A Seminar Paper on

Climate Change Risks and Food Security in Bangladesh

Course Title: Seminar
Course Code: SSC 698

Submitted to

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Abstract

The impact of climate change on food security in Bangladesh is a significant concern due to the country's reliance on agriculture as a primary source of income and food production. The objective of the study is to review climate change risks and food security in Bangladesh. Climate change has caused erratic weather patterns in Bangladesh, with fluctuations in sunshine and rainfall affecting more than a third of the country. Therefore, temperature is gradually rising, frequency of floods, river bank erosion, storm surge, magnitude of cyclone, salinity intrusion, and the volatility of rainfall has increased comparing to past. All these led to the probability of decreasing the crop production which is a great concern for countries food security. Agricultural adaptation strategies are essential to mitigate and adapt to climate change impacts on the agriculture sector. Some adaptation and mitigation options are applied to agriculture include agronomic managements for water, soil, nutrient, pest, and weed, adjusting planting system and distribution by crop diversification and switching, conservation agriculture by no-tillage, biotechnology by breeding crops with improved climatic stress tolerance or genomics, strengthening agro-climatic disaster prevention and control, and enhancing agricultural infrastructure construction. As climate change is a great concern in Bangladesh, it is the time to take appropriate adaptation and mitigation strategies and install proper rules and regulations for ensuring food security.

Key words: Climate change; impacts of climate change; agriculture and food security

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CHAPTER I

INTRODUCTION

Climate change is a major problem today and poses a threat to the entire world. Climate change is a significant global health threat of the 21st century and it has become a great concern around the world (Shakeel, 2014). The underdeveloped and developing countries are most vulnerable due to climate change for its direct impacts on socio-economic status (Shakeel, 2014 and Elahi, 2016). Global warming has been the leading evidence for worldwide climate change. The temperature of the earth is increasing significantly and could be increased by 2^0 to 6^0 Celsius by the end of 21st compared to the end of the 20th century (Field and Barros, 2014). Bangladesh is flat, low-lying riparian, flown over by many numerous rivers, 80% land are floodplains and densely populated nation of over 160 million people in a land of 147,570 km^2 (Shakeel, 2014). The Bay of Bengal is in the south of the country and the country has a 711 km long coastline with a vast flow of the Ganges-Brahmaputra-Meghna (GBM) Himalayan River system (Shakeel, 2014). The coastal region covers 47,203 km^2 of total land of Bangladesh and the population of coastal area is 40 million (about 28% of total population of the country) which is predicted to be 57.9 million in 2050 (Minar *et al.,* 2013).

In recent years, Bangladesh achieved enormous success in economic growth and poverty reduction, where, poverty has been reduced almost 26% from 1991 to 2010 (Yosef *et al.,* 2015). Agriculture has been playing the dominant sector for economic growth for a long (Davis *et al*., 2018). Alongside providing raw materials for industries, agriculture plays a significant role in ensuring country's food security; rural poverty reduction, employment generation, and importing foreign currency (Mozumdar, 2012). A very large portion of Bangladeshi people are directly or indirectly depend on agricultural activities or they are benefited by agriculture. This sector shared almost 14.22% of the total national GDP in 2016, although it is in gradual decreasing rate at 5% from 2010 (Brammer, 2014). Agriculture can be divided in different sub-sectors including crop, livestock, agro-forestry, fisheries. Climate variables including temperature, rainfall, length of day, humidity have significant negative impact on agriculture (Brammer, 2014). So, agriculture is highly vulnerable sector to climate change, for each degree of global temperature increase, wheat yields are expected to reduce by 4-6%, increases in temperature are expected to similarly impact maize productivity and by the end of the century the areas producing 56% of the

world's maize are predicted to experience a decline in yield (Bassu *et al.,* 2014). Plant pathogens and pests have already demonstrated latitudinal distribution shifts as a product of climate change, and the changes in regional climate conditions are expected to alter plant pathogen virulence and infection rates, exacerbating yield losses. With changes in climatic conditions such as the number of unusually hot or cold days, it is also likely that optimal locations for planting different crops will alter (Pathak *et al.,* 2018), and crop management and cultivar production will have to keep pace with these changes. The issue of climate change and its adverse impact on food production has been recognized in Bangladesh extensively. Because, in the country, food production often face tremendous difficulties due to climate change (Mahmuduzzaman *et al.,* 2014 and Davis *et al.,* 2018). Seasonal characteristics, CO^2, rainfall, light intensity, temperature, soil and water salinity are strongly influencing to the agricultural activities in Bangladesh. (Mahmuduzzaman *et al.,* 2014). Mondal, (2010) found that approximately 80000 hector of arable land be going out of production in every year and country's crop production is frequently affected by flood, drought and salinity. As a result, crop productivity as well as food security would be seriously threatened.

Considering the vulnerable risks of climate change and its adverse impact on food production, the present seminar paper was undertaken to obtain the following objectives:

1. To highlight the climate change risks and food security in Bangladesh.
2. To review the adaptation strategies in the agriculture of Bangladesh.

CHAPTER 2

MATERIALS AND METHODS

This paper is absolutely a review paper. So, all the information for this paper was collected from secondary sources with the intention of preparing it. The title was selected with the consultation of my major professor. Various relevant books and journals that were available in the library of Bangabandhu Sheikh Mujibur Rahman Agricultural University were used for the preparation of this paper. I also used different websites and journals for collecting recent information. Good suggestions, valuable information, and kind consideration from my honorable major professor and other teachers in the Department of Soil Science, Bangabandhu Sheikh Mujibur Rahman Agricultural University, helped to enrich this paper. After collecting the necessary information, it has been compiled and arranged chronologically for better understanding and clarification.

