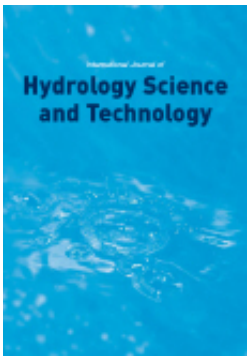


**International Journal of Hydrology Science and Technology**

ISSN online: 2042-7816 - ISSN print: 2042-7808
https://www.inderscience.com/ijhst

# People's perception on climate change effects and adaptation in the Haor Basin of Bangladesh

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**DOI:** 10.1504/IJHST.2021.10041194

**Article History:**

| | |
|---|---|
| Received: | 04 February 2021 |
| Accepted: | 05 April 2021 |
| Published online: | 21 December 2022 |

# People's perception on climate change effects and adaptation in the Haor Basin of Bangladesh

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**Abstract:** The purpose of this study is to understand the people's perception on climate change occurring in the Haor Basin of Sunamganj, Bangladesh. The results from focus group discussion (FGD) show that the change in the rainfall affects economic, residential, health, in a word every aspect of life of local people. Historic analysis of data reveals that flash flood is common in the Haor areas. Flash floods seriously damage the crops as they occur in March–April when the winter rice is semi-ripe, just 15–20 days earlier than the harvest time. However, trend analysis of rainfall data reveals a decreasing trend in most of the months. Further investigation of daily rainfall data shows that heavy rainfall in consecutive three to five days along with upstream discharge causes the flash flood. This heavy rainfall does not have a serious effect on total rainfall but brings misfortune to farmers.

**Keywords:** climate change; Haor Basin; Bangladesh; flash flood; rainfall; Mann-Kendall test; focus group discussion; FGD.

**Reference** to this paper should be made as follows: Bari, S.H. and Husna, N-E-A. (2023) 'People's perception on climate change effects and adaptation in the Haor Basin of Bangladesh', *Int. J. Hydrology Science and Technology*, Vol. 15, No. 1, pp.40–53.

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## 1 Introduction

Haors are large and circular-shaped floodplain subsidence. They are important for humans, biodiversity, aquatic resources, and crop production (Islam et al., 2018), etc. The formation and hydrology of the Haor create a unique hydrological area with uncountable opportunities (Choudhury, 2015; Jakariya and Islam, 2017) including agricultural production. Traditionally, people living in the Haor regions are mostly farmers. Their main farming is Boro rice cultivation in the winter (Kazal et al., 2010; Rahman et al., 2020). However, agriculture and livelihood in the Haor region strongly depend on rainfall amount and pattern. Although temperature change may affect the complex biodiversity of the area, a shift in rainfall brings immediate catastrophe to the people living in these low lands. Unfortunately, recent phenomenon of climate change is triggering the change in rainfall patterns in the Haor basin areas (Bari et al., 2016).

Climate change related hazards and hydrometeorological extremes make human communities living remote and geomorphically fragile flood plain areas of Bangladesh particularly vulnerable (Monwar et al., 2018). It is reported that due to the implication of the changing climate about 18% of current lowly flooded areas will be susceptible to higher levels of flooding, while 12%–16% new areas will be at risk of inundation in the country (Mustafa et al., 2019). As Haor areas are low lands, increasing inundation will certainly cause greater impacts in this region. In line with inundation, the intensity of daily rainfall (1 day to 5 day maximum) is projected increasing resulting in a subsequent flash flood (Nowreen et al., 2015). These flash floods damage crops (mainly rice) almost every year in the northeast Haor region (Kamruzzaman and Shaw, 2018; Roy et al., 2019). This crop loss threatens the food security of the local inhabitants as well as the country (Roy et al., 2019). Therefore, to ensure self-sufficiency and food security, the Haor basin deserves special attention (Kamruzzaman and Shaw, 2018).

So far, study on climate change impacts and their adaptation strategies in some Haor areas of Bangladesh has been done by a few researchers. Monwar et al. (2018) deployed the focus group discussion (FGD) survey to find the adaptation practices to reduce the climate change impact at the Hail Haor of Moulvibazar, Bangladesh. Ferdushi et al. (2019) studied people's perception on climate change immediately after a flash flood. They mainly concentrated their study on the agricultural aspects in a particular Haor. In addition to crop damage, floods may bring catastrophic results in other aspects of living viz. health, communication, bio-diversity, etc. which need to be addressed. A study in Moulvibazar by Monwar (2013) demonstrates that climate change affects almost every aspect of livelihood. Climate change in Dekhar Haor resulted in a shift to the breeding season, reduced fish biodiversity, wide variations in fish growth and taste (Roy et al., 2019). However, a comprehensive study including people's perception is lacking for the Sunamganj Haor basin. Though, Haor households in Sunamganj district are more vulnerable to floods and natural disasters in terms of food, water, and health (Hoq et al., 2021).

