

**Research Article**

**RIVERINE COMMUNITY VULNERABILITY TO FLOODING:  
AN INSIGHT FROM THE BRAMHAPUTRA-JAMUNA RIVER  
AT HARIRAMPUR UPAZILA, MANIKGANJ**

**Md. Abdul Malak<sup>1\*</sup>, Md. Mafizur Rahman<sup>2</sup>, Seam-Ur-Rahman Khan<sup>1</sup>, and  
Mohammad Abdul Quader<sup>1</sup>**

<sup>1</sup>*Department of Geography and Environment, Jagannath University, Dhaka-1100, Bangladesh*

<sup>2</sup>*Department of Public Administration, Jagannath University, Dhaka-1100, Bangladesh*

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**ABSTRACT**

Bangladesh is one of the nations that has a distinctive environment for floods. Most of the land is low-lying, and 80% is a floodplain, making it highly susceptible to frequent flooding. This research aims to investigate the susceptibility of riverine communities to flooding and display the spatial distribution of vulnerability for the study region (Harirampur Upazila). A vulnerability assessment index is developed using multiple variables related to social, physical, and economic vulnerability. A quantitative survey is conducted to gather data on physical, social, and economic factors contributing to household vulnerability to floods. The results reveal that out of the five unions in Harirampur Upazila, Gopinathpur, and Lesraganj unions, they have been found to have a high vulnerability to flooding (vulnerability scores of 3.19 and 3.10, respectively). Kanchanpur Union is severely vulnerable to flooding (score 3.57). On the other hand, Gala Union is designated as a lowly vulnerable (score of 2.23) area, and Ramkrishnapur Union is classified as a moderately vulnerable (score of 2.83) area. Finally, this study would help to assign government and non-government initiatives following the vulnerability category during critical conditions of any disaster period.

**Keywords:** *Household, Susceptibility, Vulnerability Index, Flooding, Riparian community*

**Introduction**

It is estimated that disasters in the last century have taken more people than the two world wars combined (Cohen and Werker, 2008). From 1980 to 2016, there were around 10,500 documented catastrophes, resulting in 2.4 million fatalities and economic loss of \$2.9 trillion (EM-DAT, 2016). Approximately 10,000 individuals died, and economic damages worth \$317 billion were inflicted by roughly 350 disasters in 2017 alone (EM-DAT, 2018). Bangladesh is one of the most vulnerable country to climate change and its associated consequences (Ahmed, 2006).

\* **Correspondence:** [amalak@geography.jnu.ac.bd](mailto:amalak@geography.jnu.ac.bd)

Bangladesh usually experiences catastrophies like tropical cyclones, storm surges, coastal erosion, floods, and drought every year. Floods in 1988, 1998, 2004, 2007, and 2017 were devastating and had caused extensive damage and fatalities (Hossain *et al.*, 2020). When these terrible floods and riverbank erosions are combined together, it accelerates the process of pauperization in rural Bangladesh, this adversity has made a worse situation (Islam *et al.*, 2017). According to Gruntfest (1995), individuals have grown more susceptible to high poverty levels since they now reside in risky regions like river flood plains and on embankments. Also, due to its dense population, Bangladesh struggles to spread the benefits of the current economic growth and social welfare to a more significant portion of its population. Additionally, many factors, such as global warming and climate change, are making all development efforts extremely difficult.

Vulnerability refers to a system's capacity to foresee, control, tolerate, and recover from a natural hazard's effects (Fatile and Adejobi 2012). The poorest countries and its inhabitants suffer the most because of their geographic location, less wealth, less institutional capacity, and greater reliance on climate-sensitive businesses like agriculture (Mani, 2008). Climate change effects are also more pronounced in environmentally sensitive areas, especially for marginalized people who depend on natural resources (Nath and Behera, 2011). Populations, particularly in poorer nations, are more vulnerable to floods than other developed countries (Ariyabandu and Wickramasinghe's 2003 research). Floods cannot be stopped, but their disastrous impacts can be reduced with enough preparedness (Sinclair and Pegram, 2003). Physical vulnerability and human susceptibility have a high dynamicity and ever-evolving interaction (Smith and Ward, 1998). In Bangladesh, extensive research has been done on disasters, floods, and vulnerability assessment. Many researchers explained vulnerability from different perspectives. It is noticeable that most research assessed the vulnerability based on exposure, sensitivity and adaptive capacity.

Moreover, the existing research are mostly focused on vulnerability particularly, either physical or, social or economic vulnerability. Little attention has been paid to an integrated assessment of physical, social, and economic vulnerability. Therefore, this research aims to assess household vulnerability by developing a Disaster Vulnerability Index, taking physical, social, and economic context in the face of flooding.

The study area (Harirampur Upazila, Manikganj) with a population of 171274, is a low-lying, extremely flood-prone area next to the Padma River. Agriculture is the primary industry in the studied area. 245.42 sq km in size, the Harirampur Upazila (Manikganj district) is situated between 23°38 and 23°48' north latitude and 89°50 and 90°03' east longitude. Shibalaya, Goalanda, and Faridpur Sadar upazilas are on the west; Manikganj Sadar, Nawabganj (Dhaka), and Dohar upazilas are on the east, and Shivalaya, Ghior, and Manikganj Sadar upazilas on the north and south, respectively. Out of 13 unions, five unions—Gala, Gopinathpur, Kanchanpur, Ramkrishnapur, and Lesraganj have been selected for this research including the unions that are closed to the river and the unions that are distant from the river (fig. 1).

## **Materials and Methods**

This study has used a quantitative approach to assess the household vulnerability to flooding. A quantitative survey was conducted to gather data on physical, social, and economic factors