CHAPTER 3

REVIEW OF FINDINGS

3.1Climate change in Bangladesh-Erratic Weather Patterns

A misconception of global warming is that it will cause a complete decrease in rainfall and an increase in temperature. In reality, the weather has grown increasingly erratic and extreme, with significant fluctuations in sunshine and rainfall affecting more than a third of the planet. In some areas of Bangladesh, rainfall is actually heavier. Rainfall during a period of global warming may sound like a blessing, but in reality, these heavier rainfalls have caused more floods. Additionally, as the frequency of rainfall and floods are unstable and inconsistent, mitigation services dependent on weather forecasting may be unreliable. As a result, farmers would be unable to take precautions to cut potential losses. Conversely, in the western and northern regions, rainfall is lower. Weather anomalies are projected to continue causing catastrophic damage to agricultural output. Several reports predict that erratic rainfall will play a significant role in the loss of several thousand tons of agricultural production in the near future. Weather patterns will continue to change as the northern region may possibly be plagued with abnormally high temperatures and droughts while the central region may experience unusual rainfall and floods. On the other hand, agriculture production has also been hampered by cold waves. Record shown, several seedbeds were damaged because of severe cold spells as well as foggy weather. High production costs of planting crops during unpredictable extreme weather conditions directly affect to the poor famers. Reluctance supply of certain crops inevitably will increase the prices of most basic commodities, and so our cost of living will be increased substantially. Thus the chaotic weather changing conditions will continue to create a detrimental and difficult to the farming environment as well as food security.

3.1.1 Erratic rainfall and temperature rise

It was reported that the average increase in temperature would be 1.3 ^{oC} and 2.6 ^{oC} for the two projection years, 2030 and 2075, respectively. It was found that there would be a seasonal variation in changed temperature: 1.4^{oC} change in the winter and 0.7^{oC} in the monsoon months in 2030. For 2075 the variation would be 2.1 ^{oC} and 1.7 ^{oC} for winter and monsoon, respectively. It was reported that the winter rainfall would decrease at a negligible rate in 2030, while in 2075

there would not be any appreciable rainfall in winter. On the other hand, monsoon precipitation would increase at a rate of 12 percent and 27 percent for the two projection years, respectively.

Table 1. Past and future temperature and precipitation patterns and possible changes in different seasons in Bangladesh

Year	Average Temperature			Temperature increase			Average Precipitation			Precipitation increase		
	W	M	Ave	W	M	Ave	W	M	Ave	W	M	Ave
	(°C)			(°C)			Mm/Month			Mm/Month		
1990	19.9	28.7	25.7	0.0	0.0	0.0	12	418	179	0	0	0
2030	21.4	29.4	27.0	1.3	0.7	1.3	18	465	189	+6	47	10
2075	22.0	30.4	28.3	2.1	1.7	2.6	00	530	207	-12	112	28

Note: W stands for winter (i.e., December, January and February: DJF) and M stands for monsoon

Source: Ahmed and Alam, 1998

The main impact of climate change is predicted to be the change in temperature and precipitation. Temperature records over the last couple of decades indicate a warming surface temperature and a considerable amount of change in rainfall patterns have also been found which is not a good-looking for us. Higher temperatures are also likely to lead global warming and ultimately sea level rise which may have a great threat for agricultural development in Bangladesh.

Table 2. Changes in temperature and precipitation for Bangladesh

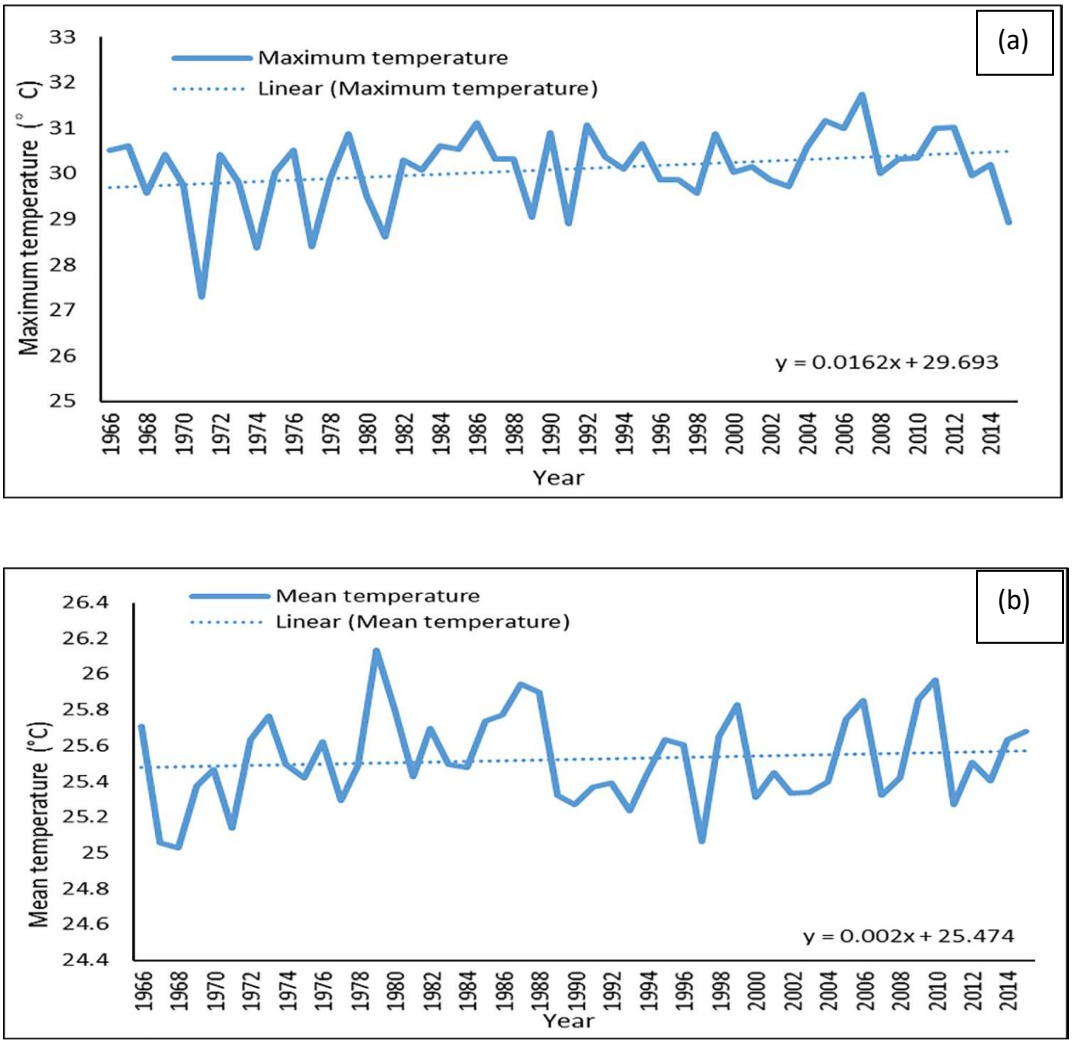
Year	Temperature change (°C)			Rainfall	Change (%)		Sea Level
		mean			mean		Rise (cm)
	Annual	DJF	JJA	Annual	DJF	JJA	
2030	1.0	1.1	0.8	5	- 2	6	14
2050	1.4	1.6	1.1	6	- 5	8	32
2100	2.4	2.7	1.9	10	- 10	12	88

