

# Household-Based Approach to Assess the Impact of River Bank Erosion on the Socio-economic Condition of People: A Case Study of Lower Ganga Plain



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**Abstract** The Ganges, upstream of Farakka Barrage in the Malda district has been experiencing extensive erosion along the left bank even though it has been strongly protected. However, the erosion problem is not only restricted to the upstream section; it is widespread throughout its course in West Bengal. Hence, the risk of river bank erosion in the riparian state is increasing day by day due to changing land use patterns. In the current study, a household-level assessment of the impact of river bank erosion has been done. 600 households were surveyed for the study to assess the impact of river bank erosion on the socio-economic condition of affected people. The assessment was carried out by comparing socio-economic status before and after river bank erosion. Up to 1990, 19 households out of 600 got affected by river bank erosion, while during 1991 and 2000, the number of households who experienced the loss had increased to 424, whereas in between 2001 and 2010, the number declined to 124, and with the subsequent years of 2011–2018, it further reduced to 33. Till 1990, people who suffered river bank erosion were less affected while during 1991–2000, the reduction in average monthly income reflected the disaster's impact. In comparison to the previous two time series, the reduction in 2001–2010 was greater. On the other hand, among all the time series, the reduction in mean monthly income from 2011 to 2018 was the greatest. As a result, it can be said that the affected people's income rate had recovered over time. The recent river bank erosion gave residents, a greater negative impact on monthly income. Among 600 households, 92.16% household lost their agricultural land due to river bank erosion. The overall change from kacha house to semi pucca was 38.20%, and the change from semi pucca to kacha was 1.5%. The rebuilt from semi pucca to kacha was 0.20%. The difference between kacha and pucca was 1.5%. Only 0.20% of the 600 homes were converted from pucca to semi-kacha. Hence, the study revealed that due to river bank erosion, people were affected in terms of every socio-economic aspect.

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**Keywords** Socio-economic conditions · Mouza · Homestead · Up and down stream · Agricultural land

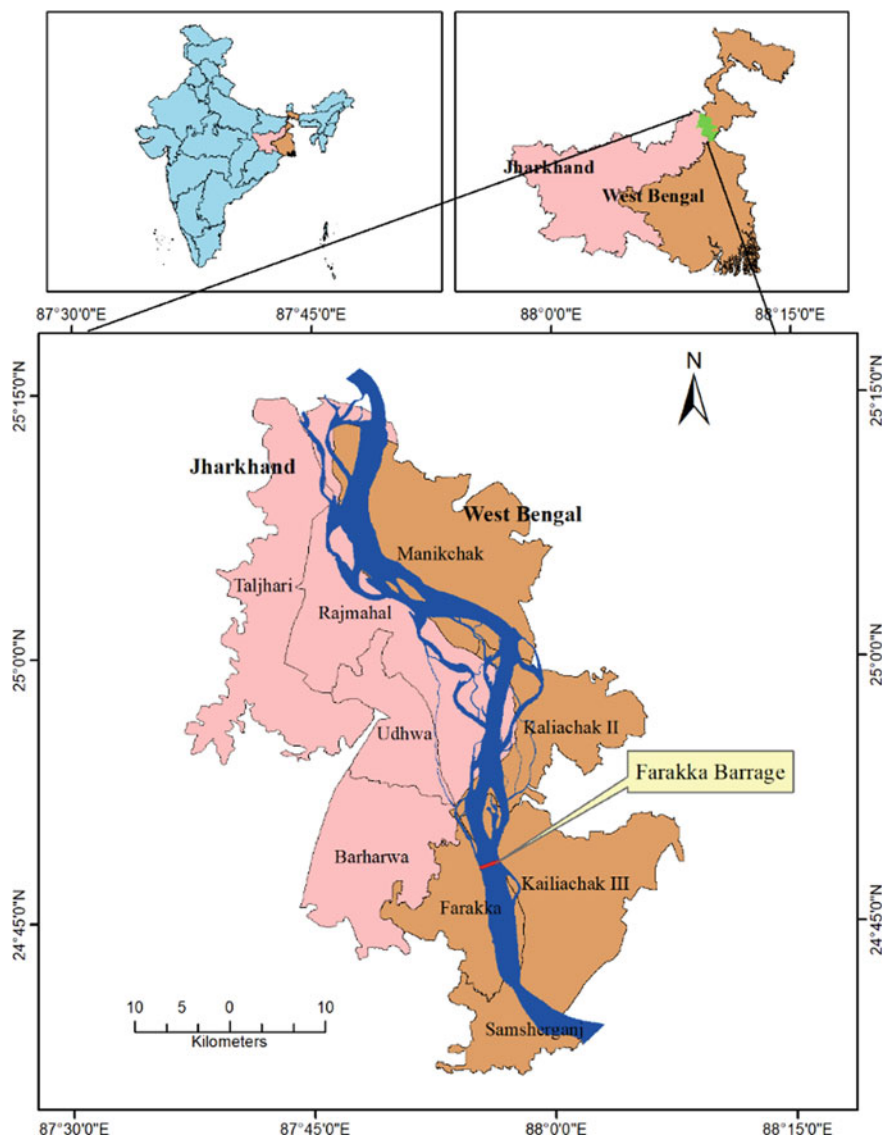
## 1 Introduction

Natural hazards are the physical events that have the potential to damage properties, loss of life, and disrupt social and economic activities (Ignacio et al. 2015). The impact of disaster is not only controlled by its physical condition, but also the sort of interaction between man and nature; changing land use patterns, economic activities, rising settlements, and pressure on resources are all having an impact on the man–nature relationship in multiple dimensions. Therefore, with the changing man–nature relationship, the repercussions such as the number of morbidities, mortalities, property losses, and structural losses are increasing (Ahsan and Warner 2014; Parveen et al. 2021). Though the researches on the impacts of natural hazards on human beings have been prevailing in the scientific community, with the development of the concept of vulnerability, these issues are profoundly discussed in social sciences too (Ignacio et al. 2015).

River bank erosion is a conventional mechanism to shape the river course wherein persists various processes at different spatial and temporal scales. These mechanisms are controlled by several environmental factors of natural and anthropogenic origin. Bank erosion, however, occurs greatly in meandering rivers, and the worst impact of river bank erosion in the long term could be observed along the river Ganga and Brahmaputra (Dewan et al. 2017; Das et al. 2017). One of the miserable impacts of river bank erosion is human displacement which is also considered a push factor for forced migration (Das et al. 2014). Many villages lost their existence after being engulfed by the river Ganga in Malda and Murshidabad districts (Laha 2015).

The rate and amount of river bank erosion by the Ganga River varies in the study area (Fig. 1). However, the amount of land loss alone could not represent the entire picture of the disaster, and to analyze the ramification of river bank erosion on socio-economic conditions, there should be assorted parameters, such as economic loss, infrastructural loss, degradation of social status, increasing social and economic insecurity, etc. The growing population in the study area along the river Ganga has increased the risk of a severe impact on people's life. Based on previous scientific researches, severe erosion might occur in any part of the river.

Ganga within the study area at any time can cause a huge loss (Das et al. 2014; Ghosh and Sahu 2018; Mukherjee 2011; Sinha and Ghosh 2012). In order to understand the adaptive and coping mechanism for river bank erosion, it is indispensable to assess the impact of a past event of the disaster. For policymakers, assessment of the socio-economic vulnerability is crucial to study for disaster risk reduction. Since, there is limited research that has been conducted to assess the socio-economic vulnerability induced by river bank erosion that quantifies the domains such as exposure, sensitivity and adaptive and coping capacity. Hence, the main objective of the current



**Fig. 1** Location of the study area

study was to assess the impact of river bank erosion on socio-economic condition of the people.

