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Original Article

Impacts of flooding on rural communities in Bangladesh

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Abstract
Flooding is a regular phenomenon in many countries, including Bangladesh, causing severe damage to communities. Despite widespread impacts, most studies focus on a single community. This study examines the impacts of flooding on three key rural Bangladeshi communities: agriculture farmers, fish farmers, and fishermen. Data were collected from three flood-prone areas: Roumari Upazila (Kurigram district), Chauhali Upazila (Sirajganj district), and Char Bhadrasan Upazila (Faridpur district). The mean age of respondents varied across groups (LMM: $F = 21.2$, $p < 0.001$), but not across study sites. The mean education level was 6.9 ± 4.9 years, with fish farmers having the highest schooling at 7.4 years. Monthly income varied across groups (LMM: $F = 174.3$, $p < 0.05$). Most respondents (84.7%) received financial loans from non-government sources. Flooding negatively affected agricultural and fish farmers, who lost their crops. However, fishermen experienced a positive effect, with increased fishing days and duration, leading to higher fish harvests during floods (LMM: all $p < 0.05$). The study also highlights respondents' expectations to minimize flood impacts. The findings of this study are crucial for understanding the variation in flood impacts on key communities in rural Bangladesh and can inform effective flood management planning.

Keywords: agriculture farmer; fish farmer; fishermen; flooding; rural livelihood; natural disaster

1 | INTRODUCTION

Flooding is a common natural disasters in different parts of both developing and developed countries (Kousky 2014; Allaire 2018; Petrucci 2022) and often responsible for devastative impacts on socio-economics of the people through damaging the agricultural crops, infrastructures and employment (Allaire 2018; Talbot *et al.* 2018). Flood is also responsible for killing numerous people each year (Petrucci 2022). Flood events can be influenced several factor including heavy rainfall over prolonged periods, dam failure or even volcanic eruptions (Tu *et al.* 2017). Despite wide recognition of the flood impacts, most studies are limited to determining the infrastructural damages leaving less focus on social and business impacts of the flood affected communities (Allaire 2018). However, comprehensive understanding of flood impacts on different components of the society is a must to inform risk mitigation (Allaire 2018).

Bangladesh, a small South Asian country, is considered one of the largest floodplains of the world (Islam 2012). Being located in the centre of Ganges–Brahmaputra–Meghna drainage systems, most parts of the country are highly vulnerable to flooding (Hossain *et al.* 2020). Although flooding impacts received wide attention by the researchers in the country (e.g. Hossain *et al.* 2020), but, most of the research was conducted to determine impacts on a specified group of people (e.g. char dwellers; Hossain *et al.* 2020). However, analysis of such a highly flood-vulnerable group might not allow us to understand the extent of impacts of flooding on people with

different occupations. To determine the actual impacts of flooding in an area, all major occupational groups should be considered separately.

In rural areas of Bangladesh, agricultural farmers constitute the major proportion of the society who experience flooding impacts (Hossain *et al.* 2020). However, there are other groups of people too such as fish farmers and fishermen. It should be noted that different parts of the country are being flooded every year but studies to determine the impacts of flooding covering a larger geographical area are also scanty. Therefore, the actual overall scenario of flood impacts may not be known without considering a study involving the major occupational groups of the society from larger geographical area coverage. In this study, the impacts of flooding on major groups of people from three highly flood-prone areas of Bangladesh were determined. The study outcomes will help to broaden the knowledge of flood impacts on key rural communities and also to develop effective flood management strategies because a comprehensive understanding of its impacts on society is a prerequisite for the effective mitigation of flood risks (Allaire 2018).

2 | METHODOLOGY

2.1 Study area and period

This study was conducted in three districts of Bangladesh comprising of Roumari Upazila of Kurugram district, Chauhali Upazila of Sirajganj district and Char Bhadrasan Upazila of Faridpur district (Figure 1). These areas are widely known for their vulnerability to regular flooding in the country (Islam 2012). Data were collected through standardised procedures in two stages, between January and March in 2023 (first stage) and 2024 (second stage).