Note: DJF represents the months of December, January and February, usually the winter months. JJA represents the months of June, July and August, the monsoon months.

Source:GOB, 2005

Figure 1 show the annual average maximum and mean temperature, respectively. Although highly fluctuating, the temperature has followed a slight upward trend. A linear estimate shows

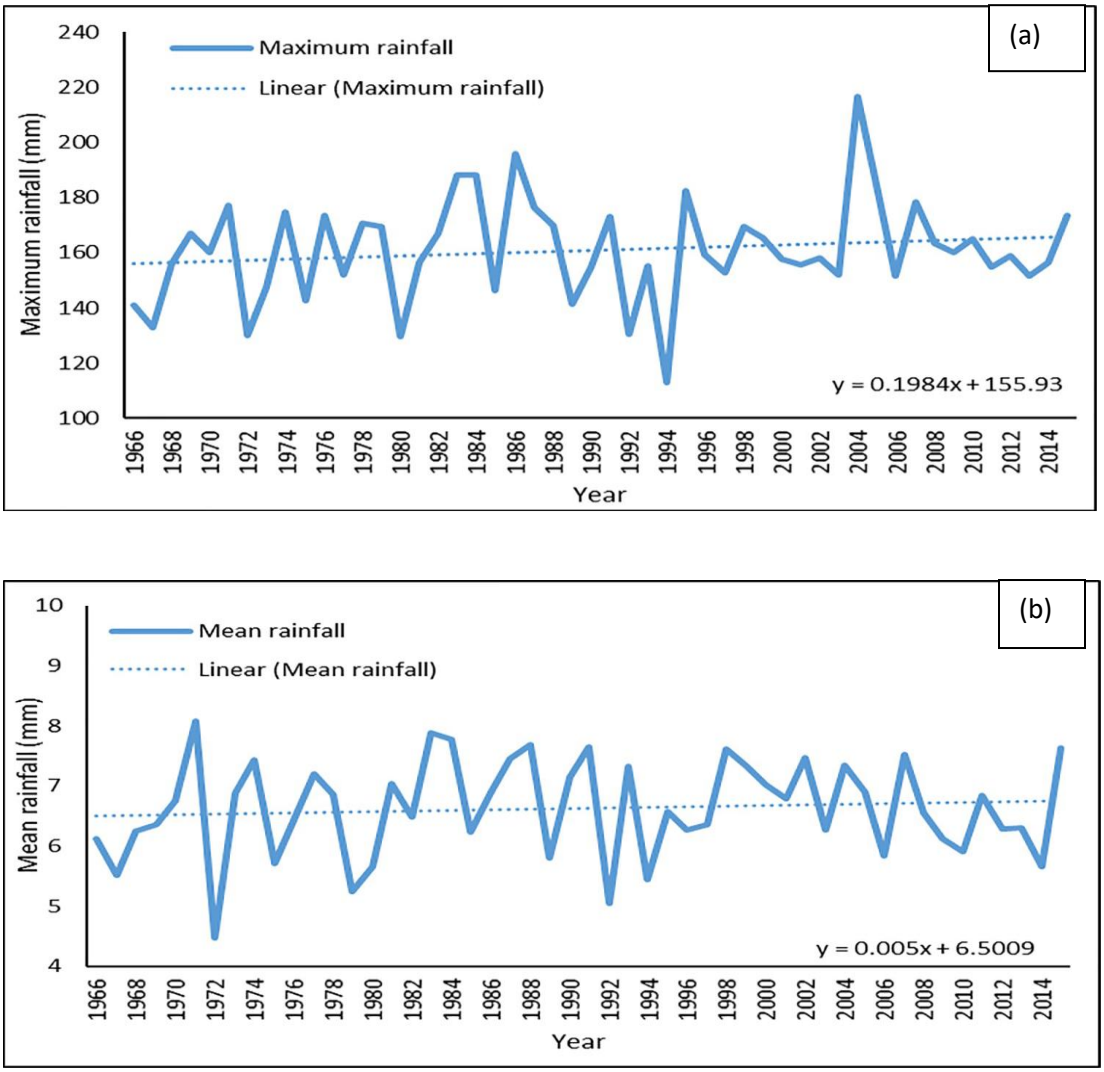
that the maximum temperature increased at a rate of 0.016 degrees Celsius per year during the five decades, while the mean temperature increased by 0.002 degrees Celsius each year.



