequency and damage data were collected from Kaliaghai-Kapaleshwari-Baghai (KKB, 2023) project division (Circle -I, II & III), District Disaster Management Authority (DDMA, 2023), Block Disaster Management Office (BDMO, 2023) and West Bengal State Disaster Management Authority (WBSDMA, 2020). **Population and Economic Data:** Census of India (2011), District Statistical Handbook and Agriculture Department reports were used. **Scientific literature:** "Environmental Significance of Water Front Embankments in South and Eastern Medinipur coast" (Sahu, 2007) and statistics from peer-reviewed journals and previous case studies on flooding in coastal West Bengal (Jana & Roy, 2018; Bhattacharya, 2020) were used.

B. Primary Data Collection

Primary data collection included field visits and participatory assessments in selected flood-prone villages on both banks of the river from March to June, 2023. The researcher used Slovin's formula (1960) for sample size selection. According to this formula, a sample size of 400 was taken for the flood-affected population of about 5 lakh people located in the Kaliaghai River Basin.

Sample size (Slovin's formula 1960) $n = (N/1+Ne^2)$

$n = (N/1+Ne^2)$
$n = 500000/1+500000*(0.05)^2$
$n = 500000/1+500000*0.0025$
$n = 500000/1+1250$
$n = 500000/1251$
$n = 399.68$
$n = 400$ (approx.)

Where, n= **Sample size, N= Population size, e=Margin of error, e=5% or 0.05**

Household survey: Household Survey: Stratified random sampling of flood-affected blocks located in the Kaliaghai River Basin was used. Structured questionnaires were used to collect data from 400 households. The questions included land use, damage assessment, livelihood impact, health problems and adaptation strategies.

Key informant interviews (KII): Data were collected from Panchayat Officers, Block Development Officers (BDOs), Block Disaster Management Officers (BDMOs), Agricultural Extension Officers, and elderly villagers with historical knowledge about the causes and patterns of floods.

Focus Group Discussions (FGD): Held in 7 blocks, in a total of 11 villages, each village had 11-14 participants, including experienced persons, women, farmers, college students, fishermen and youth, to collect information on collective flood experiences and coping mechanisms.

Transect Walk and Ground Truthing: Observation of flood-affected areas, including destroyed houses, broken embankments, damaged bamboo bridges, roads and fishing nets, and blocked drainage due to "*pata*" obstructions, etc., was conducted to collect detailed information and photos.

2.4. Data Analysis Techniques

A. Statistical Analysis

i) Descriptive Statistics:

Descriptive statistics were used to summarize and interpret key socio-economic variables collected through household surveys in flood-affected areas of the Kaliaghai River Basin. Measures such as mean, median, percentage and standard deviation were used to assess income loss, extent of crop damage, number of days of displacement and access to relief services. For example, the average income loss per household per flood event ranged from ₹12,000 to ₹25,000, while the average number of days of displacement to safe shelter ranged from 15 to 21 days on average. These statistical summaries provide a clear overview of the magnitude and variability of flood impacts across different socio-economic groups.

ii) Correlation and Regression:

The dataset reveals a clear positive relationship between the 3-day cumulative rainfall and the corresponding river water level (**Table 1**). As rainfall increases, the water level of the Kaliaghai River increases proportionally (**Figure 2**). This relationship is particularly significant when rainfall exceeds 240 mm, which typically creates a water level above 6 m, which initiates flood conditions. On 31 July 21 (250 mm rainfall), the water level reached 5.82 m - just below the flood threshold. A significant increase was observed: 14 September 21 (315 mm) → 7.5 m, 19 September 21 (382 mm) → 8.9 m, 24 September 21 (290 mm) → 7.2 m. These dates (14 Sept. 2021 to 24 Sept. 2021) clearly indicate flood events, where the water level exceeds the flood threshold by 6 m, which is directly related to high rainfall (≥290 mm). There is a strong positive relationship between the 3-day cumulative rainfall and the river water level. When rainfall reaches about 250 mm in 3 days, it often causes flooding conditions in the basin, which emphasizes the need for forecasting systems and rainfall monitoring to forecast of the onset of floods in river basins area.

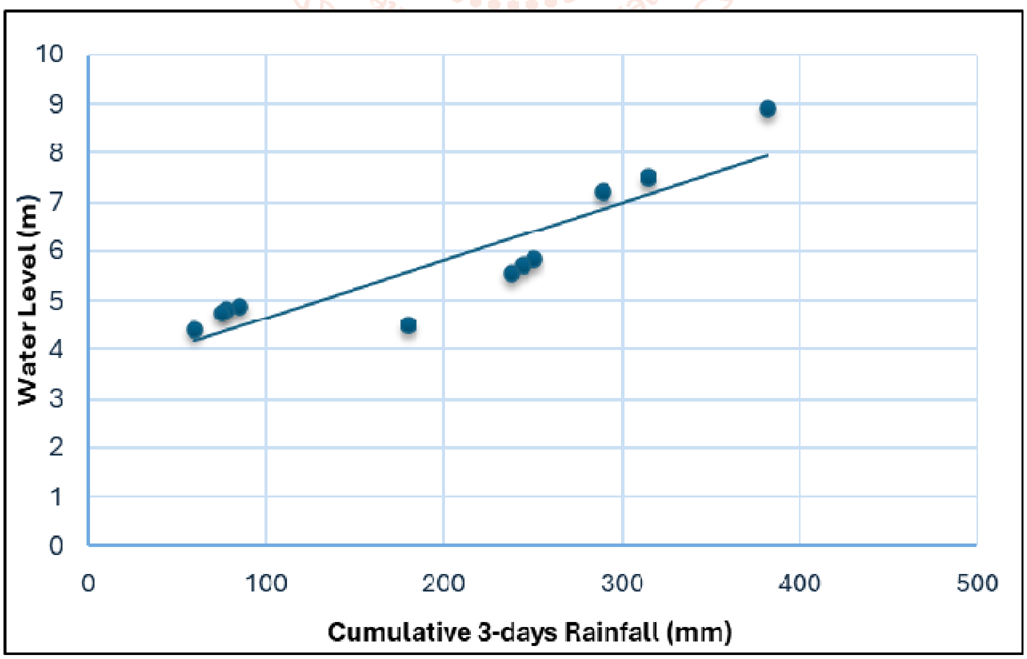

Figure 2: Relation between Rainfall and Flood Condition, 2021

Table 1: Date wise Cumulative 3-days rainfall and river water level

Date	Cumulative 3-days Rainfall (mm)	Water Level (m)
16-Jun-21	60	4.4
21-Jun-21	85	4.89
26-Jun-21	78	4.82
26-Jul-21	75	4.75
31-Jul-21	250	5.82
05-Aug-21	245	5.7
10-Aug-21	238	5.54
15-Aug-21	180	4.5
14-Sep-21	315	7.5
19-Sep-21	382	8.9
24-Sep-21	290	7.2

iii) Livelihood Vulnerability Index (LVIIPCC):

Step-I: Indicators and Sub-Components

We use **7 major components**, grouped under IPCC's three pillars.

