



Climate change adaptation strategies: a prospect toward crop modelling and food security management

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Abstract

This study is to assess the current trend of implemented climate change adaptation strategies, food security management system, and crop modelling in the context of Lechraganj Char Union, Harirampur Subdistrict, Bangladesh. The adverse impacts on the local char dwellers of various major disasters in the study area are mainly drought; flood, riverbank erosion, and norwester accelerated by climate change were elaborated in this study as well. This research paper also analyzes the implemented pre-disaster and post-disaster approaches of various climate change adaptation strategies to insecure the food security system by the local villagers. Both primary and secondary sources were used to illustrate the research problem and receiving proper outputs from the précised structure of the study. The nature and types of food insufficiency, migration process, occupation changes, agriculture process, socio-economic condition, and governmental and non-governmental organization steps in the study area were considered as research trimming.

Keywords Climate change · Adaptation strategies · Natural disaster · Food security · Food insufficiency

Introduction

The average condition of temperature, air pressure, rainfall, and humidity can be defined as the weather of a particular place, and usually, the analyzed average stipulation in the range of 25–30 years of the weather of a specific area or region may be considered as a climate (Sen et al. 2009). Climate change can be defined as the logical and recorded assessment of the trend of modification of elements and characteristics of the minimum climate change by the range of 50–200 years. Destruction of the precious ozone (O₃) layer in the atmosphere and global warming due to the excessive emission of carbon dioxide (CO₂) aggregates the process of climate change to several countries of the world

in a very alarming rate (Albaba 1993; Barton 1997; Fankhouser 1997; Feenstra and Buton 1998).

Bangladesh is one of the most vulnerable countries in the world for climate change and global warming due to its geographical position and the manmade process of over emission of CO₂ gas by the wealthier and industrially developed countries as well as their own industrial revolution and rapid urban growth (Bohle et al. 1994; Carter et al. 1994; Denevan 1983; Kates 2000). The country is in the startling position for global warming and climate change as the rise of temperature, lower rainfall, and flash floods by her rivers, which causes various natural disasters all around the country (Frederick 1997; Hardesty 1983; Huq 2001; Smithers and Smit 1997). By the sudden hit of these natural disasters aggregated by the climate change process; the normal lifestyle and livelihood of rural communities are being oppressed, and rural poor or subleased farmers, fishermen, blacksmiths, potters, women, and children have to face a lot of sufferings.

In recent days, it has been a really highly taught job to feel any of the other seasons excluding summer, rainy, and winter due to the impacts of climate change; thus, autumn is not so visible in recent days in the country (Klein and Tol 1997; Smith and Cenhart 1996; Wigley 1985). The average temperature of the north-western side of the country is almost 10 °C and 20 °C in the coastal areas during the winter

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season. The temperature of the coastal areas in the summer season is approximately 27–29 °C and the average temperature of the north-southern side in rainy season found nearby 29 °C. Average autumn temperature is in between 23 and 25 °C in all the country round. In each of the sections, the temperature has been increased of 3–7 °C from the 30 years previous temperature data (Datta et al. 2018; IPCC 1996). Thus, various natural calamities such as flood, salinity, nor-wester, tornado, tidal bore, drought, waterlogging, riverbank erosion, landslide, etc. were taken place in the country.

We have a lack of essential capital as well as skilled professionals with regards to mitigating the adverse impacts of climate change. Thus, the local rural people should adapt some wise strategies to earn the capability of facing the impacts of natural calamities and climate change. Proper propagation and planning of various adaptation strategies should be introduced to the village people of the country by the local government and non-governmental organizations, have become a key factor of mitigating of climate change impacts. About 95 natural disasters induced by climate change were taken placed in-country by the year from 1991 to 2009; which causes the demolition of 590 crore dollars in the sectors of agriculture and architectural structures. Almost 830 thousand hectors of agricultural lands were turned into barren land due to the drought aggregated by the climate change process. These disasters bring huge sufferings for the local people and also provoke various diseases, such as dengue, malaria, cold fever, diarrhea, asthma, headache, arthritis pain, lack of nutrition, etc. (Islam and Alam 2004). Besides this, a normal and professional lifestyle of people being hampered by these adverse impacts; creates the vulnerability of food security.