## **2 Research Methodology**

### ***2.1 Selection of the Unit and Households***

Based on river bank morphometric analysis and susceptibility zonation, the affected areas due to river bank erosion was identified (Sarif et al. 2021). Focused Group Discussion (FGD) was made from the study area, each FGD consisted of 7 members who were more than 30 years old and directly affected by the bank erosion. These focused groups helped to shape the idea of the impact of river bank erosion on the socio-economic condition and its spatial distribution in the study area (Ahsan and Warner 2014). A pilot survey was done to observe the affected areas which gave the idea for selecting the unit and household. Thus, the unit and households were selected based on three layers:

- i. Morphometric analysis of the river and assessment of susceptibility zonation,
- ii. Focused Group Discussion (FGD), and
- iii. Pilot survey

Hence, 5 blocks from the districts of Malda and Murshidabad in West Bengal were taken for the study. These blocks are Farakka and Samsheganj from Murshidabad district and Kaliachak III, Kaliachak II, and Manikchak from Malda district. In the next stage, 6 Mouzas from each block were selected along the river bank. Hence, a case study was employed in 30 Mouzas, from each Mouza, 20 affected households were selected (Table 1 and Fig. 2). Therefore, 600 households were interviewed for the collection of socio-economic data.

### ***2.2 Before and After the River Bank Erosion***

Before river bank erosion is considered that year when a household last time faced erosion while after river bank erosion referred to the year at the time of the household survey. Some of the indicators such as monthly income, area of agricultural land, condition of the house, size of homestead land, number of rooms, etc., were used as parameters to assess socio-economic condition. The condition of these indicators was compared in respect of before and after river bank erosion.

### ***2.3 The Time Series***

The time series analysis helps in assessing the coping ability of the people in case of occurrence of disaster like river bank erosion, with respect to time. For the analysis of the level of impact of river bank erosion with respect to time, the 600 households are categorized into four-time series. The first time series belongs to the people

**Table 1** Mouzas for primary household survey

Sl. No.	Mauza	Block	District	State
1	Gabindarampur	Farakka	Murshidabad	West Bank
2	Farakka	Farakka	Murshidabad	West Bank
3	Baniagram	Farakka	Murshidabad	West Bank
4	Kuli	Farakka	Murshidabad	West Bank
5	Arjunpur	Farakka	Murshidabad	West Bank
6	Paranpara	Farakka	Murshidabad	West Bank
7	Anupnagar	Samsherganj	Murshidabad	West Bank
8	Lalpur	Samsherganj	Murshidabad	West Bank
9	Chachanda	Samsherganj	Murshidabad	West Bank
10	Jaladipur	Samsherganj	Murshidabad	West Bank
11	Dhusaripara	Samsherganj	Murshidabad	West Bank
12	Durgapur	Samsherganj	Murshidabad	West Bank
13	Par Deonapur	Kaliachak III	Malda	East Bank
14	Sujapur Mandai	Kaliachak III	Malda	East Bank
15	Chak bahadurpur	Kaliachak III	Malda	East Bank
16	Jagannathpur	Kaliachak III	Malda	East Bank
17	Palgachhi	Kaliachak III	Malda	East Bank
18	Sultanganj(P)	Kaliachak III	Malda	East Bank
19	Navagram	Kaliachak II	Malda	East Bank
20	Panchanandapur	Kaliachak II	Malda	East Bank
21	Birodhi	Kaliachak II	Malda	East Bank
22	Shukurullapur	Kaliachak II	Malda	East Bank
23	Jotkasturi	Kaliachak II	Malda	East Bank
24	Joananta	Kaliachak II	Malda	East Bank
25	Dharampur	Manikchak	Malda	East Bank
26	Narayanpur	Manikchak	Malda	East Bank
27	Paschim Naraynpur	Manikchak	Malda	East Bank
28	Dakshin Chandipur	Manikchak	Malda	East Bank
29	Harachandapur	Manikchak	Malda	East Bank
30	Naobarar Jagir	Manikchak	Malda	East Bank

who were affected by river bank erosion up to 1990, second is within the time span of 1991–2000. The third series is between 2001 and 2010, while the fourth time series is after the years 2011–2018. The purpose of the division of the surveyed households according to the time series was to assess the impact of bank erosion more qualitatively.

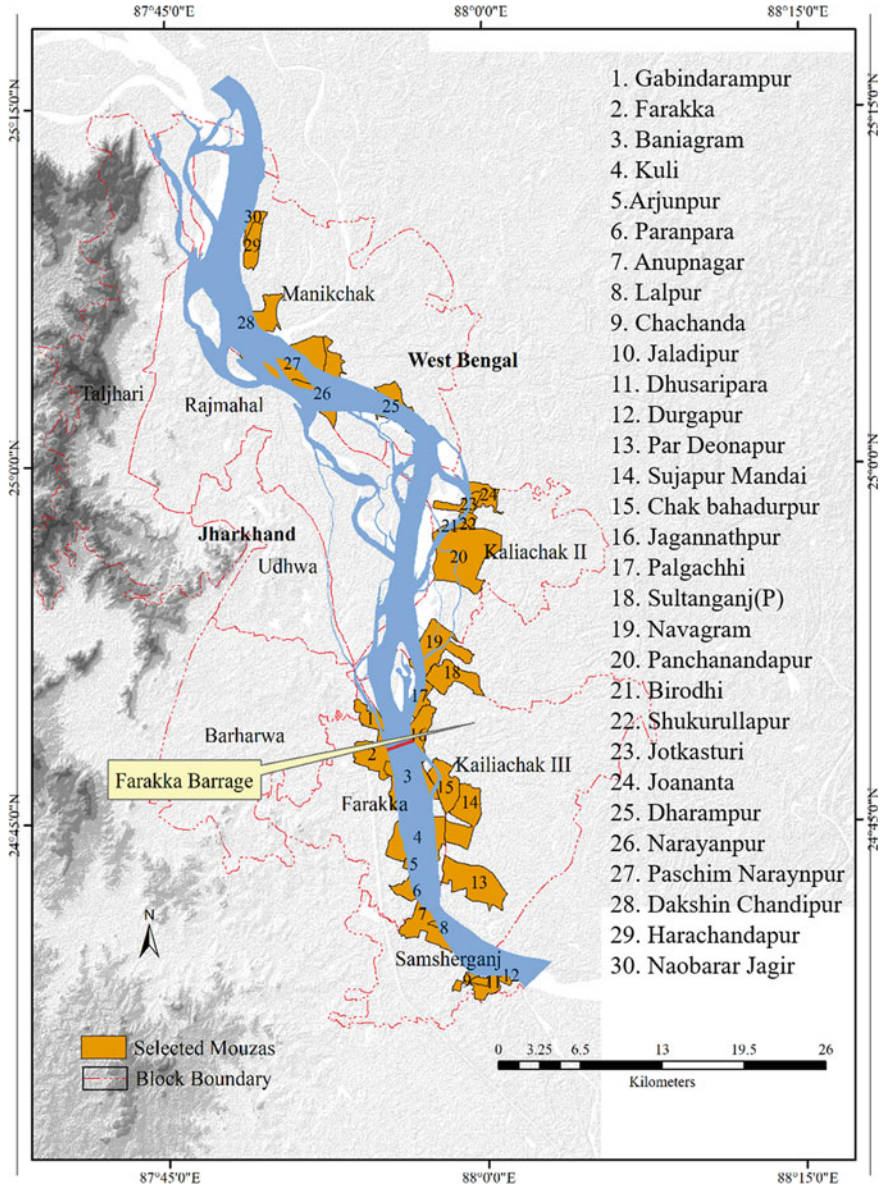


Fig. 2 Mouzas for primary household survey

## 2.4 Analysis of Indicators

The information collected from a primary survey about the change in occupation, house types, and the number of rooms were analyzed and converted into percentages so as to evaluate the change in the condition of these indicators after the impact of bank erosion. Changes in the monthly income, agricultural land, homestead land, and distance from the old house were also calculated by descriptive statistics.

