# Living with Recurrent Flooding Risks in Bangladesh: Understanding Households Perception of Riverine Flood Disaster Risks and its Determinants

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**Abstract**

Riverine people are often affected by floods because of their proximity to the riverbank. Numerous studies were conducted on the physical characteristics of floods; however, there is still inadequate knowledge on the perception of flood risk of riverine households in Bangladesh. The present study explores the risk perception of riverine households to recurrent flood disaster and its associated determinants. Using systematic random sampling technique, 377 members from 377 households (one person from each household) were interviewed from the right bank of the Teesta River, Bangladesh. The results revealed that the sex of respondents, household's income, house location, and extents of damage to the houses significantly influenced respondent's risk perception. Male and female had a different perception of flood risk. Respondents whose houses were destroyed completely were found to be more fatalists to report their concern about the future flood. The majority of the respondents underestimated the likelihood of future flood occurrence. The findings of this study offer important implications for the risk managers to provide training to the riverine people to raise their awareness and perception about flood risk.

**Keywords:** Flood Risk Awareness, Teesta River, Preparedness, Mitigation.

## 1. Introduction

Bangladesh is ranked 7$^{th}$ on the "2020 Global Climate Risk Index" in terms of the worst affected countries owing to the extreme weather events (e.g., storms, floods) during 1999-2018 (Eckstein, Künzel, Schäfer, & Winges, 2019). The country is considered one of the most flood-prone countries globally(Kundzewicz et al., 2014). Flash flood, rainfall-induced flood, riverine flood and storm surge flood are the four major types of floods in Bangladesh (Mirza, Warrick, & Ericksen, 2003) and the characteristics of

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these kinds of floods are different from each other (Raaijmakers, Krywkow, & van der Veen, 2008). Among these floods, riverine floods are distinct for Bangladesh because the country is situated at the lowest riparian zone of the Ganges, Brahmaputra, and Meghna basin. Bangladesh has a complex network of 230 rivers including 57 transboundary rivers and these rivers drain around 1200 billion $m^3$ of water annually (Ali et al., 2018). River floods are caused by the overflow of riverbanks (Mirza et al., 2003), typically affect the people who reside near the rivers (Mondal, Murayama, & Nishikizawa, 2020). The spatial and temporal extent of flooding in Bangladesh is determined by the synchronization of peak discharges in the major rivers, and the magnitude and duration of floods (Rahman & Salehin, 2013). Hence riverine floods are associated with the amount of rainfall accumulation in the upstream catchments and the volume of water carries from the upstream countries.

Riverine people in Bangladesh face regular flooding (Mondal, Murayama, & Nishikizawa, 2021). Normal flooding is expected as people have developed their own strategies to enable them to withstand and reap the maximum benefit of flooding (ADPC, 2005; Sultana & Thompson, 2017). A severe flood can occur when the peak discharges of the major rivers coincide, causing widespread damages. As risk perception is hazard-specific, understanding the factors that influence household's perception of riverine flood disaster risk is thus necessary.

Earlier studies in Bangladesh examined the awareness of floodplain residents' towards large-scale flood structural measures (Chowdhury, 2003; Paul, 1999; Paul, 1995). Mamun (1996) examined awareness and preparedness measures of riverbank erosion-prone households. Although numerous studies investigated the risk perception of riverine people (Alam, Alam, & Mushtaq, 2017; Hasan & Kumar, 2019; Sarker, Wu, Alam, & Shouse, 2020), these studies explored risk perception from the climate change perspective. Conversely, limited studies have been conducted to identify the determinants of risk perception particularly, in the context of a riverine flood. Studies on awareness and concern about floods that are directly associated with demographic characteristics, experience and exposure to floods are very limited in Bangladesh. This presents an important limitation since people's risk perception is largely influenced by a host of socio-economic variables (Qasim, Nawaz Khan, Prasad Shrestha, & Qasim, 2015). While some studies were carried out recently in the Teesta floodplain looking at issues of food risk assessment (Mondal, Murayama, & Nishikizawa, 2020), and choice of coping strategies during or immediately after a flood disaster (Mondal, Murayama, & Nishikizawa, 2021), no study to date has examined the risk perception focusing on 2017 flood in the Teesta River, Bangladesh. Considering the current research gap, this study aims to explore riverine people's awareness and concern for recurrent flood risk. More specifically, this study aims to (i) evaluate respondents' perception to the changing flood exposure, and (ii) examine the factors that determine respondent's flood risk perception. It is, therefore, necessary to understand the perception of flood risk of people from riverine areas. This will guide risk managers on the ways to promote knowledge and awareness of riverine people by identifying target variables to enhance the adaptive capacity of riverine people. The Teesta River flood serves as a case example for this study.

## 2. Flood Risk Perception

Risk is the probability of harm that an individual or person experiences (Short, 1984). Risk perception is an important part of risk management (Kellens, Zaalberg, Neutens, Vanneuville, & De Maeyer, 2011). Perception of risk differs widely between the general public and experts (Dwyer, Zoppou, Nielsen, Day, & Roberts, 2004). Risk perception of an individual is important as it influences an individual's response against any harmful event (Burn, 1999). A wide range of literature has investigated the influential factors of individuals' perception of flood risk (e.g., (Miceli, Sotgiu, & Settanni, 2008; Qasim et al., 2015; Ullah, Saqib, Ahmad, & Fadlallah, 2020)). Literature noted that flood risk perceptions and preparedness are interlinked as people with a greater risk perception tend to adapt more action to avoid risks (Qasim et al., 2015). Studies found that socio-demographic characteristics influence an individual's risk perception(Bradford et al., 2012; Bubeck, Botzen, & Aerts, 2012; Bustillos Ardaya, Evers, & Ribbe, 2017; Lin, Shaw, & Ho, 2008; Pelling, 1997), experience with a flood (Botzen, Aerts, & van den Bergh, 2009; Miceli et al., 2008; Bradford et al., 2012) and distance from the water sources (Miceli et al., 2008; Botzen et al., 2009; Miceli et al., 2008).

According to Becker, Aerts, & Huitema (2014), risk perception is the perceived severity of a hazard with its probability. Raaijmakers et al. (2008) suggest that flood risk perception is the relationship among preparedness, awareness, and worries. Awareness is the consciousness/knowledge of flood risk perceived by individual's/groups who are exposed to risk, and preparedness is the control over that risk. Worries results from a higher level of risk awareness and improper preparedness to cope with that risk (Raaijmakers et al., 2008).

In this study, flood risk perceptions have been defined as the individual's views of (i) the changes in flood severity in the last two decades (flooding was getting worse), and (ii) the changes in floods frequency in future (whether flooding will occur more frequently in future). This study assumes that there is an association between socio-demographic variables, flood experience and flood risk perception.

