MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2813-2818

Evaluation of farmers' socioeconomic vulnerability in the Indian districts of Dakshin Dinajpur and Saraikela Kharsawan: a path towards sustainability

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Abstract
In the northwest region of Bangladesh and neighboring West Bengal, India, particularly in the flood-affected corridors of the Atreyee and Punarbhaba rivers and the Subarnarekha river of Saraikela Kharsawan district, floods are a destructive natural hazard that occurs both temporally and spatially. These three rivers, which have their origins in India's hilly regions, flow through heavily populated lowlands or floodplains and provide two challenges. Their seasonal flows sustain livelihoods and agriculture, yet their hydrological and geomorphological characteristics cause devastation through floods and riverbank erosion. Particularly in areas like Biral and Dinajpur Sadar in Bangladesh and Kushmandi, Gangarampur, and Balurghat in India, embankments become overtopped or breached into abandoned areas when there is some rainfall. These kinds of locations are always at risk due to a combination of natural factors, inadequate water management, and insufficient rainfall to sustain embankments. The current study uses the Garret Ranking Method, livelihood vulnerability index (LVI), livelihood security index (LSI), and SWOT analysis to evaluate the socioeconomic vulnerability of the farming community in the riverine tract of Atreyee, Punarbhaba, and Subarnarekha.
Keywords: Flood, agriculture, Subarnarekha, Atreyee, Punarbhaba.

1.0 Introduction

The different social and economic traits that make up a certain area's population are referred to as socio-economic components. People's interactions with one another, with groups, and with their surroundings have a significant impact on how they live, work, learn, receive medical care, and access resources. Understanding these elements becomes crucial since they directly influence development plans, strategies, and sustainable growth to satisfy community demands. The goal of the current study is to assess the socioeconomic vulnerability of the agricultural community in Dakshin Dinajpur's Atreyee and Punarbhaba riverbanks. As one of the most frequent and damaging natural disasters, flooding has a more detrimental impact on economies that rely on agriculture. Approximately 1.47 billion people, mostly in the agricultural sector, are said to reside in flood-prone areas (World Bank, 2021). Farmers in the flood zones of rivers like the Ganga, Brahmaputra, Mekong, Mississippi, and Nile frequently suffer damage to their crops, animals, and infrastructure, endangering their immediate and long-term survival. Due to their poor socioeconomic resilience and limited capacity for coping, these catastrophes have a significant impact on the rural poor, who are primarily small and marginal farmers (UNDRR, 2019; Pattison & Jones, 2022; Shah & Nyangena, 2023; Timmer & Siregar, 2023). In this essay, we make an effort to comprehend the intricate connections between environmental susceptibility and the socioeconomic elements affecting the farmers who reside close to rivers that are prone to flooding. Because of their rich soil and nearby water supply, flood-prone river basins are usually exceptionally fertile alluvial plains, which double their appeal as regions with high agricultural population density. The land in these areas is undoubtedly highly productive, but because they are riverine, they are vulnerable to seasonal flooding, which is made worse by cyclones, monsoons, glacial melting, and dual mismanagement (Berkes & Folke, 2002; Ali & Zaman, 2004; Adger, 2006; Agarwal, 2010; Bashir, 2011). More than 40 million hectares, or 12% of India's total land area, are in risk of flooding (National Disaster Management Authority, 2021). Rivers with their constantly shifting courses, wetlands, backswamps, low-polder lands, and river islands—known as chars—with varying agricultural practices and vulnerability profiles are frequently found in these areas (Dewan & Khandker, 2007; Mokhtari & Shams, 2012; Kumar & Sharma, 2013; Meher & Patra, 2014). For instance, the annual flooding of char lands in Bangladesh and Assam affects crop cycles, land ownership, and settlement patterns (Choudhury & Haque, 2016). Riverbank erosion is mostly caused by floods, which also cause thousands of farmers to relocate annually, lose their land, and accumulate debt (Rashid & Chowdhury, 2005; Rao & Swain, 2008; Saha & Mallick, 2010; Paul, 2011; Sharma & Pandit, 2017). Agriculture is the primary means of subsistence or semi-subsistence farming, itinerant migration, and reliance on common property resources in these regions' flood-prone river basins (Stark & Taylor, 1991; Walker & Salt, 2006; Singh & Yadav, 2009; Yasmin & Bhuiyan, 2009; Singh & Das, 2010; Vaidya & Poudel, 2015; Shrestha & Paudel, 2016). Smallholders with landholdings of less than two hectares make up the majority of farmers in these regions. In addition to rain-fed farming, they engage in multi-cropping. Thus, vulnerability goes beyond simple exposure to include psychological, social, and political factors that influence how resilient communities are to environmental stresses (Hossain & Karim, 2003; Ibrahim & Usman, 2010; Khan & Bhattacharya, 2012; Choudhury & Islam, 2014; Chakrabarty & Bhattacharjee, 2016; Mannan & Sultana, 2018). Due to a number of their vulnerabilities, including low income, inadequate education, unstable land tenure, poor infrastructure, and limited access to financing and insurance, farmers who live next to rivers consistently receive the least attention from socioeconomic factors (Birkmann et al., 2013). In the event of a disaster, farmers in a number of countries are unable to receive compensation for their lost crops or lands due to outdated or improperly maintained land records (Deshingkar & Start, 2003; Paul & Routray, 2011; Shah & Jain, 2018; IFAD, 2022). Smallholder farmers' needs are essentially unmet by conventional lending institutions because they either lack the necessary collateral or are unaware of the financial benefits. In this instance, the smallholder farmers become reliant on the unofficial moneylenders, whose exorbitant interest rates worsen their situation. In addition, social identity is important. According to Blaikie et al. (1994), scheduled castes, tribes, and ethnic minorities frequently reside in the most vulnerable locations and receive less or delayed assistance during floods. Due to its numerous consequences, including unpredictable monsoons, glacier melting, sea level rise, and altered precipitation patterns, climate change has been one of the