It is evident that a comprehensive study will accelerate the possibility of climate change adaptation in this low-lying area of the country. Considering these, a study on climate change, its effect, and possible adaptation strategies have been done incorporating people's perceptions. It is seen that local experiences in climate change adaptation have advantages (Anik and Khan, 2012). Adding people's perceptions in addition to data analysis is expected to play a vital role in climate change adaptation policymaking.

## 2 Study area

The current study area is the Haor region of Sunamganj (Figure 1) in the northeastern part of the country. There are four rainfall stations viz. Laurergarh, Moheshkhola, Chhatak, and Sunamganj in the study area. Laurergarh and Moheshkhola are located in Tahirpur Upazila. Chhatak station is situated in Chhatak, and Sunamganj station is in Sunamganj Sadar. There are eight Haors in Tahirpur Upazila. Some renowned Haors in this area are Shonir Haor, Tanguar Haor, Matian Haor, etc. Therefore, this area was particularly selected for FGD.

**Figure 1** Haors of Sunamganj District (see online version for colours)


*Source:* Chakraborty (2009)

The Sunamganj Haor basin is surrounded by the hilly region of Meghalaya in the north, which is situated in India. Therefore, extreme rainfalls in the vicinity and upstream area can affect the Haor basin with sudden flash floods and it can play a terrific role in the life of the inhabitants. Excess rainfall in the upstream hilly areas and subsequent runoff, river sedimentation, unplanned road, and water management infrastructure, deforestation and

hill cuts, landslip, phony drainage, and the impacts of climate variability can be observed as the principal reasons for the devastation caused by flash floods (Chakraborty, 2009; Suman and Bhattacharya, 2015). In the extreme rainfall events, the aquatic and biotic communities of the Haor areas get little time to adjust; and the aquatic ecosystem gets disturbed causing a drastic reduction in aquatic resources.

## 3 Materials and methods

This study comprises of two sections viz. trend analysis of monthly rainfall data and focus group survey to understand the effects and adaption strategies of climate change. While the first will identify possible changes in rainfall, the latter will be used to find the people's perception on climate change effects and adaptive measures.

Thirty years long (1987–2016) rainfall data for the four rainfall stations in the study area are collected from the Water Resources Planning Organization (WARPO) of Bangladesh. WARPO collects meteorological data from several organizations, store, and distribute them. The flash flood information is collected from the local Water Development Board Office and also from published literature.

After quality checking of rainfall data, the Mann-Kendall test (Kendall, 1948; Mann, 1945) is used to find the trend in monthly rainfall. The test statistic S is given by the following equation:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign\left(x_j - x_k\right)$$

where

$$Sign\left(x_j - x_k\right) = \begin{cases} +1 \; if \; \left(x_j - x_k\right) > 0 \\ -1 \; if \; \left(x_j - x_k\right) < 0 \\ 0 \; if \; \left(x_j - x_k\right) = 0 \end{cases}$$

and $x_k$ and $x_j$ are the sequential data values; $n$ is the length of the data set. A positive (negative) value of $S$ indicates a positive (negative) trend. In the presence of serial correlation in the rainfall time series, the Modified Mann-Kendall test (Hamed and Ramachandra Rao, 1998) is used to detect the rainfall trend.

The magnitude of the trend in monthly rainfall is estimated using the Sen's Slope method. Sen's (1968) estimator of the slope is given by

$$\beta = Median\left(\frac{x_i - x_j}{i - j}\right), \; for \; all \; j < 1$$

In addition to trend and its magnitude, Kendall' tau is used to identify the relation of monotonic trend with time. Kendall's Tau (Kendall, 1948) correlation coefficient, an indicator of the strength of monotonic trend is given by

$$\tau = \frac{S}{n(n-1)/2}$$

People's perceptions on climate change and its effect are assessed by a focused group survey. A questioner survey is done to collect primary data regarding major problems in the Haor area, climate change effects, and possible mitigation.