## 2.5 Adjustment of the Income Value

As the data deals with different time series, the income value was different. For comparative analysis of the monthly income of households, the money value of households for different years was adjusted for a common year, i.e., 2018. The following formula has been used for adjusting the value of money according to the inflation rate of India (1):

$$x \text{ year value} = \frac{CPI \text{ in } x \text{ year}}{CPI \text{ in } y \text{ year}} \times \text{value for } y \text{ year} \quad (1)$$

whereas  $CPI =$  Consumer Price Index.

## 3 Results and Discussion

### 3.1 Impact on Livelihood

Up to 1990, 19 out of the total surveyed 600 households got affected by river bank erosion, while between 1991 and 2000, the number of households who experienced the loss had increased to 424, whereas between 2001 and 2010, the number declined to 124 and during the years of 2011–2018, it further reduced to 33. It can be observed in Fig. 3, that up to 1990, people who were living in the Farakka and Samsheganj region faced displacement as a consequence of river bank erosion. From 1991 to 2000, a huge number of households experienced losses due to river erosion in the region of Farakka, Samsheganj, Manikchak, and Kaliachak II. In the time span of 2001–2010, the worst affected block was Kaliachak III in comparison with Kaliachak II and Manikchak blocks which have also suffered severe erosion, whereas relatively, Farakka and Samsheganj blocks observed less damage (Fig. 3). Few households have faced river erosion in Farakka, Samsheganj, and Kaliachak III blocks during the period of 2011–2018. Figure 3 clearly indicates that Kaliachak III has been experiencing severe river bank erosion since 1991.

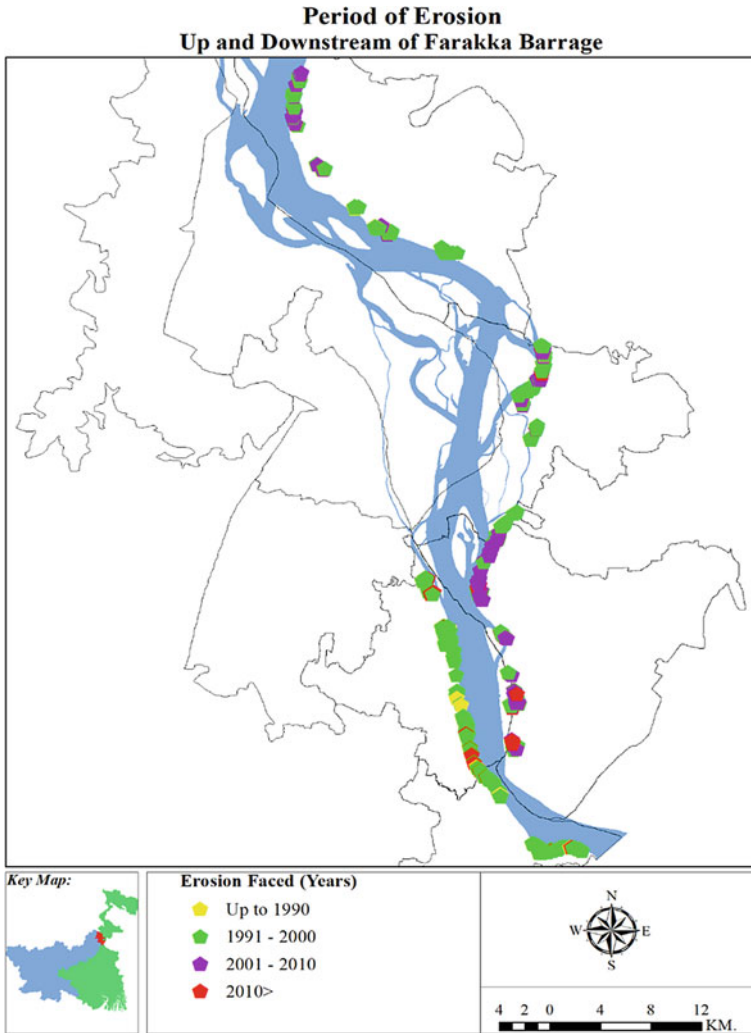


Fig. 3 River bank erosion faced by the habitants in different time period

### 3.1.1 Change in Occupation of the Households Due to Erosion—Up to 1990

The majority of those people who were affected by bank erosion prior to 1990 are still working in their old occupations. According to the victims' narration, they lived in tents for few months after losing their houses and sources of income due to bank erosion. They narrated that it was very difficult for them to survive, especially in the first few years, and they had to struggle to start their life again. Some of the sufferers reported that they had faced starvation as they did not had any food items or other



required items of basic needs. Most of them became migrant labourers at that time. Some of them reported that they had to change their occupation shortly after the disaster of bank erosion, but they were able to practice their old occupation after a few years. After many years of erosion faced by the dwellers up to 1990, the situation is somewhat better now. The change statistics of occupation of inhabitants show that only 10.5% who lost their cultivated land became agricultural labourers. The rest of them gradually returned to their previous occupation (Table 2).

### **3.1.2 Change in Occupation of the Households Due to Erosion (1991–2000)**

About 1.9% of people changed their occupation from cultivators to business from 1991 to 2000. Cultivators were replaced by the agricultural labourers, daily labourers, and out migrant labourers, respectively, by 9.7%, 2.8%, and 0.5% of the population. As a result of the river bank failure, cultivators were forced to become agricultural labourers because they had lost their agricultural land. After the bank erosion, 2.4% of daily labourers migrated to another state of the district due to lack of income opportunities during this time period. However, 1.2% of people returned to their hometown to work as daily labourers (Table 2).

### **3.1.3 Change in Occupation of the Households Due to Erosion (2000–2010)**

From 2001 to 2010, the affected people changed their occupations due to river bank erosion, from cultivators to business by 7.30%, agricultural labourers by 9.70%, daily labourers by 2.40%, and out migrant labourers by 1.60%. 0.8% of the population switched from business to daily labourers in the area. While among the daily labourers in the locality, 1.60% became businessmen, and 0.80% changed their occupation to agricultural labourers (Table 2).

### **3.1.4 Change in Occupation of the Households Due to Erosion (2011–2018)**

During the period 2001–2018, 9.1% of people changed from cultivators to labourers in the locale. While 3% of people converted into labourers and 3% of people changed their occupation from business to labourers in the exterior part of the affected area (Table 2). Some people also changed their occupations from daily labourers to agricultural labourers in the affected area.

