IMPACT OF HYDROMETEOROLOGICAL HAZARDS ON AGRICULTURAL PRODUCTION AT *CHALAN BEEL*, BANGLADESH

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ABSTRACT

Agriculture of Bangladesh is closely dependent on weather, rainfall pattern and land formation. However, frequent hydro-meteorological hazards cause to adversely affect the normal agricultural process and production. This study aimed to assess the impact of Hydro meteorological hazards on the crop cultivation practices, possible mitigation and adaptation measures for the farmers at *Chalan Beel* area under Pabna district, Bangladesh. There are 90 people having land and engaged with crop cultivation directly at *Chalan Beel* were been selected by applying purposive sampling method and interviewed by a pre-designed semi-structured questionnaire through face to face interview. The results revealed that Rice (93.75 %) and Garlic (47.5 %) are the major cultivating crops at *Chalan Beel* and 96 % of the farmers were been experienced with hydro-meteorological devastation. The farmers perceived Nor'wester (77.9 %) as the most frequent hazard causing crop damage following by Heavy Rainfall (71.4 %), Hailstorm (68.8 %), Heavy Wind (45.5 %), Flashflood (42.9 %), Heavy Fog and Floods (19.5 % and 11.7 %) respectively. It is also identified that Nor'wester (58.4 %) and Heavy Rainfall (58.4 %) had maximum damage whereas Hailstorm (55.8 %), Heavy Wind and Flashflood also considerable adverse effects on overall crop production at this area. Only 24 % of farmers were found to change their cultivation pattern as the adaptation measure. This study portrayed that hydro-meteorological hazards are adversely affecting the crop production at *Chalan Beel* area and resulting economic loss. Therefore, government should ensure the participation of farmers along with adopting their deliberative in developing a strategic plan for providing technical support for diversification and training to adapt in this hazard prone area.

Keywords: Adaption, *Chalan Beel*, Crop damage, Natural hazard

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INTRODUCTION

Bangladesh is a South Asian developing country, which is considering as a middle-income country. Fertile land and favorable weather condition have made its landmass suitable for growing varieties of crops abundantly. As a result, agriculture has become not only an important contributing source of national economy but also major source of livelihood in rural areas, where 64.29 % of the population lives (BBS, 2019). There is 15 % of the country's Gross Domestic Product (GDP) comes from agriculture and employs around 41 % of the total labor forces (Isma'il and Saanyol, 2013; Rahim et al., 2018). Rice is the principal crop with covering the 75 % of the total cropped area in 2017 (Nasim et al., 2017) and 69% in 2019 (BBS, 2019), respectively. Rice is also considered as the staple food of Bangladeshis in the everyday diet, which is usually harvests two or even three times in a year. There was 35,300,000 MT of rice production forecasted in 11,830,000 ha for 2019-2020 fiscal year, which was estimated 34,909,000 MT in 1,770,000 ha for 2018-2019 and 32,650,000 MT in 11,272,000 ha for 2017-2018 fiscal year respectively (BBS, 2019). Agriculture of Bangladesh depends on the weather, rainfall pattern, temperature and land formation types. Natural hazards, disasters and risk are essentially geographical in nature (Alam and Collins, 2010; Shahid and Behrawan, 2008)geographical location, terrain, dense river networks, and monsoon climate expose the country to a high level of physical disaster risk and socioeconomic conditions have created a high vulnerability of communities to natural disasters (Azad et al., 2013). However, Due to its geographical location (Parvin and Johnson, 2015), land characteristics, multiplicity of rivers and the monsoon climate Bangladesh suffers from frequent natural hazards in all over the country and faces food and livelihood challenges. The changing season brings different types of unpredictable natural hazards in everyday life. The common hydro meteorological hazards are flood, cyclone, storms, drought, salinity intrusion, excessive fog, temperature changing, riverbank erosion, heavy rainfall, late rainy season, water logging, etc. (Rahim et al., 2018). The hydro meteorological hazards affect the livelihood including losses and damages of crops cultivation, scarcity of pure drinking water, loss of economy, an increase of poverty, damage in fisheries, livestock, and vegetable gardens and also creates a state of unemployment among the people (Hossain and Majumder, 2018; Rahim et al., 2018). Peduzzi and Herold (2005) included the economic impact caused by medium- and large-scale hydro meteorological hazards and disasters in developing countries on agriculture and calls for enhanced mainstreaming of disaster risk reduction and resilience building within this sector (FAO, 2015; Hasan et al., 2013). Byomkesh et al. (2009) have conducted the values of wetlands, causes, and effects of its degradation, as well as management approach relation to natural resources and agriculture. Moreover, Dhar et al. (2018) stated to document farmers' livelihood aspects and agribusiness potentials in wetland areas of Bangladesh to understand the economic loss of agricultural production due to natural hazards which would help to promote agribusiness and

minimize risk. Furthermore, focused on community perception on natural hazards and its' adverse impact on livelihood in the southern part of Bangladesh.