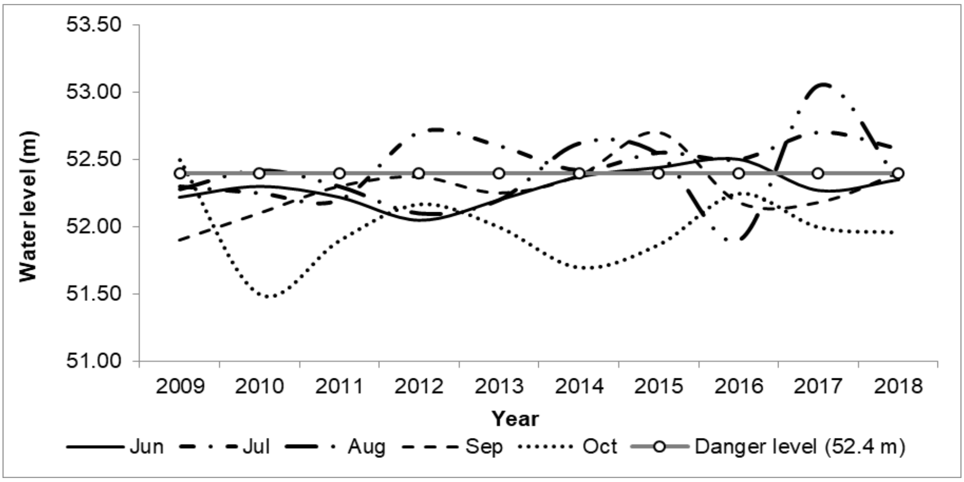
# 3. Methodology

## 3.1 Study Area

This study was carried out in the active Teesta River Floodplain in Bangladesh (TRFB). The TRFB is located in the northern region of the country. Teesta is one of the most important rivers in the Teesta River Floodplain (Mondal & Islam, 2017). Bangladesh has built a barrage, namely Teesta Barrage (TB), across the Teesta River, situated 16 km downstream of the Bangladesh border (Islam, 2016; Mondal, 2018; Mondal & Islam, 2017). On the other hand, India has built a barrage at Gozoldoba (in Indian Territory), located 66 km upstream of TB in Bangladesh (Islam, 2016). India controls Teesta River water flow unilaterally. For example, sudden water release through the Gozoldoba Barrage causes unexpected floods in Bangladesh.

Floods are recurrent in the TRFB. Recent notable severe floods in the Teesta River have occurred in 2004, 2008, 2017, 2019 and 2020.

**Figure 1: Monthly maximum water level at dalia station from 2009 to 2018**




Source: Prepared from Bangladesh Water Development Board

In particular, the devastating 2017 floods in the northern region of Bangladesh caused severe damage to crops and houses with over 150 casualties (NDRCC, 2017). The water level of the Teesta River at Dalia station crossed the danger level four times with a historical peak at 53.05 m. The water level data of the Dalia station were collected from the Bangladesh Water Development Board and presented in Figure 1. During

2014 and 2018, the water level of Dalia station reached/crossed the danger level by 29 times (danger level at Dalia station is 52.4 m) (Figure 1). These data showed an upward trend of peak discharges in the Teesta River in recent years.

### 3.2 Sample Design

A household-level questionnaire survey was administered in the three administrative districts of the Rangpur division: Nilphamari, Rangpur and Gaibandha (Figure 2). A face-to-face interview technique was adopted to collect data from the households. The questionnaire consists of several questions related to flooding hazard characteristics, exposure, vulnerability, capacity and risk perception (awareness and concern about Teesta River flood considering 2017 flood). The questionnaire was designed with both open and closed questions and was pre-tested in June 2018. The survey team consisted of ten enumerators who were familiar with the socio-cultural contexts of the study area. The original version of the questionnaire was drafted in English and was translated to Bengali. The household survey was conducted between April and May 2019. All respondents were informed about the purpose of the survey before the interview and agreed to participate in the survey voluntarily.

### 3.3. Data Collection and Sampling

This study used two stage sampling techniques: (a) selection of unions and (b) selection of households from the targeted unions. The right bank side of the Teesta River in Bangladesh was selected purposively. Three administrative districts are situated on the right bank: Nilphamari, Rangpur and Gaibandha (Figure 2). From each district, one upazila (sub-district) was selected, based on the criteria that the upazila is situated at the point of entrance of Teesta River in each administrative district. The selected three upazilas were: Dimla upazila from Nilphamari, Gangachara upazila from Rangpur and Sundarganj upazila from Gaibandha. Then, one union was selected randomly from each upazila[*] based on the criteria that the union is exposed and experienced recurrent river flooding from the Teesta River. The selected three unions were: Purbachhatnai from Dimla upazila, Gajaghanta from Gangachara upazila and Belka from Sundarganj upazila. Purbachhatnai union is located 10 km upstream of Teesta Barrage Project in Bangladesh. On the other hand, Gajaghanta union and Belka are situated

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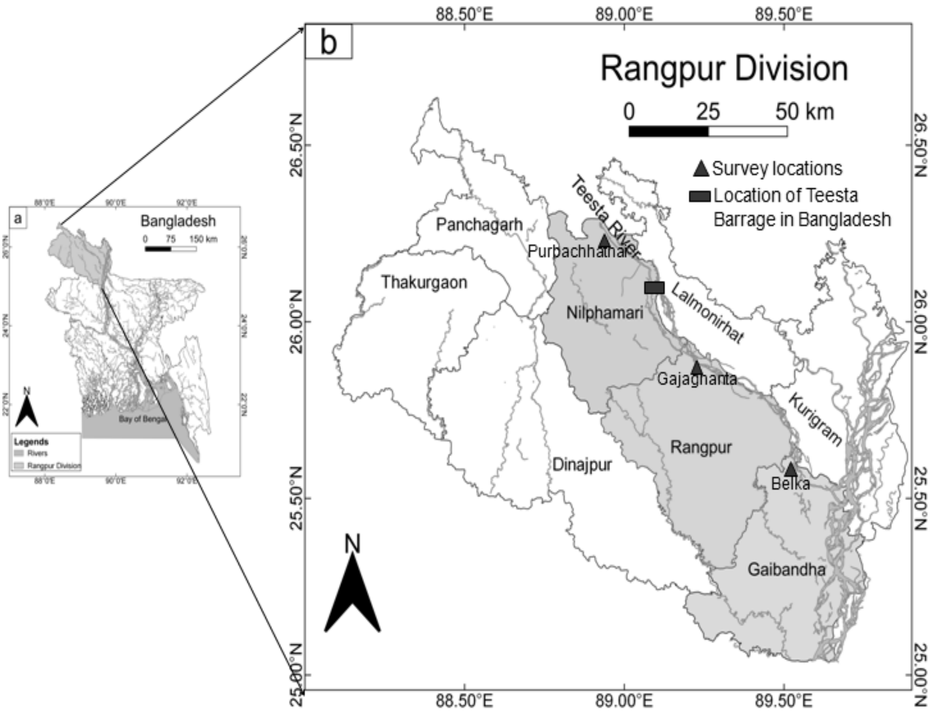
[*] Dimla upazila: Gayabari union, Jhunaganchh Chaphani union, Khalisha Chapani union, Khogakharibari union, Paschimchhatnai union, Purbachhatnai union, Tepakharibari union.
Gajaghanta upazila: Kolkanda union, Gajaghanta union, Lakshmitari union, Nohali union, Marania union.
Belka upazila: Belka union, Chandipur union, Haripur union, Tarapur union.

