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# Climate Change Impact on Food Security: Evidence from Agricultural Sectors in Bangladesh

Syed Shoyeb Hossain*
Huang Delin**

**Abstract:** Bangladesh is known as one of the most vulnerable countries to climate change due to its geographic location. Majority of the people in Bangladesh are highly dependent on agriculture-based activities and fisheries. Agriculture sectors in Bangladesh are mostly affected by climate change and emerged as biggest developmental challenge for Bangladesh. Various undesirable climate effects such as sea-level rise, increasing temperatures, enhanced precipitation, and an increase in intensity and frequency of different natural calamities will degrade agricultural sectors in Bangladesh intensely mainly by reducing production in agricultural sectors. The analysis of this paper finds that the impact of climate change on agriculture in Bangladesh will result in problems with food security and may threaten the livelihood activities in near future. The rest of this paper constructs the potential impact of climate change on Agricultural sector in Bangladesh and links to the food security concern.

**Keywords:** Climate change, Food security, Social Vulnerability, Adaptation, Bangladesh.

## Introduction

Bangladesh, a low-lying country is well known globally as one of the most vulnerable countries due to climate change. Drought, surges, floods and tropical cyclones are widespread in Bangladesh and likely to become more frequent in upcoming days.The geographical location and geo-morphological condition made Bangladesh one of the most vulnerable to climate change. United Nations Development Programme (UNDP) has identified Bangladesh to be the most vulnerable country in terms of cyclone and the sixth most vulnerable country in terms of floods. Bangladesh's climate is subtropical monsoonal and summers are hot and wet, while winters can be quite dry, resulting in drought in some regions (Yu et al., 2010).Nowadays climate change as well as natural calamities decreases not only the production of agriculture but also the production of livestock farming. Bangladesh is a country where agricultural activities depend entirely on nature and climate change degrading this situation more intensely. Erratic rainfall, high and low temperature is hampering the agricultural production of Bangladesh in various ways. Food security has always been a national priority for Bangladesh. High population density (1117/km2) and low GDP (US$1900/year) put

* Syed Shoyeb Hossain, PhD Candidate, The Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences, 12 Zhongguancun Nandajie, Haidian District, Beijing, 100081, China. Tel: 86-132-6946-3239. E-mail: hossainsyedshoyeb@gmail.com

** Profesor, The Institute of Agricultural Economics and Development, The Chinese Academy of Agricultural Sciences, Beijing, China

food security as one of the key priorities for national development (Tandon, 2012; Faisal and Parveen, 2004). Climate change is multiplying the crisis by declining cultivated land and inaccessibility to fresh water supply. The primary objective of this paper is to examine the possible outcome of climate change and its impact on food security.The rest of this paper discusses the existing climate variability and future projection, economy-wide impact of climate change on agriculture and food security challenges in Bangladesh.

## Agriculture in Bangladesh

Agriculture is the cornerstone of the stability of the food security in Bangladesh. In Bangladesh, major crops like rice (73.94%), wheat (4.45%), jute (3.91%), rape and mustard (3.08%), lentil (1.54%), chuckling vetch (1.25%), potato (1.13%), sugarcane (1.12%), and chili(1.05%) are grown on one percent or more of the crop acreage (14.61 million ha). Meanwhile minor crops like Gram, millets, maize, onion, black gram, sweet potato, groundnut, green pea, sesame linseed, garlic, pea, barley etc. are grown on less than one percent of the gross cropped area (GCA) in Bangladesh. (http://www.banglapedia.org/httpdocs/HT/C_0376.HTM accessed on 19 June 2012). There are mainly two agricultural seasons Kharif and Rabi; and different kinds of agricultural products are grown on these particular seasons. Different season of agricultural products need certain weather condition to grow. Most agricultural lands in Bangladesh surrounded in coastal area and agriculture in those areas highly vulnerable due to global climate change activity such as sea-level rise, salinity intrusion and river flooding during heavy rains. Food security in Bangladesh will be vulnerable due to the effects of climate change hazard because its dependence on agriculture. Although the agricultural sector contribution to the GDP is only 16%. Climate change effect has already been noticed by many farmers in Bangladesh from many parts. One study found that 80% of farmers reported that they had noted changes in climate such as unseasonable rain, intense dry season, and less rain (Thomas et al.,2013). There agricultural land had also been affected by natural hazards such as floods, droughts and cyclones in the last five years and these effects are likely to continuously increasing day by day.