Source: Chen et al., 2020

Fig. 1 Annual average of maximum temperature (a) and average of mean temperature (b) in Bangladesh for 1966–2015

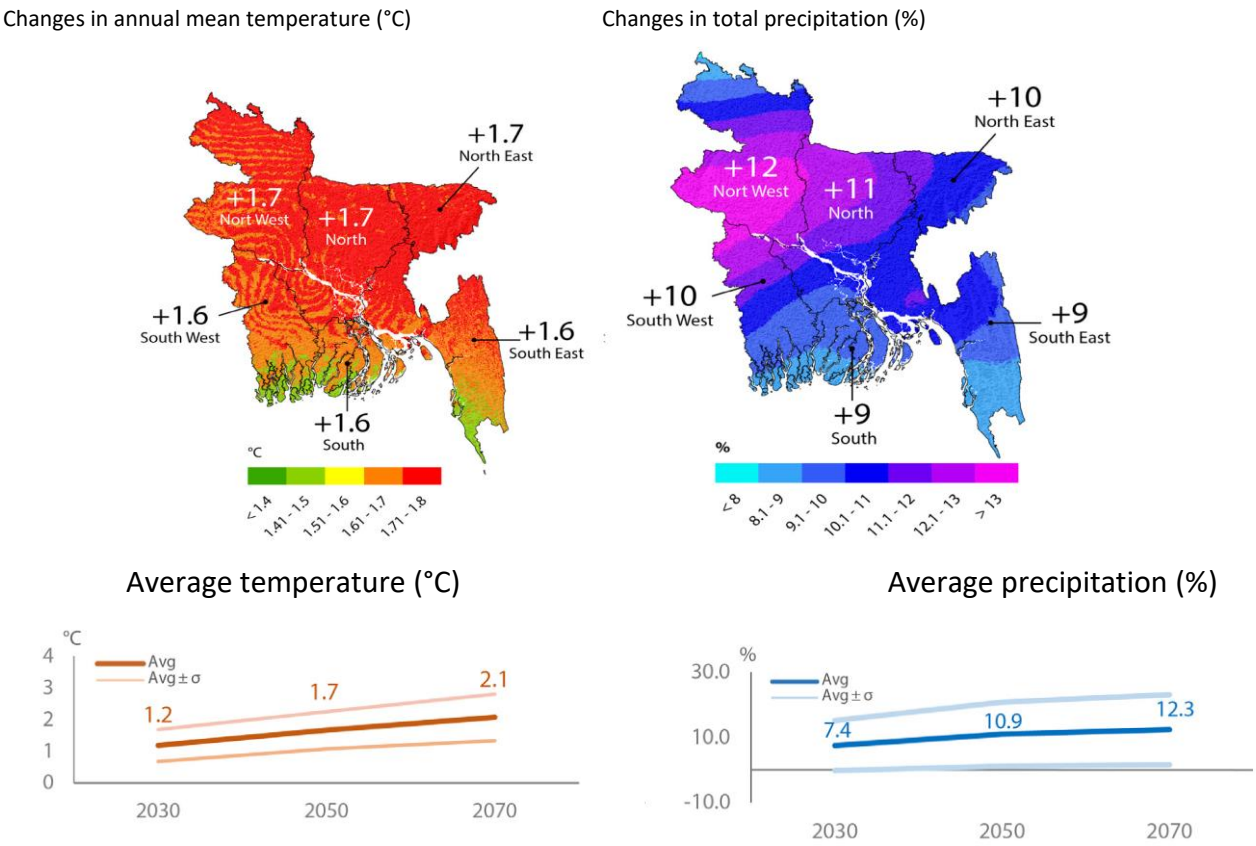
Figure 2 show the annual average maximum and mean daily precipitation, respectively. Precipitation also shows a slightly increasing trend with fluctuation over this period. According to the linear estimate, the maximum daily rainfall increased by 0.198 mm per year, while the average daily rainfall increased by 0.005 mm (Chen et al., 2020).



Source: Chen et al., 2020

Fig. 2 Annual average of maximum rainfall (a) and average of mean rainfall (b) in Bangladesh for 1966–2015

Figure 4 showed that the mean temperature in north and north-east region is high, south west and southern region comparatively moderate. On the other hand , incase of total precipitation north West region showed high rainfall ,some northern region, North East region and some south East region showed moderate rainfall.



Source: Ramírez-Villegas, & Thornton, 2015

Fig. 3 Projected changes in temperature and precipitation in Bangladesh by 2050

3.1.2 Flood and cyclone

Combined with inevitable natural calamities such as cyclones and heavy rainfall, the vulnerability and destructive impact of floods are increasingly amplified causing severe damage in the low-lying countries like Bangladesh (Annual Flood Report,BBS,2012).

Table 3: Year-wise Flood Affected Area in Bangladesh

Year		Flood affected Area
	Sq-Km	%
1995	32,000	22
1996	35,800	24
1998	1,00,250	68
1999	32,000	22
2000	35,700	24
2001	4,000	2.8
2002	15,000	10
2003	21,500	14
2004	55,000	38
2005	17,850	12
2006	16,175	11
2007	62,300	42
2008	33,655	23
2009	28,593	19
2010	26,530	18
2011	29,800	20
2012	17,700	12

(Source: Annual Flood Report,BBS,2012).

3.1.3 Sea Level Rising and salinity increase

Ahmed et al. (1999) predicted that in Bangladesh sea level will rise by 30 cm and temperature will rise by 0.7^0 C and 1.3^0C in monsoon and in winter respectively in 2030 compared to base year 1990 whereas in 2050 the sea level will rise by 50 cm and temperature by 1.1^0 C in monsoon and 1.8^0 C in winter.