40 km and 85 km downstream of the Teesta Barrage Project in Bangladesh (on Google maps).

**Figure 2: Map of the study area**




The following equation is used to determine the sample size for this study based on Cochran (1977). The total number of households for the targeted three unions are 18972 (3435 households in Purbachhatnai, 7929 households in Gajaghanta and 7608 households in Belka unions)(BBS, 2013). Then the proportional allocation technique was applied to determine the sample sizes for these three unions: 68 for Purbachhatnai, 158 for Gajaghanta and 151 for Belka, respectively.

$$n_0 = \frac{Z^2\,pq}{e^2} \qquad (1)$$

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} \qquad (2)$$

where,

N= Population size (total number of households in targeted three unions)

n= Sample size

$n_o$= Sample size for infinite population

Z= Z value (Z= 1.96 at 95% confidence level)
p = percentage picking a choice expressed as a decimal
q = 1-p
e = confidence interval (5% margins of errors)

This study used a systematic random sampling technique to a select household for interview. Every fifth or sixth house situated along the riverbank was considered as the starting point of each interviewer. The interviewers conducted the questionnaire survey with every third or fourth house on the vertical paths. On vertical paths, one interviewer collected data from a maximum of 10 households. The respondents were the household head, spouse or elderly. In total, 377 members from 377 households (one person from each household) were interviewed. The data collectors were trained on data collection procedures before the survey.

### 3.4. Variables Selection

The indicators of this study were selected based on the literature and data availability (Table 1). Demographic characteristics, house location and flood experience was considered as the explanatory variables for risk perception. Demographic variables include the respondent's age, sex, education and occupation, and income of household. Location was measured by one item: location of the house from the riverbank. Experience with the flood was measured by two items: frequency of house inundation in 2017 and house damaged by a flood in the last 5 years.

To measure the perception of flooding risk, a three-point rating scale (agree, disagree, no idea) was used to assess awareness about the changes in flood severity, and concern about the likelihood of changes in flood frequency in future (Table 1).

**Table 1: Variables for analysis**

| Category Name | Variable Name | Variable Description |
|---|---|---|
| Flood Risk Perception | Awareness | Flooding in Teesta River is getting worse (agree, disagree, no idea) |
| | Concern | Flooding in Teesta River will happen more frequently in future (agree, disagree, no idea) |
| Socio-demographic | Sex | Sex of the respondents (male, female) |
| | Age | Age of the respondents (below 35 years, 35 to 50 years, above 50 years) |
| | Education | Education of the respondents (below primary, secondary or more) |

| Category Name | Variable Name | Variable Description |
|---|---|---|
| | Income | Monthly income of household (Tk. 4999 or less, Tk. 5000 to Tk. 10,000, Tk. 10,001 and above) |
| | Occupation | Occupation of the respondents (agriculture, housewife, others) |
| Flood Exposure | Location | Location of house from the riverbank (0-500 m, within 501-1000 m, more than 1000 m) |
| Flood Experience | Inundation | Frequency of house inundation in 2017 (numbers) |
| | Damage | House damaged by flood in the last 5 years (completely, partially, no damage) |

Source: Variables derived from questionnaire dataset for analysis

### 3.5. Data Analysis

Data analyses were performed in Statistical Package for Social Sciences (SPSS v.26). Two bivariate tests were employed to achieve the given research objectives: the Chi-square test and the Kruskal-Wallis test. The Chi-square test of independence is a non-parametric test used to explore the association between two categorical variables. The Kruskal-Wallis rank sum test is also a nonparametric test, used to discover the differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. Differences in risk perception can be revealed using these tests.

## 4. Results and Discussion

### 4.1 Socio-demographic Characteristics

The average age of the respondents was 44 years (SD=14 years): 36% respondents were below 35 years, 31% within 35 to 50 years age group and rest of them (33%) were more than 50 years age group (Table 2). More than half of the respondents (55.2%) were the heads' of the households, while 36.3% were the spouses and 8.5% senior members of the households. The selected sample had an over-representation of males (59%). The majority of the respondents had no formal education (65%), while 19% had primary level education and 16% secondary level or more. Agriculture was the main occupation for the majority of the respondents (41%), followed by a housewife (37%). A majority of the respondents (76.1%) earn less than Tk. 10,000 BDT[*] per month. Around one-third of the respondents had been living in their present residence since birth.

[*] 1 USD= 84.25 Bangladeshi Taka(Source: Bangladesh Bank,as of April 2019).

**Table 2: Characteristics of surveyed respondents (n=377)**

| Variables | Percentage |
|---|---|
| Age of respondents (years) | |
| <35 | 35.8% |
| 35-50 | 31.3% |
| >50 | 32.9% |
| Sex of respondents | |
| Male | 58.9% |
| Female | 41.1% |
| Education of respondents | |
| No formal education | 65% |
| Primary level | 19% |
| Secondary level | 13% |
| Higher secondary or more | 3% |
| Occupation of respondents | |
| Agriculture | 41.1% |
| Housewife | 37.1% |
| Others | 21.8% |
| Income of household (monthly) | |
| Tk. 4999 or less | 25.5% |
| Tk. 5000 to Tk. 10,000 | 50.7% |
| Tk. 10,001 and above | 23.9% |
| Years of living in current residence | |
| ≤ 5 years | 30% |
| 6 years or more | 38% |
| Since birth | 32% |

Source: Field survey, 2019

### 4.2 Flood Exposure and Experience

Around 85% respondents have their dwellings within 1000 m from the riverbank (Table 3). Almost one-third (31%) of the respondents informed that their houses were completely damaged by a flood in the last five years. Only 3% of respondents' houses were not inundated by the 2017 flood, while around 46% reported that they faced inundation twice or more.