Hydro-meteorological hazard is the combination of Hydro-meteorological hazard which are related and characterized to a severe excess or lack of water and atmospheric patterns or conditions and are generally caused by weather factors such as precipitation, temperature, wind speed, and humidity. The common types of hydro-meteorological hazards are flood, drought, soil erosion, tropical cyclones, monsoons, hailstorms, windstorms, thunderstorms, fog, etc. (Chowdhury and Ward, 2004; Mirza, 2003; Mondal et al., 2013).

Bangladesh is vulnerable for its geographical location at Ganges-Brahmaputra-Megna basins having hydro meteorological characteristics that eventually cause often extreme hazards and devastation to gross domestic product (Mirza, 2003). Historically it has been suffering from different hydro meteorological hazards like cyclone, flood, salinity intrusion, storm surge, erosion and drought (Mondal et al., 2013). The economy of Bangladesh is predominantly agriculture based which annually impacted by these types hazards and lead to adverse negative short-run and longer-term economic and budgetary impacts (Biswas et al., 2019; Huq et al., 2015; Shahid and Behrawan, 2008; Sivakumar, 2005).

This study conducted at *Chalan Beel, the* largest wetland in the northwest side of Bangladesh and one of the vulnerable areas due to hydro meteorological hazards. The common hydro-meteorological hazards in this wetland are known to be drought, flash flood, heat wave, heavy fog, hail storm, and northwester storm. As a consequence of these hydro meteorological hazards, the people of this area are facing different types of challenges in livelihood. Crop cultivation, vegetation, fisheries, and other agricultural activities have been hampered and adversely affecting the economy.

The study aims to assess the impact of Hydro meteorological hazards on the crop cultivation practices, possible mitigation and adaptation measures for the farmers at *Chalan Beel* area under Pabna district, Bangladesh. The aims have been achieved by answering the questions i.e., What have the types of hydro-meteorological hazards occurred in *Chala Beel*? What is the relation between local-level agricultural practice and hazard? What are the economic impacts of hazards on crop production? And what are the mitigation and adaptation practices to protect corps from hazards?

METHODOLOGY

Study Area

The largest wetland of Bangladesh, Chalan Beel is located between $24^0.35'$ to $24^0.70'$ N latitude and $89^0.10'$ to $89^0.35'$ E longitudes with covering 52-78 sq. km (dry season) to 375 sq. km (rainy season). Spatially, it belongs to Chatmohar upazila (Pabna), Tarash, Roygonj and Ullapara upazila (Sirajgonj), Singra, Grudashpur and

Boraigram upazila (Natore) and Ahasanganj and Manda Upazila (Noagaon) (Galib et al., 2009). This Beel has a rich water network and biodiversity with supporting livelihood to 5 million (Hossain et al., 2009). This study selected the part of *Chalan Beel* under Chatmohar upazila of Pabna district (Figure 1). Three adjacent villages of Chalan Beel i.e., Ramnagar under Beel Chalan union, Boyailmari under Chhaikhola union and Dhulaury village under Haripur unionat Chatmohar Upazila of Pabna districthave been selected for conducting this study.
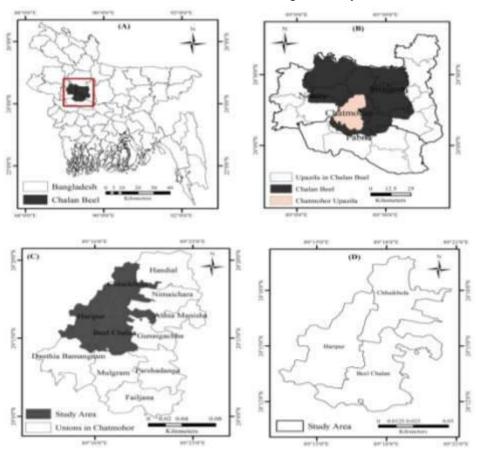