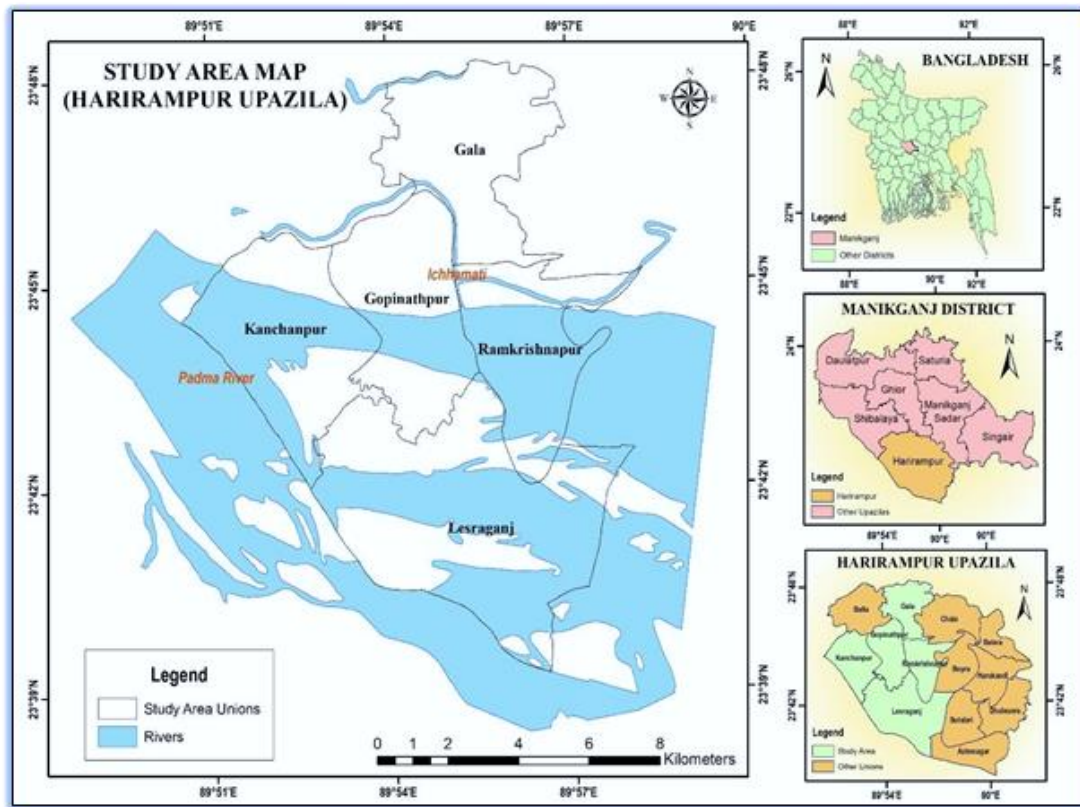


Fig. 1. Location of Harirampur Upazila, Manikganj.

contributing to household vulnerability to floods. The survey was administered to a sample of households in flood-prone areas. The physical vulnerability of households has been assessed by examining the level of exposure and susceptibility to flood hazards. This includes an analysis of the house distance from the road and cyclone shelter, house location from the river and riverbank erosion condition and so forth. The social vulnerability of households has been assessed by examining the social characteristics of the household, such as age, educational status, occupation, early warning system, access to local government, number of children, safe drinking water and so on. The economic vulnerability of households has been assessed by examining the economic characteristics of the household, such as income, amount of savings, dependency ratio, and credit accessibility.

#### Sample Size and Respondent Selection for Survey Questionnaire

A convenient sampling techniques were used to determine the sample size for questitative questionnaire survey. The sample size was selected by random sampling with a 5% significance level.

$$\text{Sample Size, } n = N \times \frac{\frac{z^2 \times p \times (1-p)}{e^2}}{[N - 1 + \frac{z^2 \times p \times (1-p)}{e^2}]} \quad (1)$$

Here,  $n$  = sample size,  $N$  = population size,  $z$  = critical value of the normal distribution at the required confidence level,  $e$  = margin of error,  $p$  = sample proportion.

With a population size of 67,188, a critical value of 1.96, a margin of error of 0.05, and a sample proportion of 0.5, a total sample size of  $381.98 \approx 382$  respondents is calculated using equation 1. A total of 400 respondents' were finalized for equitable distribution (80 participants from each Union). 4 villages has been selected from each union and 20 participants has randomly selected from each village. The participants were selected with divers economic background such as farmer, fishermen, day labourer, businessmen, services, so on.

#### Vulnerability Calculation Methods

As vulnerability is the combination of physical, social, and economic vulnerabilities, the ultimate vulnerability should be the average of these three.

So, the equation stands as:

$$\text{Vulnerability score (Ultimate/Final)} = (\text{Physical Vulnerability} + \text{Social Vulnerability} + \text{Economic Vulnerability})/3$$

After identifying the variables of the factors, each variable of the vulnerability scored from 5 to 1 scale representing severe vulnerability to less vulnerability. The scale is given following the Disaster Crunch Model (Venton & Hansford, 2006). Waliuzzaman *et al.* (2016) considered assessment level using a score from 1 to 5. They categorized three assessment levels where 2.5-2.8 was considered low, 2.81-3.35 was considered medium, and 3.36-3.75 was high. Based on this, the vulnerability index of this study has been categorized in the following manner, where five levels of vulnerability are considered for more specification of the vulnerable area.

Table 1. Vulnerability Assessment level

Scale	1-2.2	2.2-2.50	2.51-3.00	3.01-3.50	3.51-4.99
Level	Lower	Low	Moderate	High	Severe

[Source: Fahim & Miti, 2022]

## Results and Discussion

### Social Vulnerability Assessment

Certain social and demographic traits that make some groups more vulnerable than other groups are referred to as social vulnerability. Social vulnerability or sensitivity is a significant hazard category or threat source, in contrast to biophysical vulnerability or other exposure indications. Thirteen assessment parameters, including age, occupation, education, early warning system, access to local government, number of children, and social facilities such as irrigation facilities, electricity, fuel, sanitation, and healthcare facilities, have been chosen to measure the social vulnerability score.

Table 2. Social Vulnerability Assessment

Factors	Scale of Scoring (1 to 5)	Social Vulnerability Score for each Union				
		1	2	3	4	5
1. Age	Above 60 = 5					
	Below 10 = 4					
	11-17 = 3	2	2	2	2	2
	41-59 = 2					
	18-40 = 1					
2. Occupation	Fishing = 5					
	Farmer = 4					
	Small Business = 3	3	5	4	4	3
	Official Job = 2					
	Large Business = 1					
3. Educational Status	Illiterate = 5					
	Below SSC = 4					
	SSC = 3	2	4	2	3	3
	HSC = 2					
	Graduate = 1					
4. Health Condition	Poor = 5					
	Fair = 4					
	Good = 3	3	3	3	3	3
	Very Good = 2					
	Excellent = 1					
5. Health care Facilities	Poor = 5					
	Fair = 4					
	Good = 3	2	3	3	3	3
	Very Good = 2					
	Excellent = 1					
6. Electricity Accessibility	Poor = 5					
	Fair = 4					
	Good = 3	3	4	4	4	4
	Very Good = 2					
	Excellent = 1					
7. Sanitation Facilities	Poor = 5					
	Fair = 4					
	Good = 3	3	5	4	5	4
	Very Good = 2					
	Excellent = 1					