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2813-2818

primary causes of both the escalation and increase in floods in river basins (IPCC, 2021). Even after the dam was constructed, the Subarnarekha, Atreyee, and Punarbhaba rivers continue to suffer from severe flooding (Fig. 1).

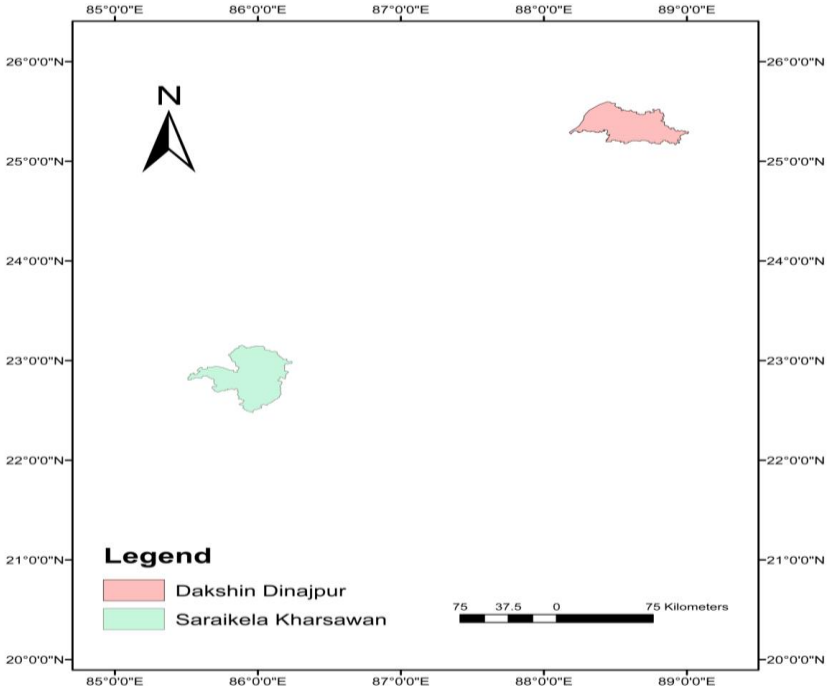

Fig. 1 Location map of the study area

2.0 Materials and methods

2.1 SWOT

SWOT analysis is one of the most widely used strategic planning approaches. In essence, it lists and assesses the four components of a business: opportunities, threats, vulnerabilities, and strengths. The approach significantly facilitates decision-making by identifying elements that help and impede decision-making by compiling a list of internal and external considerations. The organization's internal elements include both strengths and disadvantages. A strong brand name, highly skilled employees, or even patented technology are examples of strengths that make a firm invaluable. Weaknesses are areas where a company performs poorly, such as inadequate funding, a poor location, or outdated technology. Threats and opportunities, however, come from beyond the company. Opportunities are beneficial trends or gaps in the market that a business can fill, such as emerging markets or technological advancements. Unfavorable external circumstances that may result from heightened competition, regulatory changes, or economic downturns are known as threats.