Table 2:LVI-IPCC Indicators and Sub-Components

IPCC Category	Major Component	Sub-component Indicator
Exposure (E)	Natural Disasters	% of HHs affected by floods
		Frequency of flood events (20 years)
Sensitivity (S)	Socio-demographic	Dependency ratio
	Health	% HHs with illness
	Livelihood Assets	% landless households
Adaptive Capacity (A)	Social Networks	% HHs in SHGs or cooperatives
	Education	Literacy rate (%)
	Access to Services	% HHs with access to early warning systems

Step-II: Block wise Calculation of Indicators and Sub-Components

Table 3 : Block wise Calculation of Indicators and Sub-Components

Component	Indicator	Name of the Blocks					Min	Max
		Sabang	Patashpur-I	Patashpur-II	Bhagwanpur-I	Narayangarh		
Exposure: Flood Affected	% HHs affected by flood	73	71	50	45	47	20	80
Exposure: Flood Frequency	Times in 20 years	12	8	6	5	7	4	13
Sensitivity: Dependency	Ratio	0.87	0.85	0.60	0.55	0.58	0.50	0.90
Sensitivity: Illness	% HHs with chronic illness	67	65	35	37	33	20	70
Sensitivity: Landless	% HHs without own land	35	34	20	22	25	10	40
Adaptive: Social Network	% HHs in groups	47	35	28	23	29	20	55
Adaptive: Literacy	% literacy	76	74	74	71	73	60	80
Adaptive: Early Warning	% HHs with access	70	70	61	50	65	30	75

Source: Calculation by the researcher

Step-III: Standardize Each Indicator
Using the formula:

$$SD = (S_i - S_{min}) / (S_{max} - S_{min})$$

Example for one indicator:
Flood-affected (% HHs): Sabang Block
SD_{Sabang} = 73-20 / 80-20
SD_{Sabang} =53/60
SD_{Sabang} =0.883

Flood-affected (% HHs): Patashpur -I
$SD_{Patashpur-I}$ = 71-20 / 80-20
$SD_{Patashpur-I}$ =51/60
$SD_{Patashpur-I}$ =0.850

Table 4: For Standardized Values

Name of the Blocks	Flood Affected	Flood Frequency	Dependency	Illness	Landless	Social Network	Literacy	Early Warning
Sabang	0.883	0.889	0.925	0.940	0.833	0.771	0.800	0.889
Patashpur-I	0.850	0.444	0.875	0.900	0.800	0.429	0.700	0.889
Patashpur-II	0.500	0.222	0.250	0.300	0.333	0.229	0.700	0.689
Bhagwanpur-I	0.417	0.111	0.125	0.340	0.400	0.086	0.550	0.444
Narayangarh	0.450	0.333	0.200	0.260	0.500	0.257	0.650	0.778

Source: Calculation by the researcher

Step-IV: Calculate Averages for Each IPCC Component
Example for Sabang Block

- **Exposure (E) = (Flood Affected + Flood Frequency) /2**
  Exposure (E) = (0.883 + 0.889)/2 = 0.886
- **Sensitivity (S) = (Dependency + Illness + Landless) / 3**
  Sensitivity (S) = (0.925 + 0.940 + 0.833) / 3 = 0.899
- **Adaptive Capacity (A) = (Social Network + Literacy + Early Warning) / 3**
  Adaptive Capacity (A) = (0.771 + 0.800 + 0.889) / 3 = 0.820

Table 5: Calculate averages for each IPCC Component and LVI

Name of the Blocks	Exposure (E)	Sensitivity (S)	Adaptive Capacity (A)	LVI-IPCC	Rank	Vulnerability Level
Sabang	0.886	0.899	0.820	**0.322**	1	High Vulnerability
Patashpur-I	0.647	0.858	0.672	**0.278**	2	High
Bhagwanpur-I	0.264	0.288	0.360	**0.064**	3	Low
Narayangarh	0.392	0.320	0.562	**0.050**	4	Very Low
Patashpur-II	0.361	0.294	0.539	**0.039**	5	Very Low

Source: Calculation by the researcher

Step-V: Livelihood Vulnerability Index-IPCC
Livelihood Vulnerability Index $_{IPCC}$ = Exposure (E) + Sensitivity (S) – Adaptive Capacity (A)

$$LVI_{IPCC} = \{(E - A + S)/3\}$$

Where: E = Average of Exposure indicators, A = Average of Adaptive Capacity indicators, S = Average of Sensitivity indicators.

1. Sabang Block - Highest Vulnerability (LVI = 0.322), Very High Flood Risk (Frequent and Extensive), High Vulnerability (**Table 2, 3, 4 & 5**) due to High Dependency and Illness and Medium Adaptation Capacity. But not sufficient to meet the vulnerability, urgent flood adaptation and health infrastructure support is needed. **2.** Patashpur-1 Block - High Vulnerability (LVI = 0.278), High Flood Risk and Vulnerability, Slightly Better Adaptation Capacity than Sabang. Support is still needed in the areas of Health and Livelihood Diversification. **3.** Bhagwanpur-1 Block - Low Vulnerability (LVI = 0.064), Low Vulnerability and Vulnerability, Medium Adaptation Capacity. This region can become a model for resilience practice. **4.** Narayangarh Block - Very Low

Vulnerability (LVI = 0.050), Low Flood Risk and Medium Adaptation Capacity. Early Warning Coverage needs to be further improved. **5.** Potashpur-2 Block - Lowest vulnerability (LVI = 0.039), least vulnerable to flood hazards and good adaptation measures despite moderate sensitivity. Long-term resilience requires stronger flood management.