Table 4. Prediction of SLR and temperature in 2030 and 2050 in Bangladesh (Ahmed et al., 1999)

Year	Climate Change Scenarios	
	Sea Level Rise (cm)	**Temperature Increase (^{0}C)**
2030	30	+0.7 in monsoon; + 1.3 in winter
2050	50	+1.1 in monsoon; +1.8 in winter

Source: Ahmed et al.,1999

A one-meter SLR will cause salinity intrusion, river bank erosion, crop failure, frequent floods and storm surges, increase in cyclone intensity, loss of biodiversity, fisheries destruction, lack of fresh water which will affect all the ecosystem of the country (Davis et al., 2018).

Table 5. Possible impacts of different forms climate change in Bangladesh

Year	**2020**	**2050**	**2100**
Sea level rise	10 cm	25 cm	1 m
Land below SLR	2% of the total land=2500 km^2.	4% of land=6300 km^2.	17.5% of land =25000 km^2. Patuakhali, Khulna and Barisal regions most affected.
Storm surge	-	A cycle like 1991 happens again with a 10% increase in intensity, storm surge goes from 7.1 to 8.6 m with 0.3 m SLR	Storm surge goes from 7.4 to 9.1 m with 1 m SLR
Salinity	Increase	Increase	Increase
Flooding	20% increase in areas subject to flooding.	Increase flooding in Meghna and Ganges floodplain.	Both inundation area and flood intensity will increase tremendously. Devastating flood may cause crop failure for any year.

Source: World Bank, 2000

3.1.4 Drought

Global warming has contributed more frequent, severe and vast extent of the recent droughts (Dash et al., 2012; Eskander and Barbier, 2017). It threats to food security in many regions worldwide including Bangladesh. For instance, the northwestern region of the country, experienced one of the most severe droughts of the century, which started in October 1994 and was broken in July 1995 with the onset of monsoon rain, was the major factor for crop damage between 1994 and 1995 in Bangladesh, led to a shorten of rice production of 3.5 million tons (Dash et al., 2012). Rahman et al. (2007) showed that drought caused 25 to 30 % of crop

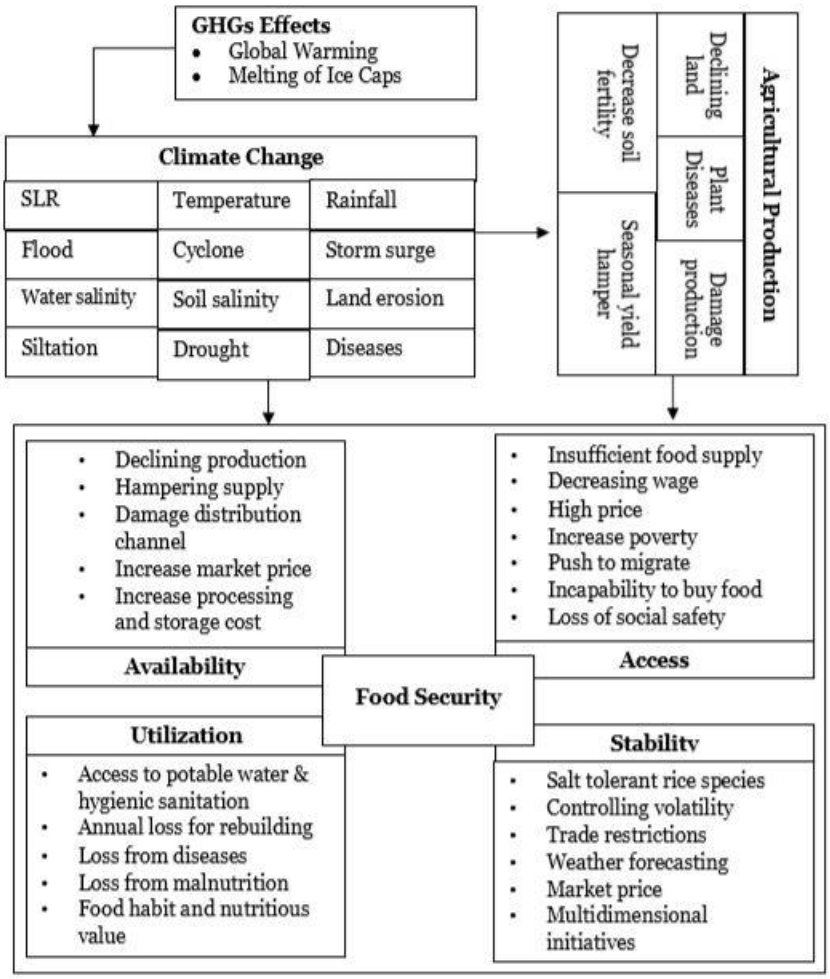
reduction in the northwest part in Bangladesh. About 17% of the Aman crops are lost due drought in a year (Alam, 2015).

3.2 Impact of climate change on food security in Bangladesh

According to the FAO definition, food security means that all people at all times have physical and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. It covers four dimensions of food: availability, accessibility, utilization, and system stability (FAO; 2016). Climate changes could influence the food production system and supply-demand balances. Furthermore, climate changes (elevated temperature, CO_2 and O_3) also affect the compositions and quality (protein, mineral nutrients, heavy metals) of crop foods, thus threaten human health. By 2050, climate change may lead to per-person reductions of 3.2% in global food availability, 4.0% in fruit and vegetable consumption, and 0.7% in red meat consumption, and these changes would be associated with more than half million climate- related deaths worldwide, which most occur in south and east Asia (Springmann *et al*., 2016). Inherently, these food effects also vary with time, places, and people.