2.1.1 External factors evaluation matrix (EFEM)

i) We list the opportunities and threats at the outset.
ii) We give each component a weight between 0 and 1. A factor is considered negligible if its weight is 0, and it is considered very important if its weight is 1. Every weight adds up to one.
iii) Next, we assign a rating, ranging from 1 to 4, to each factor. We use ratings 1 and 2 for threat considerations. A significant threat is indicated by a rating of 1, and a mild threat is indicated by a value of 2. The small and major opportunities receive ratings of 3 and 4, respectively.
iv) In the fourth step, we multiply each factor's weight by its rating to determine its weighted score.
v) The weighted scores of each factor are then added up to determine the overall weighted score.

2.1.2 Internal factor evaluation matrix (IFEM)

i) We start by identifying all of the system's advantages and disadvantages.
ii) Each factor is assigned a weight between 0 and 1. A weight of 0 indicates that the factor is not important, and a weight of 1 indicates that the element is extremely important.
iii) At that point, factors are ranked from 1 to 4. Rates of 3 and 4 are given to strengths. Major strength typically receives a rating of four, whereas minor strength typically receives a grade of three. Conversely, the rates for weaknesses are 1 and 2.
iv) To obtain each factor's weighted score, multiply its weight by its rating.
v) After that, we move on to the fifth step, which involves summing the weighted scores of each factor to determine the overall weighted score. The optimal approach is determined using the strategic position and action evaluation (SPACE) matrix. The aggressive, conservative, defensive, and competitive quadrants make up this matrix. We determine the type or nature of the approach used based on the location of computed total weighted score values in the internal and external factors assessment matrix within the SPACE matrix.

3.0 Results and discussions

3.1 SWOT

3.1.1 Strengths

Beneficial government policies and subsidies have been identified as the region's most significant agricultural strength, with a weighting of 0.27. This implies that the government is mostly responsible for the advancements in agriculture as a whole as well as the investment and uptake of technology. Similarly, subsidies can lower input costs, shield farmers from hazards, and allow them to obtain credits. The report lists the ease and speed of obtaining bank loans for agriculture as an additional benefit, scoring 0.24. It indicates that banks support farmers' investments in equipment, high-quality seeds, fertilizer, and irrigation systems. Although fertile soils and level fields were mentioned as additional noteworthy benefits, their weight of 0.135 was lower than that of the characteristics related to finance and policy. The fertile soils suggest high production with minimal to no artificial inputs, and the flat fields make irrigation and milling simple, which is essential for water management and control (Ray et al., 2020). Another feature of the region has been support for women's empowerment

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
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and youth. This category's weighted score of 0.14 indicates the region's progress toward inclusive agricultural development. The empowerment of the marginalized will increase the diversity and resilience of the agricultural labor force. Compared to other states, lower labor costs for agriculture will help create competitive advantages that will raise profit margins and draw more funding for agricultural initiatives.

Table 1 Strengths listed for the area

SL.NO.	ELEMENTS OF STRENGTH IN AGRICULTURE	SCORE	WEIGHTAGE	WEIGHTED SCORE
1	Fertile soil and homogeneous terrain properties	3	0.045	0.135
2	Ample amount of rainfall	4	0.04	0.16
3	Supply of formidable amount of water from reliable sources	3	0.025	0.075
4	Healthier seed supplied by the government	3	0.05	0.15
5	Empowering women and encouraging young groups through financial support	4	0.035	0.14
6	Lower rate of agricultural labour compared to other states	4	0.035	0.14
7	Easy and simple process of agricultural loan from banks	3	0.08	0.24
8	Helpful Government policies and Govt. provided subsidies	3	0.09	0.27
9	Lack of other economic activities	3	0.06	0.18
10	Growing local and regional markets with improving marketing facilities	4	0.05	0.2
			0.51	1.69

3.1.2 Weakness

However, a number of issues still affect regional agriculture's efficacy and sustainability. The town's biggest disadvantage is agricultural growing using subpar techniques, which has a weighted score of 0.08. The methods that result in low agricultural yields, water waste, and deteriorated soil are either outdated or inappropriate. The disadvantage brought about by the construction of dams on international rivers was another significant defect that received the same weighted score of 0.08. Therefore, dams may cause disputes over the shared use of waters if the river in question crosses a border. Downstream customers would be less able to work as a result, and they would be unable to water their lands during crucial times. With a lower weighted score of 0.07, capital flow into agriculture has also been identified as a weakness (Table 2). Lack of funding prevents access to new technologies, hinders research and development, and prevents modernization of agricultural techniques. Without adequate financial support, farmers are unable to switch to more profitable and ecologically beneficial methods. In order to fully realize the potential of the region's agriculture, several of these shortcomings individually highlight the need to address the fundamental problems of agricultural methods, water-related disputes between the nations, and the lack of investment.