Factors	Scale of Scoring (1 to 5)	Social Vulnerability Score for each Union				
		1	2	3	4	5
8. Early Warning System	Poor = 5 Fair = 4 Good = 3 Very Good = 2 Excellent = 1	2	2	2	2	3
9. Irrigation Facilities	Poor = 5 Fair = 4 Good = 3 Very Good = 2 Excellent = 1	3	3	2	3	3
10. Fuel Facilities	Poor = 5 Fair = 4 Good = 3 Very Good = 2 Excellent = 1	3	4	4	4	3
11. Access to Local Government	Poor = 5 Fair = 4 Good = 3 Very Good = 2 Excellent = 1	2	3	2	3	3
12. Fresh Drinking Water Supply	Poor = 5 Fair = 4 Good = 3 Very Good = 2 Excellent = 1	2	4	4	3	3
13. No. of Children (Each Family)	4 and Above = 5 3 = 4 2 = 3 1 = 2 None = 1	2	4	2	3	3
Average Scale		2.46	3.53	2.92	3.23	3.07
Vulnerability Level		L	S	M	H	H

[1 = Gala; 2 = Kanchanpur; 3 = Gopinathpur; 4 = Lesraganj; 5 = Ramkrishnapur]

The most crucial factor in determining a particular area's vulnerability is age. In this study, "age over 60" and "age under 10" are given higher scores, indicating that people in these age ranges are

more vulnerable to disasters. Farming and fishing are two occupations that are more susceptible to disasters than other occupation. In this approach, the vulnerability rating system gives these two occupations a greater value. As a result, scores are established for each of the social vulnerability assessment factors.

The majority of the people in the study area are between the age group of 18-59. The number of people under 18 years is lesser because we only consider the respondents above 17 years of age. People found above 60 years of age is 23%.

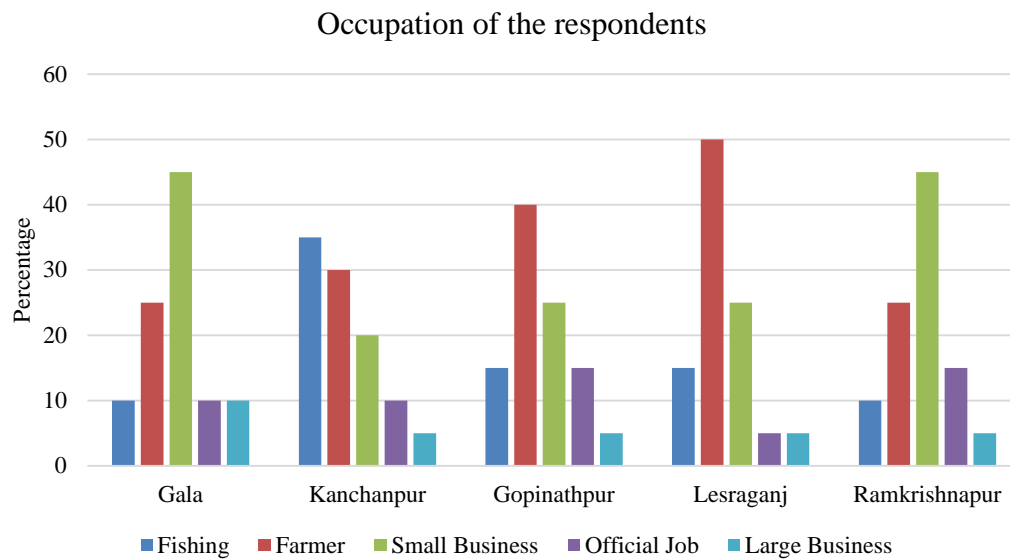


Fig. 2. Occupation of the participants.

The above diagram indicates the occupation of the respondents of the 5 unions. Most of the people of Gala and Ramkrishnapur unions engaged in small business-like shopkeeping, CNG driving, tea stall, etc. Union 2, 3, and 4 have fishing and farming as their major occupation. Also, a noticeable number of people engaged in small business in these three unions. A small proportion of people worked in official jobs and large businesses (fig. 2).

Most of the people in the unions are below the secondary educational level (fig. 3). A large number of people are illiterate and below SSC within the study area. Most of the people in the study area are farmer-fishermen. A tiny proportion of people have higher educational qualifications.

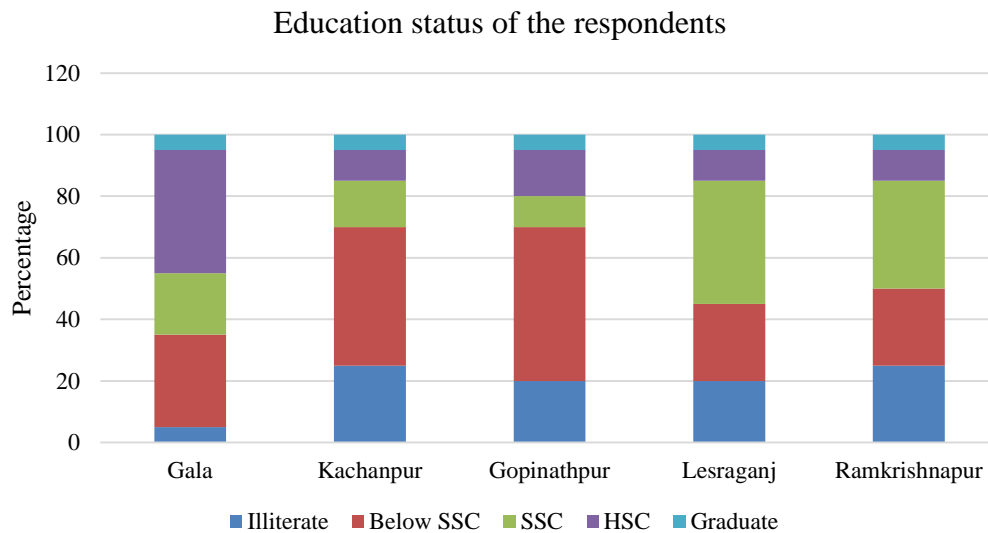


Fig. 3. Education status of the respondents.

Effective early warning lowers any disaster risk, including floods and cyclones. Therefore, losses and damages will drastically decrease if warning systems are effectively disseminated among the mass population. The research area's disaster warning conditions are shown in Table 2. According to the field study conducted in 2022, approximately 60% of respondents agreed that they received disaster early warning. Additionally, it is discovered that the primary sources of early warnings are government organizations, news media, police, and community-based clubs or organizations.