## 4 Results and discussion

### *4.1 Trends in rainfall*

Rainfall trend analysis is done on a monthly scale. Monthly trend analysis has several benefits including a better understanding of rainfall regime change, seasonal change, and their impact on agricultural production and fish breeding. The result shows that monthly rainfall has a negative trend for almost all months and stations with a few exceptions. However, the majority of the positive or negative trends are non-significant at a 95% confidence limit. Kendall's tau also represents a weak strength of trend over time. Despite weak strength, these results may have very significant impacts on the complex biodiversity, water, and agricultural production of the Haor basin. It is anticipated that the changing phenomena may be the outcome of global climate change response. Results of monthly rainfall trends are given in Table 1. In the table, positive results are marked in italics.

**Table 1** Monthly rainfall trend analysis results using the Mann Kendall trend test

| *Month* | *Station* | *S* | *Kendall's tau* | *P-value (two-tailed)* | *Alpha* | *Sen's slope* |
|---|---|---|---|---|---|---|
| January | Laurergarh | –14.00 | –0.158 | 0.468 | 0.05 | 0 |
| | Moheshkhola | –17.00 | –0.643 | 0.042 | 0.05 | –1.465 |
| | Chhatak | –10.00 | –0.225 | 0.419 | 0.05 | –0.429 |
| | Sunamganj | *6.00* | 0.078 | 0.759 | 0.05 | 0.116 |
| February | Laurergarh | –19.00 | –0.158 | 0.431 | 0.05 | 0 |
| | Moheshkhola | *3.00* | 0.087 | 0.831 | 0.05 | *0.358* |
| | Chhatak | –91.00 | –0.283 | 0.047 | 0.05 | –1.261 |
| | Sunamganj | –58.00 | –0.212 | 0.157 | 0.05 | –1.005 |
| March | Laurergarh | *3.00* | 0.020 | 0.939 | 0.05 | 0 |
| | Moheshkhola | –26.00 | –0.217 | 0.260 | 0.05 | –5.002 |
| | Chhatak | –81.00 | –0.200 | 0.133 | 0.05 | –2.938 |
| | Sunamganj | –46.00 | –0.113 | 0.399 | 0.05 | –1.337 |
| April | Laurergarh | –28.00 | –.206 | 0.266 | 0.05 | –17.471 |
| | Moheshkhola | –36.00 | –0.265 | 0.149 | 0.05 | –8.623 |
| | Chhatak | –23.00 | –0.057 | 0.680 | 0.05 | –1.76 |
| | Sunamganj | –36.00 | –0.089 | 0.511 | 0.05 | –3.5 |
| May | Laurergarh | –4.00 | –0.033 | 0.893 | 0.05 | –1.276 |
| | Moheshkhola | –22.00 | –0.162 | 0.387 | 0.05 | –12.785 |
| | Chhatak | –40.00 | –0.114 | 0.416 | 0.05 | –4.286 |
| | Sunamganj | –48.00 | –0.110 | 0.402 | 0.05 | –5.455 |