2.2 Sampling framework

Data were collected from three major groups of rural communities, namely (i) agriculture farmers, (ii) fish farmers, and (iii) fishermen, from the study areas. A total of 360 respondents (n = 120 from each site and 40 from each group) were selected randomly by visiting the study areas in December 2022. During the first stage of data collection in 2023, interviews with the respondents were conducted using a questionnaire to collect a wide range of socio-economic and flooding data, covering age, education (in years of schooling), income, family members, loans, other income options, experience, land, religion, number and area of ponds, loss due to flooding, flood management costs, problems, government subsidy status, and awareness issues. Flood and related data from 2022 were collected in 2023, whereas in 2024, data from the year 2023 were collected. Flood events during the study years may be considered regular and it did not affect household infrastructure of the respondents. Therefore, impacts on primary economic activities were recorded to determine the flood impacts.

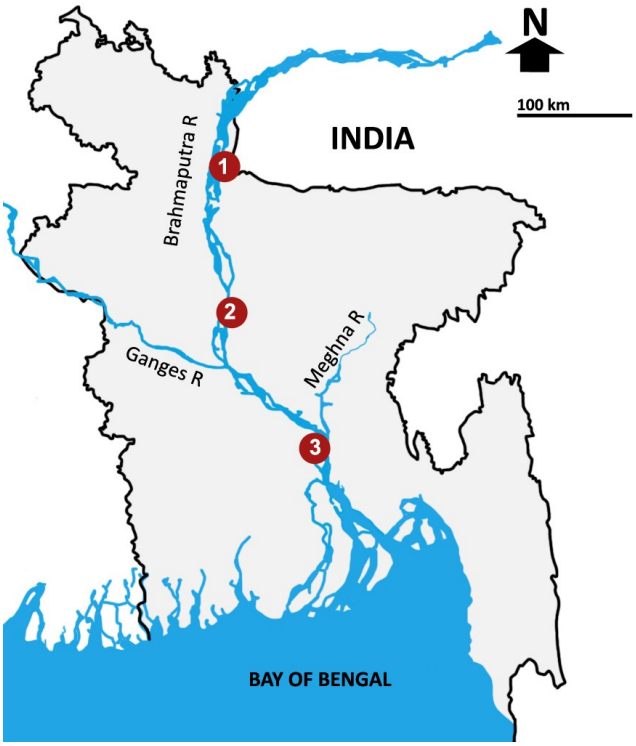

FIGURE 1 Map of Bangladesh showing the study areas; 1, Roumari Upazila of Kurugram district; 2, Chauhali Upazila of Sirajganj district; and 3, Char Bhadrasan Upazila of Faridpur district.

In addition to interviews, nine Focus Group Discussions (FGDs) involving 5 – 7 respondents from each respondent group (n = 3) at each sampling area (n = 3) were also conducted in 2024 to understand the community views on different issues relevant to the study objectives. All respondents were informed that their participation was voluntary and that the data generated from this study would be used for research purposes only. They were also assured that their identities would remain confidential.

2.3 Data analysis

Collected data were subjected to simple descriptive analysis. Data were analysed using the R (R Core Team 2022). To identify differences in age, experience, income and other similar parameters across groups a linear mixed effect model (LMM) was employed using the 'lme4' and 'lmerTest' packages in R (R Core Team 2022). During modelling, respondent groups (3 levels: agricultural farmers, fishermen and fish farmers) was considered the fixed effect and study sites was considered the random effect. To identify difference in data across sites for separate respondent groups, data were subjected to one-way analysis of variance (ANOVA) in R. All data were checked for normality assumptions before analysis and were transformed on a log-scale to meet the assumptions for

the analysis concerned, if required (McDonald 2014).

3 | RESULTS

3.1 Demographic of the respondents

All respondents were male. Majority of the respondents were Muslim (100% agricultural farmers, 100% fish farmers and 36.7% fishermen). Majority of the fishermen (63.3%) were Hindus. Age of the respondents varied across groups (LMM: F = 21.2, p < 0.001; Table 1, Figure 2). The mean age of agricultural and fish farmers was similar, 49.6 ± 11.9 years and 47.8 ± 11.3 years respectively, but higher than fishermen (40.7 ± 10.8 years) (Table 1, Figure 2). No such variation in age was recorded for each group across study sites (ANOVA: all $p > 0.05$).