Adapting with the changing climate by implementing various indigenous strategies called as the climate change adaptation and it also refers to the adaptation of new environment, socio-economic condition, as well (Smit and Menabb 1997; Blaik and Wisner 1994; Titus 1990). The adaptation strategies were used to insecure the food security and for searching better options to solve the negative impacts of climate change and to improve the life standard (International Federation of Red Cross and Red Crescent Societies 2009). Major adaptation strategies of climate change were executed on by most vulnerable and disaster-prone area people suffering from a huge risk of the impacts. People of different villages of various subdistricts in Bangladesh, nowadays, were being alerted of various adapting strategies for climate change to deal with the impacts of above-mentioned disasters (Smith and Barton 2000). In the Haor regions of Bangladesh, local people uses a dry straw, bulrush, holt, dolkumri, bamboo, muck sticks, etc. to save their home and pets and sow Churakka and Amon rice seeds before the flash flood. Again, the people living near the bank of Jamuna River preserve some dry foods, such as nuts, sesame, linseed, wheat,

parched rice, cake, sugarcane, sugar, biscuit, etc., for the upcoming flood seasons as their food security. The Rakhine communities of coastal regions made high entresols to free from the impacts of tidal bore accelerated by climate change (Shahzahan 2009).

The broad aim of this research is to identify and assess the real scenario of implementing climate change adaptation strategies to ensure food security and management and crop modelling. Research objectives are mainly to identify the major disasters accelerated by the impacts of climate change and those impacts on the food security exiting in the study area; to assess the implemented pre-disaster and post-disaster climate change adaptation strategies applied by the local people on various fields of agriculture, socio-economic fields; and to assess and identify the real scenario of the agriculture structure and food security management of the study area as well as applied adaptation strategies to ensure food sufficiency. The study of climate change adaptation strategy and food security management is proposed by the influence of the personal field interest and academic field arena of the authors. The working (non-directional alternate) hypothesis of the research was—there may have some existing climate change adaptation strategies implemented by the local char dwellers in the study area; which ensure the food security system as the acceleration of various disasters taken place by climate change. The major scopes of the study are climatology, natural hazard and disaster, climatic risk and vulnerability, climate change, climate change adaptation strategy, food Security, agricultural geography, socio-economic geography, and so on. The ethical considerations of this research work were assuring the privacy of the research and appropriate use of it; including no harmful issues which affects individual or a community and society; follow human and property rights carefully during data collection and other field techniques and issues which can have an adverse impact on the biophysical environment were always been evaded.

Materials and methods

Both primary and secondary data sources were used to shape the research work. Various types of qualitative and quantitative techniques such as participatory observation, structured closed questionnaire, in-depth interview, focus group discussion, photograph taking as primary data sources and related books, journal articles, government and non-governmental organization information used as secondary data sources after assuring data reliability, truthiness, and validity to identify the existing climate change adaptation strategies and food security system. In this research, 50 structured closed questionnaires, in-depth interview, and five focus group discussions were conducted from various people of different occupations

such as farmers, housewives, teachers, fishermen, students, day labors to elaborate the existing situation, and information obtained from local poor farmers was given priority for the expressive concept.

Study area

Lechraganj Char Union of Harirampur subdistrict in Manikganj District is an island bar of the great Padma River standing on the southeastern part of Harirampur Sadar and Boyra Union of Harirampur subdistrict in Bangladesh (Islam et al. 2017). The total number of households is almost 2653; where the population is 11,853 (male 5793 and female 6060) people lives in union (BBS 2014). This char union is flooded during rainy season almost every year as well as existing bank erosion process by the Padma River. Thus, the Union is created naturally by the force of erosion and accretion process of the Padma River (Fig. 1).