Table 2 Weaknesses listed for the area

SL.NO.	ELEMENTS OF WEAKNESS IN AGRICULTURE	SCORE	WEIGHTAGE	WEIGHTAGE SCORE
1	Variable and unpredictable rainfall patterns	1	0.06	0.06
2	Insufficient availability of irrigational infrastructure	1	0.06	0.06
3	Flawed techniques employed in crop cultivation	2	0.04	0.08
4	Large number of small firms with weak organisational set up	1	0.06	0.06
5	Financial investment in agriculture is insufficient	2	0.035	0.07
6	Prices of agricultural product is not satisfactory	1	0.06	0.06
7	Cost of fertilizers and pesticides increases day by day	1	0.045	0.045
8	Sizable portion of agricultural outcome goes to waste during transportation and storage	2	0.02	0.04
9	Lack of research in agriculture	2	0.03	0.06
10	Disadvantage of dam created on international rivers	1	0.08	0.08
			0.49	0.615

3.1.3 Opportunities

With a score of 0.32, remote sensing technology for flood, soil, and climate assessment was one of the first facilitators among the opportunities. Accurate and real-time agricultural status monitoring is made possible by remote sensing technologies. As a result, farmers can decide how to manage pests, crops, and irrigation. The increase in production is another benefit of using such remote sensing technologies to optimize water extraction from rivers, in addition to reducing environmental risks.

Figure 3, which depicts crops with 0.32 weight and less sensitivity to weather perturbations, is another crucial potential. By considerably reducing agricultural vulnerability to climate change, crop mixing would offer a dependable source of income and food security.

Table 3 Opportunities listed for the area

SL.NO.	ELEMENTS OF STRENGTH IN AGRICULTURE	SCORE	WEIGHTAGE	WEIGHTAGE SCORE
1	Remote sensing based assessment of climate, soil, flood etc	4	0.08	0.32
2	Additional income of farmers through agro-forestry and agro- tourism	3	0.04	0.12
3	Drastic development in agro- industry and food processing industry	3	0.05	0.15
4	Changes in type of crops ,those are less affected by climatic disruption	4	0.08	0.32
5	Large private organisational investment in agriculture	3	0.05	0.15
6	Agricultural insurance enhancing the security	4	0.065	0.26
7	Market information through social media	4	0.07	0.28
8	Remarkable development in transport and communication.	4	0.065	0.26
.			0.5	1.86

3.1.4 Threats

There are certain significant risks that could prevent this area's agriculture from expanding further. The most relevant risk factor was a lack of interest in agriculture, as indicated by the weight of 0.12 (see table 4). Urbanization, the idea that agriculture pays poorly and requires a lot of labor, and the availability of alternative job possibilities are all contributing factors to this. Labor shortages and a sectoral steady decline are inevitable if this alternative to agricultural issue is not resolved. Not surprisingly, erosion, another significant risk problem, had the same score of 0.12 as risk. In addition to harming farming methods and causing silting in rivers and dams, erosion lowers soil productivity. Plans must be established to use sustainable land management techniques because, despite this danger, deforestation and subpar farming methods are the main causes of erosion. The highest score of.28 was given to using social media to look for market information, which once more represents a novel approach for farmers to interact with consumers, learn about pricing patterns, and develop their expertise in agricultural knowledge networks. Farmers may be able to obtain information through social media that can strengthen their negotiating position and promote best practices.

