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Vulnerability of Agricultural Production due to Natural Disaster at Mongla Upazila (Sub District) in Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author MNH designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed literature searches. Authors MMR and KI managed the analyses of the study and review. All authors read and approved the final manuscript.

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ABSTRACT

Mongla upazila (sub district) of Bangladesh has the traditional practice of agriculture but now is extremely vulnerable due to frequent and intensive recurring phenomenon of natural hazards such as salinity intrusion, water logging, flood, cyclone and tidal surges. Therefore, this study was conducted for the assessment of vulnerability and its potential impacts on agricultural productions. This study was also focused to develop a strategy for minimizing the vulnerability. A total of 12 Focus Group Discussion's (FGD) and 5 Key Informant Interviews (KII) were conducted. A well-organized survey questionnaire was developed and used considering objectives and variables throughout this survey. Primary data was collected by face to face interviews, oral talk with local

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experts, FGD, KII methods and 3 time field visits. Secondary data was collected from different books, reports, daily newspapers, journal articles, research thesis. The major findings of this study were the causes of severely vulnerability of the production of two main crops that is Aman and Boro and also the agricultural labor. Furthermore, the drinking water was also found as severely vulnerable. This study was also revealed that, 88% respondent opined that the salinity has decreasing agriculture productions due to water logging followed by 4%. In contrast, 81% respondent opined that, the agriculture based occupation is shifting besides; 14% viewed that migration was also increased (climate refugee) due to salinity problem and 79% respondent viewed that, saline tolerant rice (HYV) cultivation is taken as a part of adaptation option. Furthermore, this study also emphasized that, the importance of adaptation of introducing saline tolerant rice varieties; re-excavation of canals, streams, and rivers. Moreover, it is suggested that the negotiation between local leaders and farmers to stop conversion of agriculture based lands into shrimp cultivation lands (gher) may be played as vital role to minimize the vulnerability of sustainable agricultural productions.

Keywords: Vulnerability; agriculture; production; natural disaster; Bangladesh.

1. INTRODUCTION

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of global warming induce climate change, including climate variability and extreme events. Vulnerability is a function of the character, magnitude, and rate of change of climate and variation to which a system is exposed, its sensitivity, and its adaptive capacity as defined by the Intergovernmental Panel on Climate Change (IPCC) [1]. Vulnerability is a set of conditions and processes resulting from physical, social, economic and environmental factors that increase the susceptibility of a community to the impact of hazards [2]. Vulnerability we mean the characteristics of a person or group and their situation that influence their capacity to anticipate, copes with, resist and recover from the impact of a natural hazards [3-5].

According to the Disaster Management Act, Disaster means natural, environmental and human induced hazards which require a significant coordinated response by the Government and other entities to help the community recover with external assistance as it is not able to do so with its own resources and capabilities [4]. The United Nations defined a disaster as a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental impacts, which exceed the ability of the affected community or society to cope using its own resources [2]. Bangladesh is one of the most disaster-prone countries in the world and the consequences of disasters and the resulting environmental degradation pose a serious threat to the economic development of the country [6]. Bangladesh is extremely vulnerable to the global warming induce climate change and its impact, due to its very flat and low-lying topography, subject to riverine flooding and more vulnerable to sea level rise. The estuary of three great rivers the Padma, the Brahmaputra, and the Meghna makes the country a great deltaic plain. The extensive floodplains are the main physiographic features of the country. Both riverine flooding and sea level rise can result in inundation of agricultural crop production; sea water, in particular, can result in salinization, causing permanent loss of currently agricultural crop production. Besides, in the north is the biggest mountain Himalayas and in the south the funnel-shaped Bay of Bengal have made Bangladesh more vulnerable to the catastrophic devastation of floods, droughts, cyclones, storm surges and salinity intrusion etc. [7].

The United Nations defined Hazard is a potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazard can include latent conditions that may represent future threats and can have different origins: natural (geological, hydro-meteorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity, frequency and probability [2]. According to Community Risk Assessment (CRA, 2009) report the major hazards of Mongla upazila (Mongla upazila is a coastal city of Bangladesh is situated in bank of Pasur big river and opposite side of Sundarban) as salinity intrusion, water

logging, tidal surges, cyclone and virus attack. It was also reported that salinity problem create the most economic loss in land productivity [8]. Bangladesh Agricultural Research Council (BARC, [9]) showed that due to salinity problem loss of rice production was 4.42-MT which comprises the cost 586.75 million US$ per year. Adaptation is a concept that originated from ecology, which is defined as 'characteristics that help living organism survive under a given set of environmental conditions [10]. The IPCC defined adaptation as the 'adjustment in natural or human systems to a new or changing environment; The Climate change: impacts, adaptation and vulnerability stated that Bangladesh will lose the largest amount of cultivated land globally due to rising sea levels. This could lead to a significant drop in the production of rice (8%) and wheat (32%) by the year 2050 [1].