Figure 1. Showing the study area, (A) Chalan Beel in three districts of Bangladesh, (B) Chatmohor Upazila in Pabna district, (C) Study unions at Chatmohor Upazila and (D) Study area

Data types and respondents

The study has been conducted by applying mixed approach with combining both qualitative by reviewing secondary documents i.e., journal articles (Chowdhury and Ward, 2004; Hossain et al., 2009; Mirza, 2003; Mondal et al., 2013), reports (BBS, 2016; BBS, 2019), quantitative approach and direct field surveys. An extensive field

survey has been conducted to collect primary data where face to face interview method has been used with a pre-designed semi-structured questionnaire. The respondents for the study were the people who were living in selected three villages (i.e. Ramnagar, Boyailmari and Dhulaury) having agricultural land in Chalan Beel and actively engaged in cultivation at least one year.

Sampling size, collection and analysis technique

Purposive sampling method has been applied to do in-depth study because the respondents need to have their own land and they should cultivate their land as it the inclusion criteria of this study. However, it was tough to fulfill these conditions as many of the people work in others agricultural land as a labour because they do not owe any land on the other hand there many land owners, who do not cultivate their land the ylease their land to other persons. To select the respondents based on the inclusion criteria: (i) Persons who have own agricultural land in Chalan Beel*, ii) Persons who* direct involved crop cultivation in their own land and (iii) Persons age greater than or equal to18 years. Total 18,139 people lived in the Chalan Beel Union among 13 village, where, 8,803 male and 9,336 female. 90 samples were selected purposively and distributed equally among the villages i.e., 30 samples from each village. Data have been analyzed by SPSS version 20 software.

RESULTS AND DISCUSSION

Demographic and socioeconomic characteristic of the respondents

There are 16.7 % of the respondents were between 18 to 30 years old, 31 to 40 years were 24.4 % and 58.9 % were above 41 years respectively (Table 1). It was observed that the farmers aged more than 30 years, were generally involved in agriculture. The highest number of respondents was between 41 to 50 years and including the rest of the higher aged people was 60.1 %, which represents less involvement of younger people directly in agricultural production. The identified reason for high proportion of elderly people engagement in agricultural activities was low profit and tendency to involve in jobs. Besides, there are 97 % of the respondents were male and 3 % are female farmers. However, this study found most of the female members were to be directly involved with agriculture through assisting male farmers during harvesting and drying up the corps, seed preparation as well as storing in the houses.

Table 1. Age and educational level of the respondents

Age and educational level of respondents		
Respondent's age (years)	Number	Percentage
18-30	15	16.7
31-40	22	24.4
>41	53	58.9
Total	90	100
Educational level		
Primary	63	70.0
Junior secondary	12	13.33
SSC/Equivalent	3	3.33
HSC/Equivalent	7	7.78
Graduation	5	5.56
Total	90	100

Most of the respondents have completed primary education (70 %), whereas only 5.56 % were found, graduate. Aside from this, 13.33 %, 3.33 %, and 7.78 % have passed junior secondary, SSC and HSC equivalent levels respectively (Table 1). Mean while, 52.22 % of the respondents had both homestead and agricultural land, whereas 44.44 % and 1.11 % only had agricultural land and homestead. Aside from 2.5 % of respondents were pond owners, who were practicing aquaculture for their livelihood. This result illustrates most of the farmers aren't educationally sound to use advanced technology or adapt change quickly so need to be engaged more educated person to enrich the agriculture.

Crop cultivation and hydro-meteorological hazards

This study assessed the agricultural crop cultivation practice during 2018 in the Chalan Beel and found Rice (93.75 %) as the main crop for cultivation followed by Garlic (47.5 %), wheat (25 %), jute (17.5 %), pulses (16.25 %), onion (6.25 %), vegetables (5 %) and fruits and mustard or oilseed (2.5 %), respectively (Figure 2). Rice, as like countrywide, is also the staple food in Chalan Beel area. Along with traditional crop practices, geographical, biophysical and climatic conditions have made suitable this area to cultivate rice yearly three times.
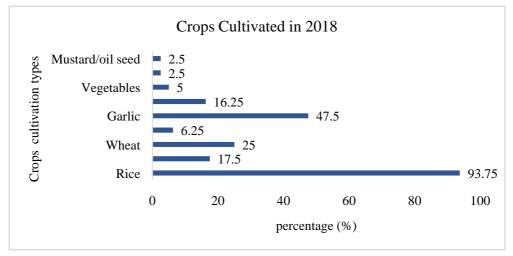
Crops Cultivated in 2018