Mean overall education level was 6.9 ± 4.9 years for the respondents with the highest schooling year of 7.4 years for the fish farmers (Table 1). However, schooling year did not vary across respondent groups (LMM: $p > 0.05$). Unlike education, monthly income of the respondent varied significantly across groups (LMM: $F = 174.3$, $p < 0.05$; Table 1, Figure 3). Majority of the respondents (84.7%) received financial loans from non-government sources (Table 1). Among respondent groups, 95% fish farmers received loans whereas this figure was 89% and 85% for agricultural farmers and fishermen respectively (Table 1).

TABLE 1 Demographic information of the respondents.

Parameter	Agriculture farmers	Fishermen	Fish farmers	Overall
Age (year)	49.6 ± 11.9	40.7 ± 10.8	47.8 ± 11.3	46.0 ± 11.9
Education (schooling year)	6.4 ± 4.9	6.8 ± 4.8	7.4 ± 4.8	6.9 ± 4.9
Income (BDT month^{-1})	16450.1 ± 7581.7	51505.61 ± 28699.68	37078.2 ± 14285.7	35011.3± 23817.1
Received loan from NGO (*n*)	89 (72.5%)	102 (85%)	114 (95%)	305 (84.7%)

BDT, Bangladesh Taka; 120 BDT = 1 USD$.

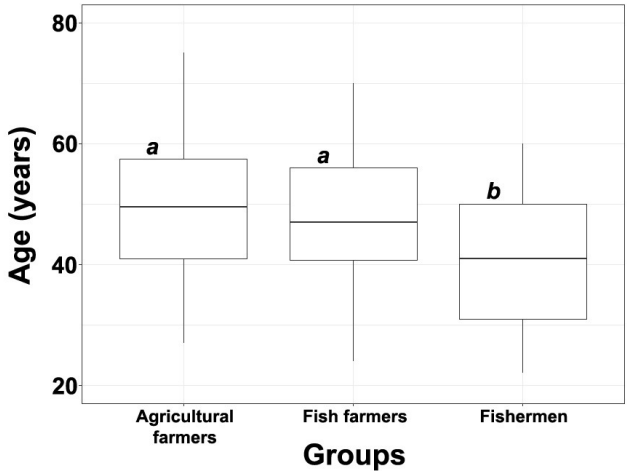

FIGURE 2 Boxplots showing the variation in age of the respondents. Midline within the box is the median; upper and lower limits of the box represent the third and first quartile (75th and 25th percentile) respectively. Different letters above the boxes represent statistically different groups.

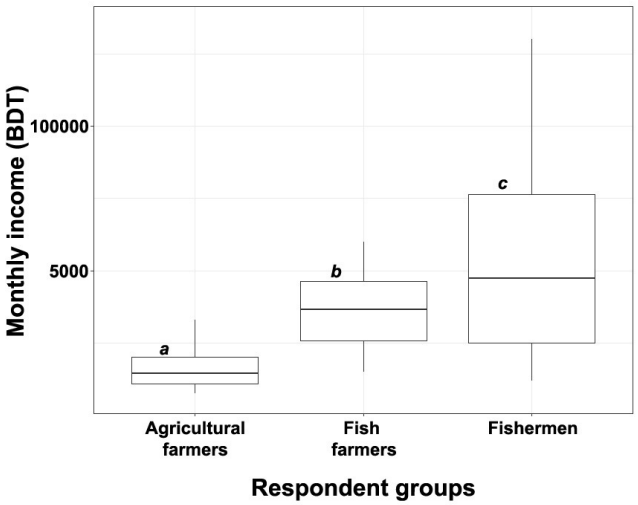

FIGURE 3 Boxplots showing the variation in monthly income of the respondents. Midline within the box is the median; upper and lower limits of the box represent the third and first quartile (75th and 25th percentile) respectively. Different letters above the boxes represent statistically different groups.