The local authority has done an incredible job for reducing the probability of disaster. Because the local government authority is located quite close to the respondents of all five unions, it is discovered that they may easily access it (Field study 2022). More than 80% of people answered that access to local government is either good or very good. Most households in the study area claimed access to clean drinking water. According to the respondents, more than 60% of the houses in the study area have access to fresh drinking water. Other 23% of households have a fair supply of fresh drinking water.

As per the field survey conducted in 2022, more than 50% of the houses in the study area have two or more children, and 25% have only one child. From Table 2, it is seen that the majority of the houses in Kanchanpur union have three children, while in Lesraganj and Ramkrishnapur, the majority of the houses have two children & the majority of homes in Gala and Gopinathpur have only one child.



Table 3. Status of social facilities in the study area

Social Facilities	Health Care Facilities	Electricity Facilities	Sanitation Facilities	Irrigation Facilities	Fuel Facilities		Percentage				
							Ramkrishnapur	Lesraganj	Gopinathpur	Kanchanpur	Gala
	Poor Fair Good Very Good Excellent	Poor Fair Good Very Good Excellent	Poor Fair Good Very Good Excellent	Poor Fair Good Very Good Excellent	Poor Fair Good Very Good Excellent						
	10 70 20	5 65 35	25 55 15 5	35 45 20	5 25 60 10		45 55	20 60 20	30 70	40 50 10	
							20 60 20	10 60 30	20 60 20	5 55 40	
							55 45	35 45 20	55 40 5	10 20 45 25	
							20 60 20	5 25 60 10	5 60 30	45 40 15	
							10 55 35	5 65 30	10 70 20	20 50 30	

Table 3 shows the status of social facilities in five unions of the study area. People with poor social facilities are more vulnerable to hazards, while having sufficient social facilities is very important to reduce social vulnerability and make people more resilient to natural hazards. In Gala Union, irrigation facilities, electricity, fuel, and sanitation facilities are good, while healthcare facility is also outstanding. In other unions, these facilities are fair.

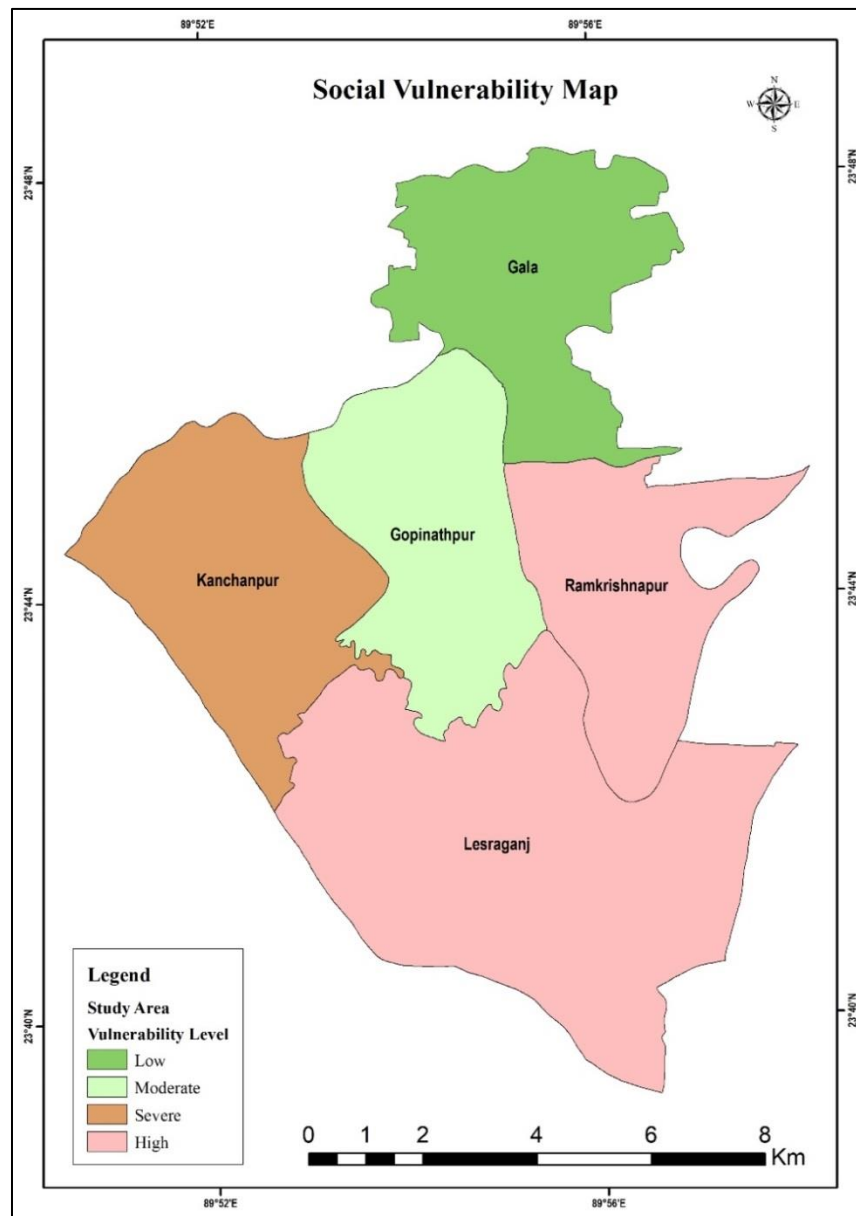


Fig. 4. Social vulnerability map of the study area.

Using the Vulnerability Assessment Level of Table 1 and the Social Vulnerability Score calculated above of the study area (fig. 4), this study identified four different types of socially vulnerable conditions out of five vulnerable conditions. According to the Vulnerability Assessment Level (Table 1), Gala Union is a less vulnerable area; Gopinathpur is a moderately vulnerable area; Union four and five is a highly vulnerable areas; and Kanchanpur is a severely vulnerable area.

## Economic Vulnerability Assessment

Income, savings, dependency ratio, and credit accessibility are key factors determining economic vulnerability. These elements are more critical to the study area's population's susceptibility. To lessen the economic vulnerability to disasters in the study area, a high income, intense savings situation, and low dependency ratio or multiple earners are crucial. People are capable to withstand disaster damage because of these variables.