**Table 2** Change in occupation of the habitants due to bank erosion

Period	Occupation before bank erosion		Occupation after bank erosion											
	Cultivators		Business		Agricultural labourer		Daily labourer in the area		Out migrant labourer		Private job		Other commercial establishment	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Up to 1990	Cultivators	-	0	0	2	10.5	0	0	0	0	-	-	-	-
	Business	-	-	5	26.3	0	0	0	0	0	-	-	-	-
	Daily labourer in the area	-	-	0	0	0	0	9	47.4	2	10.5	-	-	-
	Out migrant labourer	-	-	0	0	0	0	0	0	1	5.3	-	-	-
1991-2000	Cultivators	49	11.6	8	1.9	41	9.7	12	2.8	2	0.5	1	0.2	0
	Business	0	0	40	9.4	0	0	4	0.9	0	0	0	0	0
	Agricultural labourer	0	0	0	0	26	6.1	0	0	0	0	0	0	0
	Daily labourer in the area	0	0	10	2.4	0	0	188	44.3	10	2.4	1	0.2	1
2011-2018	Out migrant labourer	0	0	1	0.2	0	0	5	1.2	24	5.7	0	0	0
	Private job	0	0	0	0	0	0	0	0	0	0	1	0.2	0
	Agriculture	7	21.2	0	0	3	9.1	1	3	0	0	-	-	0
	Business	0	0	4	12.1	0	0	1	3	0	0	0	-	0
Agriculture labourer	0	0	0	0	2	6.1	0	0	0	0	-	-	0	

(continued)

Table 2 (continued)

Period	Occupation after bank erosion															
	Occupation before bank erosion		Cultivators		Business		Agricultural labourer		Daily labourer in the area		Out migrant labourer		Private job		Other commercial establishment	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Daily labourer in the area	0	0	1	3	1	3	11	33.3	1	3	1	3	-	-	0	0
Other commercial establishment	0	0	0	0	0	0	0	0	0	0	0	0	-	-	1	3
Overall change (up to 1990-2018)	71	11.8	17	2.8	58	9.7	16	2.7	4	0.7	1	0.2	0	0	0	0
Agriculture	0	0	56	9.3	0	0	6	1	0	0	0	0	0	0	0	0
Business	0	0	0	0	38	6.3	0	0	0	0	0	0	0	0	0	0
Agriculture labourer	0	0	13	2.2	2	0.3	257	42.8	15	2.5	2	0.3	1	0.2	0	0.2
Daily labourer in the area	0	0	1	0.2	0	0	7	1.2	32	5.3	0	0	0	0	0	0
Out migrant labourer	0	0	0	0	0	0	0	0	0	0	0	0	1	0.2	0	0
Private job	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.3
Other commercial establishment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source Based on primary data (2017 and 2018)

### **3.1.5 Overall Change in Occupation of the Households (1990–2018)**

In totality, 2.8% of people switched from agriculture to business. 9.7% of cultivators became agricultural labourers, while 2.7% changed their job to day-to-day work in the area (Table 2). One percent of the business population became daily labourers in the area. While 2.2% day-to-day labourers started their own business. The results also showed that 2.5% of people who worked within the area switched to work outside the area (Table 2). Hence, during the entire time period of study, i.e., from 1990 to 2018, the result indicates that people have not changed their occupations on a large scale. However, in the case of cultivation, the change was higher as compared to other occupations due to the loss of agricultural lands.

## **3.2 Impact on Income**

### **3.2.1 Change in the Monthly Income of the People Due to Erosion—Up to 1990**

Up to 1990, people who faced river bank erosion in the study area experienced a maximum change of Rs. 4500 and a minimum change of Rs. -4372 in their total monthly income (Table 3). As the minimum change in value was negative, thus the monthly income grew at a negative rate. The average increase in the income for people, who changed their occupation from cultivator to other, was Rs. 3050. Figure 4 depicts the upward trend in monthly income in this group from 1990 to 2018. The mean change in the monthly income of the people who did not change their occupation was Rs. 475 which indicates positive growth (Table 3).

### **3.2.2 Change in the Monthly Income of the People Due to Erosion (1991–2000)**

The household survey revealed that people, who changed their income from cultivators to others between 1991 and 2000, had a mean monthly income change of Rs. -941.28. The monthly income is growing at a negative rate, as shown by the mean change. The results showed the variation in the monthly income for people who changed their occupation from one category to other, i.e., the income of Rs. -3025, -686, -266, and -808 was found for people who had switched from business to other, daily labourers to other, out migrant labourers to other, and people who did not change their income respectively (Table 3). Thus, the results clearly revealed that households had experienced negative growth in income. The people are still trying to recover from the losses caused by river bank erosion as of 2018.

**Table 3** Change in the monthly income of the people due to erosion—up to 1990

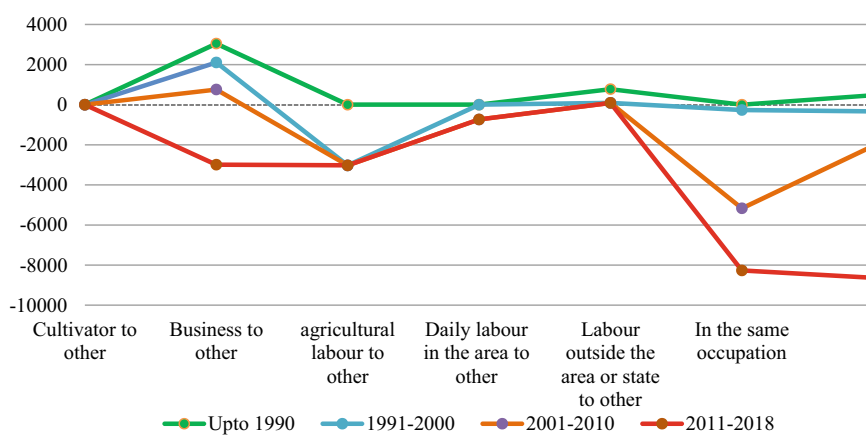
Period	Changed occupation	Number	Mean	Standard deviation	Standard error	Minimum amount of change	Maximum amount of change
Up to 1990	Cultivator to other	2	3050	2050.61	1450	1600	4500
	Business to other	0	–	–	–	–	–
	Agricultural labourer to other	0	–	–	–	–	–
	Daily labourer in the area to other	2	775	106.066	75	700	850
	Out migrant labourer to other	0	–	–	–	–	–
	In the same occupation	15	475.2	2391.012	617.3567	–4372	4500
1991–2000	Cultivator to other	64	–941.281	2624.881	328.1102	–7200	7700
	Business to other	4	–3025	2173.131	1086.566	–600	–5400
	agricultural labourer to other	0	–	–	–	–	–
	Daily labourer in the area to other	22	–686.364	2285.419	487.2529	–3500	7500
	Out migrant labourer to other	6	–266.667	1486.831	606.9962	2100	–2300
	In the same occupation	328	–808.11	2289.782	126.4321	–7900	10,400
2001–2010	Agriculture to other	26	-1350	2259.07	443.0402	3200	–5500
	Business to other	1	–	–	–	–	–
	Agricultural labourer to other	6	–733.33	1772.76	1772.757	1000	–3400

(continued)

**Table 3** (continued)

Period	Changed occupation	Number	Mean	Standard deviation	Standard error	Minimum amount of change	Maximum amount of change
	Daily labourer in the area to other	0	–	–	–	–	–
	Out migrant labourer to other	2	–4900	1555.63	1100	–3800	–6000
	In the same occupation	89	-1719.6	3128.27	331.5964	5900	–15,800
2011–2018	Cultivator to other	4	-3750	1968.93	984.4626	-6700	–2700
	Business to other	1	–	–	–	–	–
	Agricultural labourer to other	0	–	–	–	–	–
	Daily labourer in the area to other	0	–	–	–	–	–
	Out migrant labourer to other	3	–3100	3700	2136.196	–6800	600
	In the same occupation	25	–6584	13,535.6	2707.112	–70,800	–600