In Bangladesh agriculture is the overwhelmingly dominant sector of the economy, involving 80 percent of the total population and contributing to 25 percent the gross domestic product (GDP); Disasters like floods and cyclones cause substantial damage to standing crops, causing food insecurity and unemployment, for instances in 2007 devastating floods damaged 890,898 hectares of crops [6]. Most of agricultural production is concentrated on a limited number of crops, with rice occupying 82.6 percent of total cultivated area [11]. According to the Bangladesh Bureau of Statistics (BBS) District Statistics 2011, about 21.41% of people in Mongla upazila are involved in agricultural production. Total amount of cultivable land is 12867 acres, current fallow land 465 acres where single crop is 12987 acres, double crop is 6352 acres and triple crop land is 957 acres. Rice is the main crop, coconut; betel nut and sugarcane are nearly extinct crops. Main fruits are mango, black berry, lemon palm and papaya [12]. It is a coastal belt and near to bay of Bangle so cyclone, heavy rainfall, and tidal wave hits almost every year and affects the people, damages their houses and crops, increase their sufferings which make them more poor/ultra-poor. Poverty is persistent due to natural disaster and low income growth in this upazila. In the rainy season paddy, vegetable and other crops usually suffered by water logging, fish farmer's loss their fishes due to overflow of saline water [13]. Previous studies found that, Mongla upazila, Bagerhat District, an area subjected to frequent climate induce hazards. The frequency and intensity of these hazards are likely to increase due to the effects of climate change. Most remarkably, salinity was extensively recognized as a major problem for the community agriculture, fisheries, biodiversity, trees and plants, are all highly vulnerable and very few perceived an increased risk due to climate change [14].

According to the IPCC Report (2007), Agriculture is a major sector of Bangladesh's economy and the coastal area of country is very fertile for growing rice. Due to salinity intrusion in both soil and water will have serious negative impacts on agriculture and its adverse effects will be significant on coastal agriculture [15]. Coastal flooding and the intrusion of salt water on land similarly result in loss of cultivatable land, although there is no official record of reduced agricultural output due to salinity of the soil, analyses estimate the drop in agricultural production could be as much as 50 percent over the past 30 years, for instances, in Khulna and Satkhira districts there have thousands of shrimp farms, in some cases farmers have chosen to shift from agricultural production to shrimp farming due to salinization [16]. Salinity ingress also causes an increase in soil salinity, especially when farmers irrigate their lands with slightly saline surface water at the beginning of the low flow period [17]. SRDI [18] reported that, soil salinity levels south of Khulna and Bagerhat towns ranged between 8 to 15 dS/m during the low flow season. Bangladesh is a disaster-prone country almost every year, the country experiences disasters of one kind or another such as tropical cyclones, storm surges, coastal erosion, floods, and droughts causing heavy losses [19] for farmers and agriculture sector. Agricultural activities are by nature prone to risks and uncertainties of various nature- biophysical, abiotic, climatic, environmental, biotic (pests, diseases) and economic [20]. At present roughly 25% of the population is considered food insecure [21]. Agriculture plays a vital role in enhancing productivity, profitability and employment in the rural areas for improving the livelihood security status of the poor of the country [22].

The main objectives of the present study were to assess the vulnerability in agricultural production, and to identify the existing adaptation technique as well as to develop a strategy for minimizing the vulnerability.

2. METHODOLOGY

2.1 Study Area, Demography and Socio-economic Status

Current research work was conducted at Mongla upazila (sub-district) of Bagerhat district in Bangladesh. The Mongla upazila occupies an area of 1461.20 sq. km. of which 1260.87 sq. km. is land area. On the other hand the reserve forest area and riverine area is 5.46 and 1.56 sq. km. respectively. It lies between 21° 49´ and 22° 33` north latitude and between 89° 32` and 89° 44` east latitude. It is bounded on the north by Rampal upazila, on the east by Morrelganj and Sarankhola upazilas, on the south by the Bay of Bengal and on the west by Dacope upazila of Khulna district [12]. According to CRA report, 2009, the livelihood groups and their corresponding activities of Mongla upazila are very much diversified. The major livelihood activities include farming, fish culture, agro-labor, fishing service, business, van/rickshaw (mechanized van) pulling, cart pulling, date/palm climber), carpenter (wood), masonry, pottery, boat plying, blacksmith, barber, handicraft, imam etc. [8]. In the upazila the distribution of working people shows agriculture 21.41%, fishing 6.23%, agricultural laborer 12.41%, wage laborer 13.39%, commerce 15.09%, and transport 1.94%, service 16.27%, others 13.26% [12].