Table 4. Economic Vulnerability Assessment

Factors	Scale of Scoring (1 to 5)	Economic Vulnerability Score for each Union				
		1	2	3	4	5
1. Income	Below 5000 BDT = 5 6000-11000 BDT = 4 12000-17000 BDT = 3 18000-23000 BDT = 2 Above 23000 BDT = 1	1	3	2	2	1
2. Dependency Ratio	More than 6 Persons = 5 5 to 6 Person = 4 3 to 4 Person = 3 2 to 1 Person = 2 0 person = 1	2	3	2	2	3
3. Amount of Savings	Below 3000 BDT = 5 4000-6000 BDT = 4 7000-9000 BDT = 3 10000-12000 BDT = 2 Above 12000 = 1	4	5	5	4	4
4. Loan/ Credit Facilities	Poor = 5 Fair = 4 Good = 3 Very Good = 2 Excellent = 1	2	3	3	3	3
Average Scale		2.25	3.50	3	2.75	2.75
Vulnerability Level		L	H	M	M	M

The fig. 5 describes that, more than 40% and 60% of respondents of Gala and Ramkrishnapur earn above 23000 BDT monthly. Most of the respondents from the Kanchanpur union earned

BDT 12000-17000 monthly, and a remarkable number of people earned more than 17000 BDT in that Union. On the other hand, more than 45% of the respondents from the Gopinathpur and Lesraganj union earned BDT 18000-23000 per month.

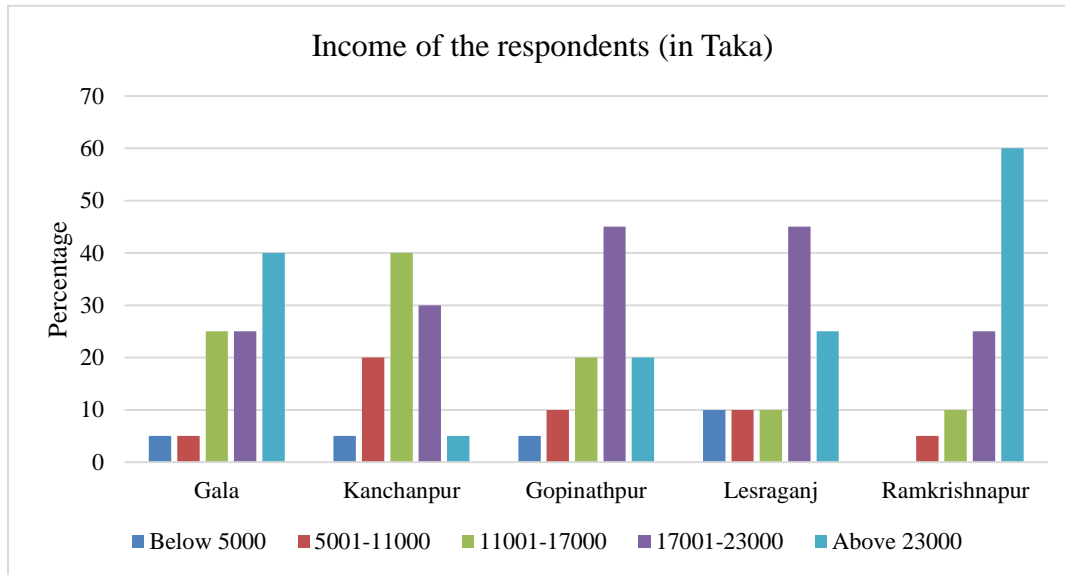


Fig. 5. Participant's Income (in Taka).

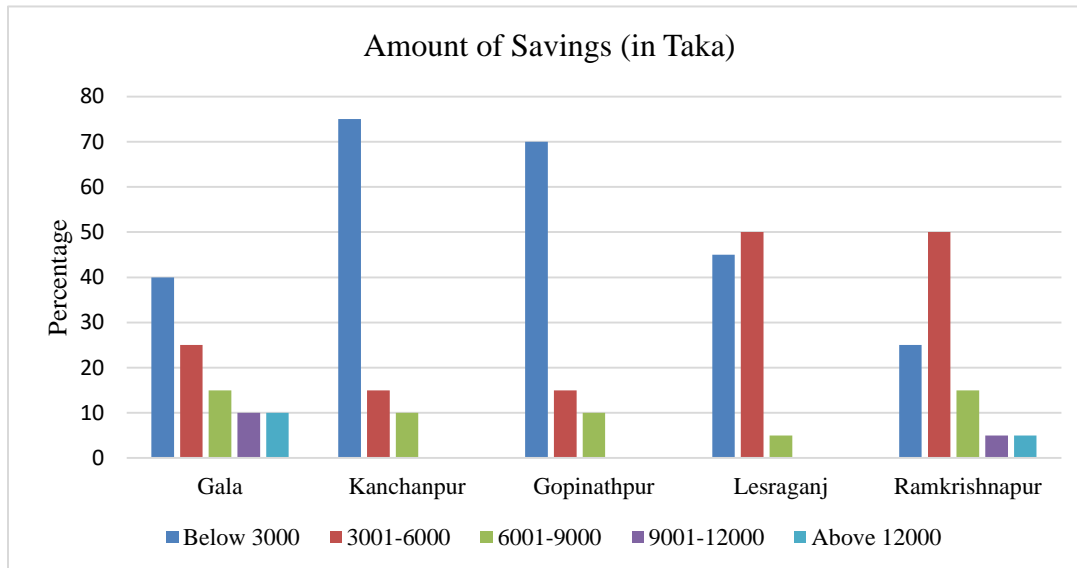


Fig. 6. Amount of savings (in Taka).

Regarding savings and assets, most of the respondents from Lesraganj and Ramkrishnapur had savings in various banks and financial institutions (fig. 6). The respondents' tendency to save money is not