Figure 2. Types of crops cultivation in 2018

There is a change in climatic conditions in Bangladesh has been observed with increasing temperature trend and decreasing in precipitation with changing pattern as well as shifting zones (Hossain and Majumder, 2017; Khatun et al., 2019). Temperature is usually high with very humid weather at the end of March to April create an idle condition for Nor-wester (in Bangla *Kal Boishaki).* This study revealed that 96 % of the respondents of this area know these types of hydro meteorological hazards. There was 77.9 % respondents replied Nor-wester as the main devastating hazards to cause damage of crop production at Chalan Beel. The damage becomes very severe because Nor-wester strikes during the crops' maturing stage. In addition, respondents also identified heavy rainfall (71.4 %), hailstorm (68.8 %), heavy wind (45.5 %), flash flood (42.9 %), heavy fog (19.5 %), drought (15.6 %), floods (11.7 %) and soil degradation (1.3 %) as the hydro meteorological hazards to cause damage on their crops, respectively. Among these, heavy rainfall, hailstorm, heavy wind, flash flood starts to occur usually at the end of April, and continue to mid of October, whereas, heavy fog and drought occur from November to end of February.

Effect of hydro-meteorological hazards on crop production

There are 58.4 % respondents opined that Nor'wester and heavy rainfall causes to damage their crops, whereas, 55.8 % perceived to the hailstorm, 27.3 % to heavy wind, 18.2 % to flash flood, 10.4 % to heavy fog, 3.9 % to floods and only 1.3 % to drought as the most adverse effects on crop production in 2018 (Figure 3).
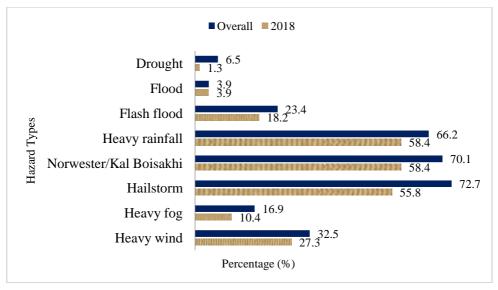
Figure 3. Crop damaging hazards at Chalan Beel

Besides, this study by analyzing the experiences of respondents revealed the most frequent crop-damaging hydro-meteorological hazards. It is found that 72.7% responded hailstorm is the most frequent hazard at Chalan Beel area which caused to damage their crops during the previous cultivation periods. Hailstorm caused most damage because the ice cube come with heavy force and hit on the crop ground which creates permanent damage. Besides, 70.1 % experienced tonor' wester, 66.2 % to heavy rainfall, 32.5 % to heavy wind, and 23.4 % to flash flood, 16.9 % to heavy fog, 6.5 % to drought and 3.9 % to floods respectively (Figure 3).

Economic losses of hydro-meteorological hazards

There are 82.5 % of respondents were found to know calculating their losses by comparing the expected production with the actual production due to hydro-meteorological hazards. And in practice, it is observed that respondents were not aware of their financial losses even never measured or estimated. The farmers were not aware to measure their loss as well as did not have knowledge on estimation process. In this vein, there was a loss estimation process that had been illustrated to the respondents during the survey. Understanding total expenditure and yielding amount as well as converting them into money helped the respondents to estimate their financial loss (Table 2).

Table 2. Economic analysis between actual and expected crop production.

Multiple Response	Crops Production (Kg)					Expected Production (Kg)		
	N	%	Median	Range		Median	Range	
				Min	Max		Min	Max
Rice	75	93.7	1800	200	28000	2000	320	35000
Jute	14	17.5	520	120	1400	640	240	19660
Wheat	20	25.0	360	60	2000	520	160	2000
Garlic	38	47.5	1200	160	7200	1400	560	16000
Pulses	13	16.2	190	60	360	280	80	480

(N= Number of responses)

