Assessing factors affecting drought, earthquake, and flood risk perception: empirical evidence from Bangladesh

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Abstract
Understanding household disaster risk perception is crucial to formulate and apply disaster risk reduction strategies. Using survey data from 300 households from three highly disaster-prone areas of the lower Teesta River basin in Bangladesh, this study explores households’ risk perception of drought, earthquake, and flood at the local level. The ordered probit regression model was applied to identify the factors influencing household disaster risk perception. Most of the respondents perceived the likelihood of occurring drought, earthquake, and flood hazards on a large scale in the selected areas which cause negative impacts on their quality of life and financial losses. They have lack knowledge on mitigation actions which makes them unable to control the devastating impacts of disasters. Econometric results show that households’ age, gender, education, and income-generating sources had significantly influenced the respondent’s drought, earthquake, and flood risk perception. Female participants have less knowledge on mitigations actions and are less capable of controlling the hazards than their counterparts making them more vulnerable to the impacts of hazards. Urgent action is required to improve their socio-economic conditions, and to reduce the knowledge gap between males and females as well as to improve the household’s understanding of mitigation and preparedness for disaster risk.

Keywords Disaster risk reduction · Econometric model · Probit regression · Risk perception · Bangladesh

1 Introduction
Risk perception (RP) is an essential constituent for formulating and implementing disaster risk reduction (DRR) approaches and plans (Peacock et al. 2005; Sattar and Cheung 2019). Under the connotation of community participation in DRR strategies, the household’s RP has gained much attention in recent studies (Birkholz et al. 2014; Rana and Routray 2016;...
Alam et al. 2017; Sattar and Cheung 2019). Bangladesh is an extreme disaster-prone country ranked 5\textsuperscript{th} position in terms of the occurrence of disasters in the world (Dastagir 2015). Floods, droughts, and earthquakes are the most challenging and common disasters in the country (Barua et al. 2016; Rahman 2019; Zhang et al. 2019; Ahmed et al. 2021). Every year millions of people lose their livelihoods, lands, and societal status due to these frequently occurring disasters (Habiba et al. 2012; Alam et al. 2018).

The Lower Teesta Basin (LTB) of northern Bangladesh has been facing the difficulties of floods and droughts on a different scale every year. Although earthquake is not a frequently occurring event in northern Bangladesh, this region is seismically active due to the Dauki fault and Shillong plateau in its north causing infrastructure disruption, environmental disruption, and so on when it occurs (Paul and Bhuiyan 2010; Haque 2015; Islam et al. 2016; 2021a). These disasters cause huge losses of crops resulting in regional and seasonal food insecurity, livelihood loss, migration-related crises, psychological problem, and environmental degradation (Paul 1997, 1998; Azad et al. 2013; Islam et al. 2014; Barua et al. 2016; Rahman 2017; Mardy et al. 2018; Haque et al. 2019; Mamun et al. 2021; Islam and Ghosh 2021a). However, the degree of disaster risk and loss differs from individual to individual based on the perception of the respective disaster (Fernandez et al. 2018; Alam et al. 2017). Consequently, clear perception and understanding of any disaster by the household might contribute to reducing the potential losses through forward planning of how and which initiatives are needed to lessen the disaster impacts. For this reason, a number of researches have been conducted throughout the world by several scholars for assessing disaster risk perception, especially for earthquakes, floods, and droughts events (Liu et al. 2018; Lechowska 2018; Shapira et al. 2018; Wens et al. 2019; Khan et al. 2020; Rana et al. 2020). Reliable local level data are the primary prerequisite of getting clear insights into the contemporary level of the RP of residents in local areas, which is very essential to act accordingly to mitigate the bad effects of extreme events caused by a lack of proper knowledge on hazards preparedness and mitigation in local areas. Therefore, it is crucial to assess RP at a local scale, instead of constructing a generalized idea by considering a large area.