**Table 3: Flood exposure and experience of respondents**

| Variables | Percentage |
|---|---|
| Location of House from the Riverbank | |
| 0-500 m | 66.8% |
| Within 501-1000 m | 17.8% |
| More than 1000 m | 15.4% |
| Experience with Flood | |
| Average number of house inundation in 2017 | 1.6 (±0.8) (minimum: 0 and maximum: 3) |
| House Damaged by Flood | |
| Completely | 31% |

| Variables | Percentage |
|---|---|
| Partially | 55% |
| No damage | 14% |

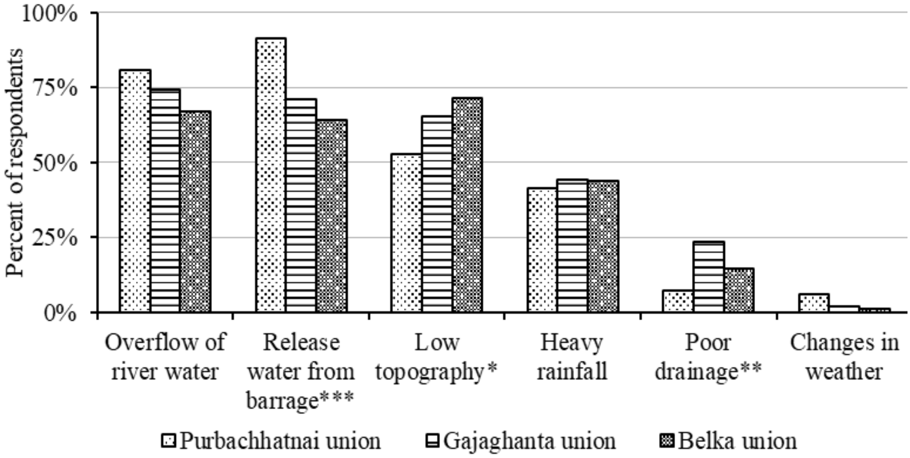
Source: Field survey, 2019

### 4.3 Perception of Causes of Flooding

The respondents identified numerous causes of flooding including the overflow of the riverbank (72.4%), the release of water from the barrage (71.9%) and low topography (65.5%) (Figure 3). Further analysis of survey data revealed that a significantly ($\chi^2$=17.0, df=2, p<.001) higher proportion of respondents from Purbachhatnai reported that water release from the Gozoldoba Barrage (Indian Territory) causes flood. This is because Teesta River enters Bangladesh at Dimla upzaila, Nilphamari and thus water carried from India enters directly in Purbachhatnai (upstream of Teesta Barrage in Bangladesh). The respondents from Purbachhatnai unanimously reported that the water release from India is the major causes of flood in their locality.

Respondents from the downstream of Teesta Barrage reported that both barrages (Bangladesh and India) are responsible for flooding in their areas. On the other hands, a higher proportion of respondents from Belka ($\chi^2$=7.2, df=2, *p*=.03) informed that low topography caused a flood in their locality. This might be because Belka is located in the downstream portion of Teesta River in Bangladesh and has a low lying, flat topography than the other two surveyed areas. Around 17.0% of respondents believed that poor drainage was the major reason for flood in their area, which was found significantly ($\chi^2$=9.7, df=2, *p*=.008) higher among the respondents from Gajaghanta. Another reason attributed to flooding in the study area is heavy rainfall (43.5%). A small percentage of respondents (2.4%) attributed that flooding is caused by the changes in weather. This presents an important indication that the respondents were aware of the causes of floods in their locality. It should be noted that anthropogenic factors such as the release of water from the barrage, which have become more pronounced in the last two decades leaves people in the uncertainty of flooding (Mondal & Islam, 2017).

**Figure 3: Causes of flood (multiple responses considered) (n=377)**

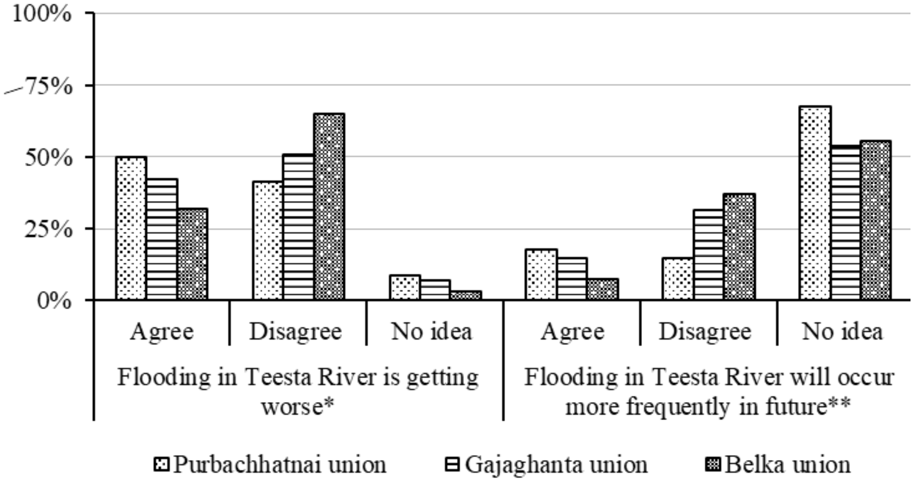



Note: *, **, and *** are significant at 5%, 1% and 0.1% level, respectively
Source: Field survey, 2019

### 4.4 Flood Risk Awareness and Concern

Figure 4 present an overview of the perceived flood risk by the respondents. The awareness ($\chi^2$=13.2, df=4, $p$=.01) and concern ($\chi^2$=14.7, df=4, $p$=.005) of respondents about the Teesta River flood were significantly different among the study areas. Among the three survey locations, there were significantly ($p$=.01) higher proportion of respondents from Purbachhatnai (50.0%) who agreed that the flooding in Teesta River is getting worse while the lowest percentage of respondents was from Belka (31.8%). However, the majority of the respondents disagreed (55%) that flooding in the Teesta River is getting worse. Fatalism plays a vital role in shaping respondents' risk perception when inquired about the likelihood of a flood(concern). Around 57% of respondents reported that they had no idea about the likelihood of future flood occurrence, although they have been living in the riverine area for a long time. One possible explanation of this finding could be that uncertainty of water release from barrages and dams built upstream which blocks the natural flow of water, makes it difficult to predict floods using people's traditional knowledge. Overall, respondents from Purbachhatnai had better risk perception as compared with Gajaghanta and Belka. This may be because Purbachhatnai is situated upstream of the Teesta River Barrage in Bangladesh and water enters there directly from India. These findings were consistent with Haque, Aich, Subhani, Bari, & Diyan (2014) which reported that unions adjacent to the barrage experience more flooding events.