## Existing Climate Trend and Projection

Bangladesh,located in the delta of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna rivers and known as a riverine country; and nearly a quarter of Bangladesh is less than seven feet above sea level.The averages increase in temperature in Bangladesh would be 1.3°C and 2.6°C by the year 2030 and 2075 respectively compared to the base year 1990 (Ahmed and Alam, 1998). In Bangladesh a year can be divided into four seasons: the relatively dry and cool winter from December to February, the hot and humid summer from March through May, the south-west summer monsoon from June through September,and the retreating monsoon from October to November. The southwest summer monsoonis the

dominating hydrologic driver in the GBM basin and more than 80 percent of annual precipitation occurs during this period. Climate change has direct impact on precipitation and changes in precipitation due to climate will make immense threat to agricultural sectors in Bangladesh.

## Existing Climate Trend

Agriculture and Bangladesh are depended to each other. Bangladesh will continue to depend on the agriculture sector for her economic growth. Most Rural households will continue to depend on the agriculture sector for income and livelihoods. Increasing temperatures, changing rainfall patterns, rising sea levels, and increasing frequency and intensity of extreme weather events are very common in Bangladesh and the situation is degrading day by day. However, there is considerable debate on how adverse effects of climate change will genuinely be in different parts of Bangladesh in coming years.Figure 1 shows the trends in the annual and seasonal precipitation levels averaged across 32 rainfall stations (both BMD and BWDB stations) in Bangladesh between 1960 and 2001.The maximum rainfall occurs during the June,July, and August monsoon months (JJA). Neither the annual nor seasonal precipitation time series show any statistically significant changes over this time period.

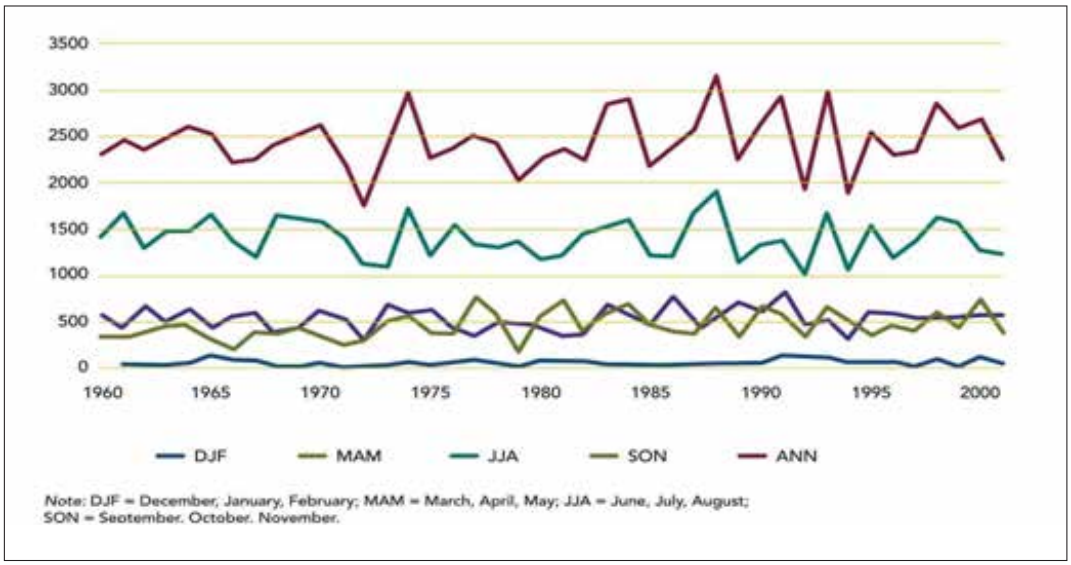


Fig.1: Annual and Seasonal (MM) Precipitation Averaged Across Meteorological Stations By Year.
Source: Yu, W.H., et al. (2010)

Table 1shows pick discharges during severe flood events with dates in the three main rivers and it indicates that the timing of the peak discharges of three rivers does not coincide on average. The Brahmaputra peak time is in July and August and starts rising

in March because snow starts to melt in the Himalayas this time. Meanwhile the Ganges peak time is in August and September and starts rising early June. Monsoon rainfall occurs in the Brahmaputra and Meghna basins earlier than the Ganges basin (The Bangladesh Water Development Board).The 1998 flood dischargein the Ganges and Brahmaputra rivers was evenhigher because all three rivers had peaks within one week of each other. In 2004, the Ganges and Brahmaputra peaked early (See Table 1).