This is also crucial to understand the factors that influence household RP for adopting options by policymakers and planners for sustainable disaster management, especially for sustainable agricultural crop management (Islam et al. 2020). Several studies have found that socio-economic characteristics such as gender, education, age, family size, and monthly income are significantly correlated with various risks perception variables such as controllability, knowledge of mitigation options, and perceived likelihood of disaster. These characteristics influence people to take appropriate measures for reducing disaster losses (Abid et al. 2015; Daramola et al. 2016; Qasim et al. 2016; Mills et al. 2016; Shah et al. 2017; Ahmad and Afzal 2020). There is, however, a lack of studies on households’ RP in many Southeast Asian nations, including Bangladesh. Even after the great flood in northern Bangladesh in August 2017, there is no notable research found on flood RP (Islam and Haque 2018). Previous studies on RP conducted in north-western Bangladesh considering in single risk perspective of drought (Habiba et al. 2012; Salam et al. 2021), earthquake (Islam et al. 2016; Alam 2019), riverbank erosion (Alam et al. 2017), and flood risk (Alam 2007; Rahman 2017). However, the integrated RP studies of drought, earthquake, and flood are still unexplored in Bangladesh. Previous studies have mainly focused on reasons, outcomes, and measures for lessening the risks of these disasters in northern Bangladesh (Habiba et al. 2012, 2014; Azad et al. 2013; Islam et al. 2014, 2017; Barua et al. 2016; Ferdous and Mallick 2019; Rahman 2019; Haque et al. 2019; Kamruzzaman et al. 2021). To the best of the authors’ knowledge, no prior published studies have been explored the local level RP at the household level and the factors influencing their
simultaneous RP of drought, flood, and earthquake in Bangladesh. In northern Bangladesh, disaster risk management strategies had been prepared at different administrative scales (Islam and Haque 2018), without a deeper insight into the level of household RP and what provisions they had implemented to avoid disaster risks (Habiba et al. 2012). For motivating local households to take disaster preparedness actions, it is very essential to recognize which factors stimulate them to take cautionary actions. This study fills the void in the gaps in RP research. Thus, the prime objectives of this study are: (1) to understand the local level of RP of drought, earthquake, and flood among the local households at three disaster-affected areas of the LTB of northern Bangladesh; and (2) to detect the socio-economic and observed factors affecting households’ RP. This paper takes an inclusive approach to assessing the individual, household, and disaster risk perception with esteems to socio-demographic and experiential factors that affect a specific area. The innovation of this paper lies on the integrated disaster risks and affecting factors to have an opportunity to draw a theme of the disaster RP, especially the three most common disasters, e.g., drought, earthquake, and flood in Bangladesh perspective. The findings of this study will help policymakers and practitioners to take precise DRR strategies.

2 Theoretical framework

RP is defined as common views, attitudes, decisions, and emotional states on the possibility and significance of the events, or technologies (Fernandez et al. 2018). In other words, psychological, spiritual, cultural, social, indigenous knowledge of the individual which is collectively regarded as experiences of certain risk factors can clearly define any hazardous satiation and its fate known as RP. In a short term, the progression of collection, selection, and interpretation of the impacts of certain unpredictable events denotes RP (Wachinger 2013; Castro et al. 2017). Most scholars do believe that commons RP can influence their preparedness for, response to, and recovery from natural disasters (Grothmann and Reusswig 2006; Ho et al. 2008; Salam et al. 2021). RP plays a vital role in managing any hazardous and disastrous event. Knowledge of RP may give a significant understanding of common people’s readiness to implement cautionary measures and may assist government and non-governmental organizations (NGOs) DRR strategies (Pidgeon 1998; Rana and Routray 2016). Researcher scholars reached a consensus that RP is measured higher by scholars than the two vital features of risk: possibility and magnitude of effect (Ren 2001).

Nowaday, the impacts of several disasters increased nearly exponentially throughout the world. Nature and extent of disaster impacts vary from place to place, season to season, and community to community. The mitigation actions, as well as adaptive strategies, are also depending on the respective communities’ and places’ socio-economic and geographic characteristics, respectively. The lower Teesta basin (LTB) of northern Bangladesh is susceptible to drought, earthquake, and flood due to its geographic location, physical characteristics, and socio-economic characteristics of the people of that area (Haque 2015; Mardy et al. 2018; Haque et al. 2019; Islam et al. 2021a, b). Prolonged shortage of groundwater along with surface water for a considerable period due to rainfall deficiency, extensive withdrawal of groundwater, and deforestation causing extensive structural, environmental, agricultural, and socio-economic disruption of a certain community regarding as drought (Pal et al. 2021; Islam et al. 2017; Mardey et al. 2018; Ahmed et al. 2019). Earthquake is the most unpredictable and overwhelming geo-tectonic hazard in the earth history defined as the sudden vibrating of the surface of the earth due to the intension of severe energy
discharge mainly caused by movement of plates and seismic activities (Paul and Bhuiyan 2010). On April 28, 2021, a strong earthquake measuring 6.0 magnitude on the Richter scale had been felt in almost all regions of Bangladesh and the epicenter of that ground shaking is situated 43 km west far-flung Assam Tezpur (The Daily Star 2021). Due to its unpredictability, a small-scale earthquake is able to cause severe structural, hydrogeological, and environmental damages which then disrupts the normal economic and social life status of the affected community. A flood is a hydro-meteorological event defined as the outflows of water of the bank of the river which then flows onto dry land and persists for a long time on that land. Several natural, as well as anthropogenic factors, act as triggering elements for occurring floods such as heavy rainfall, deforestation, unplanned structural establishment by grabbing river, and unplanned river dredging (Tingsanchali 2012; Azad et al. 2013). Therefore, the planners and policymakers must know the RP about a certain disaster to formulate appropriate rules, laws, and regulations for sustainable risk management for a certain community.

3 Data and methods

3.1 Study area description

The LTB is the home of around 30 million people. About 71% area of the Teesta Basin has covered the LTB positioned in the northwest part of Bangladesh. The present research has been executed by selecting the three Upazilas (i.e., sub-district) Kaunia, Lalmonirhat Sadar, and Char Rajibpur, respectively, from the districts Rangpur, Lalmonirhat, and Kurigram by taking into consideration the severity of drought, earthquake, and flood (Fig. 1). In Bangladesh, mouza has been recognized as the lowermost administrative unit made of one or more than one village (BBS 2014). For this reason, mouza has been taken into consideration with a view to collecting comparatively precise data. Data were collected from Haibat Khan (Kaunia), Madhuram (Lalmonirhat Sadar), and Swikar Pur (Char Rajibpur) mouza of Te papamadhipur, Rajpur, and Mohanganj unions, respectively.