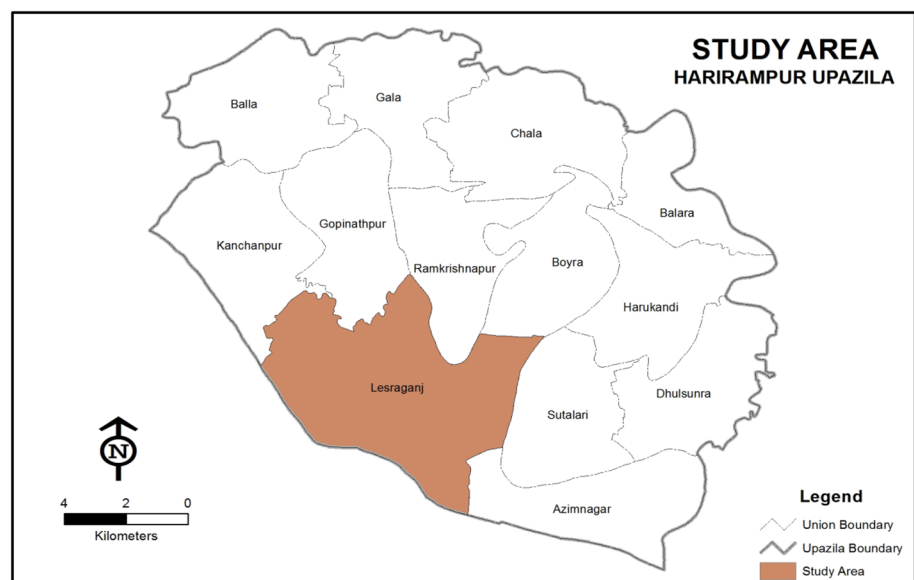
The island is about 10 km west by the river way from the south riverport of Andharmanik village of Harirampur subdistrict, only having one communication system of trawler or boat with the mainland. Due to its geographical position and an island bar of Padma river; Lechraganj Union is an alarming zone for various natural calamities accelerated by the influence of climate change. Various types of natural calamities were taken place in every year and having a great adverse impact on the livelihood of the local people; mainly the farmers. Thus, they implemented various indigenous adaptative measures to reduce the impacts and insecure their food security.

Results and discussion

Food security is generally defined as the availability of food for existence and fulfillment of standard nutrition level of human beings in the global, natural, regional, or any other social micro-unit context (Anderson 2008). Harirampur sub-district of Manikganj district is one of the most vulnerable areas for its geographical context, various natural disasters, and food insufficiency. People of this region face various types of natural disasters, such as flood, drought, bank erosion, and norwester almost every fiscal year. These disasters trigger the existing food security management system through damaging and hampering regional crops, reducing crop productivity.

The crop productivity of Lechraganj Union changes rapidly during flood events. Local farmers make a selection of crop types and change their cropping pattern depending on the alluvion or sediment inundation. In previous years from 2000 to 2013, the production of rice was very high. However, in recent times, people are getting more interested in various Rabi crops instead of rice due to the damaging nature of climate change-induced high-volume floods. Most of the local peoples also used to rear various domestic animals, such as cow, goat, sheep, ox, etc., which are very helpful for increasing land fertility through their muck. Insecticides were used in household and bar lands for organic cultivation of vegetable, masala, wheat, payra, sesame, tishi, etc. Local char dwellers share all those seeds with each other for better profit. The current price of 2.47 acre in Lechraganj Union is approximately 80,000 BDT. The production of Maskalai is quite satisfactory and the cost of production process found very low. Almost 10 mounds of Maskalai can be produced in 2.47 acre. Again, the production of lentils found very low in the