2.2 Methods and Data Collection

In order to determine the vulnerability of agricultural production and to identify natural disaster simple stratified random sampling method was followed for selecting the villages in Mongla upazila. Mongla upazila consisted of 6 union parishads among them 3 unions were selected. The data collection methods included the Focus Group Discussion (FGD), structured interviews (questionnaire survey) with the community peoples, and oral talk with local experts direct field observation and Key Informant Interviews (KII). A total of 12 FGD sessions were conducted among farmers, day laborer, fisheries and female groups. A total of 144 respondents were selected from 3 villages for questionnaire survey. A total of 5 key informant interviews (KII) were done by sectoral specialists and social/community leader including upazila food and disaster management officer, fisheries' officer and agriculture extension officer of Mongla Upazila. The further necessary secondary data was pertaining by accessing the relevant information from different books, Reports, maps, website, daily newspapers, journal articles, research thesis, and data from different local government administrative offices like union and upazila office. During data collection the following questions were focused to get the information i) The major hazards of the study area resulting losses in agricultural production ii) The amount of the agricultural production of the area; and iii) The occupational pattern and changes of livelihood during and without disaster. This study was conducted from September 2013 to March 2014.

2.3 Data Processing and Analysis

After completion of all the relevant data and information, all of them were tabulated manually including editing, coding. All the data processing and analysis was done using Microsoft Office and Excel program. According to the United Nations Development Programme [23] defines Risk is conventionally expressed by the equation, Risk = Hazard + Vulnerability, [R= (H+V)]; other scientists defines Risk (disaster), vulnerability, and hazard, whose relations it convenient to schematize in a pseudo-equation: R = H x V, [24]. Therefore vulnerability assessment and computation was done following the equation; V= H x R, (Here, V = Vulnerability, R = Risk and H = hazard) [25].

Table 1. Demography and socio-economic status of the study area

No. of villages	76	Density (per sq. km.)	93
No. of Municipality	1	Literacy rate	57.2
No. union parishad	6	No. of cycle shelter	21
Total population (Male-71000. Female-65000)	137000	No. of river flow	02
Household	32383	Total agricultural land (acre)	3500
Average size of household	4.02	Diagnostic health center	2

(Source: BBS, District Statistics 2011: Bagerhat)