An overview of the study areas is presented in Table S1 (please see the supplementary file). Table S1 shows the climatic condition of the three Upazilas. These areas are located in the northern part of Bangladesh, adjacent to the largest Teesta and Brahmaputra rivers. Heavy monsoon rain and water from upstream sources have triggered rivers to raise their water levels. The rivers become dry for removing water from their upstream in certain periods of the year, and this region is situated in the seismically active zone. For these reasons, these areas are highly vulnerable to flooding, drought, and earthquake hazards. Although, these three areas are not experiencing earthquakes frequently as flood and drought. However, these areas fall under the seismically most active zones (Kurigram—Zone I; Lalmonirhat and Rangpur—Zone I and Zone II). If any earthquake originates in any area surrounding Bangladesh, the northern part of Bangladesh is normally shaken the most as well as has experienced the most severe damage (Mamun et al. 2021). Besides, it is widely known that the northern part of Bangladesh is facing severe droughts along with floods every year. Although it is a dilemma, these scenarios are worsening these days because of a very unsuccessful international activity, called the “Teesta Treaty” (Arfanuzzaman and Syed 2018). The authority of India has released their excess water to the downstream region of Bangladesh during the monsoon for avoiding flooding in their country but has stored water by disturbing the natural movement of water in the Teesta River during the
dry season to feed their own agriculture (Arfanuzzaman and Syed 2018). All these activities have aggravated the drought and flood risk in the northern part of Bangladesh.

Several natural hazards have severely damaged the population leading to death tolls and property losses. Most of the people in this region depend on agriculture as their main source of income. The local people have comparatively given priority to the indigenous knowledge they hold instead of scientific approaches for building different types of disaster. All these reasons together have driven to choose these specific areas for this study (Fig. 2).
3.2 Ethical consideration

Informed permission was taken before the questionnaire investigation. The field assistants were trained beforehand, and consent was taken from the survey respondents. They were informed that the information will be used for research purposes. The authors took help for correctly reviewing and approving the content of the questionnaire and the procedure of...
the survey from a committee of the Department of Disaster Management of Begum Rokeya University, Rangpur, Bangladesh, that has been working for evaluating the proposal and considering the ethical issues.

### 3.3 Design of the questionnaire, collecting and coding the data

Data have been collected by making some field visits with the intention of collecting the required information needed to complete the proposed study from the selected study areas. The total number of populations of Haibat Khan, Madhuram, and Swikar Pur, respectively, are 2995, 2704, and 1098 (BBS 2014, 2015). The present study has utilized the method proposed by Cochran (1977) for calculating the total sample size for each area. After applying Cochran’s formula, the total number of calculated samples sizes found for this study ($p < 0.05$ and error value at $\pm 10\%$) were 98, 98, and 92, respectively, for Haibat Khan, Madhuram, and Swikar Pur mouza. This study has increased the sample size up to 100 for each mouza of Haibat Khan, Madhuram, and Swikar Pur. Thus, the total sample size taken for this study is 300. Before finalizing the structured questionnaire, in early August 2019, a pre-testing questionnaire survey was conducted for assessing the rationality along with the topicality of the questions. By considering all the feedbacks collected from the participants of the pre-testing survey, the questionnaire was finalized (see the supplementary file). There are two parts to the questionnaire: (1) demographic information, and (2) risk perception items. The questionnaire consisted of 16 questions, where 9 questions were for the basic demographic profile and disaster experience of the respondent and the remaining 7 questions were under risk perception items using a Likert scale 1–5.

The household head (both male and female) was selected as the respondent for the interview. A random selection method was applied for selecting the respondents. Before commencing the interview, the purpose of the survey was informed to the participants. If any participant hesitated to talk, then the surveyors have stepped forward to another one. From the time between August and September 2019, in-person interviews were conducted.

In case of the absence of the household head, an adult member of that household was interviewed. When both household head and adult members were absent, data collectors were moved to the next-door household. The collected data were then coded and analyzed utilizing the software Statistical Package for the Social Sciences (SPSS v23).