3.2 Flooding impacts on agriculture farmers

Flooding negatively impacted the respondents (i.e. agricultural farmers) in all study areas (Table 2, Figure 4). However, agricultural farmers in Faridpur area received more flood damages than other study areas (Figure 4). Mean flood management costs, due to the initiatives considered before and during flooding to prevent crop damage, also varied significantly across study sites (Table 2). This figure was the highest in Sirajganj (BDT 3046.6 ± 2906.1), followed by Kurigram (BDT 2406.7 ± 3306.5) and Faridpur (BDT 1406.7 ± 2383.7).

3.3 Flooding impacts on fish farmers

The flooding incidents negatively affected fish farmers of the study area. Overall mean (± SD) fish yield loss was equivalent to BDT 114200 ± 268857 for fish farmers in the study areas (Figure 5). However, this loss did not vary across study sites (Table 2, Figure 5). For flood management, the overall mean cost was BDT 38550 ± 41272 (range: 200 – 200000). The mean flood management cost

was also similar across study sites (Table 2).

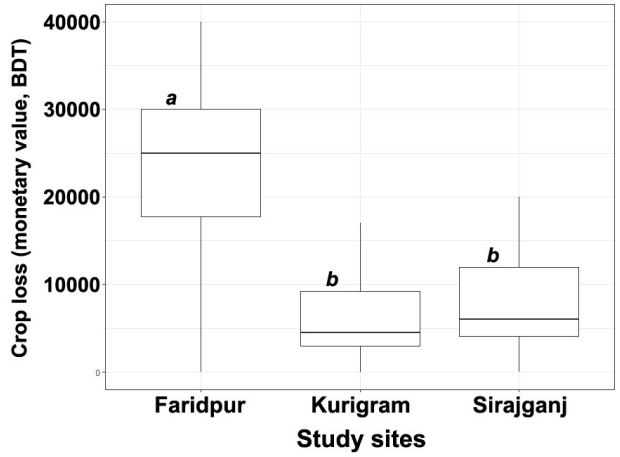

FIGURE 4 Boxplots showing the variation in agricultural crop loss due to flooding in the study areas. Midline within the box is the median; upper and lower limits of the box represent the third and first quartile (75th and 25th percentile) respectively. Different letters above the boxes represent statistically different groups.

TABLE 2 Spatial flooding impacts on the respondents' income through regular sources (agricultural crops for agricultural farmers; aquaculture fish for fish farmers), determined through linear mixed-effect modelling.

Flooding issue	*F*-value	*p*-value
Impact on agricultural crops / fish		
Crop loss for agricultural farmers	11.2	**<0.001**
Fish loss for fish farmers	0.6	0.544
Flooding management cost		
Agricultural farmers	4.0	**0.022**
Fish farmers	0.7	0.507

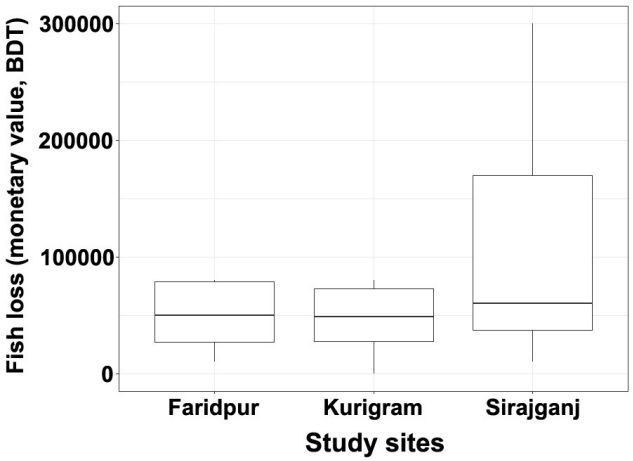

FIGURE 5 Boxplots showing the variation in fish yield loss due to flooding in the study areas. Midline within the box is the median; upper and lower limits of the box represent the third and first quartile (75th and 25th percentile) respectively.