**Table1:** Pick Discharge and Timing During Extreme Flood Years

| Extreme Years | Brahmaputra | | Ganges | | Meghna | | Return period (area) | Return period (vol) |
|---|---|---|---|---|---|---|---|---|
| | Date | m3/s | Date | m3/s | Date | m3/s | | |
| 1974 | 7-Aug | 91,100 | 3-Sep | 50,700 | - | 21,100 | 7 | 7 |
| 1980 | 20-Aug | 61,200 | 22-Aug | 57,800 | 7-Aug | 12,400 | 2 | 2 |
| 1984 | 20-Sep | 76,800 | 17-Sep | 56,500 | 17-Sep | 15,400 | 2 | 4 |
| 1987 | 16-Aug | 73,000 | 20-Sep | 75,800 | 4-Aug | 15,600 | 9 | 10 |
| 1988 | 31-Aug | 98,300 | 4-Sep | 71,800 | 18-Sep | 21,000 | 79 | 34 |
| 1998 | 9-Sep | 103,100 | 11-Sep | 74,280 | - | 18,600 | 100 | 52 |
| 2004 | 12-Jul | 83,900 | 19-Jul | 77,430 | - | 16,300 | 10 | 20 |
| Average | | 67,490 | | 51,130 | | 13,370 | | |
| Min | | 40,900 | | 31,500 | | 7,940 | | |

Source: BWDB (The Bangladesh Water Development Board)

Table 2 shows the trends in daily mean water levels in the coastal zone and the trends may provide some insight on the historical rise in sea level. Observations from 13 stations over 12 to 42 years are summarized in Table 2.There is no change at the Chandpur station and the changes on Hiron point station is statistically significant ranges from 5.6mm/yr. The water level increased at a rate of 1.4mm/yr at Cox's Bazar in the southeast and 3.9 mm/year at Companyganj in the middle of thesouthern coastal zone. Trends are positive at all stations.

**Table 2:** Water level Trends at Different Stations along the Coastline

| Station Name | Station Location | Duration | No. of years | Trend (mm/yr) |
|---|---|---|---|---|
| Hiron Point | Passur | 1977 – 2002 | 26 | 5.6* |
| Khepupara | Nilakhi | 1959 – 1986 | 22 | 2.9 |
| Galachipa | Lohalia | 1968 – 1988 | 21 | 3.3 |
| Dasmunia | Tentulia | 1968 – 1986 | 19 | 1.3 |
| Kyoyaghat | Tentulia | 1990 – 2002 | 12 | 3.6 |
| Daulatkhan | Lower Meghna | 1959 – 2003 | 31 | 4.3 |
| Nilkamal | Lower Meghna | 1968 – 2003 | 33 | 2.3 |
| Chadpur | Lower Meghna | 1947 – 2002 | 50 | 0.0 |
| Companyganj | Little Feni Dakatia | 1968 – 2002 | 32 | 3.9 |
| Chittagong | Karnafuli | 1968 – 1988 | 16 | 3.1 |
| Dohazari | Sangu | 1969 - 2003 | 32 | 2.0 |
| Lemsikhali | Kutubdia Channel | 1969 - 2003 | 27 | 2.1 |
| Cox's Bazar | Bogkhali | 1968 - 1991 | 22 | 1.4 |

* statistically significant to $p < 0.05$

Source: BWDB (The Bangladesh Water Development Board)

In Bangladesh, climate change has been observed different parts and weather patterns have been more erratic and less predictable than before (World Bank 2011). There was a significant increase in rainfall in some areas but annual rainfall did not change significantly between period 1960 and 2003 (Shahid, S., 2009). Rainy season has become shorter and length of cool and dry season decreased. Sea-level is also rising significantly and led to an increase in soil salinity in many parts of Bangladesh especially in coastal areas.

**Future Projection**

Future climate in Bangladesh will be worsen compared to present scenario. Temperature of Bangladesh will continue to increase by 1°C by 2030, 1.4°C by 2050 and 2.4°C by 2100 due to global warming (IPCC, 2007).Yu and others. (2010) predicted temperature and precipitation changes by16 global circulation models and Projected monthly, annual, and seasonal temperature changes inthe 2050s relative to the corresponding data for1980–99.The temperature rises during all months and seasons and medium warming prediction for Bangladesh across the models by 2050s is 1.55°C (See Figure 2).