### 3.4 Econometric analysis

Previous studies on factors influencing households’ disaster RP employed the probit model, binary logit model, multinomial logit model, and ordered probit model (Gbetibouo 2009; Mabe and Donkoh 2014; Fadina and Barjolle 2018; Fernandez et al. 2018; Ullah et al. 2018). Some scholars have argued for using the ordered probit model due to its robustness, simple statistical calculation, and reliable outcomes (Alauddin and Tisdell 2006; McKelvey and Zavoina 2007; Ho et al. 2008; Farnandez et al. 2018). The ordered probit model has benefitted from the ordered format of the Likert scale questionnaire. Because of the ordered format, the ordered probit model has best fitted the ordered data by avoiding any assumption between interval data. For this reason, the ordered probit model is best and most appropriate for the data that are maintained in order (Islam et al. 2021b). For this reason, this study also used an ordered probit model to explore the factors affecting drought, earthquake, and flood risk perceptions of the households in the study areas. The model can be stated as follows Duncan et al. (1998):
where in this study, $y^*$ denotes dependent variable (i.e., perceived likelihood—PL, dread or fear—DR/FR, threat to life—TL, anticipation of financial loss—AFL, effect on the quality of life—EQL, knowledge of mitigation actions—KMA and controllability—CR); $\beta'$ denotes the vector of estimated parameters, and $x$ is the vector of explanatory variables (i.e., age, gender, education, monthly income, family size, income-generating source, housing type, and experience of disasters); $\epsilon$ denotes error term. This model explored the factors affecting drought, earthquake, and flood RP in the study areas. In recent decades, the ordered probit model has been extensively used by several scholars from different parts of the world for exploring the factors influencing the RP of fire, cyclone, and earthquake hazards (Alauddin and Tisdell 2006; McKelvey and Zavoina 2007; Ho et al. 2008; Farnandez et al. 2018).

The present study has considered these 7 variables because these variables cover all the spectrum associated with any hazard or disaster. For covering all the sectors, these are adopted for modeling to give an explicit idea to the reader. Because all these variables are also directly or indirectly connected together. So, if any variable is overlooked, it may not give a clear insight. Besides, having an obvious idea about all the spectrums can assist the reader to get the right picture of the affected people as well as can assist the policymakers to further thinking for making any policy for that community. All these reasons have made the authors to take the 7 dependent variables for modeling. The descriptions of the explanatory variables are presented in Table S2. Table S3 shows the description of the dependent variables used in the model.

4 Results

4.1 Demographic information

Table S2 of the supplementary document shows the mean, standard deviation, and description of the explanatory variables. The mean age of the respondents is 39.96 (SD 13.60). The majority has no education (45%) and lived in a Teen-made house with a mean family size is 5.37 (SD 2.17). Most (58%) of them had a monthly household income of BDT 5100–10,000 from agriculture or farming (47%), as it is their main income-generating source. The majority of the respondents (91%) had experienced drought disasters followed by floods (90%) and earthquakes (78%) disasters (Table S2).

4.2 Perception of drought, earthquake, and flood

The respondent’s perception of drought, earthquake, and flood is graphically represented by Fig. 3 and is numerically presented by Table S4. Surprisingly, most of the respondents believe drought, earthquake, and flood will likely happen in the upcoming years (Fig. 3a). About 42.9% of the respondents perceived flood, 52.1% drought, and 33.3% earthquakes will occur largely in the upcoming years in the study areas (Table S4). Very few respondents perceived that drought (5.0%), earthquake (33%), and flood (1.7%) will occur on small scale and a group of people was neutral to speak out about the future likelihood of drought (3.3%), earthquake (6.9%) and flood (9.6%) (Fig. 3a).
Fig. 3 Respondent’s degree of perception about drought, earthquake, and flood
Figure 3b illustrates the perception among the respondents about the threat created by drought, flood, and earthquake in the study areas. Very few respondents were neutral on the topic. Few respondents perceived these disasters as a less threat to their life. Approximately, 58.4% of the respondents perceived flood, and 47.2% of respondents perceived drought as a very serious threat to their life (Table S4). Almost 46.5% of the respondents perceived that earthquake poses a little serious threat to their everyday life (Table S4).

Figure 3c describes the perception of the respondents about the impacts of the selected disasters on their quality of life. Nearly three fourth number of the respondents perceived that these disasters have both serious and very serious effects on their quality of life. About 38.2% of respondents thought that the earthquake had little impact on their quality of life (Table S4). Almost 46.5% of the respondents perceived that earthquake poses a little serious threat to their everyday life (Table S4).

A small number of respondents anticipated a little serious financial loss due to the disasters. About two-thirds of the respondents anticipated serious and very serious financial loss due to the disasters (Fig. 3d). About 52.8% of the respondents said flood and 41.8% said drought was liable to very serious financial loss and earthquake (37.2%) posed a little serious financial problem in the study areas (Table S4).

It is evident that most of the participants are afraid and very afraid of disasters (Fig. 3e). About 52.6% of people are very afraid of floods and 53.1% of drought and approximately 54.4% of people are afraid of earthquake (Table S4). A few respondents who can face disaster or have some resources are not afraid of any disaster at all. Very few respondents were neutral about their fear of disasters (Fig. 3e).

Figure 3f shows that about one-third of the participants have unclear mitigation knowledge of the disasters. Very few respondents pose very clear mitigation actions against the selected disasters. Surprisingly, many respondents (66%) pose unclear mitigation measures related to the earthquake. Nearly, 35.3% and 44.2% of the respondents have unclear knowledge of mitigation strategies against flood and drought disasters, respectively (Table S4).