Fig. 1 Study area in Harirampur subdistrict



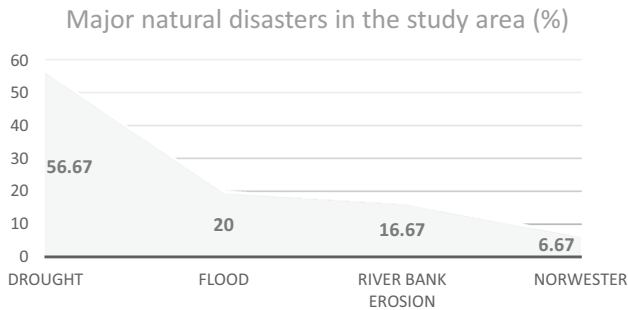


Fig. 2 Major natural disaster risk for food security in the study area

study area. The cultivation of wheat is very popular to the local people. Nearby 30 mounds of wheat can be produced in 1.23 acre of land; priced as 700 BDT/mound. Hijoldigha, Jholdigha, Vhawaijhak, Choto-vhawaiilla, Boro-vhawaiilla, etc. were cultivated as a pre-flood adaptation strategy. 75 mounds of Boro rice were produced in the same area. Sometimes, the production of Boro rice reduces if the amount of sediment found higher. *Triticum aestivum*, Maskalai, lentils, wheat, maize, etc. were cultivated in the July–August season as an adaptation strategy during extreme drought. The local area people also cultivate various types of vegetables and spinach, such as Edible root, Mallet, Katanhotta, Dolonhotta, Punk spinach, Telakucha spinach, etc., for ensuring their food security.

Various adaptation strategies and existing food security management system

Lechraganj Union is one of the most vulnerable regions of Harirampur subdistrict for climate change. Various types of natural disasters, such as drought, flood, bank erosion, norwester, etc., were taken place by the adverse impacts of climate change. Local village people adapt various strategies during pre-disaster and post-disaster periods to ensure food security system (Fig. 2).

Drought

Drought is one of the major climate changes induced natural disaster which has a great adverse impact on the existing food security management system and food sufficiency. Drought took place almost every year in the season of March–April and damages most of the cultivatable lands. People used to cultivate wheat, maize, Irri, sesame, kaun, kalai, lentils, *T. aestivum*, onion, garlic, etc. during the drought seasons. These crops were selected due to their less damaging and cost-effective nature in those seasons. People also cultivates wheat, payra, Boro, potato, mustard, sugarcane, nut, peanut, chili, chickpea, blackjack, Punk spinach, Matty, etc. in these seasons (Fig. 3).