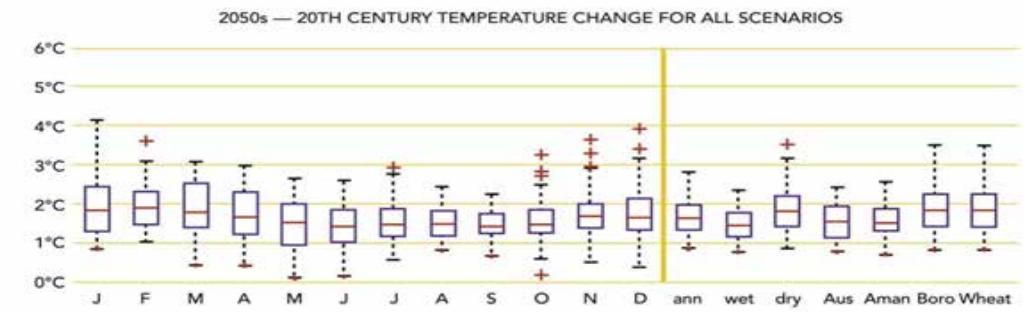


Fig. 2: Monthly, Annual, and Seasonal Temperature Changes
Source: Yu, W.H., et al. (2010)

The projected monthly, annual, and seasonal precipitation changes for the 2050s relative to the corresponding data for1980–99. Annual and wet season precipitation increases and the median prediction precipitation increases of 4 percent by the 2050s (See Figure 3).

It has been observed that the warmer and wetter future climate trend will severely affect the agriculture sector in Bangladesh. The combined effects of rising temperatures,higher precipitation, severe flooding, occasional seasonal droughts, and loss of arable land in coastal areas resulting from climate change are expected to declines agricultural production in Bangladesh. Sea level raise will worsen this situation more adverse and affect a large number of people in Bangladesh. By 2050, about 27 million will be at risk due to the effects of sea level rise.

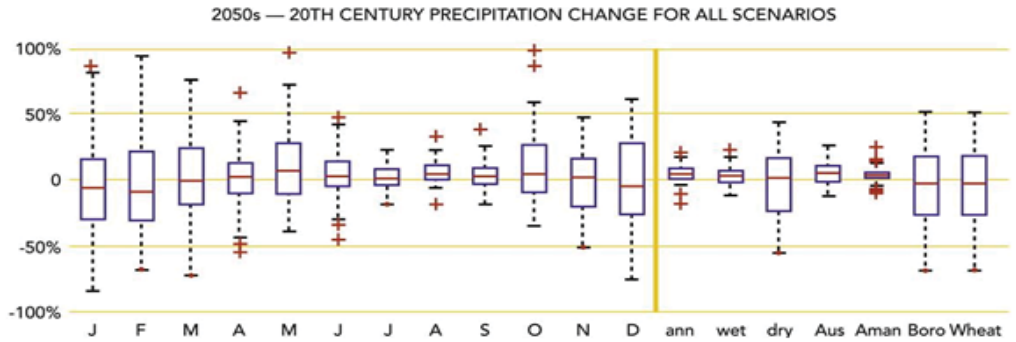


Fig. 3: Monthly, Annual, and Seasonal Precipitation Changes

Note: The box and whiskers diagrams in Figure 2 and Figure 3 consist of a red line representing the median value, a box enclosingthe inter-quartile range, dashed whiskers extending the to the furthest model that lies within 1.5x the inter-quartile range fromthe edges of the box, and red plus symbols for additional models that are perceived as outliers. Source: Yu, W.H., et al. (2010

## Economy-wide Impact of Climate Change

### Impact on Macro economy

The impacts of climate changes in Bangladesh are many and diverse through effecting agriculture and other resource sectors. Bangladesh economy and annual growth will be directly affected by climate related hazards. World Bank estimates climate change will decrease agricultural GDP by 3.1% each year which is equal to a cumulative loss in added value of USD 36 billion between 2005 and 2050. Yu and others. (2010) finds Bangladesh's average annual GDP growth rate might be 0.1 percentage points lower under the IPCC's A2 emissions scenario. Climate change also has indirect effects such as decreaseing trade and investments channels with other country. Climate change has already slower down the other countres, and this adversely affecting Bangladesh economy through decreasing trade and investment. There is also evidence that climate extremes can detrimentally impact a country's trade by affecting production costs, relative prices, and demand for imports and exports (Gassebner et al., 2006). Some of Bangladesh's major trading partners have already sluggish or negative growth due to climate change and this will adversely affect Bangladesh economy in the long run.