Qualitative Analysis

To complement the quantitative data, qualitative methods were used to gain deeper insights into the lived experiences, perceptions, and institutional challenges associated with recurrent floods in the Kaliaghai River Basin.

i) Thematic coding:

Responses from in-depth interviews and focus group discussions (FGDs) with affected households, local leaders, farmers, and block-level officials were transcribed and thematically coded. The analysis identified several recurring themes: **Coping strategies:** Common household responses include temporary migration, switching to wage labour, reliance on informal credit, and changes in cropping patterns. **Perceptions about flood causes:** Local respondents often attributed factors such as siltation of riverbeds, blockage of natural drainage, and construction of illegal "pata" fishing structures to the increase in flood severity. **Obstacles to government assistance:** Many participants reported delays in relief distribution, inaccurate beneficiary targeting, and lack of transparency in the compensation process. A sense of distrust in institutional arrangements was a recurring pattern.

ii) Content analysis:

District flood management plans, disaster preparedness guidelines and irrigation department reports were reviewed using content analysis techniques. The analysis revealed: Lack of integration between river management and land-use planning. Minimal attention to community-based early warning systems. Insufficient emphasis on post-flood livelihood restoration, especially for smallholder farmers and fisherfolk. Absence of regular maintenance protocols for dams and drainage channels.

Results and Findings

This section presents empirical findings and key observations from primary data (field surveys, interviews, FGDs), remote sensing analysis and secondary data sources. The results are categorized into five main categories and several sub-categories: **A) Flood Frequency, Extent, and Trends, B) Socio-Economic Consequences**- 1. Impact on Livestock, 2. Impact on Human life and Livelihood, 3. Impact on Economy, **C) Agricultural Impact and Livelihood Disruption, D) Infrastructure and Health Impact-** 1. Impact on Houses, 2. Impact on Road, 3. Impact on Bamboo Poles and Concrete Bridge, 4. Impact on Health due to water contamination, 5. Impact on Property and Infrastructure, **E) Environmental Consequences and Human Intervention.**

A. Flood Frequency, Extent, and Trends

Analysis of rainfall, river gauge data and flood data obtained from the India Meteorological Department (IMD), West Bengal State Disaster Management Authority (WBSDMA, 2020), Kaliaghai-Kapaleshwari-Baghai (KKB, 2023) project division, Block Disaster Management Office (BDMO, 2023), District Disaster Management Authority (DDMA, 2023) shows that since 2019, just a few years after the river re-dressing (2011–2014), the Kaliaghai river basin has been showing an increasing trend in flood frequency. The average annual rainfall in the region is relatively stable (1550–1650 mm/year), but there has been an 11% increase in extreme rainfall events (>90 mm/day) between 2000 and 2020. The inundated area during the September 2021 floods was about 76.7 sq. km, resulting in 31 villages in different blocks being completely and 43 villages being partially affected. Historical records and interviews indicate that the years 2000, 2004, 2008, 2019, 2021, and 2023 were the major flood years. These floods typically occur between July and September, which coincides with the peak flow of the monsoon, often resulting in waterlogging for three to five weeks due to poor drainage.

B. Socio-Economic Consequences

Based on household surveys in three blocks (Sabang, Patashpur-I and Bhagwanpur-I), the floods led to significant displacement and economic distress. FGDs revealed that female-headed households, landless labourers, poor labouring households and elderly people were the most vulnerable groups.

1. Impact on Livestock:

Floods have forced most people to use flood water as a source of drinking water for livestock. They took their animals to flood shelters or high embankments. Flooding reduces the quantity and quality of animal feed, changes in pest and disease prevalence, and direct production degradation due to physiological stress all contribute to major impacts on livestock systems (Ashraf et al., 2013). The floods had a detrimental effect on livestock (**Table 6 & 7**) (Plate No) (cows, goats, sheep, poultry etc). Many cattle died (**Figure 3**) due to flood and drinking polluted water after flood. Block-wise livestock loss statistics discussed are-Bhagwanpur-I CD Block (cow-05, goat-07, sheep-05, duck-123, Poultry-203); Patashpur – I CD Block (Cow-17, Goat-13, Duck-174, Poultry-306); Patashpur – II CD Block (Cow-08, Goat-03, Duck-24, Poultry-12); Narayangarh CD Block (Cow-3, Goat-08, Poultry-51); Sabang CD Block (cow-12, goat-10, sheep-03, duck-127, Poultry-204).

Table 6: Block wise damage of Animals and Birds in Flood (2021)

Sl No	Name of CD Block	Cow	Goat	Sheep	Duck	Poultry
1	Bhagwanpur-I	5	7	5	123	203
2	Patashpur-I	17	13	0	174	306
3	Patashpur-II	8	3	0	24	12
4	Narayangarh	3	8	0	0	51
5	Sabang	12	10	3	127	204
Total		45	41	8	448	776