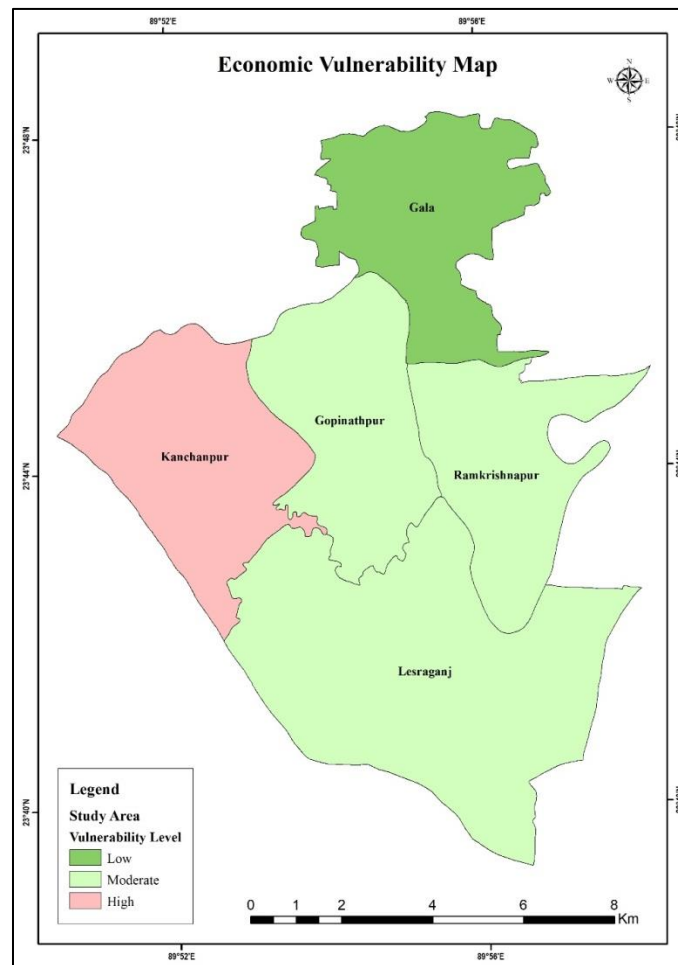


Fig. 7. Economic vulnerability map of the study area.

particularly noteworthy in all the unions of the study area. Surprisingly, more than 50% of the houses in the study area have savings below BDT 3000. The tendency to save less money makes them more susceptible to disasters.

Maximum households in the study area have more than one earning member, and the dependency ratio is low. The dependency ratio in the majority of the houses of Gala, Lesraganj & Gopinathpur union is one to two person, and the dependency ratio in most of the houses of Kanchanpur & Ramkrishnapur union is three to four persons. As per the field survey conducted in 2022, most respondents answered that loan accessibility is good in their area. In the Gala Union, credit accessibility is excellent. This factor makes the people in the study area resilient to flood.

This study's assessment of economic vulnerability reveals three different levels of economic vulnerability in the studied area (fig. 7). Compared to other unions, one Union in the Study area (Gala Union) has a low economic vulnerability. Union three, four, and five are moderately

vulnerable areas. On the other hand, Kanchanpur is a severely vulnerable area regarding economic vulnerability.

#### Physical Vulnerability Assessment

Six assessment factors have been established to determine the physical vulnerability score. These are: (1) The distance from the river to the house; (2) The structure of the house; (3) The distance from the cyclone shelter; (4) The distance from the pucca road; (5) The state of the roads leading to the cyclone shelter; and (6) Riverbank erosion. The score for "house location within below 0.5 km. from the river" factor is taken as five (5), which indicates that the vulnerability to a hazard is more significant when considering the distant respondents. The range of this rating is from 5 to 1. The highest and lowest levels of vulnerability are 5 and 1, respectively. Scores are given to the other four factors similarly to this factor (Table 5).

Table 5 shows that most Union (2-5) houses are close to the Padma River, and Union One is close to the Ichamati River. In all the unions, maximum households are located within 0.5 to 2 km of the river. So, it can be said that the study area is quite risky due to its closeness to the rivers (Fig. 8).

Table 5. Physical Vulnerability Assessment

Factors	Scale of Scoring (1 to 5)	Physical Vulnerability Score for each Union				
		1	2	3	4	5
House distance from river	Below 0.5 km = 5					
	0.5- 1 km = 4					
	1-2 km = 3	3	5	5	4	3
	2-3 km = 2					
	Above 3 Km = 1					
House structure	Mud/ Bamboo = 5					
	Tin = 4					
	Tin & Brick = 3	3	4	4	4	3
	Brick = 2					
	Others = 1					
House distance from cyclone shelter	Above 3 km = 5					
	2-3 km = 4					
	1-2 km = 3	2	3	4	4	3
	0.5-1 km = 2					
	Below 0.5 km = 1					
House distance from pucca (concreteroad)	Above 3 km = 5					
	2-3 km = 4					
	1-2 km = 3	1	3	2	2	2
	0.5-1 km = 2					
	Below 0.5 km = 1					
Condition of the Road	Kacha Road with Bad Surface = 5					
	Kacha Road = 4					
	Semi- Pucca Road = 3	1	3	3	3	2
	Pucca Road with bad surface = 2					
	Pucca (Concrete Road) = 1					

Factors	Scale of Scoring (1 to 5)	Physical Vulnerability Score for each Union				
		1	2	3	4	5
Riverbank Erosion	Very High = 5					
	High = 4					
	Neutral = 3	2	4	4	3	3
	Low = 2					
	Very Low = 1					
<b>Average Scale</b>		2	3.67	3.67	3.33	2.67
<b>Vulnerability Level</b>		Lr	S	S	H	M

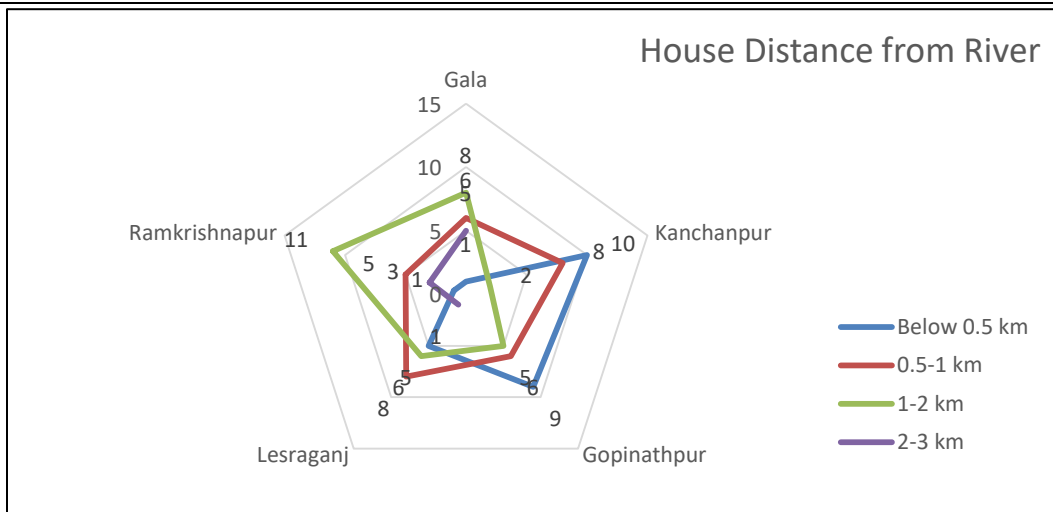


Fig. 8. Distance of Settlements from River.