Source Based on primary data (2017 and 2018)

**Fig. 4** Average change in the monthly income after river bank erosion

### **3.2.3 Change in the Monthly Income of the People Due to Erosion (2001–2010)**

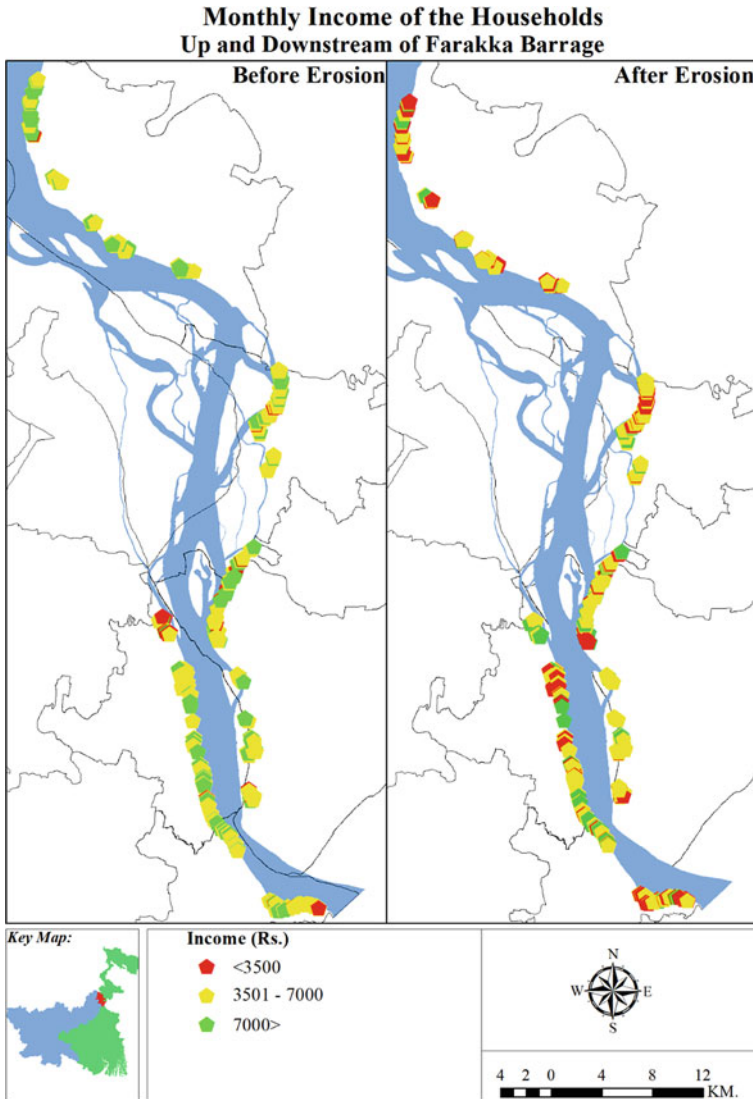
During the erosion period of 2001–2011, the average monthly income of people who changed their occupation from cultivator to other was reduced by Rs. 1350, until the date of the survey (2018). The change in monthly income of people, who changed their occupation from one business to another, was Rs. –733 (Table 3). Those who remained in the same occupation faced a monthly income reduction of Rs. 1719 and the standard deviation is also very high in this case (3128.27).

### **3.2.4 Change in the Monthly Income of the People Due to Erosion (2011–2018)**

Table 3 shows the income of people who changed their occupation from cultivator to other had decreased by Rs. –3750. The minimum and maximum changes in monthly income in this group were Rs. –2700 and –6700, respectively, with a standard deviation of 1968.93. People who did not change their occupation after being affected by river bank erosion witnessed their monthly income drop by Rs. 6584 on an average, with a standard deviation of 13,535 (Table 3).

As a result, Fig. 5 depicts the impact of river bank erosion on people's economic conditions as reflected in the change statistics of monthly income. Figure 6 showed a very interesting result regarding the disaster's impact. Till 1990, people who suffered river bank erosion were less affected, while during 1991–2000, the reduction in average monthly income reflected the disaster's impact. In comparison to the previous two time series, the reduction in 2001–2010 was greater. On the other hand, among all the time series, the reduction in mean monthly income from 2011 to 2018 was the greatest. As a result, it can be said that the affected people's income rate has recovered over time. More recent impact of the river bank erosion event faced by the dwellers, higher the negative impact on monthly income has been found.

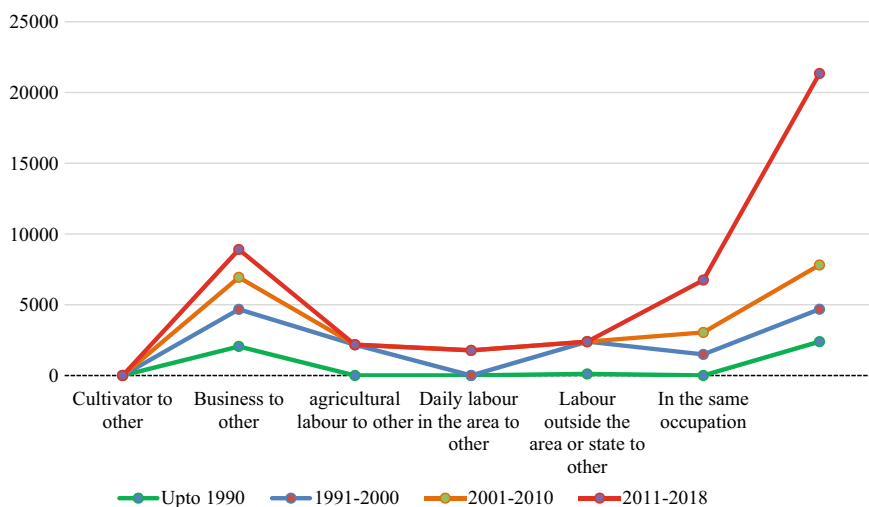
The question may arise as to why or how people who have not changed their occupation despite being affected by river bank erosion have resulted in a decrease in their average monthly income. The question is difficult to answer quantitatively. However, the facts can be revealed through a qualitative analysis based on field study and interviews with the victims. Although many people continue to work in the same occupation despite significant property losses, the size of their businesses has shrunk as a result of river bank erosion. For instance, there were many people who used to run garment businesses in their own shops, but they lost shops due to river bank erosion. There are still those affected people who sell clothes but the sizes of shops have reduced due to erosion, some afflicted individuals run the business on sidewalks, while others work as vendors. As a result, their commercial establishment's size can be explained. If a cultivator loses a significant amount of agricultural land as a result of river bank erosion, still can cultivate a small size of land. Another reason for the drop in mean monthly income is that most people have lost a lot of property, including their homestead land, yet they are gradually improving their economic situation. The



**Fig. 5** Income level among the surveyed households

impact of the disaster on the mean monthly income during the reestablishment of their houses and other socio-economic conditions is reflected in the results.