Source: Block Development Office, Purba and Paschim Medinipur, 2023

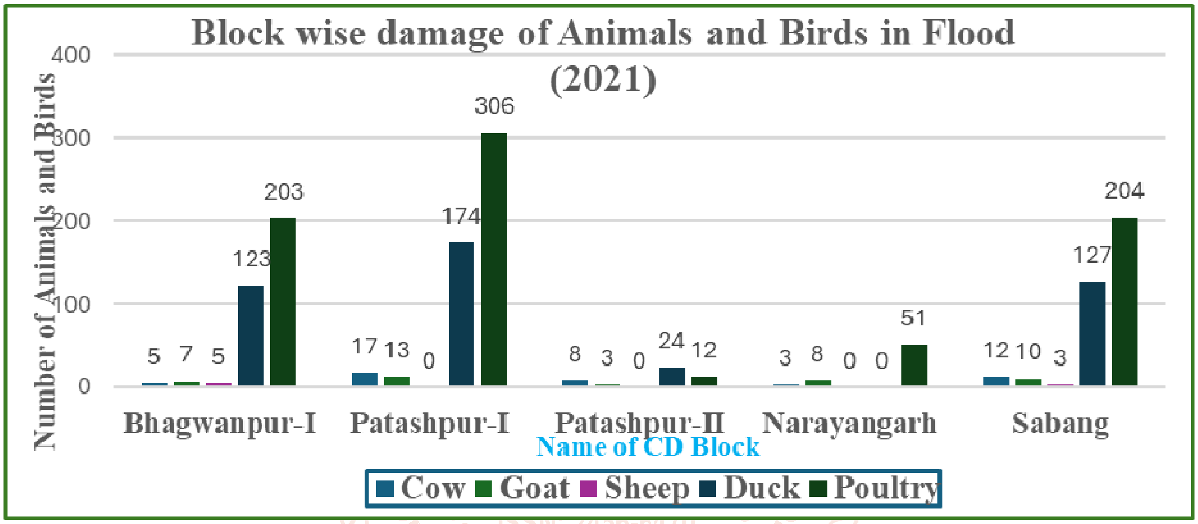

Figure 3: Block wise damage of Animals and Birds in 2021 Flood

Table 7: Number of Cattles in Cattle Camps

Sl No	Name of CD Block	Number of Cattle Camps	Number of Cattle in Camps
1	Bhagwanpur-I	119	5445
2	Patashpur-I	154	8756
3	Patashpur-II	103	5027
4	Narayangarh	107	5739
5	Sabang	136	6238
Total		619	31,205

Source: Block Development Office, Purba and Paschim Medinipur, 2023

2. Impact on Human life and Livelihood

Two people died after mud wall collapsed in Sabang block due to flood. 2 people died due to electrocution in Bhagwanpur-I block during flood. Floods often force people to evacuate their homes, resulting in temporary or long-term displacement. This displacement can put pressure on emergency shelters and affect the ability of local communities to provide support. A total of 125,607 people took refuge in 811 flood shelters (Plate No) during the Kaliaghai River flood (2021). The number of people sheltered in flood shelter according to block (**Table 8**) is- Patashpur-I (31416), Sabang (29709), Narayangarh (23213), Bhagwanpur-I (21040) and Patashpur-II (20229). As flood waters spread, they can threaten human lives, cause extensive damage to property and businesses, destroy social assets and critical infrastructure, and disrupt essential public services. Often the effects of flooding are long-term and extremely costly, catastrophic and distressing for the communities involved. On average, households reported losses of 9,000-12,000 taka per flood, mainly due to agricultural losses and wage losses.

Table 8: Number of People in Flood Shelter

Sl No	Name of CD Block	Number of Flood Shelter	Number of People in Flood Shelter
1	Bhagwanpur-I	124	21040
2	Patashpur-I	173	31416
3	Patashpur-II	117	20229
4	Narayangarh	132	23213
5	Sabang	164	29709
	Total	710	125607

Source: Block Development Office, Purba and Paschim Medinipur, 2023

3. Impact on Economy:

The flood of Kaliaghai River caused extensive damage to the agricultural crops of neighbouring blocks such as Aman Paddy, Vegetable, Spices, Betel vine, Mat Stick, Jute, Sugarcane, Flower. The livelihood of people involved in agriculture is also damaged. Due to Mat Stick damage, Sabang's famous mat making cottage industry is completely damaged. The resulting disruption to business and transportation can have a significant economic (**Table 9**) impact. Damage to infrastructure, including roads and bridges, can disrupt the movement of goods and people, affecting local and regional economies.

Table 9: Loss of Assets and their Economic Value

Sl No	Loss of Assets	Bhagwanpur-I	Patashpur-I	Sabang
1	Name of the Calamity	Flood	Flood	Flood
2	Date & time of occurrence of Calamity	14.09.2021,	14.09.2021,	13.09.2021
3	No. & Name of G.P. affected	10	17	13
4	No. of Village affected	168	197	175
5	No. of People affected	212520	282921	235357
6	No. of Human lives lost	1	2	2
7	Crop areas damaged (in ha)	21321.12	23053.14	19586.95
8	Value of the crops damaged (Rs. in Lakh	18800000	21000000	17500000
9	No. of house damaged / destroyed: -	19891	24787	22897
10	Kachchha Fully & Partly	Value (Rs. in lakh): 118872720	Value (Rs. in lakh): 135796230	Value (Rs. in lakh): 125347103
11	No. of Relief Camps open	124	173	164
12	No. of people in Relief Camps / Shelters	21040	31416	29709
13	No. of Gruel kitchen opened	18	27	24
14	No. of persons rescued	87400	114100	99250
15	No. of Boats deployed for evacuation	18	25	22
16	No. of Medical Teams deployed	10	19	17
17	No. of Cattle Camps opened	119	154	136
18	No. of Cattle in Cattle Camps	5445	8756	6238
	Total Loss (8+10)	**13,76,72,720**	**15,67,96,230**	**14,28,47,103**

Source: Block Development Office, Purba and Paschim Medinipur, 2023

4. **Displacement:** During major floods in the last twenty years (2000, 2004, 2008, 2019, 2021, and 2023), 36% of surveyed households had to leave their homes for an average of 15 to 21 days for safe shelter, during which they took shelter in the nearest primary school (15%), secondary school (4%), higher secondary school (7%), college (5%), Govt. office (1%), and community flood shelter (3%).

C. Agricultural Impact and Livelihood Disruption
The Kaliaghai River basin experienced devastating floods in 2008 and 2021. Floods cause severe damage to agricultural land through direct crop damage, dam erosion and sediment transport, cause soil pollution and can disrupt agricultural activities. This can lead to food shortages, increased prices and economic challenges for communities dependent on agriculture. In the 2021 floods, Potashpur-1 CD Block and Sabang CD Block were most affected, Bhagwanpur-1 CD Block was moderately affected, and Potashpur-2 CD Block and Narayangarh CD Block were relatively less affected. Seasonal unemployment of 47% of marginal farmers and 52% of agricultural labourers experienced loss of working days (15–25 days) post-flood. Block wise agricultural crop damage is discussed in detail-

a) Bhagwanpur-I CD Block
According to statistics from Bhagwanpur-I block, a total of 21321.12 hectares of crops in this block were destroyed in the 2021 floods. The most affected villages are Bibhisanpur (2434.75 ha), Mahammadpur-I (2147.10 ha), Kajlagarh (2078.23 ha), Ilaspur (2020.63 ha), Gurgram (2006.18 ha) etc. The crop loss statistics of Bhagwanpur-1 block are presented in detail.

b) Potashpur-I CD Block
A total of 9602.39 hectares of crops were destroyed in Potashpur-1 CD Block in 2021 flood. The most affected villages are Gokulpur (1652.77 ha), Gopalpur (1417.37 ha), Naipur (1335.43 ha), Brajalalpur (1222.97 ha), Chistipur-I (1034.83 ha), Amarshi-II (1011.42 ha) etc. Crop loss statistics of Potashpur-1 CD Block are discussed in detail.