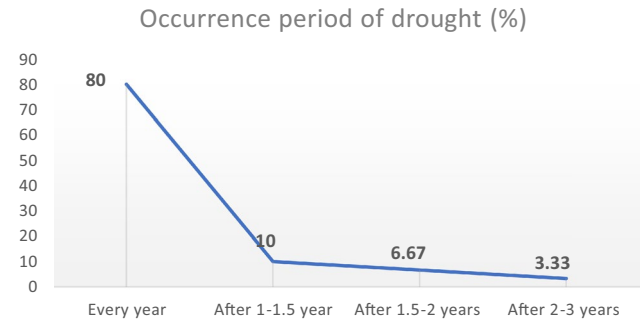


Fig. 3 Occurrence period of drought

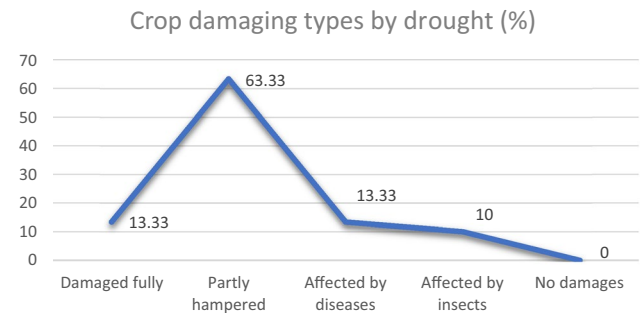


Fig. 4 Types of crops damaged by drought

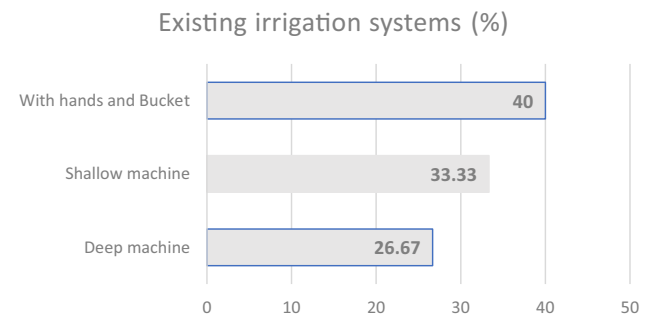


Fig. 5 Types of existing irrigation systems

Local farmers use frequent irrigation process (2–3/day in average), latest fertilizers (Uria, TSP, Potash, etc.), and insecticides for saving their crops from damaging and diseases (Fig. 4).

Farmers who are economically sound mostly use deep pump irrigations system through electricity to reduce the adverse impacts of drought for their crops and ensure food security. Maize, Irri, and jute are mostly cultivated during the drought seasons in the study area. Various types of diseases and insects affect the crops if adequate irrigation system was not assured (Fig. 5).

The amount of sandy soil found very high during the drought seasons, which have to be converted into fertile

lands using various fertilizers. Farmers share seeds with each other in the time of seed insufficiency. The food security system outbreaks and the production of crops being reduced highly in the extreme drought situation. Local poor people and farmers used to strive their days with two-time meals or two-time half meals instead of three times. Some people used to take their breakfast first and eat only the dinner after the whole day in the late nights. They also frequently visit the community clinic after being affected by various diseases and lack of proper nutrition due to their irregular food habits and food sufficiency.

People preserve molasses, chira, parched rice, biscuits for recovering their food deficits, and also as their lunch items. Again, some people took loans from various NGOs (BRAC, Grameen Bank, Gonokollan Trust, Asha etc.), relatives or neighbours, and pay them by selling their crops or seasonal day laborer works in Faridpur, Jashore, Sylhet, Dhaka, and Manikganj. Some people used to pull rickshaws and working in the brickfields for their livelihood. The water from the tube well reduces highly due to lowering down of groundwater level and aquifer in the extreme drought seasons and have to be pushed very hard for its proper functioning. The amount of relief food items are very low from the government and NGOs distributed during this period. However, only a few numbers of NGOs (BRAC, BARCIK, IFRC, etc.) help local villagers by providing the support of free seeds and proper directions for profitable cultivation.

Flood

Lechraganj Union of Harirampur subdistrict is frequently inundated with flood events as it is an island bar in Padma River. The impacts of climate change-induced floods are rising and becoming devastating day by day. High-volume floods occur after every 3–4 fiscal years and the most devastating ones were in 1988, 1998, 2005, and 2007 (Fig. 6).

Households and infrastructures were half or fully gone underwater during extreme flood events and people take shelter on their roofs or government shelters on that time. People construct new houses or repair their existing ones

as an adaptative approach. They also use an extra or open cook and preserve various dry foods, such as parched rice, chira, biscuit, etc. for assuring their food security. They also clean their all domestic wastes and weeds as their adaptative measures before floods. They squeeze the graves of their previous ancestors or relatives in front of their houses with mud or bamboo to protect them from washing away in the flood seasons. Sufferings have no bounds if the houses of local dwellers were destroyed or washed away during flood events and they have to repair them through various day laborer works in the post-disaster period. The existing food security system faces a troublesome period and creates high risks of people’s starving in those times. Various types of crops and grains, such as Amon, Aus, Irri, kalai, kaun, wheat, maize, barley, jute, sugarcane, etc., were washed away or damaged during this season. The use of various fertilizers and pesticides has to be increased in these post-disaster situations. Farmers of the area were able to collect only 20–25 mounds of Amon instead of 40–50 mounds in general periods. Rats and other worm insects hamper greatly and various crop diseases increased rapidly after flood events (Fig. 7).