**Table 1** Monthly rainfall trend analysis results using the Mann Kendall trend test (continued)

| *Month* | *Station* | *S* | *Kendall's tau* | *P-value (two-tailed)* | *Alpha* | *Sen's slope* |
|---|---|---|---|---|---|---|
| Jun | Laurergarh | –41.00 | –0.390 | 0.048 | 0.05 | –26 |
| | Moheshkhola | –24.00 | –0.176 | 0.343 | 0.05 | –11.783 |
| | Chhatak | –45.00 | –0.119 | 0.385 | 0.05 | –5.619 |
| | Sunamganj | –92.00 | –0.212 | 0.104 | 0.05 | –9.182 |
| July | Laurergarh | *16.00* | 0.118 | 0.537 | 0.05 | *8.472* |
| | Moheshkhola | –26.00 | –0.191 | 0.303 | 0.05 | –16.473 |
| | Chhatak | –134.00 | –0.330 | 0.013 | 0.05 | –18.93 |
| | Sunamganj | –165.00 | –0.379 | 0.003 | 0.05 | –20.7 |
| August | Laurergarh | *2.00* | 0.015 | 0.967 | 0.05 | *1.833* |
| | Moheshkhola | *16.00* | 0.133 | 0.499 | 0.05 | *19.827* |
| | Chhatak | –82.00 | –0.202 | 0.129 | 0.05 | –9.759 |
| | Sunamganj | –61.00 | –0.140 | 0.284 | 0.05 | –7.25 |
| September | Laurergarh | *21.00* | 0.137 | 0.449 | 0.05 | *11.286* |
| | Moheshkhola | –11.000 | –0.121 | 0.584 | 0.05 | –6.669 |
| | Chhatak | –75.00 | –0.199 | 0.144 | 0.05 | –10.664 |
| | Sunamganj | –157.00 | –0.361 | 0.005 | 0.05 | –22.58 |
| October | Laurergarh | –27.00 | –0.199 | 0.284 | 0.05 | –8.19 |
| | Moheshkhola | *2.00* | 0.015 | 0.967 | 0.05 | *1.452* |
| | Chhatak | –35.00 | –0.093 | 0.502 | 0.05 | –2.328 |
| | Sunamganj | –84.00 | –0.222 | 0.101 | 0.05 | –7.79 |
| November | Laurergarh | –14.00 | –0.193 | 0.405 | 0.05 | 0 |
| | Moheshkhola | –6.00 | –0.128 | 0.669 | 0.05 | 0 |
| | Chhatak | –7.00 | –0.092 | 0.712 | 0.05 | –0.505 |
| | Sunamganj | *2.00* | 0.009 | 0.977 | 0.05 | 0 |
| December | Laurergarh | 0 | | | | 0 |
| | Moheshkhola | *1.00* | 1 | 1.000 | 0.05 | *0.85* |
| | Chhatak | *1.00* | 0.105 | 1.00 | 0.05 | *0.18* |
| | Sunamganj | *20.00* | 0.313 | 0.188 | 0.05 | *0.442* |

## *4.2 Major problems in the Haor basin*

The Haor basin is subjected to several acute problems in its various components. Flash floods, riverbank and wave erosion, drainage congestion, poor navigability, and sedimentation affect the water resources in the Haor areas. The flash flood engulfs the agricultural lands and damages the crops. Flash flood also destroys households and other infrastructures.

Heavy rainfall in the upstream hilly region of neighbouring India causes erosion in the exposed surface of hills. These sediments are then carried away and eventually parts of them are deposited in Haor areas. Also, sedimentation in the local rivers is reducing

the discharge capacity of rivers. This phenomenon affects flood characteristics. Nowadays, a flood of lower magnitude became overwhelming for local residence. Sometimes the flash flood with high-intensity waves creates huge erosion near the households of the poor peoples and destroys the 'Hijal' and 'Karoch' trees which serve as the protection around their houses. Also, the huge amount of rocks and sediments deposited in the Haor and river beds make a change in the size, shape, and capacity of the location (Sultana, 2015). Sedimentation causes drainage congestion in December and it affects the plantation of Boro crop. However, the scenario is different in monsoon. The local inhabitants perceive that the monsoon dry spell is comparatively longer in recent days than in the past. These prolonged dry spells are often followed by heavy downpours causing devastating effects in Haor areas.

Traditional farming is still dominant in the Haor areas. Shortage of grazing fields, plentiful facilities of treatment, and shortage in the feeds and fodder are the main obstacles in traditional farming. Modern rearing techniques and technologies of farming are yet to be common practice. Also, due to poor communication and transport systems, commercial livestock farming remained unpracticed.

Health is a serious issue in the Haor region. Inundation due to heavy flood followed by a shortage of drinking water supply spreads waterborne diseases. Toilets also sink most of the time making the atmosphere unhygienic. This also accelerates open defecation. Children and women are the worst victims in this situation. Moreover, inundation makes poor people jobless and sometimes damages crops resulting in scarcity of food. This food scarcity leads poor people to the consumption of aquatic plants. This causes malnutrition especially to pregnant women, meaning carrying the effect on the future generation.

Despite the richness of the biodiversity and abundance of natural resources in the Haor basin, degradation in general terms is noticeable. It is evident that in addition to climate change, unwise use of natural resources is creating threats for the resources in terms of sustainability and growth.