It was found (Table 2) that 93.7 % of respondent's harvested Rice from 200 Kilograms (kg) to 28,000 kg (median 1800 kg) in 2018. However, they expected to harvest 320 kg and 35,000 kg (Median 2,000 kg). Similarly, 17.5 % of Jute cultivator harvested 120 kg -1, 400 kg (median 520 kg) whereas the potentiality was 240 kg- 19,660 kg (median 640 kg). In addition, 25% Wheat cultivators expected to harvest 160 kg - 2,000 kg (median 520 kg) but harvested 60 kg - 2,000 kg (Median 360 kg). Moreover, 47.5 % respondents expected to harvest 560 kg - 16,000 kg (median 1,400 kg) from Garlic cultivation, however, actual production was 160 kg - 7,200 kg (1,200 kg). And, the Pulses, 16.2 % respondents harvested from 60 kg - 360 kg (median 190 kg) against the 80kg - 480 kg (280 kg) of expectation. Therefore, it portrayed that farmers have harvested fewer crops against their expectations due to damage by hydro-meteorological hazards. The estimation of economic values, as well as economic losses based on farmers' experiences due to adverse effects of hydro-meteorological hazards, is shown in Table 3 by analyzing the to telex penditure, actual and expected price to sell of crops.

Table 3. Total expenditure and expected selling amount of major cultivated crops

Multiple response	Total Expenditure (TK)			Actual Sell (TK)			Expected Sell(TK)		
	Median	Range		Median	Range		Median	Range	
		Min	Max		Min	Max		Min	Max
Rice	22000	1000	350000	28000	2600	630000	36000	3000	2000000
Jute	12000	2000	35000	23400	2650	59500	32800	1000	83300
Wheat	6000	1200	12000	7550	1350	72000	10475	3000	22000
Garlic	19000	2000	120000	20500	2000	375000	40000	4500	375000
Pulses	3000	200	6000	7500	1600	19600	11000	1800	28000

Measures were taken to adapt and mitigate hydro meteorological hazards

Experiencing losses by hydro-meteorological events, only 24 % of farmers were changed their cropping intensity. There are 42.1 % farmers started early crop

cultivation, 31.6 % changed seed, 21.1 % changed the land using the pattern, 15.8 % reduced cultivations well as late crop cultivation, 10.5 % changed cultivation type and used new crop varieties and only 5.3 % build physical infrastructure respectively (Figure 4).
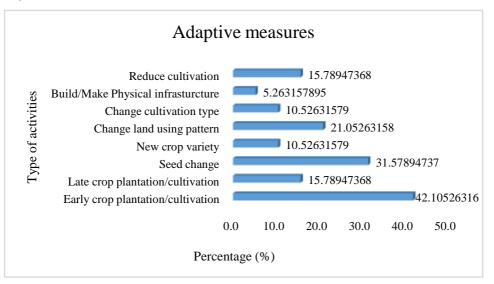

Figure 4. Types of activities to take the changes in cultivation

As mitigation actions, 23.8 % of farmers perceived the necessity of further initiatives for reducing losses from hydro-meteorological hazards. In this perspective, farmers were emphasized on more discussion in Somittee (Association in English) for sharing and dissemination of knowledge. Also, farmers opined to preserve good seed, collect and planting good seed, use of compost, loan distribution among deprived farmers by forming Somittee, using more fertilizer and modern technologies respectively (Figure 5).
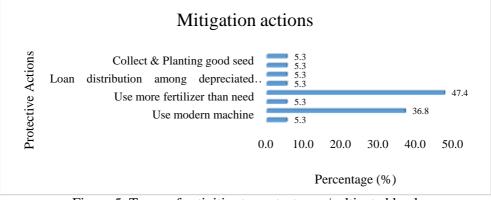

Figure 5. Types of activities to protect crop/cultivated land

CONCLUSION

Bangladesh is not only highly dependent on agricultural sector for food consumption but also main driving force of the economic growth. This study has assessed that hydro meteorological hazards have been adversely affecting agricultural sector on regular basis and causing damage to crops and economic loss. It is also revealed that farmers don't have any effective technique and tools to mitigate their damage as well as they don't have sufficient knowledge and experience to roll out the adaptation process. It is also revealed that adaptation measures by farmers were not sufficient; hence further initiatives are perceived to achieve climate-resilient agriculture. In this circumstance, agricultural extension office may enhance the close coordination with the farmers for providing continuous suggestions and technical training based on Ministry of Agriculture directives. Considering 'information is a key', there are some other initiatives can be introduced like visualization, prediction, awareness and prediction system for climate services during the entire agricultural practices. To ensure these climate services, Bangladesh Meteorological Department (BMD), Department of Agricultural Extension (DAE), Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural Research Institute (BARI), Upzaila disaster management team along with local Non-Government Organizations (NGOs) may work together for communicating this initiative.

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