**Figure 4: Summary of flood risk perception (N=377)**




Note: *, **, and *** are significant at 5%, 1% and 0.1% level, respectively
Source: Field survey, 2019

### 4.5 Determinants of Flood Risk Perception

The results of the bivariate tests are presented in Table 4. The findings showed that a significantly higher proportion of female respondents agreed that the severity of the flooding was increased as compared to male respondents (*p*=.014) (Table 4). On the other hand, a higher proportion of male respondents agreed that the frequency of flooding will be decreased in future (*p*=.012). Awareness about flooding was higher among the female respondents. It is possible, however, all of the female respondents were married, and the 47% female respondents' age was below 35 years. Therefore, female respondents were only aware of the most recent floods that they experienced after coming to the new place after their marriage. Several studies identified that females have higher risk perception than males (Liu, Li, Shen, Xie, & Zhang, 2018; Kellens et al., 2011). The sex of respondents was significantly related to concern about future floods. These findings contradict the findings of Adelekan & Asiyanbi (2016) that reported insignificant relation between concern about flooding and sex of respondents in Nigeria.

**Table 4: Relationships between risk perception variables with sex of respondents**

| Awareness: | | Sex of respondents | | |
|---|---|---|---|---|
| Flooding in | | Male | Female | Total |
| Teesta River is Getting Worse | Agree | 77 (34.7%) | 72 (46.5%) | 149 (39.5%) |
| | Disagree | 135 (60.8%) | 71 (45.8%) | 206 (54.6%) |
| | No idea | 10 (4.5%) | 12 (7.7%) | 22 (5.8%) |
| | Total | 222 (100.0%) | 155 (100.0%) | 377 (100.0%) |

Chi-square test: $\chi^2$=8.6, degrees of freedom=2, *p*=.014

| Concern: Flooding in Teesta River Will Happen More Frequently in Future | | Male | Female | Total |
|---|---|---|---|---|
| | Agree | 21 (9.5%) | 25 (16.1%) | 46 (12.2%) |
| | Disagree | 80 (36.0%) | 36 (23.2%) | 116 (30.8%) |
| | No idea | 21 (54.5%) | 94 (60.6%) | 215 (57.0%) |
| | Total | 222 (100.0%) | 155 (100.0%) | 377 (100.0%) |
| | Chi-square test: $\chi^2$=8.8, degrees of freedom= 2, *p*=.012 | | | |

Source: Field Survey, 2019

The findings revealed that age was not significant with any risk perception variables (Table 5). The result was similar with Qasim et al., (2015) in the context of developing country like Pakistan but different from developed countries' context such as Germany (Grothmann & Reusswig, 2006) and Belgium (Kellens et al., 2011) that found significant association. This may be because flood is a recurrent phenomenon in the study area.

**Table 5: Relationships between risk perception variables with age of respondents**

| Awareness: Flooding in Teesta River is Getting Worse | | Age of Respondents | | | |
|---|---|---|---|---|---|
| | | Below 35 years | 35 to 50 years | Above 50 years | Total |
| | Agree | 51 (37.8%) | 51 (43.2%) | 47 (37.9%) | 149 (39.5%) |
| | Disagree | 78 (57.8%) | 61 (51.7%) | 67 (54.0%) | 206 (54.6%) |
| | No idea | 6 (4.4%) | 6 (5.1%) | 10 (8.1%) | 22 (5.8%) |
| | Total | 135 (100.0%) | 118 (100.0%) | 124 (100.0%) | 377 (100.0%) |
| | Chi-square test: $\chi^2$=2.7, degrees of freedom=4, *p*=.62 | | | | |
| Concern: Flooding in Teesta River Will Happen More Frequently in Future | | Below 35 Years | 35 to 50 Years | Above 50 Years | Total |
| | Agree | 17 (12.6%) | 15 (12.7%) | 14 (11.3%) | 46 (12.2%) |
| | Disagree | 45 (33.3%) | 36 (30.5%) | 35 (28.2%) | 116 (30.8%) |
| | No idea | 73 (54.1%) | 67 (56.8%) | 75 (60.5%) | 215(57.0 %) |
| | Total | 135 (100.0%) | 118 (100.0%) | 124 (100.0%) | 377(100. 0%) |
| | Chi-square test: $\chi^2$=1.1, degrees of freedom=4, *p*=.89 | | | | |

Source: Field Survey, 2019

Education plays an important role in determining risk perception as education enhances individual risk perception. Although previous studies found a significant relationship between the level of education and risk perception (Adelekan & Asiyanbi, 2016; Botzen et al., 2009; Qasim et al., 2015), this study did not produce any significant relationship between those two variables (Table 6). This may be because of the lower level of education in the study area, and the level of education was thus addressed by the de facto system.

**Table 6: Relationships between risk perception variables with education of respondents**

| Awareness: Flooding in Teesta River is Getting Worse | | Education of Respondents | | |
|---|---|---|---|---|
| | | Below Primary | Secondary or More | Total |
| | Agree | 128 (40.4%) | 21 (35.0%) | 149 (39.5%) |
| | Disagree | 170 (53.6%) | 36 (60.0%) | 206 (54.6%) |
| | No idea | 19 (6.0%) | 3 (5.0%) | 22 (5.8%) |
| | Total | 317 (100.0%) | 60 (100.0%) | 377 (100.0%) |
| Chi-square test: $\chi 2$=0.8, degrees of freedom= 2, p=.660 | | | | |
| Concern: Flooding in Teesta River Will Happen More Frequently in Future | | Below Primary | Secondary or More | Total |
| | Agree | 38 (12.0%) | 8 (13.3%) | 46 (12.2%) |
| | Disagree | 93 (29.3%) | 23 (38.3%) | 116 (30.8%) |
| | No idea | 186 (58.7%) | 29 (48.3%) | 215 (57.0%) |
| | Total | 317 (100.0%) | 60 (100.0%) | 377 (100.0%) |
| Chi-square test: $\chi 2$=2.3, degrees of freedom= 2, p=.309 | | | | |

Source: Field Survey, 2019

Households' income plays an important role to deal with a disaster. The findings suggest that a significantly ($p$<.001) higher proportion of households that had an income of more than Tk. 10,000 per month reported their concern about the increase of flood frequency in future (Table 7). This may be because higher income groups are more capable of responding to flood disaster more quickly and have taken more actions to mitigate disaster risk (Shah, Ye, Shaw, Ullah, & Ali, 2020). However, some scholarly evidence (Qasim et al., 2015; Botzen et al., 2009) showed that income has no significant effects on risk perception. The variable occupation was not significant in this study (Table 8).