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Table 4 Threats listed for the area

SL.NO.	ELEMENTS OF STRENGTH IN AGRICULTURE	SCORE	WEIGHTAGE	WEIGHTAGE SCORE
1	Migration of young labour force in western provinces	1	0.08	0.08
2	Increasing temperature and heat waves in summer	1	0.075	0.075
3	Changing pattern and timing of rainfall	1	0.08	0.08
4	Decrease in total cultivable land	2	0.04	0.08
5	Higher risk of man induced flood due to dam constructions in neighbouring country	1	0.06	0.06
6	Lack of interest of young generations in agriculture	2	0.06	0.12
7	Soil erosion	2	0.06	0.12
8	Scarcity of research studies for agricultural studies	2	0.045	0.09
			0.5	0.705

3.1.5 QSPM

Agriculture suffers from a number of vulnerabilities and issues in the majority of developing nations, which are the primary causes of the current state of non-growth, food insecurity, and unproductiveness over time. Some of the issues that are making it difficult to adjust to shifting environmental and economic conditions include inadequate crop diversification, water limitations, labor shortages, traditional agricultural methods, and a lack of research capability. A quantitative strategic planning matrix (QSPM) has been used in the current study to rank potential strategies according to the issues mentioned. Using the objective format set by the QSPM, the decision-makers can assess the strategy alternatives according to their relative attractiveness and expected efficacy as a way to deal with both internal vulnerabilities and external threats. With an overall strategic attractiveness score (STAS) of 5.36, non-traditional cash crops have been ranked highest by the QSPM. Without a doubt, the suggested course of action aims to resolve the primary problems found in the SWOT analysis. The dual problems of water scarcity and inefficient use are major contributors to agriculture's uncertain future. According to QSPM, water conservation is therefore considered the second most important approach, with a STAS of 4.575 (Table 5 & 6). The primary causes of agricultural decline are the variations in rainfall, inadequate irrigation infrastructure, and growing demand for water supplies. With a rating of 4.485, mechanization of farming and upskilling of agricultural workers are the third most critical strategies. The labour crisis, the ageing population, and the urban migration of workers have reduced the availability of skilled agricultural labour to a large extent. The answer to this problem is mechanization. The efficiency of agricultural operations will improve with the implementation of modern agricultural machinery. This will lower production costs and allow the farmer to manage a greater acreage with fewer workers. However, for any machinery operation to succeed, there must be an adequate training programme for agricultural workers, to enable workers to operate the machinery safely and correctly, to do simple maintenance, as well as to operate product machines, where required. Improving agricultural studies and research is fourth in order, with the STAS scoring 4.255 and indicates that there are gaps in local R&D which limit the introduction of new technology and practices. The mechanisation of farming and training agricultural workers came third at 4.485, which suggests work is needed to address the acute shortage of skilled agriculture labor, as the population continues to age, and workers are moving to urban areas. Improving agricultural studies and research is fourth at 4.255 and indicates that there are gaps in local R&D which limit the introduction of new technology and practices.

Table 5 Weaknesses threat strategies

WT 1. Introduction of non-traditional cash crops
WT 2. Water conservation
WT 3. Promotion of alternative livelihood in the area
WT 4. Farm mechanization and training of agricultural labourers
WT 5.Improvement in agriculture related studies and research