Agricultural in Bangladesh has been greatly influenced by seasonal characteristic and climatic variables such as temperature, rainfall, humidity, day length, etc. Crop agriculture is often constrained by different hazards and disasters such as floods, droughts, soil and water salinity, cyclones and storm surges (Wassmann, 2009). According to (Hossain, & da Silva, 2013) the Geophysical Fluid Dynamics Laboratory (GFDL) model predicted an approximate 17% decline in overall rice production for Bangladesh and as high as a 61 percent decline in wheat production under a 4oC change in temperature. The highest impact would therefore be on wheat followed by rice (Aus variety). The Canadian Climate Change Model (CCCM) also predicted a significant fall in food-grain production. Extreme temperature due to climate change would affect livestock. High temperatures cause great discomfort, decrease feed intake and alter nutrient metabolism, leading to high loss of energy. The combined effects of discomfort and nutrient metabolism reduce animals' productivity, resulting in financial losses for the farmers. Apart from extreme temperature, natural disasters such as cyclones and tidal surges, as mentioned previously, cause immense loss and suffering to livestock through destruction of forage crops as well as shelter

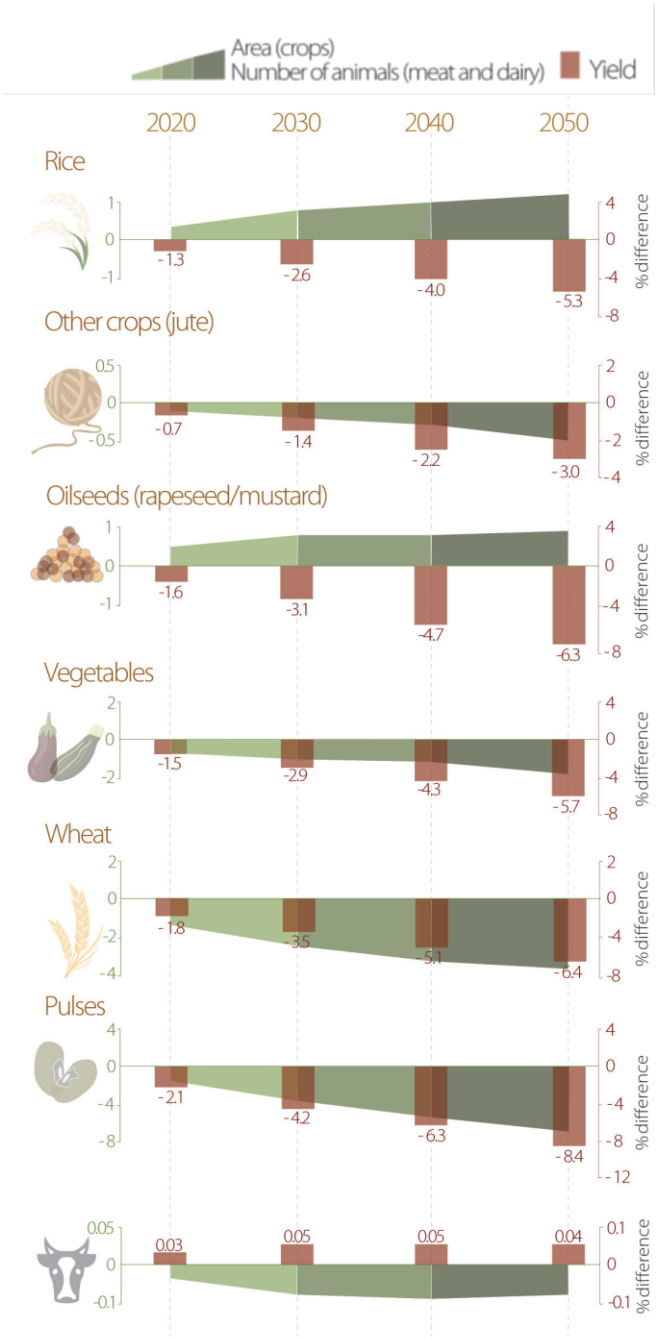
(MoEF, 2009a ; ICRIER, 2012). Despite several studies on specific issues, the probable impact of climate change on many other food and non-food goods, (such as jute) is something of an unknown in Bangladesh currently. In terms of impacts, risks and vulnerabilities, Bangladesh could be divided into regions: According to Karim et al., clearly, a shortfall in food grain production would severely threaten food security in Bangladesh. At the same time, different models diverge concerning the combined effects of climate change. For instance, carbon dioxide fertilization could facilitate food grain production Moreover, doubling of atmospheric concentrations of CO^2, in combination with a similar rise in temperature, could result in an overall 20 percent rise in rice production and 31 percent decline in wheat production. It has been proposed that Boro rice would enjoy good harvests under a severe climate change scenario with the doubling of atmospheric concentration of CO (Karim *et al*., 2010). The apparent increase in yield of Boro (dry season paddy generally grown under irrigated conditions and including high-yielding varieties) and other crops might be constrained by moisture stress, however. A 60 per cent moisture stress on top of other effects might cause as high as a 32 per cent decline in Boro yield, instead of having an overall 20 per cent net increase.



Source: Hossain & Majumder, 2018

Fig. 4 The impacts of climate change on agricultural production and food security

It is feared that moisture stress would be more intense during the dry season, which might force Bangladeshi farmers to reduce the area for Boro cultivation. Under a severe (4^{oC} temperature increase) climate change scenario, the potential shortfall in rice production could exceed 30 per cent from the trend, while that for wheat and potato could be ashigh as 50 per cent and 70 per cent respectively (Karim et al., 2010).