Various types of rice such as Amon, Aus, Irri, Boro, Manik, Kala-manik, Amboroi, Morichful, Choitali, Modhusail, Dudhsail, Tilbazar, Roya, Hijoldigha, Rajadigha, etc., were sowed before flood events as they are less impacted and increase with the water level. The middle-aged women cultivate various types of vegetables, such as vendee, jhinga, puquerade, Red-spinach, gourd, eggplant, ropes, chichinga, bloom, rice-ball, chili, tomato, etc., to secure their food availability in pre-flood seasons. The proper availability of various rice seeds, such as Aus, Amon, jute, etc., was reduced and very costly after floods. The price of different fertilizes (TSP, Uria, Potash) were also rose to almost 100–150 BDT. Thus, farmers have to preserve all those items from before. Some local farmers choose fisherman profession in the post-flood seasons. They used to catch various types of fishes, such as Carp, Sola, Gazer, Carrion, Hilsa, Coyote, Rosewood, Chanda, Prawn, Taki, Putti, Boal, etc., for their proper food sufficiency (Figs. 8, 9).

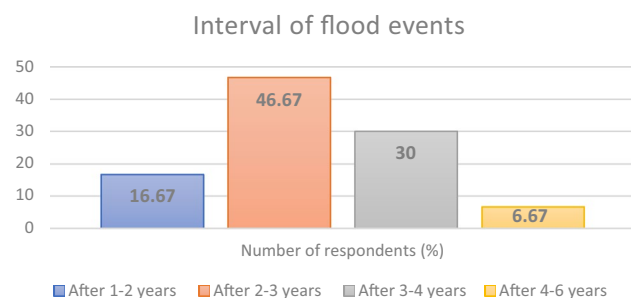


Fig. 6 Occurrence interval of flood events

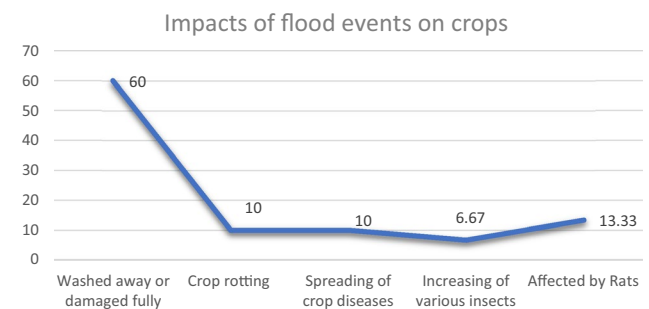


Fig. 7 Impacts of flood events on crops and grains

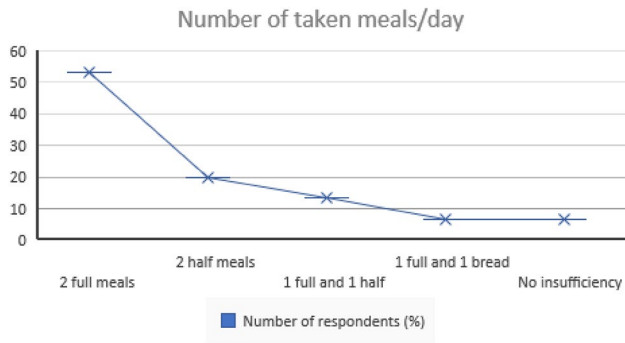


Fig. 8 Types of food insufficiency during floods

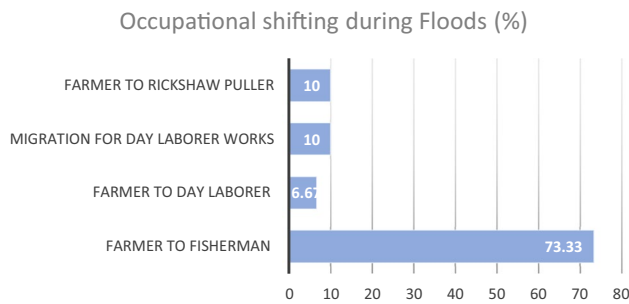


Fig. 9 Occupational shifting during flood events

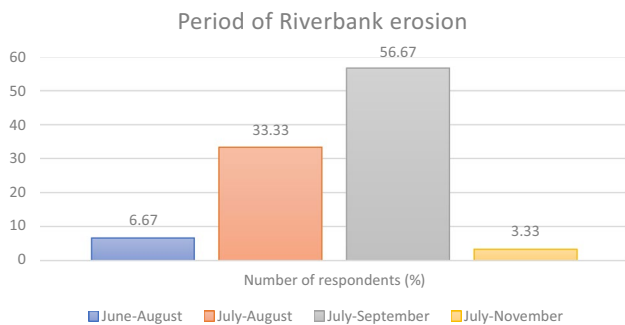


Fig. 10 Occurrence period of riverbank erosion

Local farmers of the study area recover the adverse impacts of the flood on their household and others by borrowing money from their relatives, neighbours, selling their domestic animals, and trees (Mahogany, Hinge, Korai, Palm-tree, Mango-tree, Jarul, Black-tree, Kasha-ban, Hogala, etc.). About 8–10 kg rice, sari, blanket, saline, and other medicines