**Fig. 6** Monthly average income of the households with changing occupation and remaining in the same occupation

### 3.3 Loss of Agricultural Land

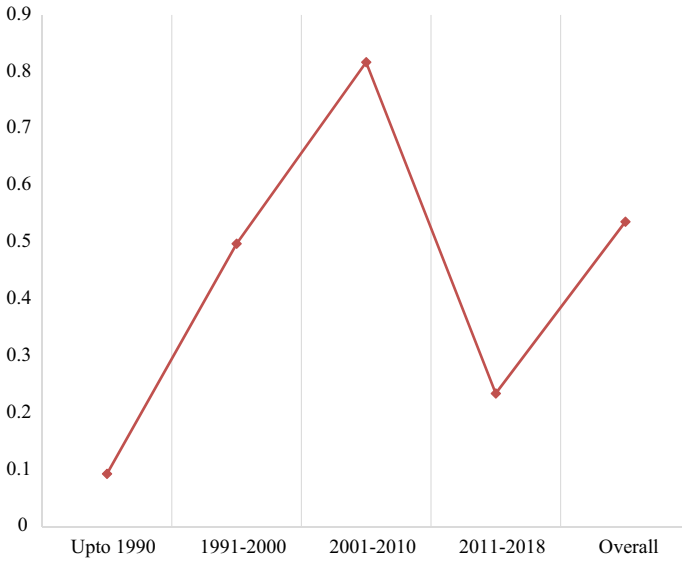
It was attempted in this study to quantify the loss of agricultural land among 600 households. Many people have lost their agricultural land as a result of river bank erosion surveyed (Table 4 and Fig. 7). Among 600 households, 92.16% households lost their agricultural land due to river bank erosion. The average amount of cultivated land loss till 1990 was 0.09 (ha), wherein the time period of 1991–2000 the average amount loss was 0.49 (ha). Between 2001 and 2010, the average loss of agricultural land was 0.81 (ha), the highest loss among all the time series. The overall average loss of agricultural land was 0.53 (ha).

Figure 8 manifested the loss of agricultural land in the study area.

**Table 4** Loss of agricultural land due to river bank erosion in different time periods

Period	% of the people loss their agricultural land	Average loss (ha)	Std. deviation
Up to 1990	89.4737	0.092747	0.145101
1991–2000	90.566	0.497611	1.286903
2001–2010	98.3871	0.81695	1.481847
2011–2018	90.9091	0.2342	0.43726
Overall	92.16666667	0.5363	1.288371

Source Based on primary data (2017 and 2018)



**Fig. 7** Average loss of agricultural land (in hectare)

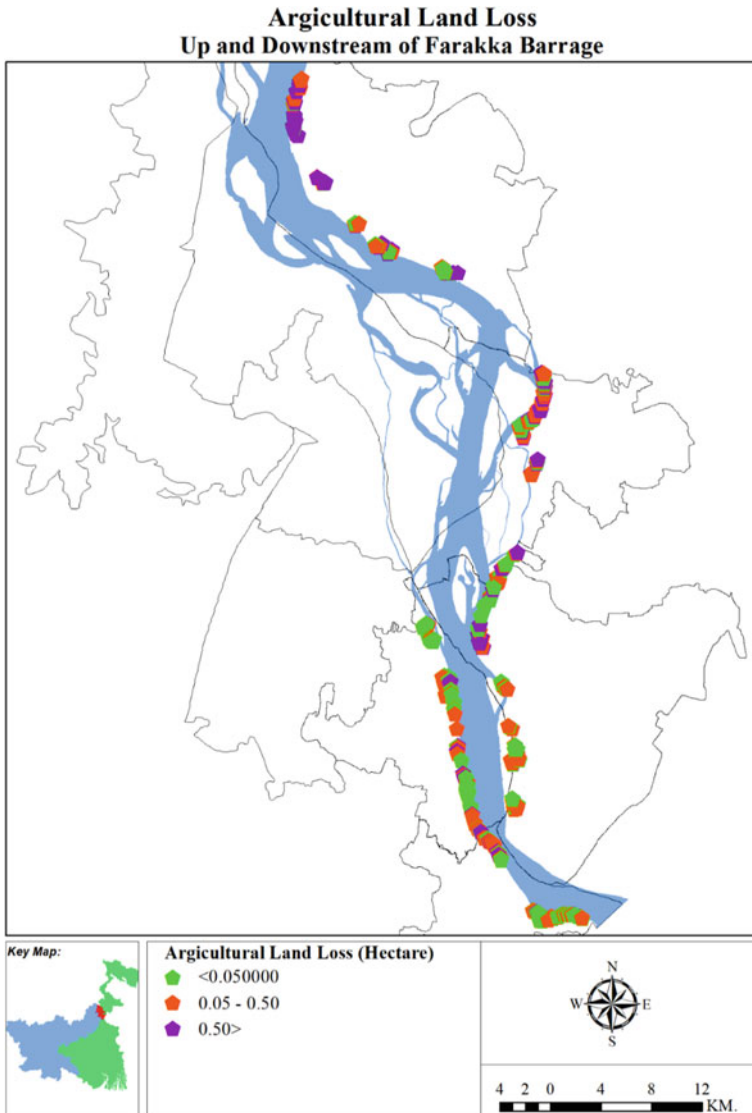
### **3.4 Changes in the House Type**

#### **3.4.1 Change in the House Type of the Household Faced Erosion—Up to 1990**

The change from Kacha to Semi pacca house was 68.40% among the surveyed households up to 1990 that experienced the disaster (Table 5). The results show that the house type has improved over time. One of the reasons for the lack of transformation of the house type from Kacha to pacca or semi pacca to kacha could be the impact of river bank erosion. The result, on the other hand, shows a general trend in the house type. The main reason for the overall improvement can be traced back to the affected people’s economic recovery prior to 1990.

#### **3.4.2 Change in the House Type of the Household Faced Erosion During 1991–2000**

Between 1991 and 2000, the percentage of households that changed from Kacha to semi pacca was 41.50, while the percentage of households that changed from Kacha to the pacca house was 1.70 (Table 5). During this time period, 0.20% of households were converted from pacca to kacha. Based on the results, the rebuilding of houses from kacha to pacca is very limited.



**Fig. 8** Spatial variation of agricultural land loss by the habitants in the study area

### **3.4.3 Change in the House Type of the Household Faced Erosion During 2001–2010**

According to the result from Table 5, between 2001 and 2010, the change in house type from kacha to semi pacca was 22.60%, while the change in house type from kacha to pacca was 0.80%. Households with 0.80% became semi pacca to kacha.

**Table 5** Change in the house type

Period	House type before bank erosion	House type after bank erosion					
		Kacha		Semi pacca		Pacca	
		N	%	N	%	N	%
Up to 1990	Kacha	1	5.3	13	68.4		
	Semi pacca	0	0	5	26.3		
1991–2000	Kacha	5	8.3	176	41.5	7	1.7
	Semi pacca	0	0	202	47.6	3	0.7
	Pacca	1	0.2	0	0	0	0
2001–2010	Kacha	10	8.1	28	22.6	1	0.8
	Semi pacca	1	0.8	82	66.1	2	1.6
2011–2018	Kacha	1	3	12	36.4	1	3
	Semi pacca	0	0	19	57.6	0	0
Overall change in the house type	Kacha	47	7.8	229	38.2	9	1.5
	Semi pacca	1	0.2	308	51.3	5	0.8
	Pacca	1	0.2	0	0	0	0

On the other hand, 1.60% of kacha houses were converted to pacca. After rebuilding the houses, 8.10% of kacha houses and 66.10% of semi pacca houses remain in the same house type (Table 5).

#### 3.4.4 Change in the House Type of the Household Faced Erosion During 2011–2018

During the period of 2011–2018, 36.40% of houses were rebuilt from kacha to pacca and 3% changed to pacca (Table 5). There was no pacca house that existed before river bank erosion in the surveyed area. All the house types were either kacha or semi pacca.