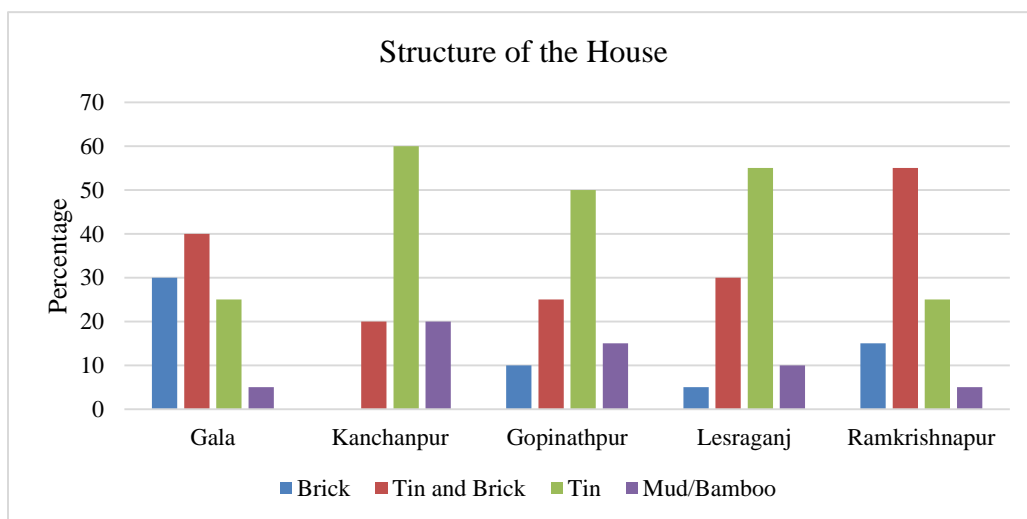


Fig. 9. Structure of the House.

From fig. 9, it can be found that the majority of the respondents from unions two, three, and four use tin as their house-building material. While in the Gala and Ramkrishnapur union, most respondents used Tin & Brick as building materials to make their houses. Therefore, it may be concluded that a substantial portion of the study area's houses is at risk for flood because of a lack of sturdy structural components.

As per the field survey conducted in 2022, the maximum respondents of unions three and four said they live within 2-3 km. from a cyclone shelter. Most of Union two and five respondents said they live within 1 to 2 km from the cyclone shelter. A noticeable respondent of the Gala Union states that they have cyclone shelters very close to them (0.5 to 1 km.). Maximum unions two and four respondents added that they live within 1-2 km. from Pucca road. Most of Union three and five respondents said they live within 0.5 to 1 km from Pucca Road. A noticeable respondent of the Gala Union states that they have concrete roads very close to them (Below 0.5 km.). It can be dangerous for those with weak housing structures who need to seek shelter on any permanent structure, such as shelter etc. From Table 5, it can be found that the majority of the roads of Union three, four, and five are semi-pucca. Only in Gala Union, a great number of roads are Pucca. On the other hand, it is noticeable that most of the roads in Ramkrishnapur Union are made of concrete with a bad surface.

The rate of riverbank erosion in the study area is high. Fig. 10 shows that riverbank erosion is high in Kanchanpur, Gopinathpur, and Lesraganj Union, Neutral in the Ramkrishnapur Union and Low in the Gala Union. Higher rate of riverbank erosion tends to increase the vulnerability of people to flood.

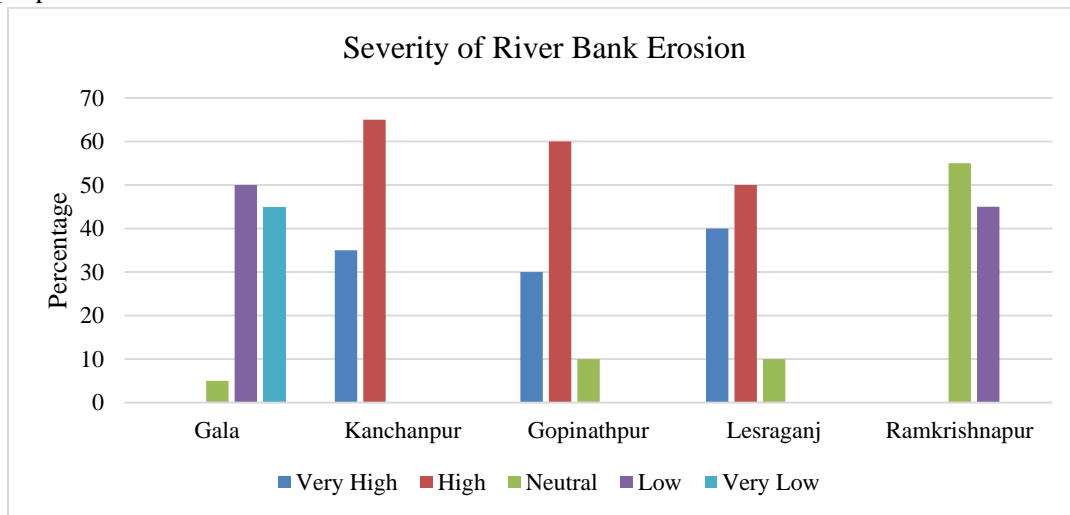


Fig. 10. Severity of river bank erosion.