Many of the respondents assume that they have little control over the negative impacts of droughts, earthquakes, and floods (Fig. 3g). One-third of the respondents believe that they cannot control the disastrous impacts of drought, flood, and earthquake at all. The rest of the respondents were neutral for giving any perception and nearly 31.0% of the respondents were neutral about the controllability of the impacts of the earthquake (Table S4).

### 4.3 Factors affecting drought risk perception

The values of the coefficient estimated by ordered probit models for drought hazards are shown in Table 1. The model offers a good fit where all the explanatory variables show the expected sign. The result indicates that respondents’ age is significantly correlated with their anticipation of financial loss (0.03, $p < 0.01$), dread/fear (0.020, $p < 0.05$), knowledge of mitigation actions (0.016, $p < 0.05$), and controllability (0.015, $p < 0.1$). Gender and education of the respondents’ have found a significant positive relationship with the perceived likelihood (2.326 and 0.717, $p < 0.1$), threat to life (1.648 and 0.539, $p < 0.01$), and negative relationship with the knowledge of mitigation actions (−2.191 and −0.413, $p < 0.1$) and controllability (−1.273 and −0.572, $p < 0.1$), respectively. Effects on quality of life (−0.194, $p < 0.01$), fear (−0.065, $p < 0.05$) and controllability (0.069, $p < 0.1$) significantly influenced by the respondents’ family size. Perceptions of the effects on quality of life (0.119, $p < 0.05$), knowledge of mitigation actions (−0.219, $p < 0.01$), and controllability (0.218, $p < 0.01$) significantly influenced
Table 1  Factors influencing drought risk perception of the respondents

| Explanatory variables | PL   | TL   | EQL  | AFL  | DR/FR | KMA  | CR   |
|-----------------------|------|------|------|------|-------|------|------|
| Age                   | 0.010 (0.010) | 0.009 (0.009) | 0.005 (0.009) | 0.030*** (0.009) | 0.020** (0.008) | 0.016** (0.008) | 0.015* (0.008) |
| Gender                | 2.326*** (0.280) | 1.648*** (0.225) | 1.454*** (0.209) | 2.501*** (0.250) | 1.485*** (0.198) | −2.191*** (0.220) | −1.273*** (0.180) |
| Education             | 0.717*** (0.116) | 0.539*** (0.094) | 0.671*** (0.093) | 0.187** (0.086) | 0.166** (0.079) | −0.413*** (0.081) | −0.572*** (0.084) |
| Family size           | −0.037 (0.046) | −0.064 (0.040) | −0.194*** (0.040) | 0.003 (0.042) | −0.065** (0.036) | 0.000 (0.038) | 0.069* (0.037) |
| Monthly income        | −0.02 (0.061) | −0.031 (0.052) | 0.119** (0.052) | 0.079 (0.052) | 0.013 (0.048) | −0.219*** (0.051) | −0.218*** (0.050) |
| Income source         | 0.146*** (0.049) | 0.108** (0.042) | 0.136*** (0.041) | 0.249*** (0.042) | 0.048 (0.037) | −0.071** (0.038) | −0.027 (0.038) |
| Housing type          | −0.464*** (0.105) | −0.195** (0.091) | −0.497*** (0.092) | −0.420*** (0.092) | −0.142* (0.083) | −0.269*** (0.089) | 0.147* (0.086) |
| Exp. of Drought       | −0.232 (0.301) | −0.295 (0.266) | −0.185 (0.259) | −0.026 (0.272) | −0.281 (0.242) | 0.041 (0.240) | 0.153 (0.241) |
| Number of samples     | 300  | 300  | 300  | 300  | 300   | 300  | 300  |

N=300. Standard errors are in parentheses
***, **, and * indicate variable significant at 1%, 5% and 10%, respectively
by the respondent’s monthly income. People’s income-generating sources (except fear and controllability) and housing type significantly correlated with the perception of the respondents related to drought events. Surprisingly, experiences of past drought hazards did not significantly influence the respondent’s perception of that hazard (Table 1).

4.4 Factors influencing earthquake risk perception

The results of the ordered probit model for the determinants of earthquake hazards are shown in Table 2.

All the explanatory variables except education and experience of earthquake significantly influenced the perceived likelihood of the respondents. Gender significantly and positively influenced the respondents’ perception of perceived likelihood (0.823, \( p < 0.01 \)), threat to life (0.489, \( p < 0.01 \)), effects on quality of life (0.953, \( p < 0.01 \)), dread (0.807, \( p < 0.01 \)) and significant negative relationship with the knowledge of mitigation actions (−0.932, \( p < 0.01 \)) and controllability (−0.634, \( p < 0.01 \)). The anticipation of financial loss was significantly related to the respondent’s age (0.02, \( p < 0.01 \)) and income-generating sources (0.073, \( p < 0.05 \)). Age and education are highly correlated with the controllability of earthquakes. Knowledge of mitigation actions is significantly influenced by respondents’ monthly income and housing type. Education and income-generating source were significantly responsible for creating fear in the mind of the respondents. Perception of the threat to life created by earthquake significantly influenced by the respondent’s age (−0.015, \( p < 0.05 \)), and housing type (0.175, \( p < 0.05 \)). Experiences of past earthquake events did not significantly influence the respondents on their perception of that hazard.