### *4.3 Flash floods in Haor basin*

Flash flood is a unique characteristic of the Haor region. It plays an important role in the economy and livelihood of people residing in or nearby the Haor basin. This kind of flood generally occurs due to heavy rainfall and hilly water (Bryndal et al., 2017). In Sunamganj, the extreme flashy character of the rivers and sudden excessive rainfall in the region causes frequent flash floods (Alam, 2011). The flash flood occurs suddenly without much long warning, especially within a day or a couple of hours. The massive amount of floodwater advances at a vigorous speed; rises and destroys the crop, infrastructures, etc.

Flash flood is unexpectedly devastating as it doesn't give any opportunity to the people to reduce their losses. Typically, flash flood occurs in areas where the upstream basin is relatively short. On addition to the destruction of infrastructures and economic valuables, flash floods have a substantial impact on food production. There was severe flash flood in the Sylhet Haor region due to heavy rain in March and April 2017. It affected approximately 850,000 households and caused severe damage to crops, housing, and infrastructure, including bridges and roads. The most affected districts were Sylhet, Sunamganj, Moulvibazar, Habiganj, and Netrokona. Officially, the flood in early April caused severe damage to nearly 220,000 hectares of crops, mostly to the ready to be

harvested 'Boro' paddy crop in low-lying areas (GIEWS Update, 2017). The flood had a marginal impact on the overall 2017 wheat output (GIEWS Update, 2017). Other notable flash floods in recent past in the study area were in 2000, 2002, 2004, 2010, and 2016 respectively.

### *4.4 Rainfall relation with flash flood*

Although there is an increasing rainfall trend for a few months, the amount is non-significant compared to total decreasing trend. Most of the months have decreasing rainfall trend in the Haor basin area. Unexpectedly, despite having a decreasing rainfall trend flash flood is common in Haor areas. A further investigation of daily rainfall data reveals that during the crop harvesting seasons in March and April, especially in April sometimes there is a heavy downpour for a couple of days. This heavy rain doesn't have a strong effect on the monthly trend but in conjunction with the upstream flow, it can cause a devastating flash flood. For example, a flash flood occurred on April 30, 2000, in Sunamganj. Before the flash flood, there was heavy rain in Moheshkhola station. It rained more than 400 mm in just 7 days. In Chhatak station there was around 250 mm rain in just 5 days, in Sunamganj station there was 365 mm, and in Laurergarh station there was 258 mm rainfall in just 4 days just before the flash flood. Upstream heavy flow coupled with this excessive rain feed water resulted in a flash flood in this region. In 2004, a flash flood occurred on April 15. Rainfall data shows that it rained more than 400 mm in Laurergarh station in Tahirpur between 11 to 16 April. In Sunamganj station there was 335 mm rainfall between 11 to 16 April and 300 mm in Chhatak. A similar thing happened before the flash flood of 2010 and 2016. There was a sudden heavy rainfall ranges from 200 mm to 500 mm in just a couple of days before the flash flood. This gives a certain understanding that excessive rainfall plays a big role in the flash flood.

### *4.5 People's perception on climate change and its effects*

In the focus group survey, most of the local people said that mostly rainfall affects their livelihood. The effect has several dimensions including the destruction of resources and obstruction of normal life. Several respondents believe that sometimes the rainfall is increasing in a specific season at a specific time.

#### *4.5.1 Rainfall impact in the crop production season*

People were asked about the losses they face due to less or no rainfall. They said that there are enough alternative sources for water. Therefore, in the dry season, the scarcity of rainfall does not have a great impact on their agricultural production. Only a few people said that they do not have a source nearby to their land and they have to depend on the rainfall. On the contrary, almost all people agreed that excess rainfall has a certain impact. They were asked about the changes happening in the production of the crop during the last couple of years due to extreme or heavy rainfall. 28% of people said that the rainfall damaged 99% of their total crops in the last 2 years. The majority of the affected people were poor farmers who mostly depend on the crops for their livelihood. Therefore, heavy rain brings a disaster to them. Amongst respondents, 31% of people said that there was huge production but they could not harvest at the right time, because of the flash flood followed by heavy rainfall. The flash flood submerges their lands

before the crops are matured. Recurrence of such episodes breaks their hope. Consequently, farmers feel so much tension to cultivate again. However, a total of 27% of people said that the excessive rainfall doesn't harm their crops, instead the hilly water does. Some of them said that not fully but 90% of their crops were damaged during heavy rainfall in the last couple of years. However, every one of them agreed that the extreme rainfall in a specific time and month damaged their crops in the last couple of years. They also added that sometimes rainfed floods due to extended duration of rainfall in the rainy season cause damages to their crops, but in this case, they get some time to harvest their crops.