c) Patashpur-II CD Block
A total of 15003.84 ha of crops were destroyed in Patashpur-II CD Block in 2021 flood. The most affected villages are Mathura (2450.91 ha), Khar (2352.69 ha), South khanda (2182.69 ha), Argoal (2120.29 ha), Patashpur (2082.57 ha), Srirampur (2001.34 ha) etc. Crop loss statistics of Patashpur-II CD Block are discussed in detail.

d) Sabang CD Block
A total of 19586.95 ha of crops were destroyed in the Sabang CD Block during the 2021 flood. There is total 232 Mouza in this block. Aman Paddy, Mat Stick, Jute, Vegetable, Sugarcane, Betel vine etc. are cultivated in these mouzas. The most flood affected villages in 2021 are Danrra (3312.26 ha), Debhog (2942.65 ha), Nowgaon (2206.50 ha), Dubrajpur (1792.27 ha), Bishnupur (1380.71 ha), Balpai (1340.30 ha) etc. Crop loss statistics table of Sabang CD Block) is discussed in detail.

e) Narayanagarh CD block
A total of 28253.26 ha of agricultural crops were damaged in the 2021 flood. The most affected villages are Mannya (1510.47 ha), Belda II (1474.43 ha), Mokrampur (1456.84 ha), Khurshi (1419.22 ha), Bakhrabad (1399.14 ha), Kushbasan (1384.64 ha), Gramraj (1380.97 ha) etc. Agricultural crop loss statistics of Narayanagarh CD block is discussed in detail.

D. Infrastructure and Health Impact
1. Impact on Houses
In Patashpur-I CD Block (Talchitkini) where the Kaliaghai River embankment breached, 9 to 10 pucca houses were fully damaged (**Figure 4**). The names of the owners of these houses (**Plate No 1**) are - Narayan Manna, Krista Manna, Ananta Manna, Sudhir Manna, Adhar Manna, Bhakti Mula, Chitta Mula, Sukumar Paik, Kalipada Paik etc. Houses were displaced by the water currents. Most of the mud houses of various blocks located in very low-lying areas in the Kaliaghai River basin are fully damaged or partially damaged (**Table 10**).

Table 10: Number of Houses Damage in 2021 Flood

Sl No	Name of CD Block	Partly Damage	Fully Damage
1	Bhagwanpur-I	11956	7935
2	Patashpur-I	13947	10840
3	Patashpur-II	12014	6735
4	Sabang	13250	9647
5	Narayangarh	11775	7695
Total		62942	42852

Source: Block Development Office, Purba and Paschim Medinipur, 2023

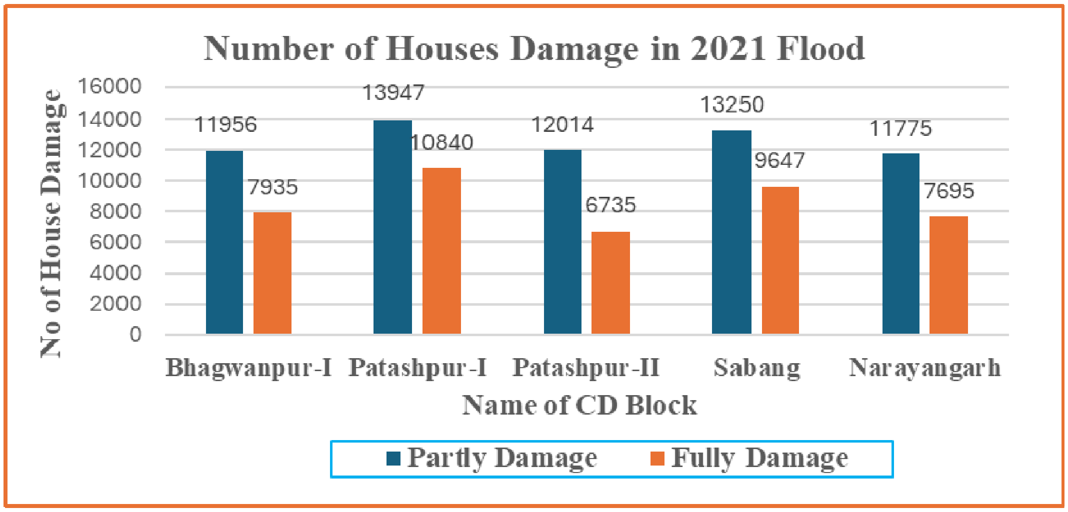

Figure 4: Number of houses damage in 2021 flood of Kaliaghai River Basin

Plate No 1: Houses Damage (Pic no. 1, 2, 3 & 4) at Patashpur-I CD Block in Flood, 2021
Source: Collected from field by the researcher

2. Impact on Road

In the flood of 2021, the entire communication system was completely damage. At this time, the main state and rural roads (27%) of the block were submerged or eroded during major flood events. State and district roads leading to Moyna, Sabang, Debra, Kharagpur, Patashpur, Egra, Contai, Bajkul, Tamluk were affected by water and traffic was stopped. Main metalled roads from Moyna to Mundumari, Moyna to Tamluk, Katakhali to Sabang, Sabang to Balichak, Themathani to Patashpur, Patashpur to Bajkul, Patashpur to Egra, Egra to Khragpur, Egra to Contai, Contai to Bajkul, Bajkul to Tamluk are heavily damaged. Besides, rural concrit roads, moram roads, zamindari roads, main roads along the river had become unusable. Moram roads have been washed away, mud roads have broken in many places, banks of rivers and canals have been damaged by water pressure. Various roads have been extensively damaged at different places due to floods (**Plate No 2 & 3**). Damaged roads included metal, concrete, moram and mud roads. Details of road damage are as follows.