Source: (Robinson et al., 2015)

Fig. 5 Climate change impacts on yield, crop area and livestock numbers in Bangladesh

3.2.1 **Agricultural Adaptation Strategies**

Mitigation and adaption

Mitigating climate change requires substantial and sustained reductions in GHGs emissions that together with adaptation can limit climate change risks (Shindell *et al.*, 2012). Mitigation copes

with climate change itself, while adaption aims at its impacts. Adaptation refers to the process of adjustment to actual or expected climate and its effects. Besides the natural adaptation, anthropogenic adaptation options have been proposed for and applied to agriculture. The agricultural measures mainly pointed at crop production, including: agronomic managements for water, soil, nutrient, pest and weed; adjusting planting system and distribution by crop diversification and switching; conservation agriculture by no-tillage; biotechnology by breeding crops with improved climatic stress tolerance or genomics; strengthening agro climatic disaster prevention and control; and enhancing agricultural infrastructure construction. Some cropping systems under moderate climate change may benefit substantially from implementation of these options (IPCC, 2014). For instance, crop-level adaptations increase simulated yields by an average of 7–15%, with adaptations more effective for wheat and rice than maize. However, their effectiveness might be limited under severer climate changes. Moreover, though adaptation experiences are accumulating and becoming embedded in some planning processes, the implementation is limited, because the drivers affecting farmers' participation in governmental programs are less considered.

Table 6: List of Adaptation Strategies in Agriculture in Bangladesh

No.	Adaptation Strategy in Agriculture
1	Change crops/ crop switching/crop diversification
2	Soil conservation
3	Water conservation
4	Mixed crop livestock farming system
5	Mixed crop fish farming system
6	Changing planting and harvesting dates
7	Using drought-resistant varieties
8	Using high-yield water sensitive crops
9	Floating garden in the flooded area
10	Cage Fishing
11	Duck rearing in the flooded area

Source: Disaster Dictionary, 2009

Adaptation is an unconstrained approach to adapt up to changing circumstance for avoiding unexpected losses (Disaster Dictionary, 2009). There are different sorts of adaptation. All kind of adaptation type has the respective application in terms of the adverse effects.

3.2.2 Structural adaptation: Structural modification means taking some fundamental measures to lessen the impacts of environmental change. Structural adjustment is immoderate approach

and not for the most part material. For ensuring food security from the unfavorable impacts of environmental change generation of the sustenance things must be expanded. For doing this job polder, floodgate door, torrent, deluge water gathering, and so on must be produced in the beach front zone (Disaster Dictionary,BBS, 2009).

3.2.3 Non-Structural adaptation: This kind of adjustment is considered as the delicate adjustment. Scattering of the appropriate and applicable data to the people, conveying issues to light among the people, thus on is joined in this sort. Migration from high danger region to the less peril zone is in like manner considered as the non-basic adjustment(Disaster Dictionary,BBS, 2009).

3.2.4 Expectant adaptation: There is an aphorism that says prevention is better than cure. This is the major point of expectant adjustment. Sooner or later more groups can take the exercises to lessen unfavourable impacts of environmental change before encountering the outcomes. This sort of adaption is appropriate for the creating countries like as Bangladesh for absence of financing (Disaster Dictionary,BBS 2009).

3.2.5 Reactive adaptation: Post calamity adjustment infers the responsive adjustment. Choices are taken in the wake of considering the results of the calamities. This is adjustment is excessive and tedious. Areas influenced are identifier firstly than the correct steps are taken to ensure the sustenance security from the environmental change (Disaster Dictionary,BBS, 2009).

3.2.6 Autonomous and planned adaptation: In its 2007 report, FAO made the difference between two adaptations i.e. autonomous, which is a micro-farm level and planned which is called macro-policy level. Illustrations of autonomous adaptation to environmental change incorporates changes in planting dates, generation of distinctive yield diversities or species, changes in the usage of irrigation and water supply, variations in the use of different inputs or in farm administration such as fertilizer, tillage methods, and grain drying. Planned adaptations are division wide changes in procedures or frameworks to manufacture atmosphere flexibility or to elevate shifts in assets to a more proficient use under environmental change impacts. Samples of planned adaptation includes focusing the variations in food insecurity, distinguishing proof of vulnerabilities, reassessment of agrarian research requirements, fortifying of agribusiness augmentation and correspondence frameworks, modifications in item & trade strategy, and expanded education and training (FAO, 2007).

Table 7. Some significant measures undertaken in different climate-vulnerable areas of Bangladesh

Measures	Drought-prone areas	Saline and storm prone areas	Flood prone areas
Application of interventions	• Introduce drought tolerant and short-duration crop varieties	• Introduce saline tolerant and short duration crop varieties • Planting deep-rooted fruits and crops	• Introduction of flood resistant varieties • Change in cropping pattern • Short-duration boro rice cultivation for flash-flood regions
Structural measures	• Excavate mini ponds, ponds, ditches to harvest rainwater • Alternative wetting and drying (AWD) method for rice production	• Floating cultivation • Cage culture • Sarjan technology • Rainwater harvesting	• Floating cultivation • Cage culture
Non-structural measures	• Encourage farmers to follow traditional and innovative practices such as zero-tillage, priming, mulching, relay cropping, dryland farming • Encourage famers to adopt homestead gardening • Adjustments to planting time • Encourage farmers to cultivate fewer water-loving crops (maize, wheat, linseed, pulses, oil crops)	• Early warning and preparedness measures	• Encourage farmers to grow pulses (mung bean, lentil), vegetables and oil seeds • Capacity-building in homestead bag planting • Use of green manure
Research and innovation (cultivars developed)	Cereal crops: BRRI dhan33, 42, 43, 56, 57, Binadhan-7, BARIgom-25, 26, BARIsharisha-11, 16 Oil crop: Binatil-1, 2, BARItil-1,2 Sugar cane: Iswardi-20	Crop: BRRI dhan40, 41, 47,53,54,55 Binadha-8, 10, 23 BARIgom-25, BARIsharisha-10 Sugar cane: Iswardi38, 39, 40	Crop: BRRI dhan28, 46, 51, 52 Binadha-11, 12 Sugar cane: Iswardi-38, 39, 40