4.5 Factors influencing flood risk perception

The values of the coefficient estimated by the ordered probit model for flood hazards are shown in Table 3. Gender and income-generating sources show significant positive correlation with perceived likelihood (0.415, \( p < 0.1 \) and 0.170, \( p < 0.01 \)), threat to life (0.980, \( p < 0.01 \), and 0.205, \( p < 0.01 \)), effects on quality of life (0.197, \( p < 0.01 \) and 0.085, \( p < 0.05 \)), anticipation on financial loss (0.803, \( p < 0.01 \) and 0.202, \( p < 0.01 \)), dread (0.459, \( p < 0.01 \) and 0.198, \( p < 0.01 \)), and significant negative correlation with knowledge of mitigation actions (−1.255, \( p < 0.01 \) and −0.109, \( p < 0.01 \)) and controllability (−0.756, \( p < 0.01 \) and −0.081, \( p < 0.05 \)), respectively. Following the drought and earthquake risk perception, experiences of past flood events did not significantly influence the respondents on their perception of that hazard. Age has a significant negative relationship with perceived likelihood, threat to life, effects on quality of life, and anticipation of financial loss. Education is a significant positive factor to influence perceived likelihood, threat to life, effects on quality of life and anticipation on financial loss, and significant negative relationship with controllability. Respondent’s family size significantly influences perceived likelihood, threat to life, knowledge of mitigation action, and controllability. Housing type significantly affects the quality of life (−0.163, \( p < 0.1 \)), knowledge of mitigation actions (−0.177, \( p < 0.05 \)), and controllability (0.321, \( p < 0.01 \)) of the respondents. The monthly income of the respondents did not show any significant correlation with perceived likelihood, the threat to life, and effects on quality of life (Table 3).
Table 2 Factors influencing earthquake risk perception of the respondents

| Explanatory variables | PL        | TL        | EQL       | AFL        | DR/FR      | KMA        | CR        |
|-----------------------|-----------|-----------|-----------|------------|------------|------------|-----------|
| Age                   | −0.013* (0.007) | −0.015** (0.007) | −0.005 (0.007) | 0.02*** (0.007) | 0.010 (0.007) | 0.004 (0.008) | 0.021*** (0.007) |
| Gender                | 0.823*** (0.163) | 0.489*** (0.162) | 0.953*** (0.163) | 0.613 (0.162) | 0.807*** (0.170) | −0.932*** (0.182) | −0.634*** (0.164) |
| Education             | 0.115 (0.072) | 0.069 (0.073) | 0.056 (0.072) | 0.047 (0.072) | −0.253*** (0.076) | −0.026 (0.076) | 0.129* (0.074) |
| Family size           | −0.076** (0.034) | −0.007 (0.034) | −0.026 (0.033) | −0.029 (0.033) | 0.014 (0.035) | 0.048 (0.035) | 0.043 (0.034) |
| Monthly income        | −0.011 (0.045) | −0.040 (0.046) | −0.008 (0.045) | −0.007 (0.045) | 0.019 (0.047) | −0.134*** (0.049) | −0.003 (0.046) |
| Income source         | 0.104*** (0.036) | 0.018 (0.036) | 0.011 (0.036) | 0.073** (0.036) | 0.108*** (0.037) | −0.031 (0.039) | 0.053 (0.036) |
| Housing type          | −0.270*** (0.080) | 0.175** (0.082) | −0.008 (0.080) | −0.050 (0.079) | −0.079 (0.083) | −0.319*** (0.086) | −0.004 (0.082) |
| Exp. of earthquake    | −0.183 (0.151) | 0.082 (0.153) | −0.051 (0.151) | −0.196 (0.150) | −0.137 (0.155) | −0.075 (0.163) | 0.068 (0.154) |
| Number of samples     | 300        | 300        | 300        | 300        | 300        | 300        | 300        |

N=300. Standard errors are in parentheses
***, **, and * indicate variable significant at 1%, 5% and 10%, respectively
| Explanatory variables | PL       | TL       | EQL      | AFL      | DR/FR    | KMA      | CR       |
|-----------------------|----------|----------|----------|----------|----------|----------|----------|
| Age                   | −0.041*** (0.009) | −0.030*** (0.010) | −0.018**  (0.009) | −0.055*** (0.010) | 0.024*** (0.008) | −0.002 (0.008) | −0.002 (0.00) |
| Gender                | 0.415* (0.196)    | 0.980*** (0.238) | 0.197*** (0.209) | 0.803*** (0.231) | 0.459*** (0.170) | −1.255*** (0.172) | −0.756*** (0.211) |
| Education             | 0.730*** (0.094)  | 0.496*** (0.100) | 0.560*** (0.094) | 0.717*** (0.109) | −0.103 (0.076)  | −0.093 (0.075) | −0.200*** (0.087) |
| Family size           | −0.111*** (0.039) | 0.111*** (0.042) | −0.053 (0.039)  | 0.028 (0.041)   | 0.047 (0.036)  | −0.062* (0.034) | −0.091** (0.042) |
| Monthly income        | 0.025 (0.051)     | −0.013 (0.055)  | −0.139** (0.055) | 0.072 (0.056)   | 0.086* (0.049) | −0.126*** (0.047) | −0.102* (0.053) |
| Income source         | 0.170*** (0.040)  | 0.205*** (0.044) | 0.085** (0.042) | 0.202*** (0.045) | 0.198*** (0.039) | −0.109*** (0.038) | −0.081** (0.040) |
| Housing type          | 0.017 (0.092)     | −0.046 (0.101)  | −0.163* (0.095) | −0.162 (0.099)  | 0.084 (0.085) | −0.177** (0.085) | 0.321*** (0.094) |
| Exp. of flood         | −0.261 (0.260)    | −0.139 (0.264) | −0.275 (0.261) | 0.068 (0.295)   | 0.015 (0.231)  | 0.198 (0.225)   | 0.097 (0.253)  |
| Number of samples     | 300                | 300                | 300                | 300                | 300                | 300                | 300                |