Plate No 2: The broken Kaliaghai River embankment at Tal-Chitkini of Patashpur-I Block

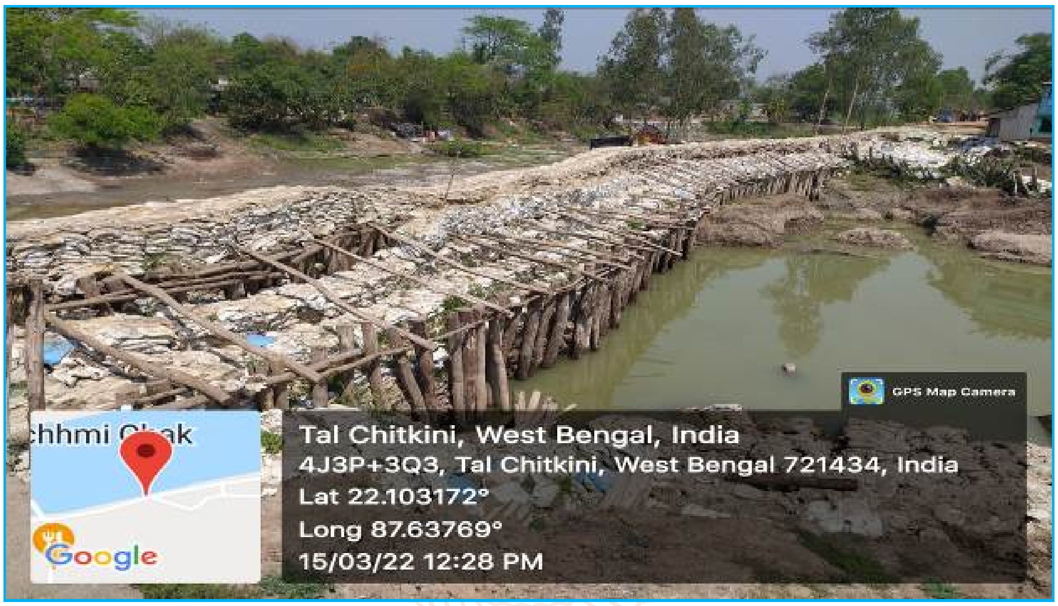

Plate No 3: The broken Kaliaghai River embankment at Tal-Chitkini of Patashpur-I Block

3. Impact on Bamboo Poles and Concrete Bridge

In floods, the bamboo poles are broken by the accumulation of garbage, plastic, and various garbage in the flood. These bridges are - Gurugram Bamboo Bridge, Varuna Bamboo Bridge, Shilakhali Bamboo Bridge, Denredighi Bamboo Bridge, Chabukiya Bamboo Bridge, Katakhali Bamboo Bridge, Langalkata wooden bridge is extensively damaged. Besides, many small bridges on Kaliaghai, Kapaleswari, Bhagai and Chandia rivers were damaged. Some concrete bridges (**Plate No 4**) and side parts of the bridge are heavily damaged. The statistics of bridge damage (**Table 11**) are given as-

Table 11: Impact on Bamboo Poles and Concrete Bridge

Sl No	Name of the Bridge	Number of Bridges
1	Gurugram Bamboo Bridge	1
2	Varuna Bamboo Bridge	1
3	Shilakhali Bamboo Bridge	1
4	Denredighi Bamboo Bridge	1
5	Chabukiya Bamboo Bridge	1
6	Katakhali Bamboo Bridge	1
7	Langalkata wooden bridge	1
8	Small Bamboo Bridges	25

Source: Block Development Office, Purba and Paschim Medinipur, 2023

Plate No 4: 1 & 2 Broken Bamboo bridge of Kaliaghai River, 3 Partly damage & 4 Fully damage concrete bridge.

4. Impact on Health due to water contamination

Floods (2021) cause extensive water pollution in flooded areas. It is a serious environmental problem that adversely affects human health, livestock health and various animals and birds. Water pollution can come from a variety of sources, such as domestic sewage, animal waste, fuel ash, agricultural runoff, industrial runoff, small canals, and groundwater pollution. Various effects of water pollution on human health are consuming contaminated drinking water can lead to various health problems, such as gastrointestinal infections, cholera, dysentery and typhoid fever. Exposure to contaminated water can lead to mental health problems, including stress, anxiety and depression. Primary Health Centres (PHCs) remained inaccessible due to waterlogging and damaged routes. 43% of households reported diarrhoea, skin infections, or vector-borne diseases (Das & Sinha, 2019). Floods can have psychological and social effects on affected communities. The stress of displacement, property damage, and the challenges of rebuilding can contribute to mental health problems.

5. Impact on Property and Infrastructure

Floodwaters can damage or destroy houses, hotels, buildings, roads, bridges, river embankment infrastructure and agriculture. In the 2021 floods, the chemistry and physics laboratory of Yogoda Satsanga Palpara Mahavidyalaya (**Plate No 5**) in Potashpur-1 block was under water for about 1 month. As a result, the chemicals of the chemistry laboratory and various instruments of the physics laboratory were particularly damaged. Sabang, Bhagwanpur-I and Patashpur-I blocks in different areas of electricity were cut off. Transformer of Sabang block submerged in water. Some current pillars collapsed due to flood water velocity, two people died due to electrocution in Bhagwanpur-I block. The extent of damage to an area depends on factors such as the severity of the flood, the type of structures in the area affected, and the preparedness of the community.

Plate No 5: Impact of Assets and Infrastructure
Source: Block Development Office, Purba and Paschim Medinipur, 2023

E. Environmental Consequences and Human Intervention

The environmental impact of the Kaliaghai River floods is both natural and anthropogenic: annual erosion has been recorded at several locations such as Talchitkini in Patashpur-I block, Bolpai and Kismat Sabang in the Sabang block. In the last 20 years, LULC analysis has shown that there has been a 21% reduction in the vegetation cover of wetlands and lowlands, mainly due to encroachment, brick kilns, fish ponds and siltation. At least 151 surveyed locations, traditional fishing barriers have been found to obstruct water flow, leading to backwater flooding and prolonged inundation. Local small canals and drains are either encroached upon or blocked by debris and uncontrolled construction, severely limiting water drainage during peak rainfall (Roy and Das, 2019). In addition, the detrimental environmental impacts of floods include soil erosion and river bank erosion, sheet erosion, landslides, loss of biodiversity and ecosystem damage. Excessive rainfall, unplanned dams, and dam failures have been identified as the main causes of lateral flooding, which results in floodwaters flowing into populated areas.

4. Discussion

The findings of this study highlight the multidimensional and interconnected impacts of Kaliaghai River floods on agricultural production, ecosystems, society and economy of the region. Floods in the Kaliaghai River basin are not only the result of natural hydro-climatic events, but also the result of long-term environmental mismanagement, infrastructural neglect and socio-economic vulnerability. The discussion synthesizes these findings and evaluates them in the broader context of disaster studies, rural livelihoods and climate resilience in Eastern India.

