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Impacts of Climate Change on Agriculture and Food Security in Bangladesh

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Abstract
Agriculture is always vulnerable to unfavorable weather events and climatic conditions. Despite technological advancement such as better crop varieties and irrigation systems; weather and climate are still key factors in agricultural productivity. Today agriculture is the single most and the largest sector of Bangladesh's economy which accounts for 12.64 percent of the Gross Domestic Product (GDP) and 47.30 percent of the labor force. It may consider as the lifeline of Bangladesh economy. It has to be noted that climate change have an effect on agriculture in various ways including through changes in average temperatures, rainfall patterns, atmospheric carbon dioxide (CO_2) and ground-level ozone concentrations (O_3), nutritional quality of some foods, and sea level rise etc. The paper will focus on the major challenges of climate change on agricultural development and food security issues in Bangladesh. Climate change has possibility of negative impact on crop production as well as all other sectors of agriculture. In effect, these changes may increase the risk of food security in our country. Field study clarified about the negative effects on food production, wherever most of the farmers observed unfavorable change in weather patterns especially in case of precipitation and temperature. Therefore it is very much urgent to determine the potential mitigation measures to cope with the problem associate with the climate change by further investigation. Government and nongovernment organizations might come forward to find out the optimum solutions; besides, national and international joint cooperation is highly required for not only saving our own country but also the human civilization.

Keywords: Climate Change, Agricultural Productivity, Sea Level Rise, Natural Calamities, Food Security

1. Introduction
Climate change has become a common occurrence in our planet. Historically, climate changes have often had dramatic effects on the environment and caused the extinction of several species. Previous climate changes took thousands of years to have significant impacts on Earth but today climate changes has become a frequent phenomenon. The increased emission of greenhouse gases is the main cause of the atmosphere to become wormer. This situation has observed substantially since the industrial revolution. Notably, anthropogenic activities are the main reasons for creation of global warming at all. Unstable and unfavorable weather conditions have created a chaotic farming environment all around the world. A few countries including Bangladesh are more vulnerable due to extreme climatic conditions. Therefore considering both the climate change and the agricultural development, this paper may have an attempt to propose a further elaboration for the possible major challenges of climate change in Bangladesh.

1.1 Background of the Study
The balance of scientific evidence now suggests that over the last century humans have begun to have a discernible influence on the earth's climate, causing it to warm [1, 2]. On the global scale, the amount of CO_2 concentrations increased more during 2012 and 2013 than during any other year since 1984 and significantly higher than they were before the industrial revolution (278 parts per million in 1750 compared with 396 parts per million in 2013). If humanity's greenhouse gas emissions continue to increase, the average temperature of the Earth's lower atmosphere could rise more than 4 °C (7.2 °F) by the end of the 21st century [3].

The increase of CO_2 in the atmosphere has been more rapid in recent years. The major reason for this increase may be attributable to the extensive use of fossil fuels, such as oil, coal and gas. The destruction of carbon sink by excessive land use and deforestation might be another important cause for the atmospheric CO_2 increase over the last 100 years [4]. In 2013, concentration of CO_2 in the atmosphere was 142% of the pre-industrial era (1750), and of methane and nitrous oxide 253% and 121% respectively [3]. The increase of CO_2 and several other green house gases such as methane, nitrous oxide, chlorofluorocarbons (CFCs) could cause an increase global temperature of about 4.2 °C and possibly a change in precipitation patterns and amounts in some regions [5]. Global warming due to increasing concentrations of green house gases poses a threat to human society by changing the living and working environment to which society has adapted over many generations [6]. Agricultural impacts of climate change could have profound effect in poor and developing countries.

Bangladesh, a developing country in South Asia, is primarily deltaic flood plains, and elevations in most of the country do not exceed 10 m. The country has a humid tropical climate. Average rainfall in drier and wetter regions is 1500 mm and 5000 mm per year respectively. In winter, the average minimum and maximum daily temperatures are about 9.7 and 26.6 °C respectively. In the summer, the average maximum temperature is about 32.2 °C [7]. Despite technological advances such as improved crop varieties and irrigation system, weather and climate are still key factors in agricultural productivity. The rise of CO_2 level in the

atmosphere and the concomitant climate change will have a direct impact on agriculture.

2. Objectives of the Study

The main objective of this study is to determine the prevailing climate change scenarios and its effects on agriculture and food security in Bangladesh. Few other objectives of this study are to know how the natural calamities hamper agriculture, find out the problem of greenhouse gas emissions, temperature rise and decreased precipitation pattern, understand the significant challenges of climate change to any societal aspiration to preserve food security issues in Bangladesh and make aware the risk of food security due to climate change.

3. Methodology

Data were collected from both primary and secondary sources. Primary data were collected through in-depth interview during July 2014 to February 2015. One hundred respondents were selected randomly from southern and northern part of Bangladesh. Most of them were directly and indirectly engaged in farming activities. Only statistical tools were used in the paper without implementing any technical or conceptual framework. However, different journal articles, chapter in books, feature from magazines, newspaper columns, government and nongovernment (published/ unpublished) reports were supported as secondary sources for this study. Moreover, simple graphs and tables were used for easy representation.