\(N=300\). Standard errors are in parentheses.

***, **, and * indicate variable significant at 1%, 5% and 10%, respectively.
4.6 Gender-based drought, earthquake, and flood risk perception

RP varies from person to person, region to region, gender to gender. The present study also reveals the same thing (Figs. 4, 5, and 6). In terms of the likelihood of the occurrence

Fig. 4 Perception of drought based on gender
of future hazards, very few respondents believed that there will be a very small and small chance. Several participants kept their opinions private because of unknown reasons. However, the majority of the respondents thought that hazards will be occurred on a large or very large scale, except for earthquakes. As earthquakes rarely occur, so people perceived

Fig. 5 Perception of earthquake based on gender
little knowledge of it. Whereas a number of female participants reported that earthquakes will occur on a large scale at their locality. Females perceived higher threat (except earthquake), fear, and impacts (except for flood) on average. Approximately, a similar degree of expected loss is perceived by both males and females for flood and earthquake. On the
contrary, males perceived a higher degree of anticipated loss in terms of drought. Very clear knowledge of mitigation actions was lacking among the respondents and a handsome number of participants perceived very unclear knowledge. Overall, in respect of the knowledge of mitigation action, a similar number of both males and females perceived similar knowledge. Although female participants perceived a bit more very unclear knowledge of mitigation actions than their counterparts. Like the knowledge of mitigation action, a similar number of both males and females perceived similar knowledge on controllability except drought. However, the majority of the female believed that they will not able to control the disasters at all. It can be stated that the female respondents perceived more risks, lack enough knowledge, and will be less capable of controlling the upcoming hazards than males.

5 Discussion

Maximum respondents perceived the likelihood of occurring future hazards in the study areas. Two-third of the respondents perceived those floods, droughts, and earthquakes create a threat to life putting negative impacts on the quality of life and financial losses. It is normal to face different types of hurdles due to the occurrence of these disasters, making the affected community vulnerable to further onset. During the hazardous or disastrous event, most of the respondents felt fear of occurring in any unpleasant situation. Very few respondents know mitigation actions for respective disasters and can manage disastrous or hazardous situations. The proper knowledge of mitigation measures is very essential to face the adverse effects of any extreme event and without having correct knowledge of it, and the losses would be more than expectation. Plapp and Werner (2006) reported that respondents perceived that windstorm, floods, and earthquakes will occur frequently in Germany. Alam (2007) and Alam (2019) stated that respondents perceive the most frequent disaster like floods and earthquakes in Bangladesh and their perceptions conform to reality. Peacock et al (2005) explored that experience of the hazardous event help households to take mitigation options which in turn play a vital role in lowering the negative threat to their quality of life. Udmale et al. (2014) observed a good perception of the severity of drought impacts by farmers in Maharashtra state, India. Furthermore, Islam et al. (2012) demonstrated that risk perceptions differ as per the nature of fluvial hazards and the socio-economic fabric of a community. The farmers having agricultural land were found to reveal a higher risk perception regarding the riverbank erosion hazards; however, landless labor perceived higher risk of flood along the banks of the River Bhagirathi in West Bengal, India (Islam et al. 2012). Recently, Ahmed et al. (2021) and Mamun et al. (2021) reported the climate risk perception in the northern region of Bangladesh and found that respondents perceived well the flood and drought in the study area, which is analogous to our study.

The study reveals that household income-generating source, gender, age, and education are significantly correlated with most of the dependent variables of drought, flood, and earthquake. Fernandez et al. (2018) found that age, gender, education, family size, housing type, and monthly household income were the influencing factors for fire, cyclone, and earthquake hazards in Myanmar. Islam and Ghosh (2021b) also found that a higher per capita income received through the international labor migration acted as a catalyst to reduce the risk perception of flood hazards in the lower Mayurakshi River, India. Therefore, reliable and permanent income-generating sources make a positive sense to the
respondents to take all the possible initiatives to manage the upcoming disasters properly which could lower the risk of creating any threats or impacts on their life. On the contrary, unstable income sources that may lose any time act as the obstacle to think properly by the respondents to take measures for lessening the impacts of upcoming disasters due to their monetary constraint.