4.1. Nature-Induced and Human-Induced Flooding

Floods in the region are caused by natural phenomena, such as short-term extremely heavy monsoon rainfall, tropical cyclones, rainfall during high tides, the meandering shape of the river course, the shallow longitudinal profile, the deposition of river sediments, ancient and weak embankments and weak natural drainage systems and settlements in the flood plains, sudden releases of water from the Mukutmanipur dam, faulty agricultural practices, poor land use practices, and river blockage by fishing nets and "*paats*" (Mondal, 2022). While floods are common in river plains like West Bengal during the monsoon, the increased density and intensity in the Kaliaghai basin indicate a systemic failure in water resource management (Bhattacharya, 2020). The presence of structures such as bamboo traps *("paats")* and fishing nets, although traditional and economically important, hinders the smooth flow of flood waters (Archarya et al., 2008; Barman, 2021; Mondal, 2022). This results in localized waterlogging, chronic flooding, and backflow in agricultural lands and settlements (Sahu, 2007; Roy and Das, 2019).

4.2. Vulnerability of Rural Livelihoods

The Agro-based economy of the Kaliaghai River Basin is highly vulnerable to seasonal floods. Field data confirms that floods not only destroy standing crops, but also degrade soil quality, limit post-flood cultivation, and reduce the income of marginal farmers and landless workers. Lack of insurance coverage, delayed compensation, and inadequate disaster preparedness further exacerbate economic distress (Jana and Roy, 2018). In addition, the decline in seasonal employment, especially among sharecroppers and agricultural workers, leads to increased migration to urban areas. The socio-economic burden falls disproportionately on women, landless farmers, the elderly, and children, who face food insecurity, disruption of education, and health-related problems.

4.3. Impact on Health and Infrastructure

As revealed in the survey, floods in the basin regularly damage roads, bamboo culverts, bridges, health centres and schools. This infrastructural deficit directly affects the ability of communities to migrate, access healthcare and receive relief. Many households lack access to clean drinking water, sanitation and medicines during and after floods, leading to increased incidence of waterborne diseases (Das and Sinha, 2019). The study also found that government relief and rehabilitation programmes lack effective targeting mechanisms. Many residents rely on informal networks or personal savings to cope with the crisis, which increases their long-term vulnerability (Laha et al, 2014).

4.4. Environmental and Ecological Degradation

Floods have a severe environmental impact on the Kaliaghai River Basin. Soil fertility is reduced by the deposition of sediment and chemical residues on agricultural land. Frequent inundation alters the wetland ecosystem, leading to a decline in biodiversity, especially fish and amphibian populations. The natural flood absorption capacity of the basin, which has been converted from wetlands to settlements or agriculture due to unplanned land use (Roy and Das, 2019). Furthermore, the destruction of forests and riparian vegetation in the lower basin has reduced the natural resilience of the region to floods. Remote sensing analysis confirms that natural wetlands have declined by 21% in two decades - mainly due to siltation, brick kilns, fish ponds, encroachment and lack of environmental protection measures.

4.5. Institutional Gaps and Governance Issues

The analysis indicates a lack of integrated governance in flood risk management. Although there are protocols in place by agencies such as Kaliaghai-Kapaleshwari-Baghai (KKB, 2022) project division, Block Disaster Management Office (BDMO, 2022), District Disaster Management Authority (DDMA, 2022) and West Bengal State Disaster Management Authority (WBSDMA, 2020) and local panchayats, their implementation is often delayed, fragmented or reactive rather than preventive. Early warning systems are weak, proper river embankment systems are lacking and community participation in flood management planning is minimal. Furthermore, policies related to floodplain areas, river restoration and sustainable aquaculture are either absent or not implemented. Traditional livelihood activities (such as fishing using rattan) are not regulated by environmental guidelines, although their role in exacerbating floods is recognized.

4.6. Regional Comparison and Broader Implications

Compared to other flood-prone regions of West Bengal (e.g., the Damodar, Ajay or Kangsabati River Basins), the Kaliaghai region has received less administrative attention and scientific monitoring despite repeated floods (Chakraborty and Samanta, 2015). This neglect has resulted in chronic vulnerability that is being reproduced year after year through cycles of extensive damage, inadequate recovery and return to the status quo. The lack of adaptive livelihood strategies and low institutional capacity have made the Kaliaghai basin a textbook example of "development deficit risk" (UNDP, 2019) – where underdevelopment and disaster risk reinforce each other. In short, the impact of the Kaliaghai river floods is a complex mix of natural disasters and socio-political failures. The findings clearly show that flood risk is not evenly distributed but is concentrated among the poorest and most marginalized. Addressing these issues will require a multi-pronged approach combining river management, policy enforcement, infrastructure investment, and community empowerment. Without these systemic changes, the basin will remain locked in a cycle of disaster, response, and vulnerability.

5. Recommendations

Recurrent flooding in the Kaliaghai River Basin reflects both natural vulnerabilities and systemic development gaps. Based on field observations, survey data and secondary research, this study proposes a comprehensive set of recommendations under three main categories: structural measures, non-structural/policy-based measures and community-level and livelihood interventions. These recommendations aim to reduce flood risk, protect rural livelihoods and promote sustainable basin management.

5.1. Structural Measures: Strengthening Physical Infrastructure

1. River Channel De-siltation and Rejuvenation

Dredging and silting of the Kaliaghai River and its tributaries at intervals of 4 to 5 years is crucial to restore natural flow and increase drainage capacity. Field visit data confirms that in low lying sections (e.g. Langalkata Bridge, Shalmara, Nona Madhabchak, Katakhali Bridge, lower course of Kapaleswari River) de-siltation and water carrying capacity are decreasing (Roy and Das, 2019). Under the River Rejuvenation Mission with technical assistance of Central Water Commission (CWC), annual pre-monsoon dredging is being carried out with the support of Kaliaghai-Kapaleshwari-Baghai (KKB, 2022) project division.

2. Repair and Modernization of Embankments

Many of the dams in the region are old, poorly constructed, or unprotected, such as Dhokra Banka (22°06'05.6"N 87°37'30.4"E), Amgachia (22°06'09.8"N 87°37' 56.6"E). These are likely to cause lateral flooding and extensive damage if they fail. Strengthen and elevate dams using geosynthetic materials; implement smart dam monitoring using IoT sensors for breach warning (NDMA, 2017).