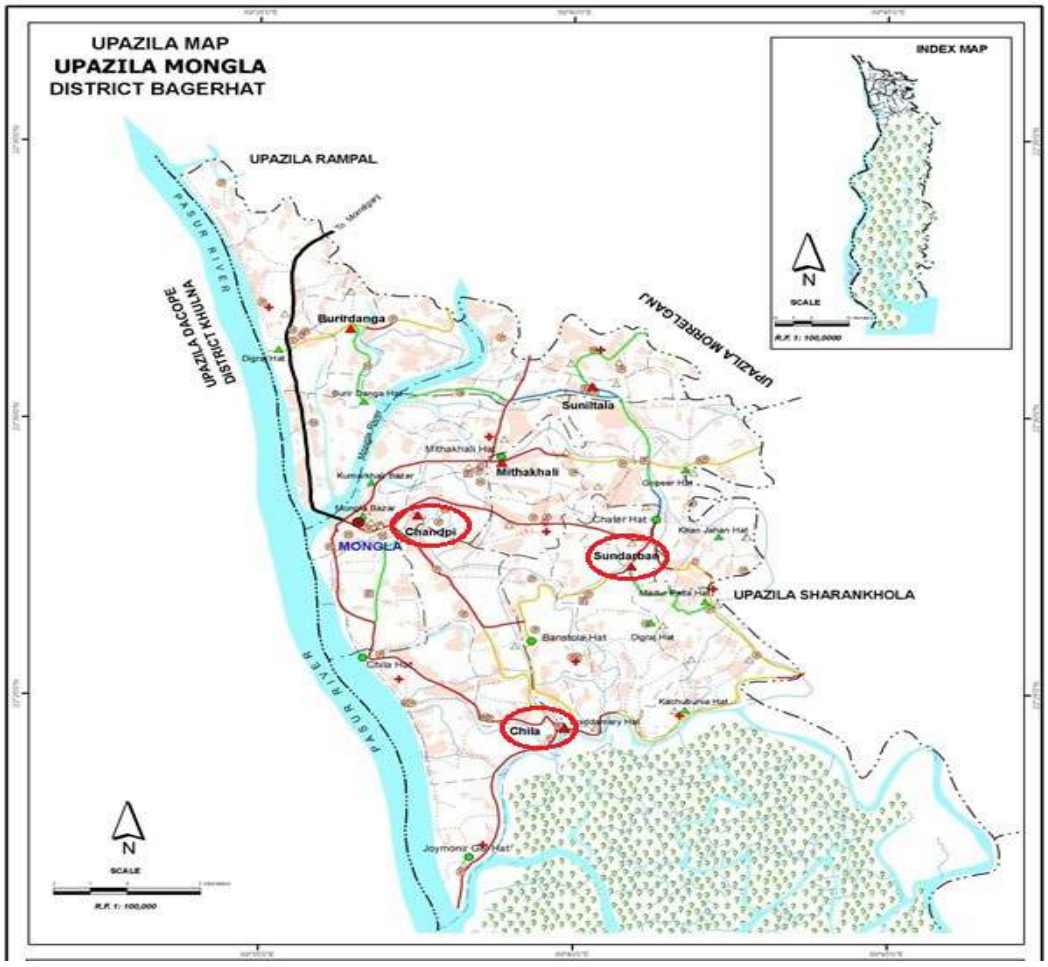

Fig. 1. Map of Mongla Upazila (Sub district), Bagerhat in Bangladesh (Source: GIS Centre LGED)

3. RESULTS AND DISCUSSION

3.1 Economic well-being and Household Information

Based on the research analysis among 144 respondent of the study area, 60% were male and 40% were female. Herewith, 46% respondent age was between 30-45 years old; 32% were 15-30 years old. The study depict that 70% respondent have elementary education and 20% of have secondary education. According to the Table 1; 55% respondent income were below 5000 (BDT)/month and 20% respondent were 5000-10000 (BDT)/month. On the other hand, in the study area 55% of the respondent average land size was below 33decimal; 15% was above 100 decimal. The study revealed that 48% respondent have farming experience of at least 10 years, 37% up to 10 years and 15% above 25 years. It has found that 40% respondent occupation was both fishermen and forest dependent; 31% respondent was farming (agriculture) and 19% day laborer. As the Mongla upazila is situated in bank of Pasur big river and opposite side of Sundarbans. Almost about 60-70% percent people are living below poverty line. Most of the people at Mongla engage in agriculture, fishing, day labor, Port labor, shrimp farming and minor forest product (honey, nypa, fish, fuel) collection from Sundarbans [13].

3.2 Hazards Identification

According to the Table 2; identification and prioritization of climate vulnerability; the prioritization was being done considering the frequency, intensity and level of impacts of the

disaster on key resources and livelihoods. The overall present hazards of the Mongla Upazila have been identified through exchanging view with the general people through Focus Group Discussion (FGD) from the recent experiences/events of the last 5-10 years.

3.3 Seasonal Calendar of Agricultural Production

The seasonal calendar of agricultural practice (Table 3) is formed by ground checking through direct conversation in the consultation meeting with the local people in the study area. The total agricultural practices of Mongla Upazila has been categorized as Aman paddy, Rabi crops, fruits like guava, sapoda, coconut/narikel, supari/betal leaf nut/areaca nut, jujube/kul, mango/amm, Boro paddy and IRRI paddy.

Table 3 showed that, respondents of study area mainly engaged with agricultural production. Aman paddy occupied the major contribution in the agricultural activities. Aman is planted in the mid-month of July and harvested in the month of January. On the other hand Rabi crops are practiced in the month of November and harvested in the months of February-March. Nevertheless, IRRI paddy also contributes in agriculture. Although it is cultivated in whole year mainly it is harvested in the months of March-April and December-January. Last two years the Department of Agricultural Extension (DAE) of Mongla upazila tries to practice Boro paddy in some selected fields. Except the agricultural practice major portion of people are engaged in various types of non-agricultural works. Among the fruit species, most of the people were practiced in the cultivation of planting indigenous species like guava, kul, mango, narikel, supari etc. Some livelihoods activities were carrying out almost throughout the year such as: shrimp and fresh fish collection, shrimp fry collection, cottage industry, poultry farm, day labor, van puller and nosimon (mechanized van) driver, fisherman, small traders, country boat and trawler driver, mobile small business, water business, bricks and silica/sand business, rearing livestock, service holders, carpenter, golpata (Nypa)/goran collection, bawali, mowali etc.