Disasters RP differs significantly from individual to individual, from community to community, and this RP is significantly associated with several explanatory variables as sex, income, occupation, education, and geographical location that is frequently reported in many studies (For example, Kellens et al. 2011; Wachinger et al. 2013; Mills et al. 2016; Rana and Routray 2016; Sattar and Cheung 2019) which is consistent with the findings of this study. RP also varies across gender. Females are perceived high risk than males. Females lack the necessary resources like economic freedom, land ownership, etc., which make them more vulnerable in case of any onset. Besides, females have to undertake several family roles as rearing children, taking care of the aged persons of the family, etc., which also acts as the hindrance to act timely for making them resilient. Moreover, the ability to make decisions by females is restricted in some families that are further aggravated their vulnerability. Aged and adult people can take proper decisions for managing any hazardous situation than the lower aged people due to their past experiences. Ahmad and Afzal (2020) explored quite similar results that gender, age, family size, monthly income, education, and location significantly influenced people to take flood mitigation actions at the household level in Pakistan.

Education plays a vital role in managing any disaster. Educated people know the procedures on how to manage any upcoming disastrous event and the positive effects of taking proper initiatives regarding lowering the impacts of disasters. Islam et al. (2021b) showed the farmers perception of typology in Teesta River Basin in northern Bangladesh and found that high educated farmers have high resilience to cope with natural disaster like drought, flood and earthquake. Not only this but also educated people know well about the bad adverse effects of hazards and disasters and they act accordingly so that they can avoid the maximum level of the danger produced from any onset. Wang et al. (2018) found that education influenced the RP of floods in China and Pakistan (Abid et al. 2015). Lower monthly income and large family size negatively affect the people for adopting any measures for reducing the upcoming disaster losses. People who have a lower monthly income and a large family are normally more vulnerable as they have to spend all their earnings for meeting the basic needs of the family members. So, they barely have anything left after spending for their family to adopt any measure for increasing disaster resilience. For this reason, they are normally less capable to fight against the adverse effects of hazards and disasters. Daramola et al. (2016) explored that lack of money savings, agricultural livelihood, and lack of multiple income sources lead people to experience negative and severe impacts due to natural disasters in Nigeria. Housing type significantly motivated the respondents about their perceptions of taking initiatives for managing drought hazards and created less threat to life, fear, and impacts on the quality of life. Normally, houses that are made of brick and cement are more stable than mud, straw, etc., made houses, during the time of extreme events. Because these materials give strength to the structures and are less susceptible to collapse during any onset making the owner of houses less vulnerable. Interestingly, past experiences of facing drought, earthquake, and flood hazards did not show any significant correlation with the dependent variables which regulate the severity of disaster risk. The present study found that the female respondents perceived more risks, lack enough knowledge, and will be less capable of controlling the upcoming disasters than the male which is supported by the findings of Salam et al. (2021). Adequate measures need to be taken to
reduce the gap of risk perception between males and females. Otherwise, anticipated progress in increasing resiliency would be a nightmare.

This research can be regarded as important because it is the first work exploring household RP of drought, earthquake, and flood in the LTB. The outcomes of this work would have put a significant effect on reducing disaster risk. Some respondents believe that in the time ahead they will be faced with drought, earthquake, and flood that may put severe damage to their daily life. For instance, this perception of the respondents may encourage the public support system of the government intending that works for lessening disasters risks, to take real-time measures for supporting the respondents. The present work did not perform any investigation toward exploring the level of vulnerability and risk of the selected areas for the selected disasters, and future studies should investigate those to make a detailed idea of how to make the people of the areas resilient against these disasters.

6 Conclusion

This study aims to explore the factors affecting household risk perception (RP) of drought, earthquake, and flood employing the ordered probit model based on a Likert scale of 0.5 in the LTB of northern Bangladesh. It is revealed that the majority of the respondents perceived the upcoming disasters at a very large (39.6%, 21.5%, and 45.8% perceived drought, earthquake, and flood, respectively) or large scale (52.1%, 33.3%, and 42.9% perceived drought, earthquake, and flood, respectively) which can create an economic loss, act as a threat to a normal lifestyle and degrade the quality of life. Their life-long experiences make them hold such a level of perception. During the hazardous or disastrous event, most of the respondents felt fear for any unpleasant situation. Very few respondents know mitigation actions for respective disasters and can manage disastrous or hazardous situations. Respondents’ age, gender, education, income-generating sources significantly influence the RP of the hazards. Stable income-generating sources, male and educated people perceived more knowledge on RP which helps them to take a proper decision at the right moment to reduce the impacts of drought, flood, and earthquake. It can be stated that the male respondents perceived fewer risks, but have enough knowledge, and will be more capable of controlling the upcoming disasters. Future research should explore how risk communication strategies and the promotion of protective behavior can be improved based on the risk perception theory. The findings of this study will help the policymakers and planners to take proper initiatives to raise awareness, create stable livelihood options and motivate people to take appropriate mitigation strategies for reducing the disaster impacts for ensuring sustainable disaster-resilient community.

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Data availability Data are available upon request to the corresponding author.

Declarations

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