3.1 Importance of Agriculture in Bangladesh

The economy of Bangladesh is primarily dependent on agriculture. About 67 percent of the total population lives in rural areas [8] and are directly or indirectly involved in different agricultural activities. The agriculture contributes 12.64 percent of total GDP [9]. Nonetheless this sector generates 47.30% percent of total national employment [9]. Agricultural exports constitute for 5.67 percent of total exports of our country [10]. The agriculture sector is one of the major contributors to income and employment generation, and a vital factor to achieve self-sufficiency in food production and foster sustainable development by reducing rural poverty and unemployment.

4. Discussions

i) Erratic Weather Patterns and Natural Calamities

A misconception of global warming is that it will cause a complete decrease in rainfall and an increase in temperature. In reality, 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 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 on agricultural output. Several reports predict that erratic rainfall will play a significant role in 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.

ii) Agriculture and Climate Change

Climate change and agriculture are comprehensively linked together as agriculture still depends on weather patterns. Climate change has already caused a negative impact on agriculture in our country because of increasingly severe weather patterns. A climate change scenarios reproduced which were largely used for a number of subsequent national assessments. 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: 1.4ºC change in the winter and 0.7ºC in the monsoon months in 2030. For 2070 the variation would be 2.1 ºC and 1.7 ºC for winter and monsoon, respectively [11]. 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. The following table reviews the climate change scenarios developed by Ahmed and Alam [11].

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. The following table represents the predicted temperature and rainfall anomalies in Bangladesh [12].

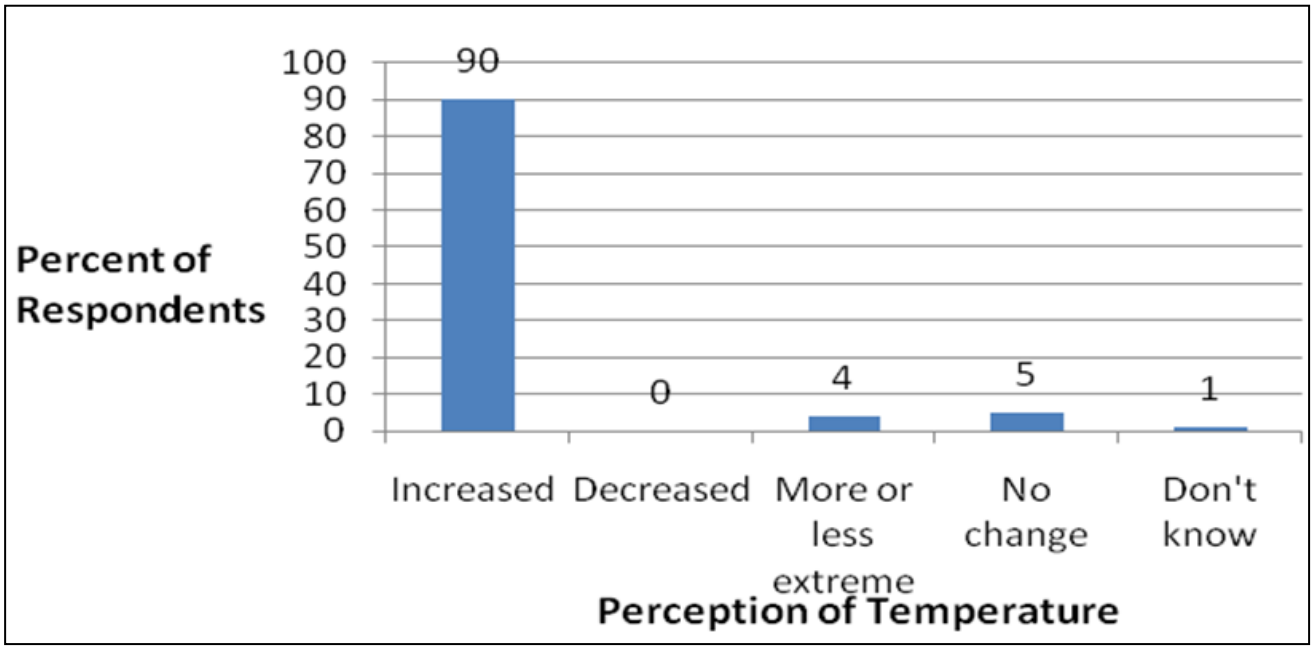
Table 2: Changes in temperature and precipitation for Bangladesh

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: Bangladesh NAPA Document (GOB, 2005)

From the field survey farmers got mixed perception regarding temperature change. Most of them (90 percent) perceived the temperature in Bangladesh to be increasing. None of them noticed the contrary, a decrease in temperature but almost five percent of the farmers noticed a no-change in temperature (Figure 1).