Source: BRKB (2021); Hassan AFR et al. (2019); Groom (2012); Ministry of Agriculture (2021)

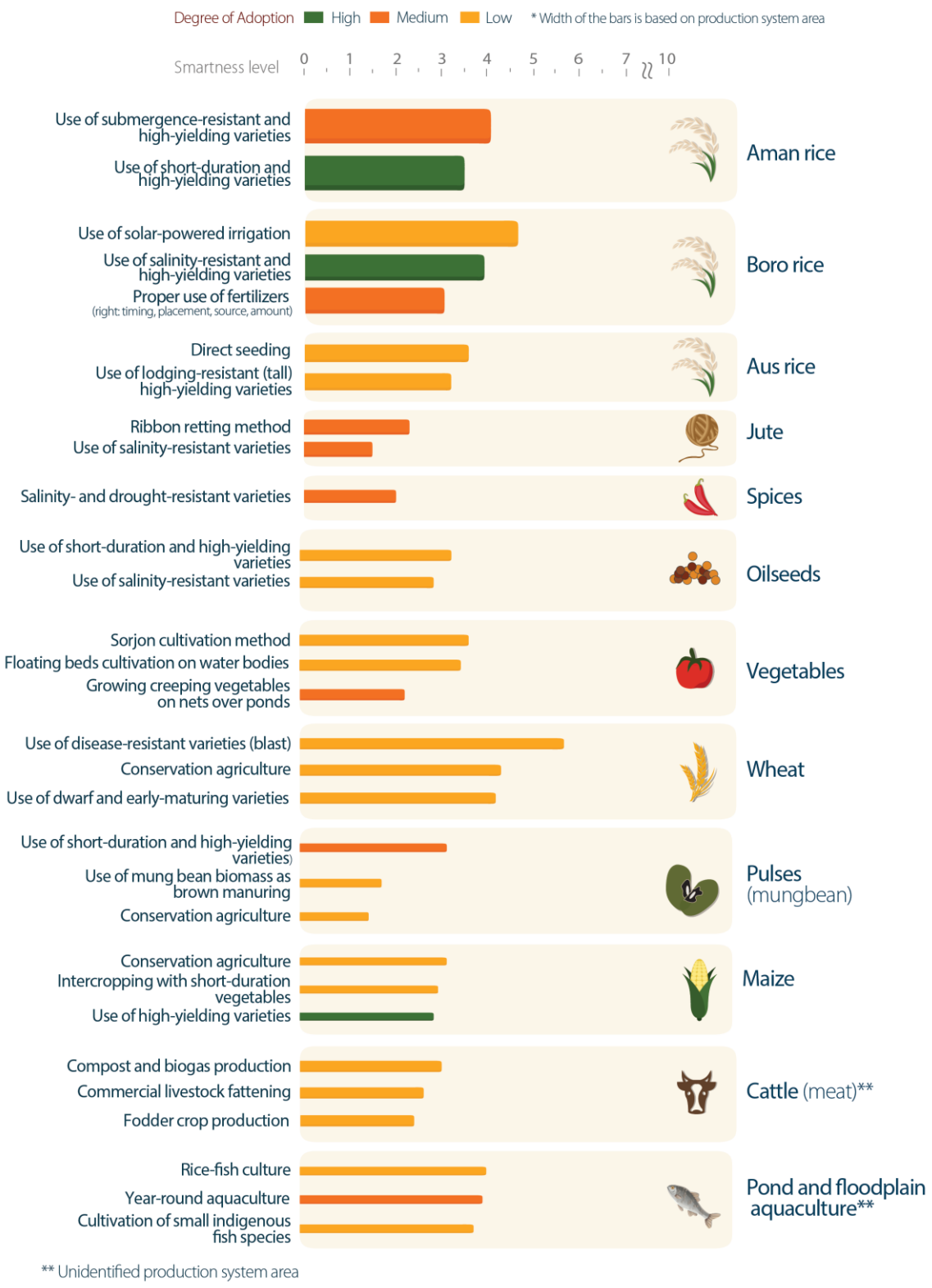


Fig. 6 Selected CSA practices and technologies for production systems key for food security in Bangladesh Source: World Bank, 2017

CHAPTER 4

CONCLUSION

Bangladesh is a more burnable country due to susceptible to the of climate change effect. Climate change has caused erratic weather patterns in Bangladesh, with fluctuations in sunshine and rainfall affecting more than a third of the country. The average increase in temperature is projected to be 1.3 ^{o}C and 2.6 ^{o}C for the two projection years, 2030 and 2075, respectively, which will have seasonal variations. Winter rainfall would decrease at a negligible rate in 2030, while in 2075 there would not be any appreciable rainfall in winter. On the other hand, monsoon precipitation would increase at a rate of 12 percent and 27 percent for the two projection years, respectively. The impact of climate change on food security in Bangladesh is a significant concern due to the country's reliance on agriculture as a primary source of income and food production. Studies predict that climate change could lead to a 17% decline in overall rice production and as high as a 61% decline in wheat production under a 4-degree Celsius temperature change. Livestock will also be affected by climate change, with high temperatures causing discomfort, decreased feed intake, and altered nutrient metabolism leading to financial losses for farmers.

Agricultural adaptation strategies are essential to mitigate and adapt to climate change impacts on the agriculture sector. Some adaptation and mitigation options are applied to agriculture include agronomic managements for water, soil, nutrient, pest, and weed, adjusting planting system and distribution by crop diversification and switching, conservation agriculture by no-tillage, biotechnology by breeding crops with improved climatic stress tolerance or genomics, strengthening agro-climatic disaster prevention and control, and enhancing agricultural infrastructure construction. Crop-level adaptations can increase yields by 7-15% on average, with adaptations being more effective for wheat and rice than maize. However, the effectiveness of these strategies might be limited under severe climate changes.

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