3.4 Vulnerability of the Socio-Economic Variables

The Socio-economic variables identified those sectors all of which are concerned with the economic vulnerability. Previous research found that, Aman and Boro paddy were identified as severely vulnerable due to salinity. Among the entire fisheries sector, including shrimp, prawn and white fish, was also seen as highly vulnerable due to the problems of salinity, virus attack and cyclones. On the other hand, the farmers and agri-labors are severely affected due to the impacts of salinity. The main cause of this severity is due to the extensive practice of gher farming and this type of farming is controlled by local leader. As a result, others farmers and agri labor were also identified as severely vulnerable [14].

Table 4 depict that, Fisheries sector (shrimp, prawn and white fish) of the study area is highly vulnerable due to the problems of salinity, virus attack, cyclone etc. Homestead tree species also highly vulnerable for the problems of salinity, water logged, cyclone and tidal surges. It was found from the field observation, questionnaire survey, KII and FGD, the most of the land area of study area is now practiced by the shrimp gher (small area inundated by saline water for shrimp cultivation) farming. There is no available grazing land for livestock farming and thus cattle were severely vulnerable condition and suffering from nutrition. Among the occupational practice, farmers and agricultural labors are severely affected due to extensive practice of shrimp gher farming and the total shrimp gher farming is controlled by some local leader. As a result, the poor farmer and agricultural labors are in severe vulnerable situation. Kacha house and Kacha road are highly vulnerable to hazards like flood, water logging and tidal surge. Drinking water scarcity and ground water lifting for irrigation purposes were also the major problem of the area. Previous research showed that salinity was extensively recognized as a major problem for the community agriculture, fisheries, biodiversity, trees and plants, are all highly vulnerable and very few perceived an increased risk due to climate change [14].

3.5 Vulnerability with Respective Hazards: People's Perception in the Sense of Agricultural Production

3.5.1 Hazard's impact on agricultural production

The study revealed that (Fig. 2), 88% respondent opined that most serious hazard for decreasing agricultural productivity of the study area is salinity; 4% respondent opined that water logging

possess hazards and 3% respondent given their opinion both tidal surges and flood retain hazards for decreasing agricultural productivity. The main cause of decreasing agricultural production is the rapid expansion of shrimp farming over the area. By using tidal fluctuation enter saline water into gher area for shrimp farming. For extensive shrimp farming in present few years the salinity level of land has been increased and the productivity has been decreased gradually. Increase in salinity intrusion and increase in soil salinity will have serious negative impacts on agriculture. In Bangladesh, rice production may fall by 10% and wheat by 30% by 2050 [15]. Impacts of Salinity 10% more land (relative to 1990) will be saline-affected and intensity will be increased by 10%; Decreases availability/ productivity of agricultural land Creates socioeconomic problems, generally women is more vulnerable [17].

3.6 Adaptation Strategies to Minimize the Vulnerability of Agricultural Production

The study analyses that the perception levels of adaptation option from the respondent were determined through the questionnaire survey, FGD, KII and field level direct observation. The database in this regard denotes only three problems are mostly identified for agricultural productivity induces vulnerability. The following figures (Fig. 3, Fig. 4, Fig. 5 and Fig. 6) showed different strategies of adaptations is taken by the community people for reducing vulnerability of agricultural production.

Table 2. Present hazards of Mongla Upazila in Bagerhat

Present hazards	Households percentage (%)	Prioritization
Increase salinity in agriculture field and homestead pond	79	1st
Water logging during tidal Surge due to siltation in the river	66	2nd
Cyclone	56	3rd
River bank erosion during tidal surge	30	5th
Crisis of fresh water for agricultural crop and fish culture	18	7th
Flood due to climate change	27	6th
Shrimp cultivation by local leader	46	4th

(Source: Field surveyed data)