and seeds were distributed among the affected peoples of the flood as a relief by the government. The International Red Crescent and Red Cross Society (IFRC) also distributes rice, biscuits, seeds, household building materials, and training to support the affected people of the region. According to our survey, 43.33% of local people responded yes to

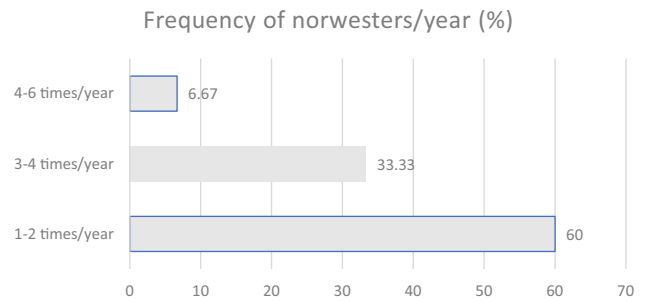


Fig. 11 Average frequency of norwesters in every year

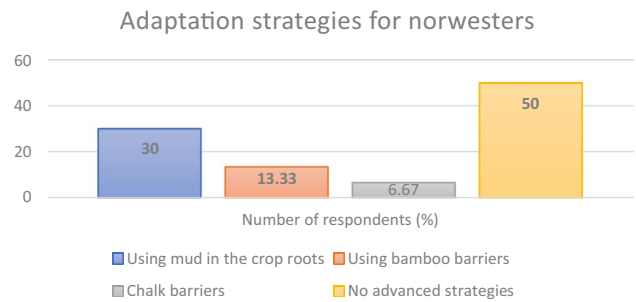


Fig. 12 Adaptation strategies for norwesters

receiving relief goods and 66.67% of people responded that they did not receive any relief goods from the government and NGOs.

Riverbank erosion

The study area is also facing high risks of riverbank erosion due to its geographical position during the flood seasons in every year (Ophra et al. 2018). The process of erosion extended up to 5–6 km in the area and affected highly in the year of 1998, 2000, 2001, 2005, and 2009 (Fig. 10).

Most of the bank areas of the study area are mainly government property. However, many influential government and local agents take control over them and rent them for cultivation to the farmers in exchange for money for a year or monsoon. According to the survey of the respondents, 16.67% of bank area lands are of the government property, 70% under the control of influential peoples, and 13.33% under the local villager ownership. The people living near the riverbank area are not too interested in the agricultural works due to bank erosion or cultivates less cost estimated crops, such as Amon, Aus, Boro, Digha, Modhusail, Joli, peanut, wheat, maize, kaun, kalai, sola, payra, Maskalai, onion, garlic, etc. As an adaptative approach, they also cut down the mature stage crops and bring them to their granary. However, sometimes, if they found the raw stage, then the