### Impact on Agricultural Sectors

Agriculture plays a vital role in the economy of Bangladesh contributing almost 85% of rural population is directly or indirectly involved in agriculture. Agriculture is the backbone of Bangladesh and is synonymous to the food security of the country. Serving as major livelihood resources, the agricultural sector plays a significant role in the food security in Bangladesh. Agriculture is also a key economic sector in Bangladesh, accounting for 65 percent of the labour force. Climate change will have a decisive impact on productivity in agriculture and degrade food security in the long run. A study estimated

that in eastern Bangladesh alone 14,000 tons of grain production would be lost due to sea-level rise in 2030 and 252,000 tons would be lost by 2075 (Karim and Iqbal, 2000). Salt water intrusion into surface and groundwater in the coastal region results in greater soil salinity which will decrease agricultural production in coastal area. Rainfall is also the major climatic factors for crop production. In the Bengal delta, more than 80% of annual rainfall occurs during the monsoon season from June to October.Changes in the patterns and seasonality of rainfall due to climate changes will significantly impact local agriculture in Bangladesh. Rice is the main food in Bangladesh and rice plays the leading role by contributing 95% of total food production (GoB, 2010) and rice is highly susceptible to climate change.The World Bank (2010) predicts that the Bangladesh national rice production will decline because of climate change and the annual growth rate will reduce from 2.9 to 2.55 percent in the average climate change scenarios during the period 2005-2050. IPCC also estimates that by 2050, rice production in Bangladesh will decline by 8 percent and wheat by 32 per cent. Climate change will reduce overall rice production in Bangladesh by an average of 7.4% every year over the period 2005-2050 (Yu et al., 2010). Wheat and other agricultural crops will also be affected by climate change.With the change in temperature (by 2°C and 4°C), the prospect of growing wheat and potato would be severely affected. Since agriculture in Bangladesh is heavily dependent on weather and crops will suffer yield losses when temperatures are too high. Food availability is related to the crop production and crop production is dependent on some elements such as temperature, CO2 level and the rate of precipitation. Any types of changes in temperature and precipitation range can cause devastating impacts on the crop production because for every certain type of crops certain range of temperature is essential.

**Impact on Food Price**

Climate change has a direct impact on rise in food price by reducing food production and by disrupting food availability.Increased climate variability such as reductions in water availability, changes in precipitation patterns, increases in temperatures, and changes in extreme weather events affects the stability of food supplies and food prices through direct impact on production. If production decrease then will affect the supply side of food and generally price will rise. Local people then spend more money for their daily calorie intakes.Some study says extreme weather events are also likely to become more severe and more frequent, and result in more volatile food prices and production. Income level of Bangladesh people remains low compared to other developing country. If income levels rise moderately but remain low, and the amount of income spent on food remains high, increases in food prices will exacerbate food insecurity trends (Schmidhuber and Tubiello, 2007). A study by the International Food Policy Research Institute (Nelson et al., 2010) suggests that by 2050 real prices might increase by 87–106% for maize, 55–78% for rice, and 54–58% for wheat relative to the 2010 baseline as a result of adverse climate-change impacts.

## Food Security Challenge and Adaptation in Bangladesh

### Food Security Challenge

Food insecurity level in Bangladesh is already high, with 56% of households reporting periods with food shortages during each year (Wright et al. 2012). Climate change is likely to increase these figures and may cause a net increase in poverty of up to 15% between 2000 and 2030 (in a low productivity scenario, Wright 2014).Climate change has various adverse impacts on food production and Bangladesh is in a big challenge to cope up with this adverse impact of climate change. Due to temperature rise wheat, Aus and Boro production will reduced by 27%, 61% and 62% respectively and agriculture lands will degrade every year which eventually intensify food security in numerous ways such as influencing growing conditions for plants by increasing temperature.Many plants won't be able to adapt to the increase in temperatures in their traditional growing regions or disappear altogether. Precipitation patterns in many parts of Bangladesh have already been changed resulting in areas of rain-fed agriculture, rains arriving just a few weeks late can havea major impact on harvest yields. Along with changes in precipitation patterns, some regions in Bangladesh will become drier which will directly impact on food security. The World Bank (2010) predicts that the Bangladesh national rice production will decline because of climate change and the annual growth rate will reduce from 2.9 to 2.55 per cent in the average climate change scenarios during the period 2005-2050.Food security is a great challenge in Bangladesh for the coming year due to climate change. The current population of Bangladesh is 164 million, with one of the highest densities (1252 persons/km2) in the world, and the population of the country is still growing at 1.37% per year (World Bank). Although this rate is expected to slow down in future, most projections estimated a 200 million population by 2050. This would mean a more than 25% increase in the demand for food grains. Therefore, providing food security to its population would be a crucial socio-economic and political priority of the government of Bangladesh.