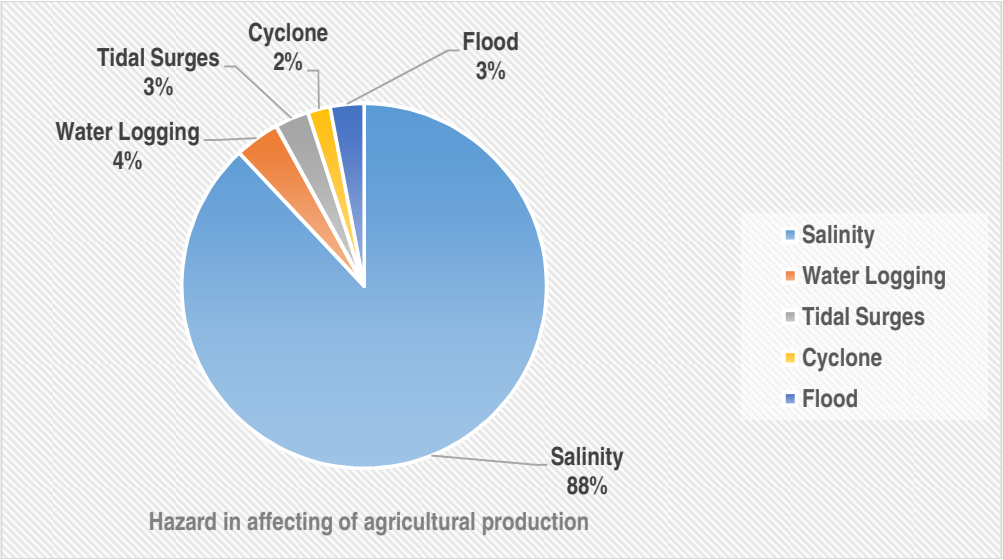

Fig. 2. Percentage of hazard in affecting of agricultural production
(Source: Field surveyed data)

Table 3. Livelihood activities and seasonal calendar (agriculture) of the study area

Main sources of livelihood	Season											
	Boishakh	Jyostya	Ashar	Sraban	Badra	Aswin	Kartik	Agrahyan		Poush	Magh	Falgun	Choitra
	Apr.	May.	Jun.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Aman Paddy													
Rabi crops													
Guava, Kul, Mango													
Boro, IRRI, paddy													

(Source: Field surveyed data)

Table 4. Vulnerability status of socio-economic variables of the study area

Major hazards of Mongla upazila: Salinity intrusion, Water logging, River siltation, Cyclone and Storm surge, Floods, Virus attack etc.				
	Hazards induced vulnerability status of Mongla upazila			
	Socio-economic variables	**Vulnerable elements**	**Ranking of vulnerability**	**Most affected sectors**
	Agriculture	Aman and Boro	++++	Aman and Boro
		Robi crop	+++	
		Wheat	+	
		Vegetables	+++	
		Fruits	+++	
	Fisheries	Shrimp	+++	Shrimp farming
		White fish	+++	
		Crabs	++	
	Forest	Forestry/Trees	++	Homestead plants
		Homestead plants	+++	
	Livestock's	Cow	++++	Cow
		Goat	++	
		Poultry	+	
		Duck-hen	++	
	Occupation	Agriculture labor	++++	Agricultural labor
		Business	+	
		Fishing	+++	
		Formal services	+	
		Informal services	++	
		Handicraft	++	
	Infrastructure	Kacha road	++++	Katcha road
		Pacca road	+	
		Office	+	
		Health care center	++	
		Educational Institution	+	
	Shelter	Pacca house	-	Katcha house
		Semi-pacca house	+	
		Kacha house	+++	
	Health	Physical/mental health	+++	Physical and mental health
		Maternal health	++	
		Child health	++	
	Water supply and Sanitation	Drinking water	++++	Drinking and irrigation water
		Water for domestic use	+++	
		Irrigation water	++++	
		Sanitation facility	+	

Notes: Ranking of Vulnerability
(Source: Field surveyed data)
++++ = severely vulnerable; +++ = highly vulnerable; ++ = moderately vulnerable, + = vulnerable; ─ = No vulnerable

The perception level of adaptation for salinity problem in agricultural production; 81% respondent opined that change/shifting their agriculture based occupation; 79% were saline tolerant rice (HYV) cultivation as a part of adaptation options. At the same time research revealed that 36% respondent said, the farmers has taken loan for agricultural practice; l4% viewed that people think to migrate from the place (climate refugee) as their adaptation approach resulting from low agricultural productivity. The graph exhibit that (Fig. 4) in case of water logging perception level of adaptation option is given by the adapt with

water logging problem 36% of population think to changes agricultural based occupation and canal cutting to drain out water, 21% respondent viewed delay crop cultivation consider adaptation practice in water logged situation. According to the Fig. 5, about the perception level of adaptation option for cyclone and storm surge of agricultural production, after taking place of a cyclone 45% of respondent take loan for agricultural production to cope with the vulnerability. In case of storm surge 43% of respondent views is to build embankment around the agricultural land for protecting the entrance of saline water into their farm land. Here, 79% respondent recommended that require modern techniques (adaptation options) in crops cultivation; 55% construct sluice gate to reduce water logging and 50% opined both re-excavate of canal, river, and streams and to enforce reducing of shrimp culture.