3. Improvement of Drainage Systems

The blockage of canals and drainage lines occupied by brick kilns, fish ponds, permanent nets and weirs delays the drainage of flood water and creates waterlogging, leading to flooding. Re-survey and restoration of traditional canal network; launch a coordinated drainage management plan by the Irrigation Department.

5.2. Non-Structural and Policy-Based Measures

4. Regulation of Fishing Nets and "Pata" Structures

Traditional fishing methods using permanent net structures are obstructing the flow of flood water, further increasing local waterlogging, resulting in frequent flooding situations in the river (Bhattacharya, 2020). Introduce seasonal fishing regulations and environmentally friendly fishing technologies. Enact local administration laws to ban nets in flood-sensitive areas during the monsoon months (June to October).

5. Floodplain Zoning and Land Use Planning

Uncontrolled construction and unscientific farming in natural floodplains increase the risk of flooding. Consequently, Floodplain Zoning Rules under the Environment Protection Act, 1986 should be implemented to restrict settlement, commercial activities and unsustainable farming in high-risk areas (MoEF & CC, 2020).

6. Early Warning and Information Dissemination

Communities remain unprepared due to the lack of real-time flood warnings. Install automatic weather stations (AWS) for early warning and link them to village-level SMS and loudspeaker-based flood warning systems. Use local language warnings through mobile applications and community radios (UNDP, 2019).

7. Strengthening Local Governance and Disaster Planning

Panchayats are often not aware of or have limited resources to properly manage flood events. Build the capacity of Gram Panchayat Disaster Management Committees (GPDMCs) through training in first aid, evacuation and relief coordination. Allocate emergency funds at the district and block levels.

5.3. Community-Based and Livelihood Resilience Strategies

8. Promotion of Flood-Resilient Agriculture

Monopoly rice cultivation in low-lying areas is highly flood-prone and economically risky. Therefore, encourage short-duration, flood-tolerant rice varieties (e.g., Swarna-1), alternative farming and agroforestry systems. Provide technical and financial support for water chestnut or water caltrop cultivation, raised-bed vegetable cultivation and integrated farming models (Jana and Roy, 2018).

9. Livelihood Diversification and Microfinance Access

Livelihoods dependent on a single source of income are at higher risk during floods. Therefore, promote alternative sources of income such as mushroom cultivation, poultry farming, or handicrafts. There is a need to facilitate access to microfinance, self-help groups, and government schemes such as PMFME (Pradhan Mantri Formalisation of Micro food processing Enterprises) and NRLM (National Rural Livelihoods Mission) for women and youth (Das and Sinha, 2019).

10. Construction of Flood Shelters and Safe Storage Units

Evacuation is often hampered by the lack of nearby shelter and storage for valuables or food. Therefore, construct multi-purpose flood shelters at each village level. Establish community grain banks and livestock shelters on elevated platforms in flood-prone villages (Mondal, 2022).

5.4. Long-Term Monitoring and Research

11. Establishment of a Regional Flood Observatory

The region lacks flood monitoring, mapping and risk assessment. The Kaliaghai-Kapaleshwari-Baghai (KKB, 2022) project division is not functioning properly. Therefore, establish a Kaliaghai River Flood Observatory in collaboration with local universities, NGOs and state disaster management authorities. Use GIS-based mapping, historical data archives and real-time monitoring to support evidence-based policies.

These recommendations aim not only at immediate flood mitigation, but also at transforming the Kaliaghai River Basin into a resilient socio-ecological system. Integrating scientific information, local knowledge and inclusive governance into future policies is crucial to ensure the safety, dignity and sustainability of vulnerable rural communities in West Bengal.

6. Conclusion

The Kaliaghai River floods in West Bengal represent a complex interplay between natural hydrological events and human-induced vulnerabilities, which have long-term consequences for the socio-economic stability and environmental sustainability of the region. This study found that while short-term increased seasonal rainfall, tropical cyclones and increased river sediment accumulation are natural contributors, human-induced activities such as unscientific farming, uncontrolled land use, obstruction of the natural flow of the river through fishing structures ("patas"), mismanagement of dams and inadequate infrastructure planning have significantly increased the intensity, frequency and spread of floods (Archarya et al., 2008; Bhattacharya, 2020; Roy and Das, 2019).

The socio-economic impact of floods is particularly severe for marginal farmers, sharecroppers, landless labourers and fishermen, who face repeated displacement, crop losses, job insecurity and health risks. Women, children and elderly residents are disproportionately affected due to limited access to resources, mobility and healthcare. These vulnerable groups are further marginalised due to gaps in disaster preparedness, corruption at local and regional administrative levels, inefficient relief systems and lack of resilient infrastructure (Jana and Roy, 2018; Das and Sinha, 2019).

From an environmental perspective, floods have accelerated soil erosion, riverbank erosion, biodiversity loss and the shrinkage of floodplains and wetlands on both sides of the river. Uncontrolled encroachment on floodplains and deteriorating drainage systems have weakened the basin's natural flood-absorbing capacity. The combined loss of ecological function and agricultural productivity threatens both environmental health and food security in the region.

Moreover, this study identified significant institutional and administrative failures – including administrative corruption, weak enforcement of land use regulations, poor coordination between departments, and inadequate investment in early warning systems and community preparedness (NDMA, 2017; WBSDMA, 2020). The absence of participatory flood management and locally customized adaptation strategies further exacerbates the region's vulnerability.

Therefore, addressing the impacts of Kaliaghai River floods requires a multidimensional and integrated approach that combines structural measures (such as development of embankments and drainage systems), policy reforms (such as floodplain zoning and river barrier control), and grassroots community engagement. Resilient agriculture, aquaculture systems, diversified rural livelihoods, and capacity building of local administration are essential for long-term disaster risk reduction.

In conclusion, flooding in the Kaliaghai River Basin is not just a natural disaster – it is a development failure. Sustainable flood management needs to move beyond a relief-focused approach and incorporate resilience into local planning, ecological restoration, and socio-economic development. Through informed policy action, community-based strategies, and environmental stewardship, it is possible to transform the region from vulnerability to resilience, ensuring both social justice and ecological balance.

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