3.3 Flooding impacts on fish farmers

Interestingly, the flooding incidents positively affected fishermen of the study area. The number of fishing days was higher during the flooding period than outside flooding period (LMM: $F = 88.2$, $p < 0.001$; Figure 6a). Similar result was also recorded for fishing hours in a day (fishing hours: 9.5 ± 2.3 hours during flood, 6.4 ± 2.0 hours outside flood period; LMM: $F = 56.0$, $p < 0.001$; Figure 6b). Fish catch was also higher during the flooding period (during flood: 6.8 ± 1.8 kg; outside flood period 2.6 ± 0.9 kg; LMM: $F = 228.1$, $p < 0.001$; Figure 6c).

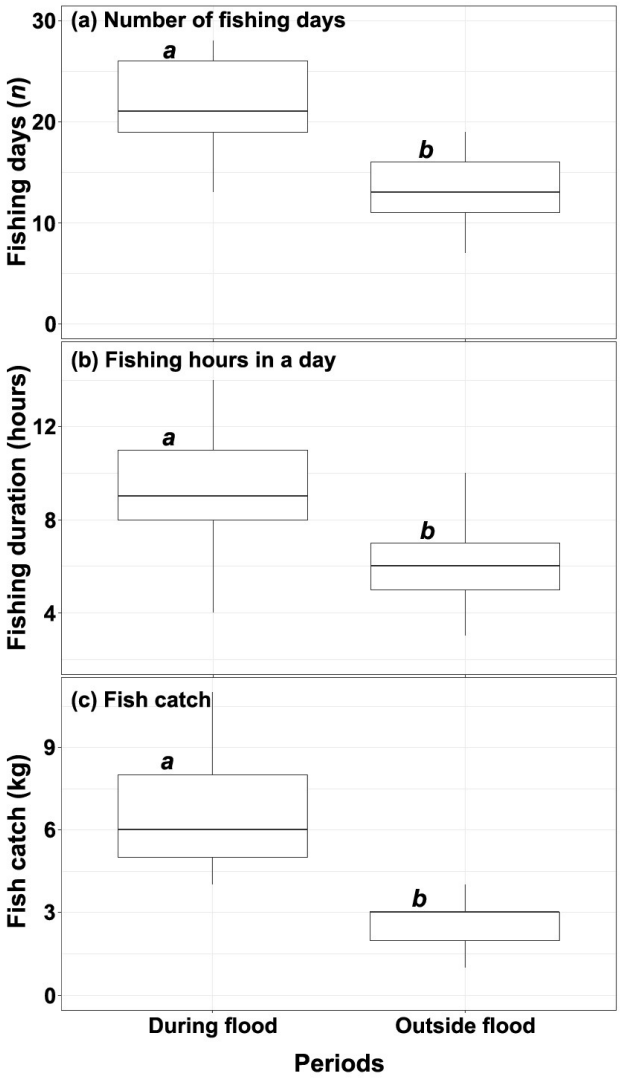

FIGURE 6 Boxplots showing the variation in fishing durations (days and hours) and fish catch during and ourside the flood. Midline within the box is the median; upper and lower limits of the box represent the third and first quartile (75th and 25th percentile) respectively. Different letters above the boxes represent statistically different groups.

3.4 Respondents' recommendations to minimise negative impacts of flood

A range of recommendations were made by the respondents of the study areas to minimise the negative impacts of flood (Table 3). Majority of the agricultural and fish farmers (80% each) wished to receive early warning of floods (Table 3). All agricultural farmers recommended for organising training on flood management by the government officials (Table 3). Most of the agricultural farmers (60%) and fishermen (90%) expected more subsidies during the flood period. Loan facilities at no or low interest rate was also recommended by fish farmers and fishermen (Table 3).

TABLE 3 Recommendations made by the respondents to minimize the flood damage.