**Table 7: Relationships between risk perception variables with income of households**

| Awareness: Flooding in | **Income of Respondents** | | | |
|---|---|---|---|---|
| | Tk. 4,999 or Less | Tk. 5000 | Tk. 10,001 | Total |

| | | | | | |
|---|---|---|---|---|---|
| Teesta River is Getting Worse | | | to Tk. 10000 | and Above | |
| | Agree | 35 (36.5%) | 81 (42.4%) | 33 (36.7%) | 149 (39.5%) |
| | Disa-gree | 53 (55.2%) | 100 (52.4%) | 53 (58.9%) | 206 (54.6%) |
| | No idea | 8 (8.3%) | 10 (5.2%) | 4 (4.4%) | 22 (5.8%) |
| | Total | 96 (100.0%) | 191 (100.0%) | 90 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=2.7, degrees of freedom=4, $p$=.60 | | | |
| Concern: Flooding in Teesta River Will Happen More Fre-quently in Fu-ture | | Tk. 4,999 or Less | Tk. 5000 To Tk. 10000 | Tk. 10,001 and Above | Total |
| | Agree | 8 (8.3%) | 16 (8.4%) | 22 (24.4%) | 46 (12.2%) |
| | Disa-gree | 26 (27.1%) | 61 (31.9%) | 29 (32.2%) | 116 (30.8%) |
| | No idea | 62 (64.6%) | 114 (59.7%) | 39 (43.3%) | 215 (57.0%) |
| | Total | 96 (100.0%) | 191 (100.0%) | 90 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=19.3, degrees of freedom =4, $p$=.001 | | | |

Source: Field Survey, 2019

**Table 8: Relationships between risk perception variables with occupation of respondents**

| | | Occupation of Respondents | | | |
|---|---|---|---|---|---|
| Awareness: Flooding in Teesta River is Getting Worse | | Agriculture | Housewife | Others | Total |
| | Agree | 57 (36.8%) | 64 (45.7%) | 28 (34.1%) | 149 (39.5%) |
| | Disa-gree | 91 (58.7%) | 68 (48.6%) | 47 (57.3%) | 206 (54.6%) |
| | No idea | 7 (4.5%) | 8 (5.7%) | 7 (8.5%) | 22 (5.8%) |
| | Total | 155 (100.0%) | 140 (100.0%) | 82 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=5.3, degrees of freedom=4, $p$=.26 | | | |
| Concern: Flooding in Teesta River Will Hap-pen More | | Agriculture | Housewife | Others | Total |
| | Agree | 15 (9.7%) | 23 (16.4%) | 8 (9.8%) | 46 (12.2%) |
| | Disa-gree | 56 (36.1%) | 35 (25.0%) | 25 (30.5%) | 116 (30.8%) |

| | | | | | |
|---|---|---|---|---|---|
| Frequently in Future | No idea | 84 (54.2%) | 82 (58.6%) | 49 (59.8%) | 215 (57.0%) |
| | Total | 155 (100.0%) | 140 (100.0%) | 82 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=6.6, degrees of freedom =4, $p$=.16 | | | |

Source: Field Survey, 2019

The location of the house from the riverbank might reflect the degree of exposure of a household to flood hazard (Liu et al., 2018). This study found significant differences between location and concern about the future flood ($p$=.01) indicating higher proportions of respondents living more than 1000 m from the riverbank agreed that the frequency of flood will be decreased in future as compared with those who live within 1000 m (Table 4). Nevertheless, irrespective of their locations around 57% of respondents neither agreed nor disagreed about the changes in future flood. The finding of this study corroborates with findings of other studies (Adelekan & Asiyanbi, 2016; Heitz, Spaeter, Auzet, & Glatron, 2009; Liu et al., 2018; Qasim et al., 2015; Ullah et al., 2020) that found positive correlation between the location of house from the water sources (rivers or seas) and flood risk perception.

**Table 9: Relationships between risk perception variables with location of respondents from riverbank**

| Awareness: Flooding in Teesta River is Getting Worse | | Location of House from Riverbank | | | |
|---|---|---|---|---|---|
| | | 0-500 m | Within 501-1000 m | More than 1000 m | Total |
| | Agree | 105 (41.7%) | 22 (32.8%) | 22 (37.9%) | 149 (39.5%) |
| | Disa-gree | 131 (52.0%) | 41 (61.2%) | 34 (58.6%) | 206 (54.6%) |
| | No idea | 16 (6.3%) | 4 (6.0%) | 2 (3.4%) | 22 (5.8%) |
| | Total | 252 (100.0%) | 67 (100.0%) | 58 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=2.8, degrees of freedom=4, $p$=.59 | | | |
| Concern: Flooding in Teesta River Will Happen More Fre-quently in Future | | Less than 500 m | Within 500 m to 1000 m | More than 1000 m | Total |
| | Agree | 37 (14.7%) | 6 (9.0%) | 3 (5.2%) | 46 (12.2%) |
| | Disa-gree | 63 (25.0%) | 26 (38.8%) | 27 (46.6%) | 116 (30.8%) |
| | No idea | 152 (60.3%) | 35 (52.2%) | 28 (48.3%) | 215 (57.0%) |

| | | | | |
|---|---|---|---|---|
| Total | 252 (100.0%) | 67 (100.0%) | 58 (100.0%) | 377 (100.0%) |
| Chi-square test: $\chi^2$=14.6, degrees of freedom=4, *p*=.006 | | | | |

Source: Field Survey, 2019

Though earlier studies (Liu et al., 2018; Brilly & Polic, 2005; Liu et al., 2018) identified that previous experience with the flood was an important determinant of flood risk perception, this study did not find a statistically significant relationship between hazard experience and risk perception variables (Table 10). One possible explanation might be associated with the definition of the indicator. Respondents were asked whether their houses were inundated in 2017, the last flood. Flood is recurrent in active Teesta floodplain, and over two-thirds of the respondents whose houses were not inundated in 2017 flood lost their standing crops. It is interesting to notice that the risk perception was higher for the households that did not face inundation compared with those that faced inundation. This may be because they became afraid to see the severity of the last flood, and thus expected that both severity and frequency of flood will be increased in future. However, the findings are consistent with those of (Grothmann & Reusswig, 2006) that argued experience does not influence risk perception.