#### 3.4.5 Overall Change in the House Type of the Household Faced Erosion

The overall change from kacha house to semi pacca was 38.20%, and the change from semi pacca to kacha was 1.5%. The rebuild from semi pacca to kacha house was 0.20% (Table 5). The difference between kacha and pacca was 1.5% only. Only 0.20% of the 600 households were converted from pacca to semi kacha (Table 5).

The change statistics of house types showed that the semi pacca house dominates the study area both before and after erosion. Although semi pacca is technically superior to kacha house, it is difficult to assess the current state of the house infrastructure due to poor building materials and infrastructure. Kacha houses are typically

made of mud in West Bengal. However, the soil along the Ganga's bank is mostly sandy, making it unsuitable for house construction. This is the primary reason, why residents in this area prefer brick walls over mud walls. During the field survey, it was observed that the semi pucca state of the houses was not substantial.

### 3.5 Impact on Homestead Size

According to the findings, the size of homestead land changed by 89.47% up to 1990, with a negative change affecting 78.94% of the households (Table 6). The positive change in the 1991–2000 time series was 84.66%, while the negative change was 78.77%. The positive change between 2001 and 2010 was 83.06%, while the negative change was 78.22%. While the difference between 2011 and 2018 was 75.75% and the negative change in this time series, on the other hand, was 51.51%. In total, 84% of the homestead size changed, with 77.16% of the change being negative.

Between the total change and negative change, a significant correlation was discovered at the confidence level of 0.05 (two-tailed) (Table 7). As a result, the study revealed that the majority of the homestead land had been reduced in size due to river bank erosion (Fig. 9). Based on the interviews, people with greater homestead land had diverse types of trees such as Mango and Neem, as well as different types of vegetables. They did not have the financial means to own as much homestead land after the river bank erosion as they used to have before the disaster.

**Table 6** Change statistics of homestead size in various time periods

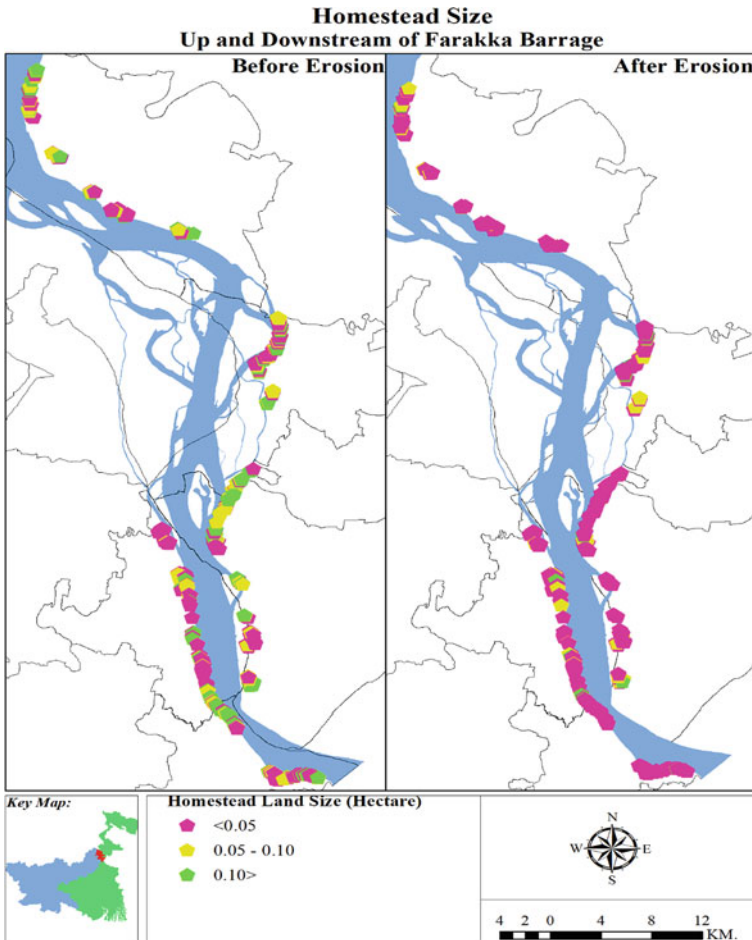
Period	Positive change (%)	Negative change (%)
Up to 1990	89.4737	78.94736842
1991–2000	84.6698	78.77358491
2001–2010	83.0645	78.22580645
2011–2018	75.7576	51.51515152
<b>Overall</b>	84	77.16666667

Source Based on primary data (2017 and 2018)

**Table 7** Correlation between the whole total change and negative change in the homestead size

	Change	Negative change
Change	1	0.88
Negative change	0.88	1

Source Based on primary data (2017 and 2018)



**Fig. 9** Spatial variation of homestead size of dwellers before and after river bank erosion in the study area

### 3.6 Change in the Number of Rooms

#### 3.6.1 Change in the Number of Rooms of the Households Which Faced Erosion up to 1990

Till 1990, people who were affected by river bank erosion had a 10.50% increase in the number of rooms from single to double and a 5.30% increase in the number of rooms from single to triple after erosion (Table 8). After the disaster, 21.10% of double-room households became single-room households. 5.30% of household room numbers had increased from two to three. Households with three rooms before

**Table 8** Change in the number of rooms in the households

Period	Number of rooms before erosion		Number of rooms after erosion													
	0		1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Up to 1990	1	-	3	15.8	2	10.5	1	5.3	-	-	-	-	-	-	-	-
	2	-	4	21.1	1	5.3	1	5.3	-	-	-	-	-	-	-	-
	3	-	1	5.3	4	21.1	0	0	-	-	-	-	-	-	-	-
	4	-	1	5.3	0	0	0	0	-	-	-	-	-	-	-	-
	5	-	0	0	0	0	0	0	-	-	-	-	-	-	-	-
1991-2000	1	1	0.2	54	12.7	53	12.5	7	1.7	1	0.2	0	0	0	0	0
	2	0	0	43	10.1	77	18.2	27	6.4	8	1.9	2	0.5	1	0.2	1
	3	0	0	21	5	43	10.1	13	3.1	4	0.9	1	0.2	0	0	0
	4	0	0	6	1.4	12	2.8	13	3.1	17	4	0	0	0	0	0
	5	0	0	2	0.5	4	0.9	0	0	0	0	1	0.2	1	0.2	0
2001-2010	6	0	0	0	2	0.5	2	0.5	0	0	0	0	0	2	0.5	0
	7	0	0	1	0.2	0	0	3	0.7	0	0	0	0	0	0	0
	12	0	0	0	0	1	0.2	0	0	0	0	0	0	0	0	0
	1	-	-	13	10.5	12	9.7	3	2.4	0	0	0	0	0	0	-
	2	-	-	8	6.5	21	16.9	15	12.1	2	1.6	1	0.8	0	0	-
2011-18	3	-	4	3.2	23	18.5	6	4.8	4	3.2	0	0	0	0	0	-
	4	-	1	0.8	2	1.6	5	4	2	1.6	0	0	0	0	0	-
	5	-	0	0	0	0	0	0	0	0	0	0	0	1	0.8	-
	1	-	3	9.1	5	15.2	0	0	0	0	0	1	3	-	-	-

(continued)

**Table 8** (continued)

Period	Number of rooms before erosion		Number of rooms after erosion													
	0		1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
2	-	-	4	12.1	7	21.2	2	6.1	1	3	0	0	-	-	-	-
3	-	-	4	12.1	1	3	2	6.1	2	6.1	0	0	-	-	-	-
6	-	-	0	0	1	3	0	0	0	0	0	0	-	-	-	-



the erosion now have 5.30% and 21.10% more single and double rooms, respectively (Table 8).