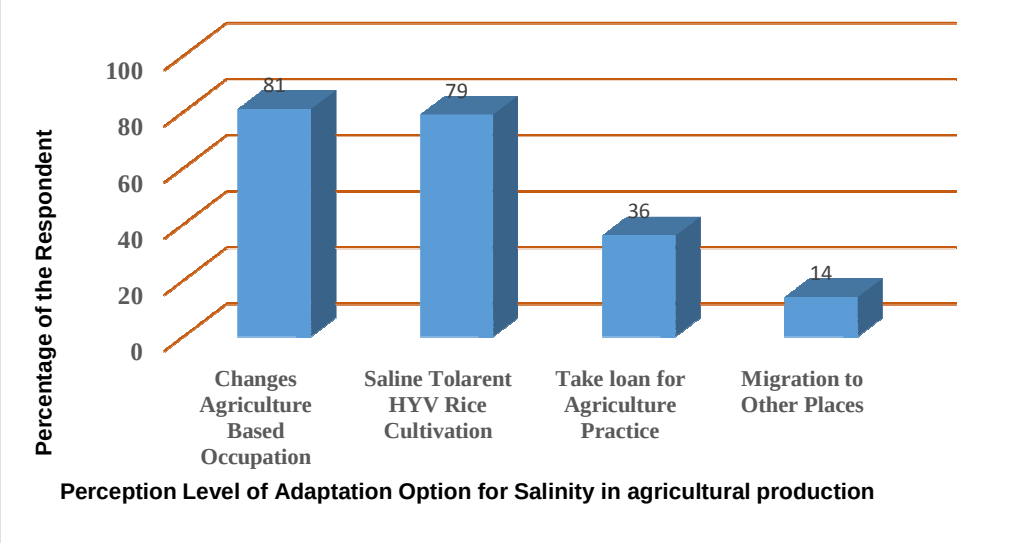

Fig. 3. Respondent perception on local adaptation option

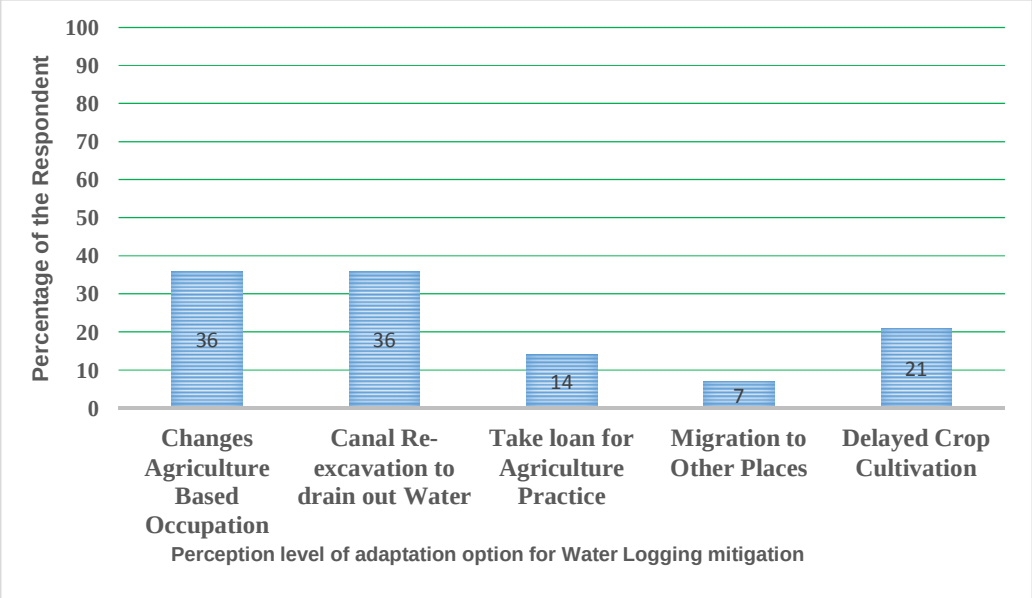

Fig. 4. Perception level of adaptation for water logging in agricultural production