**Table 10: Relationships between risk perception variables with experience with flood**

| Risk Perception Variables | Experience with Flood: Average Number of House Inundation in 2017 | | |
|---|---|---|---|
| | $\chi^2$ | df | p |
| Awareness: Flooding in Teesta River is Getting Worse | 3.9 | 2 | .14 |
| Concern: Flooding in Teesta River Will Happen More Frequently in Future | 2.2 | 2 | .39 |

Note: Kruskal–Wallis test, df=degrees of freedom.
Source: Field Survey, 2019

House destroyed by a flood was considered an important indicator as this indicator influenced all perception variables significantly: (i) awareness ($p<.001$) and (ii) concern ($p=.01$) (Table 11). It may be because personal experience such as property loss is correlated with an increased risk perception (Miceli et al., 2008; Perry & Lindell, 1990). Overall, among the respondents whose houses were partially damaged, they reported that the severity of flood decreased and the flood frequency will be decreased in future. This may be because this explanatory variable act as a proxy variable for the ownership of a house as there is a significant difference between ownership of house and house destroyed by a flood, with a higher percentage of respondents whose houses were completely damaged living in rented/government/relatives' land (*p*<.001). Households using rented or government or relatives' land have lesser options or lack of willingness to strengthen their houses; as a result, vulnerability of household increases (Mondal et al., 2020).

**Table 11: Relationships between risk perception variables with extent of damage of house**

| Awareness: Flooding in Teesta River is Getting Worse | | **House Damaged by Flood** | | | |
|---|---|---|---|---|---|
| | | Com-pletely | Partially | No damage | Total |
| | Agree | 72 (62.1%) | 62 (29.8%) | 15 (28.3%) | 149 (39.5%) |
| | Disa-gree | 36 (31.0%) | 136 (65.4%) | 34 (64.2%) | 206 (54.6%) |
| | No idea | 8 (6.9%) | 10 (4.8%) | 4 (7.5%) | 22 (5.8%) |
| | Total | 116 (100.0%) | 208 (100.0%) | 53 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=39.5, degrees of freedom=4, $p$<.001 | | | |
| Concern: Flooding in Teesta River Will Happen More Fre-quently in Future | | Com-pletely | Partially | No damage | Total |
| | Agree | 18 (15.5%) | 22 (10.6%) | 6 (11.3%) | 46 (12.2%) |
| | Disa-gree | 21 (18.1%) | 74 (35.6%) | 21 (39.6%) | 116 (30.8%) |
| | No idea | 77 (66.4%) | 112 (53.8%) | 26 (49.1%) | 215 (57.0%) |
| | Total | 116 (100.0%) | 208 (100.0%) | 53 (100.0%) | 377 (100.0%) |
| | | Chi-square test: $\chi^2$=13.2, degrees of freedom=4, $p$=.010 | | | |

## 5. Conclusion

The objective of this present study was to evaluate the risk perception of respondents to riverine floods. This study revealed that males and females had different notions on flood risk. However, a larger proportion of respondents believed that flood will decrease in future, which is not supported by the recent trend of increasing flood peaks in the Teesta River. Experience with flood hazard appeared to be linked with the risk perception in a complex manner. Respondents who experienced complete damage to their houses were found more fatalistic in reporting about the severe flood in the coming years. Flood exposure also influences respondents' concerns about flood risk.

The challenge for flood risk reduction is closely associated with the risk awareness and concern of individuals, households and community for collective actions. Flood is not a new hazard for the studied communities. Changes in the level of concern are not the direct outcome of a policy, but the result of a change in preparedness and awareness (Raaijmakers et al., 2008). This study, therefore, advocates that risk awareness and concern should be improved at the local level regardless of age, sex, educational background, occupation and exposure to hazard. On the other hand, risk awareness and concerns are not just related to taking proactive actions but also closely linked with decision making on evacuation. Therefore, it is necessary to consider the awareness and concerns of residents before designing and implementing any kinds of flood risk reduction programs. It is also necessary to focus attention on how to motivate people to take risk-reducing measures in the context of recurrent hazards that become the part of people's life.

This study attempted to assess flood risk perception of riverine people in Bangladesh, which is based on self-reported data. This self-reported data can produce response bias. Although bivariate analysis between two variables does not provide a causal relationship between them, multivariate analysis can be applied in a future study to identify the factors that influence risk perception. This study was conducted around two months before the 2019 flood when only 12% of respondents expected severe floods in future. Another study on risk perception can be conducted to understand the changes in risk perception in the same locations.

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## References

Adelekan, I. O., & Asiyanbi, A. P. (2016). Flood risk perception in flood-affected communities in Lagos, Nigeria. *Natural Hazards, 80*(1), 445-469.

ADPC, U. (2005). Integrated flood risk management in Asia.

Alam, G. M., Alam, K., & Mushtaq, S. (2017). Climate change perceptions and local adaptation strategies of hazard-prone rural households in Bangladesh. *Climate Risk Management, 17,* 52-63.

Ali, M. H., Bhattacharya, B., Islam, A., Islam, G., Hossain, M. S., & Khan, A. (2019). Challenges for flood risk management in flood-prone Sirajganj region of Bangladesh. *Journal of Flood Risk Management, 12*(1), e12450.

Ardaya, A. B., Evers, M., & Ribbe, L. (2017). What influences disaster risk perception? Intervention measures, flood and landslide risk perception of the population living in flood risk areas in Rio de Janeiro state, Brazil. *International journal of disaster risk reduction, 25*, 227-237.

BBS. (2013). Population & housing census- 2011: Community Report: Gaibandha/ Nilphamari/Rangpur. Dhaka: Bangladesh Bureau of Statistics.

Becker, G., Aerts, J. C., & Huitema, D. (2014). Influence of flood risk perception and other factors on risk-reducing behaviour: a survey of municipalities along the R hine. *Journal of Flood Risk Management, 7*(1), 16-30.

Botzen, W. J., Aerts, J., & van den Bergh, J. C. (2009). Dependence of flood risk perceptions on socioeconomic and objective risk factors. *Water resources research, 45*(10).

Bradford, R., O'Sullivan, J. J., Van der Craats, I., Krywkow, J., Rotko, P., Aaltonen, J., Schelfaut, K. (2012). Risk perception–issues for flood management in Europe. *Natural hazards and earth system sciences, 12*(7), 2299-2309.

Brilly, M., & Polic, M. (2005). Public perception of flood risks, flood forecasting and mitigation. *Natural hazards and earth system sciences, 5*(3), 345-355.

Bubeck, P., Botzen, W. J. W., & Aerts, J. C. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis: An International Journal, 32*(9), 1481-1495.

Burn, D. H. (1999). Perceptions of flood risk: a case study of the Red River flood of 1997. *Water resources research, 35*(11), 3451-3458.