### *4.5.2 Time of floods*

Approximately all (96%) people said that the flood occurs mainly in spring and summer but seldom in fall. A very few people (4%) believe that the flood happens randomly, and not in a specific month. From a careful observation of historical flood information and rainfall data for the Sunamganj Haor basin it can be stated that the flash flood generally occurs in the pre-monsoon or early monsoon (March–April).

### *4.5.3 Causes of flood occurring*

People were asked about the reason behind the devastating floods. There is a little comparison in this sphere. A total of 39% of people said that the sudden heavy rainfall is the only reason behind it. However, 31% of people said that the malpractice in the embankment (flood protection work) construction in the Haor areas is the main reason behind it, as the rainfall is unpredictable. There are also peoples (30%) who think that the upstream Indian water is the key reason behind the flood. However, the author's long-term experience and rainfall data pattern indicate that the combined effect of heavy rainfall and upstream discharge is mostly responsible.

### *4.5.4 Losses due to flood*

The amount of losses due to sudden excessive rainfall and flash floods are sometimes enormous in Haor areas. Almost all respondents (98%) said that they have to face loss. Only 2% said that it doesn't bother them at all because they are dependent on other kinds of businesses not affected by the flood. These people are also comparatively rich. In a word, disasters do not have a significant effect on rich people's life. Excessive rainfall acts as a curse for poor people only. People were also interviewed about what kind of losses they face due to the long-term excessive rainfall and flood. Among them, 47% of people said that half of their crops have been damaged due to the long-time excessive rainfall and floods. 48% of people said that 90% of their crops were damaged due to the excessive rainfall that causes floods which remains for a long time. A very few people (5%) said that long-time rainy season doesn't harm them as sudden extreme rainfall does.

### *4.5.5 Problems occurring in fish production*

People were asked about the changes happening in fish production (if any) due to variations in the rainfall pattern. There is good odd between them on this topic. 11% of people said that there is a scarcity of big fish in the Haor areas due to the floods. 2% of people said that it is difficult to catch fish for the rainfall variations. 3% of people said

that due to floods the price of the fishes and daily goods increase in the monsoon. Then there is an important feedback came from a lot of peoples (40%). They said that when flash floods cover and submerge their croplands, the decomposed crops contaminate the water and kill a lot of fishes every year. Some of them (8%) said that a lot of fishes died in 2017 due to the poisonous gas, though there is no valid evidence whether gas was responsible or not. The rest of the respondents are unaware of this issue.

### *4.5.6 Impact on animal and aquatic life*

People were asked about the problems occurring in the animal and aquatic life due to the flash floods and heavy rainfall. Most (88%) people do not have any idea about this. However, very few (4%) suspect that animal and aquatic life may be a little bit affected, but they also said it is just a guess. On the contrary, 7% of people said that the migratory birds in winter are decreasing in number maybe because of the scarcity of small fishes. Some people (5%) mentioned that diseases spread occasionally among the chickens and domestic animals during the flood.

### *4.5.7 Impact on sanitation*

Inhabitants were asked about the possible sanitation problem during the sudden excessive rainfall and floods. 43% of people said that flood brings a major problem. Many toilets sink and make the atmosphere unhygienic. As a result, many diseases spread and affect their life severely. Meanwhile, 44% of people added that availability of drinking water is also a problem at this time. The casual sources of drinking water get inundated during floods. Lack of knowledge on the easy purification system of non-potable water leads to drinking polluted water causing a serious health risk. Surprisingly, outnumbered people said that they do not face any problem in sanitation. However, waterborne diseases are common especially diarrhoea.

### *4.5.8 Impact on communication*

One of the hurdles Haor people encounter daily during the rainy season is communication. 35% of people said that during flood the roads sink, bringing a lot of problems. They lose their quick communication system. 16% of people said that they have to use a boat which is time-consuming. Another 16% said that emergency medical services become unavailable due to sinking of roads. Besides, the muddy roads make the environment damp and unhealthy. The old peoples, children, and women are the worst victim of these events. In a word, they get separated from the Sunamganj (the nearest town). However, 33% of people said that communication difficulties happen but not every time.