Table 1 List of cultivated crops in Lechraganj Union

Sl. no.	Name of the crop	April–May	May–June	June–July	July–Aug	Aug–Sep	Sep–Oct	Oct–Nov	Nov–Dec	Dec–Jan	Jan–Feb	Feb–Mar	Mar–April
1.	Boro		↑										
2.	Amon	○		○									
3.	Jute				↑								
4.	Coriander					○							
5.	Blackjack						○	○					↑
6.	Chili	○	○					↑					○
7.	Mustard												↑
8.	Payra								○	↑			
9.	Maskalai					○							
10.	Mung-beans					○							
11.	Almond		↑							○			
12.	Sesame			↑								○	○
13.	Kaun			↑									○
14.	Musuri												
15.	Tomato						○	○				↑	↑
16.	<i>Triticum aestivum</i>												
17.	Onion												↑
18.	Radhuni-saz												↑
19.	Garlic												↑
20.	Cauliflower						○	○					
21.	Gourd						○	○					
22.	Edible root			↑									
23.	Sugarcane			↑									
24.	Maty												↑

○ Time of seed sowing
 — Crop maturing stages
 → Time of storing in granary

farmers use them only for the food of their domestic animals or household fuel. To protect their bankside cropland; they arrange sediment sacks in the riverbank. Thus, they reduce their vulnerability of food insufficiency during the bank erosion of the mighty Padma River.

Norwester

Norwesters took place almost two-to-three times in every fiscal year in the study area; mostly in the March–April. High-speed norwesters (≥ 80 km/h) have huge adverse impacts on various types of crops, such as maize, sugarcane, Irri, Amon, Boro, etc. Thus, people cultivate various less impacted crops, such as kalai, sesame, nut, barley, payra, kaun, and so on (Fig. 11).

The upper portion of rice, maize, jute, sugarcane, etc. were broken down or laid due to the high-speed wind movement of the norwesters. Farmer uses mud in the crop roots and creates chalk or bamboo barriers to protect their crops from the impact of norwester. Impacted maize crops were used as the food of domestic animals. Some people took extra care and put potash fertilizer after the norwester events. This is how local char dwellers ensure their food security system during the pre-disaster and post-disaster period of norwesters (Fig. 12, Table 1).

Some other implemented adaptation strategies

In recent days, most of the farmer preserves various types of seeds, fertilizers, and pesticides as their effective adaptive approach of various natural disasters. They also used to sell their produced crops and unfertile lands in exchange for money to assure proper food security. Again, some of them sell their household fruit trees and other wooden trees from their houses. Almost 30–40% local people fulfill their daily necessary commodities, such as rice, flour, onion, garlic, sugar, milk, salt, chili, twig, etc., owing from their neighbouring shops or bazaars and later on pay them after crop retailing. Almost 2–4 cows or 3–5 goats or sheep were reared in most of the families. All these domestic animals were being protected from various disease infections and given on-time vaccines before flood events. They were also given healthy foods, such as chaff, chita, kura, grass, etc., for reducing disaster effects and finally sell them in their struggling periods.

Conclusion

The farmers and their family members of the study area are the most vulnerable people for existing various natural disasters and post-disaster periods. They used to adapt various

types of climate change adaptation strategies through their indigenous knowledge and face the challenges of securing their family food management system. During the pre-disaster and post-disaster period, they assure the availability of foods for their family through effective crop cultivation, vegetable cultivation, seed collection, use of adequate fertilizers, insecticides and proper irrigation system, collection of loans, dry foods, selling advance crops and trees, mortgaging their own lands, occupational change, and through other day laborer works. The current situation may be improved and proper food security can be assured by different governmental and NGO steps, such as enhancing proper propagation and trainings on various latest climate change adaptation strategies, building adequate awareness among the villagers, spreading various governmental adaptation supports, relief responses, increasing social services, and finally brings them under a well-structured guideline.

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