Table 6 QSPM decision support system

Key factors	Key Factor	Weight	WT1		WT2		WT3		WT4		WT 5	
			AS	TAS	AS	TAS	AS	TAS	AS	TAS	AS	TAS
Fertile soil and homogeneous terrain properties	S1	0.045	4	0.18	3	0.135	1	0.045	3	0.135	1	0.045
Ample amount of rainfall	S2	0.04	4	0.16	4	0.16	1	0.04	3	0.12	1	0.04
Supply of formidable amount of water from reliable sources	S3	0.025	4	0.1	4	0.1	1	0.025	3	0.075	1	0.025
Healthier seed supplied by the government	S4	0.05	3	0.15	1	0.05	1	0.05	3	0.15	3	0.15
Empowering women and encouraging young groups through financial support	S5	0.035	2	0.07	1	0.035	3	0.105	2	0.07	2	0.07
Lower rate of agricultural labour compared to other states	S6	0.035	3	0.105	1	0.035	3	0.105	3	0.105	1	0.035
Easy and simple process of agricultural loan from banks	S7	0.08	3	0.24	1	0.08	1	0.08	4	0.32	2	0.16
Helpful Government policies and Govt. provided subsidies	S8	0.09	4	0.36	3	0.27	2	0.18	3	0.27	4	0.36
Lack of other economic activities	S9	0.06	2	0.12	1	0.06	3	0.18	1	0.06	1	0.06
Growing local and regional markets with improving marketing facilities	S10	0.05	4	0.2	1	0.05	1	0.05	1	0.05	2	0.1
Variable and unpredictable rainfall patterns	w1	0.06	4	0.24	3	0.18	1	0.06	3	0.18	2	0.12
Insufficient availability of irrigational infrastructure	w2	0.06	2	0.12	3	0.18	1	0.06	3	0.18	3	0.18
Flawed techniques employed in crop cultivation	w3	0.04	3	0.12	1	0.04	1	0.04	3	0.12	3	0.12
Large number of small firms with weak organisational set up	w4	0.06	2	0.12	2	0.12	1	0.06	3	0.18	1	0.06
Financial investment in agriculture is insufficient	w5	0.035	3	0.105	1	0.035	2	0.07	4	0.14	3	0.105
Prices of agricultural product is not satisfactory	w6	0.06	3	0.18	1	0.06	1	0.06	1	0.06	1	0.06
Cost of fertilizers and pesticides increases day by day	w7	0.045	3	0.135	3	0.135	1	0.045	1	0.045	2	0.09
Sizable portion of agricultural outcome goes to waste during transportation and storage	w8	0.02	1	0.02	1	0.02	1	0.02	2	0.04	3	0.06
Lack of research in agriculture	w9	0.03	2	0.06	2	0.06	1	0.03	2	0.06	4	0.12
Disadvantage of dam created on international rivers	w10	0.08	2	0.16	3	0.24	2	0.16	2	0.16	2	0.16
Remote sensing based assessment of climate, soil, flood etc	O1	0.08	3	0.24	4	0.32	1	0.08	4	0.32	4	0.32
Additional income of farmers through agro-forestry and agro- tourism	O2	0.04	1	0.04	2	0.08	1	0.04	3	0.12	3	0.12
Drastic development in agro- industry and food processing industry	O3	0.05	3	0.15	2	0.1	3	0.15	3	0.15	3	0.15
Changes in type of crops ,those are less affected by climatic disruption	O4	0.08	4	0.32	3	0.24	1	0.08	2	0.16	3	0.24
Large private organisational investment in agriculture	O5	0.05	2	0.1	4	0.2	1	0.05	3	0.15	2	0.1
Agricultural insurance enhancing the security	O6	0.065	3	0.195	3	0.195	1	0.065	1	0.065	2	0.13
Market information through social media	O7	0.07	2	0.14	1	0.07	1	0.07	1	0.07	1	0.07
Remarkable development in transport and communication.	O8	0.065	2	0.13	1	0.065	2	0.13	1	0.065	2	0.13
Migration of young labour force in western provinces	T1	0.08	1	0.08	1	0.08	4	0.32	1	0.08	1	0.08
Increasing temperature and heat waves in summer	T2	0.075	3	0.225	3	0.225	1	0.075	2	0.15	1	0.075
Changing pattern and timing of rainfall	T3	0.08	2	0.16	4	0.32	1	0.08	1	0.08	1	0.08
Decrease in total cultivable land	T4	0.04	2	0.08	2	0.08	3	0.12	3	0.12	1	0.04
Higher risk of man induced flood due to dam constructions in neighbouring country	T5	0.06	3	0.18	3	0.18	2	0.12	1	0.06	3	0.18
Lack of interest of young generations in agriculture	T6	0.06	2	0.12	1	0.06	3	0.18	1	0.06	1	0.06
Soil erosion	T7	0.06	2	0.12	3	0.18	1	0.06	3	0.18	3	0.18
Scarcity of research studies for agricultural studies	T8	0.045	3	0.135	3	0.135	1	0.045	3	0.135	4	0.18
			5.36	1	4.575	2	3.13	5	4.485	3	4.255	4

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ISSN: 1053-7899
Vol. 35 Issue 2, 2025, Pages: 2813-2818

Conclusion

Low gradients, meandering channels, thick silt on discharges, and significant seasonal variations in rainfall are characteristics of the Atreyee and Punarbhaba Rivers. During the monsoon season, the physical characteristics of the rivers cause overbank flooding. Due to their proximity to the Himalayas and the phenomena of orographic effect, North Bengal's upper catchments, which include Malda, Dakshin Dinajpur, and Uttar Dinajpur, see significant rainfall. In Bangladesh's Dinajpur and Naogaon districts, for example, the accumulated runoff from these rivers runs through their lower reaches and often exceeds their flow capacity. The carrying capacity of the rivers will be further reduced by the aggradation of the riverbed and the sedimentation that reduces the cross-sectional flow area. The embankments are therefore overtopped or breached in moderate rainfall events during monsoon rains of the same intensity, particularly in Biral and Dinajpur Sadar in Bangladesh and Kushmandi, Gangarampur, and Balurghat in India. Natural forces have a greater influence on flood relief than water governance and careless embankment upkeep.

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