### *4.5.9 Impact on family health*

Waterborne diseases and malnutrition are the key health impacts during inundation. People were asked about the impacts which occurred in their family life during heavy rainfall and floods. 15% of people said that they had to face food problems due to financial losses arising from crop damage. Many of them (47%) mentioned that they had to face diseases in addition to the food problem. Meanwhile, 27% said that sometimes they had to starve with their family due to crop damage as agriculture is the only way of

earning for them. Only 1 person said that it does not affect his life because he is not dependent on agriculture, and 3 persons said that it does not bring direct economic loss in their life but brings many waterborne diseases.

### *4.5.10 Impact on education*

Education is found affected seriously when the flood water engulfs the whole area. Most of the respondents (90%) said that they stopped their children's education because of the effect of the flood. Flood destroyed their crop that is the only income source. Therefore, they had to start working on other people's lands and industries with their children, since single people's income is not sufficient. Some people also send their young girls as a maid to the rich families. As a result, children get parted from their studies. Besides, educational institutes get closed during the flood because of unfavourable weather, rough communication, and inundation of schools. This study gap affects the children mentally and drops their interest in the study. Meanwhile, 10% of people said that it does not affect their children's study.

### *4.5.11 Impact on electricity*

People were asked about the electricity supply during the heavy rainfall. 45% of people said that it affects adversely the electricity system during heavy rainfall and floods. 55% of people said that the electricity supply system was normal during the flood but they experience prolonged power cut during heavy rain or flood.

## *4.6 Impact of 2017 Flash Flood*

One of the severe floods Haor people experienced in recent times was recorded in 2017. To understand the tangible impacts of the flood people were asked about the individual economic losses they had to face. Among them, 26% of people quoted a monetary loss of 50 thousand to 2 lac taka. In contrast, 40% of people said that the loss was 2–10 lac and it broke their economic backbone. Now they are suffering a lot from this damage. A total of 19 people said that they lost almost everything they had; their loss was around 10–15 lac. An economic disaster occurred to their family due to this flood. 15 individuals said that they lost all of their money and now they often starve.

## *4.7 People's perception on reducing flood losses*

People were asked if they have any ideas to cope with the devastating flood or reduce damages. It is expected that the long-term experience of local inhabitants may give some out of the box solution. Everyone stated their idea. Most of them (58%) said that Haors are not dug for a long time. As a result, silting has reduced the water holding capacity. They propose excavation of Haors and eliminating the malpractices in development work will surely halt the flood and damages. They also mentioned the name of some specific Haors (e.g. bonlai, patlai) which should be excavated on a priority basis. Few (9%) people said that there should be more sluice gates to reduce the losses. However, some other people (23%) said that a permanent strong embankment wider than the current one can stop the losses from sudden extreme rainfall and floods.

### 4.8 Status of flood protection works

Several embankments are constructed in the Haor areas to protect properties and croplands from floods. Most of the people (81%) think that the placement of the embankments is all right but are not constructed strongly to resist the waves of flash floods and hilly water. On the other hand, 19% of them think that the placement is not right, they proposed to change the position of the embankments. People were further asked why already built embankments fail to prevent the damage. Malpractice in construction was identified as the key reason by 33% of people. In contrast, 60% of people said that embankments are under-designed.

## 5 Conclusions

During the current study, the Haor basin is found greatly influenced by rainfall and subsequent flood. The Mann-Kendall trend test reveals that the rainfall is decreasing in the study area. But during the FGD the local people said that sometimes there are sudden heavy rainfalls within a short time. Investigation of historical daily rainfall also supports this. By observing the flash flood timing and daily rainfall it is found that most of the time just before the flash flood there was sudden heavy rainfall in just a couple of days. This rainfall ranges from 200mm to 500 mm. This sudden rainfall does not significantly change the total rainfall trend but has a great influence on the flash flood. Flood occurs mostly in early and mid of April which is the crop harvest time. In addition to the crop damages, this affects almost all spheres of people's life. To minimize the flood damage, some protective measures can be taken. Strong embankments and Haor excavation can prevent and reduce severe flash flood effects. In addition, there are some other options. Cultivation of crops that can sustain in the flash flood can be a promising alternative. They can cultivate crops which can be harvested in raw or semi-ripe condition and can be moved to another place without any damage. A strong communication network is also required. Adaptation of an early warning system will give people time and can also reduce the losses. Lastly, focus should be given to effective collaboration between different stakeholders (local and national) to develop a sustainable coping mechanism.

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