### Adaptation

Adaptation is a process through which people reduce the negative effects of climate on their health and well-being and adjust their lifestyles to the new situation around them. Adaptation seems to be the most efficient and effective mean to the people of Bangladesh although a little contribution to global climate degradation. Adaptation has the potential to reduce adverse impacts of climate change. Bangladesh people are now coping with different types of adaptation strategy as for example rural households have adapted their farming systems by switching to high-yielding rice crops instead of low yielding deep water rice. As a result, agricultural production has actually risen over the past few decades. The most common form of adaptation in rural area is the migration of day labourer. Storage of food and drinking water before an extreme climate event is also a common coping strategy in rural area. In the coastal region in Bangladesh different forms of agricultural adaptations take place. Among these, improvement in crop varieties, innovative cropping

techniques, infrastructural development, farm machinery, changes in cropping pattern, etc., are the major ones. Adaptation practices are therefore linked with improvement in crop varieties such as, salinity and submergence tolerant rice and non-rice varieties, short-duration pulses and vegetables. Bangladesh has already developed salinity tolerant, flood-tolerant and shorter maturity varieties of rice and this will help in the short run. Bangladesh government has already taken various initiatives to combat the climate change for ensuring food security in near future. Besides this Bangladesh has ratified National Biodiversity Strategy and Action Plan in 2004, the Convention to Combat Desertification (CCD), the United Nation Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and also signed the Paris Agreement in April 2016. Bangladesh also implemented National Action Plan for Adaptation (NAPA) which focusing on coastal afforestation. In the year 2008 NAPA were updated and embedded in a new Bangladesh Climate Change Strategy and Action Plan (BCCSAP) which describes immediate, short, medium and long-term programmes such as food security, social protection and health; comprehensive disaster management; infrastructure; research and knowledge management; capacity building and institutional strengthening; and mitigation and low carbon development.

## Conclusion

Climate change is a long time process and has become a major issue affecting the agriculture sector in Bangladesh. Nowadays impacts of climate change in agriculture are global concern but for Bangladesh where lives and livelihoods totally depend on agriculture becoming a great threat for national food security.Adaptation and mitigation are two main options for Bangladesh to cope up with climate change. Of which, the first one is country-specific, or even local specific, but mitigation demands collective efforts of global communities. Bangladesh is one of the least contributing countries to the global climate change phenomenon and high vulnerability to climate change impacts,so adaptation is the only option to deal with this situation. Bangladesh is trying to develop different adaptation strategy to cope up climate-related hazards like floods, droughts, tidal-surges etc. through support of the government. Climate change adaptation is often hampered by limited capacity of resources, lack of coordination, and limited participation of stakeholders such as small farmers and fishermen. Corruption or mismanagement is also a major problem to implement proper adaptation strategy. Bangladesh is going to be confronted with food insecurity problem in the upcoming years and climate change will pose a negative impact on cultivated area, agriculture production and overall the economy of Bangladesh. Majority of the people of Bangladesh depends on agriculture as a source of food and income and thus their food security may be affected by climate change. The issue of climate change assumed special importance in Bangladesh because it's become a big challenge. Coastal communities in Bangladesh are mainly victimized and their livelihood is at stake for this climate change and this is a concerning matter for Bangladesh.Continuous research, water

level information sharing with neighbouring country and innovation of technology is needed to implement to reducefuture climate change-related hazards. Implementation of intensive training program for climate-vulnerable community could reduce food security concern in Bangladesh.Finally Bangladesh needs to take efficient development plan, integrated farming model and sustainable innovative technology to reduce climate change hazard in the long run and stability of the food security.

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