Recommendation	Respondents (%)
By agricultural farmers	
Regular visit by government officials	48
Organise training by government officials	100
More subsidies	60
Development of drainage facility	100
Early warning of flood	80
By fish farmers	
Regular visit by government officials	48
Development of drainage facility	100
Loan at zero interest rate	80
Support in increasing dyke height	80
Early warning of flood	80
By fishermen	
More subsidies for all	90
Assistance in selling of fishes	100
Loan facilities at a low or zero interest rate	80

4 | DISCUSSION

This study provides evidences that not all the communities are being impacted negatively by the regular flooding events in which household infrastructures remained unharmed. Fish or aquatic resource-dependent communities such as fishermen might be benefitted from it. However, this may not be the case during severe flooding event because it can negatively affect the whole livelihoods of the respondents (Dewan 2015).

4.1 Flooding impacts

Impacts of flooding may be widespread. It can negatively affect the infrastructures and economic activities of the affected people and make a country economically vulnerable (Weir 2009). Loss of agricultural crop due to flood is a very common phenomenon all over the world (CRED 2020; Kim *et al.* 2023) including Bangladesh (Baky *et al.* 2012; Ninno *et al.* 2021).

In Bangladesh, massive flood control, drainage and irrigation (FCDI) structures have been built over the years to prevent or minimise negative impacts of flooding (Galib *et al.* 2018). The FCDI project benefitted the agricultural crop production to a great extent. Despite FCDI activities in different parts of the country, people in many areas remain highly vulnerable to flooding impacts. The areas of this study are some of such locations where flood event is common every year. A comprehensive flood forecasting system may be of help to minimise the flood damages. Although the rainfall is considered very important for the flood (Ali 2007; Kim *et al.* 2023), an inundation-based flood indicator is more reliable for assessing flood-induced crop losses. This is because inundation provides direct information about water balance in and on the rhizosphere, while precipitation only represents the input into the water balance (Kim *et al.* 2023).

Floods can severely affect aquaculture and fisheries industry (Olutumise 2023). Escape of fish from aquaculture facilities is common during the flooding period in Bangladesh (Galib *et al.* 2018; Parvez *et al.* 2023). This might promote establishment of non-native species in the wild as majority of the aquaculture species in Bangladesh are of non-native origin (Rahman 2005). Although fish farmers often try to protect their aquaculture ponds by increasing the height of the pond dyke or by installing fence, primarily made of bamboo splits– it is not always possible to prevent the fish from escaping. Better guideline from the responsible officials may improve the situation in this regards, also recommended by the respondents.

Almost all freshwater fishes of the country breed during the monsoon period (i.e. rainy season or flooding time; Rahman 2005, Parvez *et al.* 2023) and therefore, it is expected that there will be more fishes in the open waters of the country including those in the flooded areas. Increased fishing efforts during the flooding time, therefore, justifies the increased fish catch by the fishermen in the study area.

4.2 Respondents' recommendations

Training on flood management or associated issues was recommended by the respondents which is really important in dealing with the flood problems. Education might play a key role in this aspect as it can assist in reducing people's sensitivity and vulnerability to flood (Haque *et al.* 2023). Respondents recommended introducing an early warning system of flood. Unfortunately, despite its high importance the early warning system of flood in Bangladesh is lacking (Nayem *et al.* 2021). Respondents also recommended financial loans at no or low interest rates to cope up with the flooding impacts. As most of the respondents received financial loan from non-government organisations (NGOs), they remained vulnerable to financial exploitation as the interest rate of NGO loans may be much higher than the banks (Shalehin *et al.* 2022).

5| CONCLUSIONS

The accelerated retreat of glaciers and the heightened intensity of monsoon precipitation observed in recent years have led to a rise in the frequency of floods in Bangladesh (Agrawala *et al.* 2003; Dewan 2015). All people in flood-prone areas should be aware of flooding, its mechanisms, impacts, and safety/mitigation measures. Responsible authorities should play a key role in disseminating the relevant information. An early warning system for floods must be introduced in all parts of the country. Additionally, support such as financial loans at no or low interest rates should be ensured to help flood-affected people in Bangladesh. Moreover, it is important to develop an effective national and regional flood policy through the use of scientific research, traditional, and conventional practices (Dewan 2015). Although people dependent on fish and aquatic resources might find regular flooding beneficial as they can get more catch during this time, flooding events negatively affect most communities in society.

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CONFLICT OF INTEREST

The author declares no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the author.

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