Chowdhury, M. (2003). The Impact ofGreater Dhaka Flood Protection Project'(GDFPP) on Local Living Environment–The Attitude of the Floodplain Residents. *Natural Hazards, 29*(3), 309-324.

Cochran, W. a. G. (1977). Sampling Techniques, John Wiley & Sons Inc. *New York*, 135.

Dwyer, A., Zoppou, C., Nielsen, O., Day, S., & Roberts, S. (2004). Quantifying social vulnerability: a methodology for identifying those at risk to natural hazards.

Eckstein, D., Künzel, V., & Schäfer, L. Global Climate Risk Index 2020 Germanwatch eV 2020. In.

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: Why some residents take precautionary action while others do not. *Natural Hazards, 38*(1), 101-120.

Haque, A., Aich, D., Subhani, R., Bari, E., & Diyan, M. (2014). Tale of a Tamed River: The value of Ecosystem Services of Teesta River–An estimate of value of provisional services in agriculture and fisheries. *Asian Center for Development, Dhaka*.

Hasan, M. K., & Kumar, L. (2019). Comparison between meteorological data and farmer perceptions of climate change and vulnerability in relation to adaptation. *Journal of Environmental Management, 237*, 54-62.

Heitz, C., Spaeter, S., Auzet, A.-V., & Glatron, S. (2009). Local stakeholders' perception of muddy flood risk and implications for management approaches: A case study in Alsace (France). *Land Use Policy, 26*(2), 443-451.

Islam, M. F. (2016). *Water use and poverty reduction*: Springer.

Kellens, W., Zaalberg, R., Neutens, T., Vanneuville, W., & De Maeyer, P. (2011). An analysis of the public perception of flood risk on the Belgian coast. *Risk Analysis: An International Journal, 31*(7), 1055-1068.

Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., Mach, K. (2014). Flood risk and climate change: global and regional perspectives. *Hydrological Sciences Journal, 59*(1), 1-28.

Lin, S., Shaw, D., & Ho, M.-C. (2008). Why are flood and landslide victims less willing to take mitigation measures than the public? *Natural Hazards, 44*(2), 305-314.

Liu, D., Li, Y., Shen, X., Xie, Y., & Zhang, Y. (2018). Flood risk perception of rural households in western mountainous regions of Henan Province, China. *International journal of disaster risk reduction, 27*, 155-160.

Ludy, J., & Kondolf, G. M. (2012). Flood risk perception in lands "protected" by 100-year levees. *Natural Hazards, 61*(2), 829-842.

Mamun, M. Z. (1996). Awareness, Preparedness and Adjustment Measures of River-bank Erosion-prone People: A Case Study. *Disasters, 20*(1), 68-74.

Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy. *Journal of environmental psychology, 28*(2), 164-173.

Mirza, M., Warrick, R., & Ericksen, N. (2003). The implications of climate change on floods of the Ganges, Brahmaputra and Meghna rivers in Bangladesh. *Climatic change, 57*(3), 287-318.

Mondal, M. S. H., Murayama, T., & Nishikizawa, S. (2020a). Assessing the flood risk of riverine households: A case study from the right bank of the Teesta River, Bangladesh. *International journal of disaster risk reduction, 51*, 101758.

Mondal, M. S. H., Murayama, T., & Nishikizawa, S. (2020b). Determinants of household-level coping strategies and recoveries from riverine flood disasters: empirical evidence from the right bank of Teesta River, Bangladesh. *Climate, 9*(1), 4.

Mondal, M. S. H. (2018). Human adjustment with uncertain floods An empirical study on the inhabitants of Teesta river floodplains, Bangladesh. Journal of Rural Development, 40.

Mondal, S. H., & Islam, S. (2017). Chronological trends in maximum and minimum water flows of the Teesta River, Bangladesh, and its implications. *Jàmbá: Journal of Disaster Risk Studies*, *9*(1), 1-11.

NDRCC. (2017). Daily Disaster Situation: 12 September 2017. Dhaka: The National Disaster Response Coordination Centre (NDRCC), Department of Disaster Management. Retrieved from The National Disaster Response Coordination Centre (NDRCC), Department of Disaster Management. website:https://modmr.gov.bd//sites/default/files/files/modmr.portal.gov.bd/ situationreport/11983c27_1b 40_4344_9ca3_ad037ea64c02/ scan0309.pdf

Paul, B. K. (1995). Farmers' responses to the flood action plan (FAP) of Bangladesh: an empirical study. *World Development*, *23*(2), 299-309.

Paul, B. K. (1999). Women's awareness of and attitudes towards the Flood Action Plan (FAP) of Bangladesh: a comparative study. *Environmental management*, *23*(1), 103.

Pelling, M. (1997). What determines vulnerability to floods; a case study in Georgetown, Guyana. *Environment and Urbanization, 9*(1), 203-226.

Perry, R. W., & Lindell, M. K. (1990). Predicting long-term adjustment to volcano hazard. *International journal of mass emergencies and disasters, 8*(2), 117-136.

Qasim, S., Khan, A. N., Shrestha, R. P., & Qasim, M. (2015). Risk perception of the people in the flood prone Khyber Pukhthunkhwa province of Pakistan. *International journal of disaster risk reduction, 14*, 373-378.

Raaijmakers, R., Krywkow, J., & van der Veen, A. (2008). Flood risk perceptions and spatial multi-criteria analysis: an exploratory research for hazard mitigation. *Natural Hazards, 46*(3), 307-322.

Rahman, R., & Salehin, M. (2013). Flood risks and reduction approaches in Bangladesh. In *Disaster risk reduction approaches in Bangladesh* (pp. 65-90): Springer.

Sarker, M. N. I., Wu, M., Alam, G. M., & Shouse, R. C. (2020). Life in riverine islands in Bangladesh: Local adaptation strategies of climate vulnerable riverine island dwellers for livelihood resilience. *Land Use Policy, 94*, 104574.

Shah, A. A., Ye, J., Shaw, R., Ullah, R., & Ali, M. (2020). Factors affecting flood-induced household vulnerability and health risks in Pakistan: the case of Khyber Pakhtunkhwa (KP) Province. *International journal of disaster risk reduction*, *42*, 101341.

Short, J. F. (1984). The social fabric at risk: Toward the social transformation of risk analysis. *American sociological review*, *49*(6), 711-725.

Sultana, P., & Thompson, P. (2017). Livelihoods in Bangladesh floodplains. In *Oxford research encyclopedia of natural hazard science*.

Ullah, F., Saqib, S. E., Ahmad, M. M., & Fadlallah, M. A. (2020). Flood risk perception and its determinants among rural households in two communities in Khyber Pakhtunkhwa, Pakistan. *Natural Hazards*, *104*(1), 225-247.