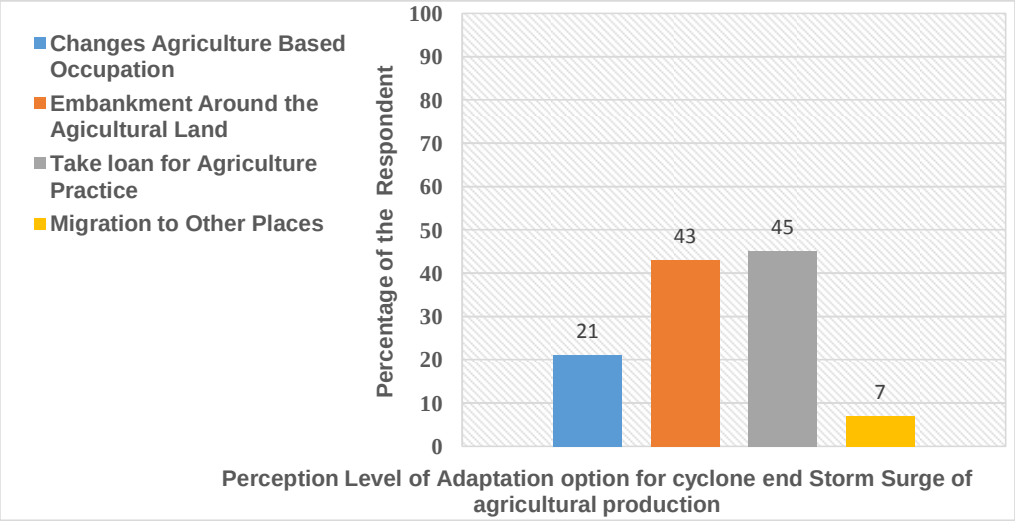

Fig. 5. Perception level of adaptation option for cyclone end storm surge of agricultural production

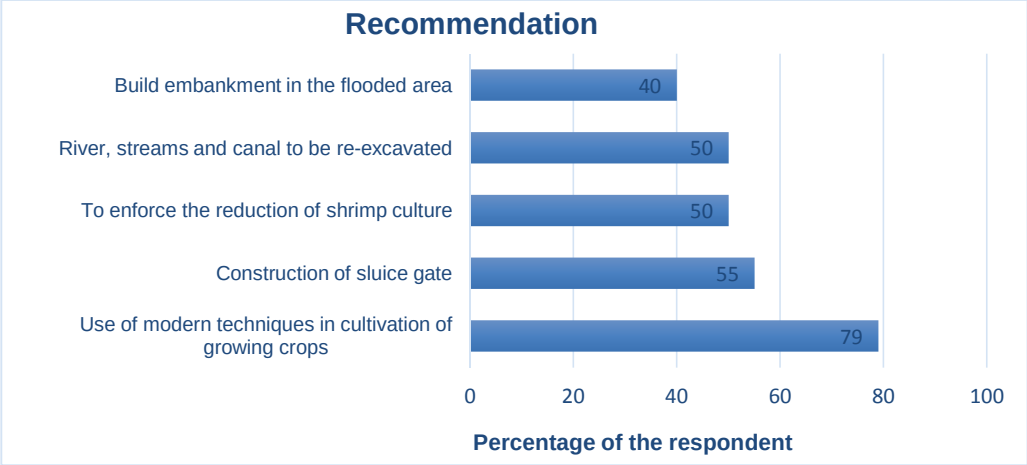

Fig. 6. Recommendation of the respondents

4. CONCLUSION

Bangladesh is a disaster-prone country almost each year, the country experiences to disasters such as tropical cyclones, storm surges, coastal erosion, floods, and salinity intrusion causing heavy losses for farmers and agriculture sectors. Agricultural activities are by nature prone to risks and uncertainties of various nature- biophysical, abiotic, climatic, environmental, biotic (pests, diseases) and economic. Due to different types of hazard like salinity intrusion, water logging, flood, cyclone and tidal surges causing the agricultural productivity gradually low down and makes the people economically vulnerable. Among them most remarkably, salinity was extensively recognized as a major hazards for the community, agriculture, livestock, agriculture labor, and water supply and sanitation. Present research shown that delayed crop cultivation, shifting agriculture based occupation, saline tolerant rice cultivation, changing cropping pattern, rivers, streams and canals re-excavation to drain out water, built embankment around the agriculture land were adopted by the farmers to cope with climate vulnerability. The study also revealed that, although a variety of low cost, indigenous technologies have been used as adaptation strategies within these communities are not enough or modernized to minimize the vulnerability. Future research will help the policy maker to make local level adaptation plan and

farmer's friendly participatory climate vulnerability assessment plan which will benefit that community to ensure sustainable agriculture.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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