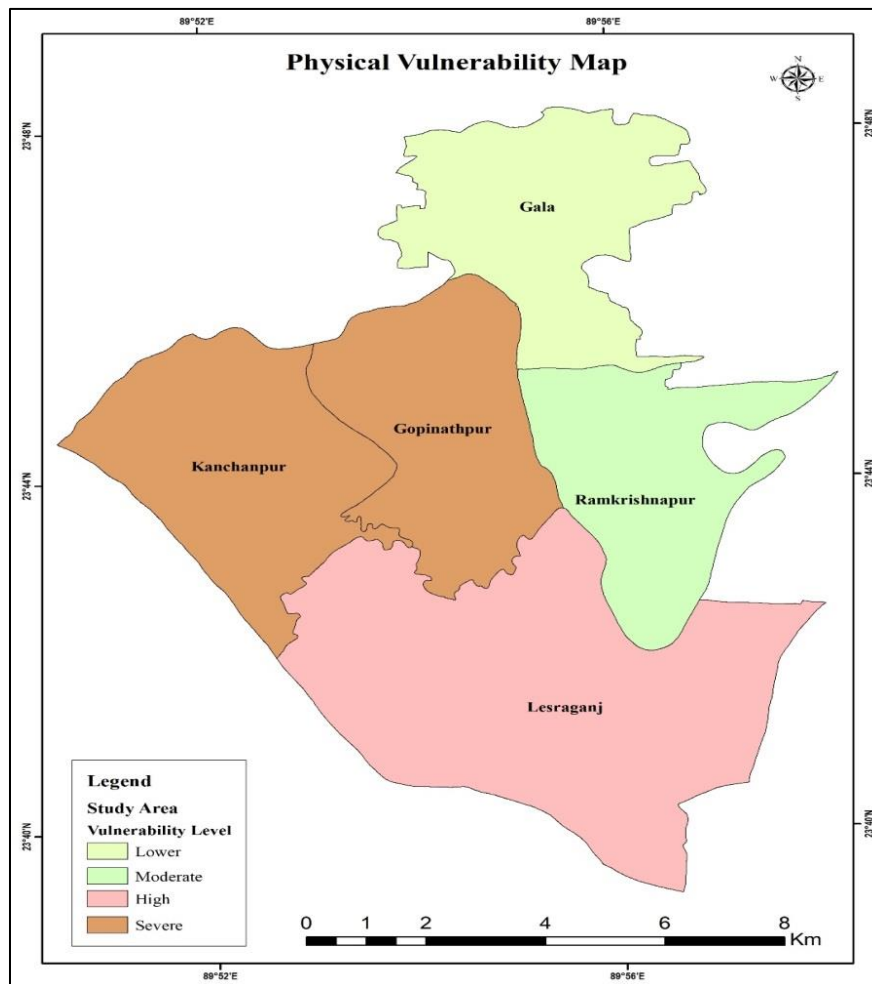


Fig. 11. Physical vulnerability map of the study area.

Four levels of physically vulnerable conditions - lower, moderate, high, and severe vulnerable areas are discovered in the study area using the Vulnerability Assessment Level (Table 1). Union one

(Gala) and five (Ramkrishnapur) are lower and moderately vulnerable areas, respectively, while the Lesraganj union is a highly vulnerable area. On the other hand, Union two and three are severely vulnerable areas regarding physical vulnerability (fig. 11).

#### Vulnerability Assessment Index (VAI)

The table 6 provides a combined picture of household vulnerability score computing the physical vulnerability, social vulnerability, and economic vulnerability using formula mentioned in the section 3.3. The table 6 and fig. 12 reveals four categories of vulnerability, and Kancharpur union found as severe vulnerable while Gala union is designated as low vulnerable area.

Table 6. Vulnerability Assessment Index

Union	Physical Vulnerability	Social Vulnerability	Economic Vulnerability	Vulnerability Scale	Vulnerability Level
Gala	2	2.46	2.25	2.23	Low
Kanchanpur	3.67	3.53	3.50	3.57	Severe
Gopinathpur	3.67	2.92	3	3.19	High
Lesraganj	3.33	3.23	2.75	3.10	High
Ramkrishnapur	2.67	3.07	2.75	2.83	Moderate
Vulnerability Scale	3.06	3.04	2.85	2.98	--
Vulnerability Level	High	High	Moderate	Moderate	--

However, when considering the three forms of vulnerability of the five unions, it is found that the physical & social vulnerability is high, and the economic vulnerability is moderate. Finally, according to the Vulnerability Assessment Level (Table 1), the households' combined vulnerability in the study area to the disaster flood is Moderate.

### Conclusion

This study assessed the vulnerability to floods at five unions of Harirampur upazila through a quantitative approach. Regarding social vulnerability, Gala Union has been found least vulnerable area; Gopinathpur is a moderately vulnerable area; Union four (Lesraganj) and five (Ramkrishnapur) is a highly vulnerable area; and Kanchanpur is a severely vulnerable area. According to economic vulnerability, the Gala Union has a minimal level of vulnerability. Unions 3(Gopinathpur), 4(Lesraganj), and 5(Ramkrishnapur) have a moderate level of vulnerability. Kanchanpur, on the other hand, is a severe vulnerable region. As for physical vulnerability, Unions 1 (Gala) and 5 (Ramkrishnapur) are lower and moderately vulnerable, respectively; Union Lesraganj is a highly vulnerable area. However, Unions 2 (Kanchanpur) and 3 (Gopinathpur) are incredibly vulnerable zones. Out of the five unions in Harirampur, Upazila, Gopinathpur, and Lesraganj have been identified as highly vulnerable to flooding. Kanchanpur Union is severely vulnerable to flood (vulnerability score 3.57).

On the other hand, Gala Union is designated as a low vulnerable area (vulnerability score 2.23), and Ramkrishnapur Union is classified as a moderately vulnerable area. However, it is discovered that the physical and social vulnerability is high, while the economic vulnerability is moderate when taking into account the three types of vulnerability of the five unions. The findings of this study will provide insights into the physical, social, and economic dimensions of household vulnerability to floods. The study will contribute in developing effective flood mitigation and adaptation strategies considering the different vulnerability dimensions.

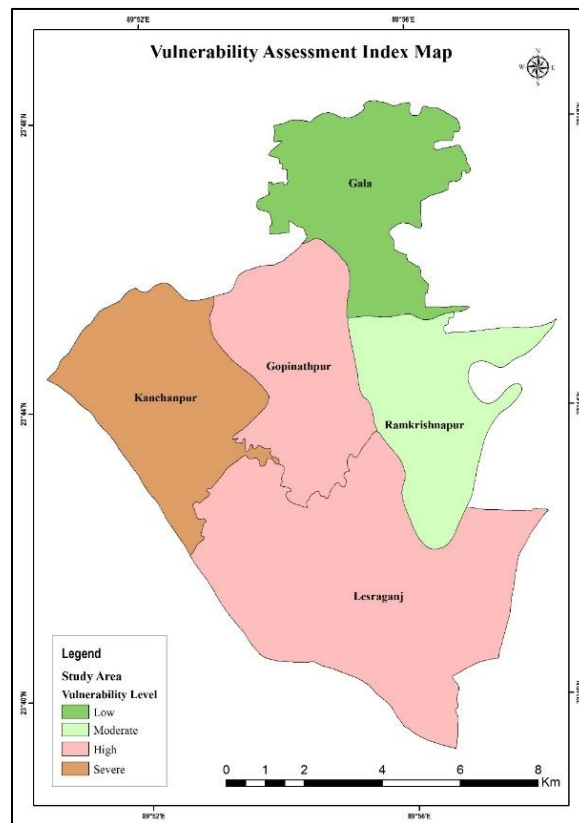


Fig. 12. Vulnerability Assessment Index Map.

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