### **3.6.2 Change in the Number of Rooms of the Households Which Faced Erosion from 1991–2001**

Households affected by the disaster increased their number of rooms from a single room to a double room by 12.50% (Table 8). 10.10% of households with a double room now have a single room. In this time series, 6.40% of households have upgraded to triple rooms from double rooms and 0.90% have upgraded to four rooms from double rooms. By 5% and 10%, a three-room house was reduced to a single room and a double room, respectively. People who used to have four rooms before the disaster now have single rooms at a rate of 1.40%, double rooms at a rate of 2.80%, and three rooms at a rate of 3.10%, respectively (Table 8).

### **3.6.3 Change in the Number of Rooms of the Households Which Faced Erosion from 2001–2010**

During this time, affected households increased their number of rooms by 9.70% and 2.40% from single to double and triple respectively (Table 8). After river bank erosion, 6.50% of households-owned double rooms were adapted to single rooms, while 12.10% of the same were changed to triple rooms. Following the disaster, 18.50% of triple rooms were transformed to double rooms and 3.20% into single rooms. There was also a 3.20% increase in the number of people in triple rooms. After facing river bank erosion, people who had four rooms before the disaster reduced to single, double, and triple rooms by 0.80%, 1.60%, and 4%, respectively (Table 8).

### **3.6.4 Change in the Number of Rooms of the Households Which Faced Erosion from 2011–2018**

In this time series of 2011–2018, the affected households went from having a single room before the river bank erosion to hold double rooms and 5 rooms by 15.20% and 3% respectively (Table 8). Before the river bank erosion, 12.10% of households that had double rooms were reduced to a single room. Though, there was an increase of 6.10% in the number of double rooms to triple in the results. People who had three rooms lost their house and homestead lands in the same time period, and their number of rooms was reduced from three to single and double rooms by 12.10% and 3%, respectively, after the disaster (Table 8).

The results of the time series unveiled how river bank erosion affects the number of rooms in the households. In some cases, the number of rooms increased, but the results showed a significant reduction in the size of the homestead. In some cases,

the size of rooms should be very small, whereas findings showed an increase in the number of rooms even after being affected by river bank erosion. The result of the change in homestead land and the number of rooms indicated that the house is in poor condition. Due to a lack of homestead land, the affected people are unable to add rooms to their homes even after the number of people increases.

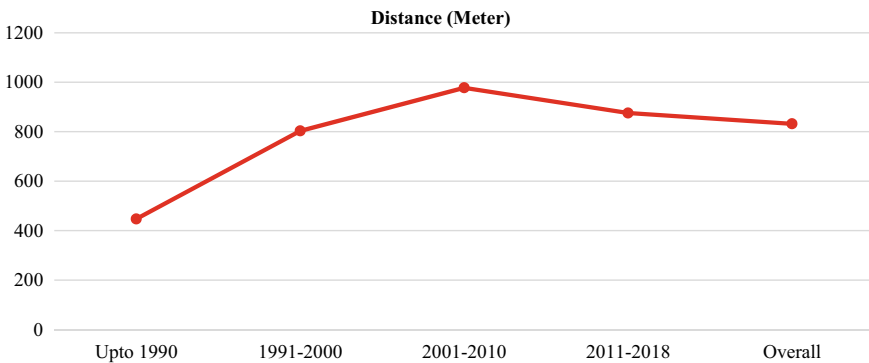
### 3.7 Average Distance of Households from Former Homestead

Due to the loss of their previous homestead lands, each of the 600 households surveyed had to relocate. The pattern of resettlement can be assessed based on the average distance from the older homestead land. Based on primary survey findings, people who were displaced by the disaster resettled within an average distance of 447.02 m in the year 1990 (Table 9). The average distance between 1991 and 2000 was 803.09 m, while the maximum distance was 977.47 m. People resettled in an average distance of 875.76 m between 2011 and 2018. As a result, the overall distance from the previous homestead land was approximately 831.83 (Table 9 and Fig. 10).

Affected people were relocated within 250 m and 251–500 m in Samsherganj and Farakka blocks, respectively. In these blocks, the majority of the land along the Ganga is urban, sub-urban, or congested. It was difficult for the affected people to

**Table 9** Average distance from the old house of the people who faced erosion in the different time periods

Period	Distance (meter)
Up to 1990	447.02
1991–2000	803.09
2001–2010	977.47
2011–2018	875.46
Overall	831.83



**Fig. 10** Average distance from the former homestead land

buy land in the villages or towns' interiors. People in Kaliachak III, Kaliachak II, and Manikchak live more than 500 m apart because the area along the river bank of these blocks is less congested. Furthermore, most of the land along the river in these three blocks is used for agricultural practices.

The primary findings revealed that people prefer to settle along the river. The survey report of this study indicates that all the surveyed households faced river bank erosion in the past. Many of them experienced the disaster more than one time. One of the main concerns regarding the settlement of the affected people was that these people repeatedly resettle themselves near river Ganga. Due to the short distance from the river bank, people were again exposed to river bank erosion hazards. Through discussion and interviews with locals, the reason for their decision to settle near the Ganga was found. One of the most common reasons was that the soil along the Ganga is fertile and poor people usually drawn to the plains along the river. This wasn't just the case, though. After losing their homestead land, most people were unable to purchase land that was far from the river to avoid river bank failure. Lands closer to the river bank are very uncertain, unpredictable, and might be engulfed by the river at any time. As a result, the landowner's offer sells it for a lower price and affected people relocate to these cheaper lands. Though, there are other factors as well for settling along the river such as a connection to the area, relatives, and people that shouldn't be overlooked.

### ***3.8 Impact on Mental Health***

In every disaster, affected people go through stress and trauma, and in the case of river bank erosion, it was not exceptional. People who lost their homes and livelihood went through a high level of mental stress. For the survival of their family, they adopted different economic activities. The coping capacity played a vital role in the status of mental health of the victim. According to the study of Naher and Soron (2019) switching to the different occupations, suppression, homelessness, and lack of jobs, makes the victim stressed. The impact on mental health could also be observed in the people who were not affected by river bank erosion but have fear of losing homes and properties since they live nearby the river.

## **4 Conclusions**

In the present study, the impact of river bank erosion was analyzed by evaluating various socio-economic indicators. A comparative study of socio-economic conditions before and after river bank erosion was done by simple descriptive statistics. The entire time period was divided into four time series for analyzing the impact of bank erosion on the dwellers. The result showed that more than 50% of the cultivators had to change their occupation due to river bank erosion. Most affected people converted

from cultivators to marginal agricultural labourers or daily labourers. Among the other occupation, daily labourers and migrated labourers could not uplift their socio-economic condition due to heavy loss in a disaster. From 1990 to 2017–2018, no significant increase in monthly income was found, rather significant decrease in the level of monthly income was observed among the affected residents. In the time series from 2001 to 2010, the highest average agricultural land loss was noted with a significant reduction in the size of homestead land, number of rooms, and pattern of resettlement indicated that the river bank erosion in the study area was one of the biggest barriers to socio-economic development. Based on impact analysis, major issues of river bank erosion were explained in the study, which includes homelessness, poor condition of living in the river islands, land dispute, land resource management, issue of river bank protection, and lack of government aid. Though the impacts were analyzed by only descriptive statistics, the more interesting outcome of the study could be achieved by using advanced statistical techniques. The study could be used by different development authorities, regional planners, and policymakers to form strategies for mitigating the socio-economic impact of river bank erosion.

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