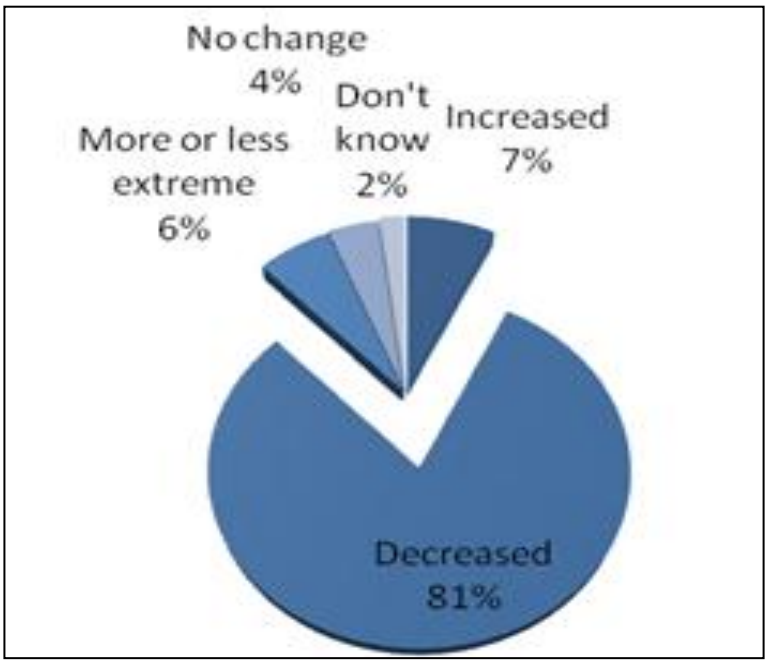


Source: Field Survey, 2015

Fig 1: Farmers' perceptions of changes in temperature in Bangladesh

Fig 1 shows the farmers' perceptions of changes in temperature in Bangladesh

On the other hand, most of the respondents (81 percent) observed decrease in precipitation and only seven percent noticed an increase in precipitation. However six percent found more or less extreme in precipitation and 4 percent denoted no change in precipitation (Figure 2).



Source: Field survey, 2015

Fig 2: Farmers' perceptions of changes in precipitation in Bangladesh

Fig 2 shows the farmers' perceptions of changes in precipitation in Bangladesh

a) Effects of Temperature Rise and Natural Calamities

The primary reason for rise in sea level may be the rise in temperature. Very general the increase temperature in the oceans causes the water to expand and therefore causing a rise in sea level. Bangladesh is highly vulnerable to sea level rise, as it is a densely populated coastal country of smooth relief comprising broad and narrow ridges and depressions [13]. World Bank showed 10 cm, 25cm and 1 m rise in sea level by 2020, 2050 and 2100; affecting 2%, 4% and 17.5% of total land mass respectively [14]. Additionally, due to plate tectonics, the ground level is moving downwards. 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 [15].

Table 3: Year-wise Flood Affected Area in Bangladesh

Year	Flood Affected Area		Year	Flood affected Area		Year		Flood affected Area
	Sq-Km	%		Sq-Km	%		Sq-Km	%
1954	36,800	25	1975	16,600	11	1995	32,000	22
1955	50,500	34	1976	28,300	19	1996	35,800	24
1956	35,400	24	1977	12,500	8	1998	1,00,250	68
1960	28,400	19	1978	10,800	7	1999	32,000	22
1961	28,800	20	1980	33,000	22	2000	35,700	24
1962	37,200	25	1982	3,140	2	2001	4,000	2.8
1963	43,100	29	1983	11,100	7.5	2002	15,000	10
1964	31,000	21	1984	28,200	19	2003	21,500	14
1965	28,400	19	1985	11,400	8	2004	55,000	38
1966	33,400	23	1986	6,600	4	2005	17,850	12
1967	25,700	17	1987	57,300	39	2006	16,175	11
1968	37,200	25	1988	89,970	61	2007	62,300	42
1969	41,400	28	1989	6,100	4	2008	33,655	23
1970	42,400	29	1990	3,500	2.4	2009	28,593	19
1971	36,300	25	1991	28,600	19	2010	26,530	18
1972	20,800	14	1992	2,000	1.4	2011	29,800	20
1973	29,800	20	1993	28,742	20	2012	17,700	12
1974	52.600	36	1994	419	0.2			

Source: Annual Flood Report, 2012

Floods have historically caused huge losses in agricultural output as well as irreversibly damaged crops and cultivatable land. It is quite evident that agriculture plays a pivotal role in economic development of our country.

The growth and development of crops are directly related to the photosynthesis which is openly related to the temperature. Therefore, an optimum temperature is required for plant growth that ranges from 25 to 30 °C. Estimation show that the effect of maximum temperature would drastically reduce the

yield of rice and every 2 °C increase of temperature crop yield could decrease several times. Maximum temperature has significant negative impact on Boro rice yield about 2.6 to 13.5% due to increase 2 °C maximum temperature and 0.11 to 28.7% for 4 °C of increase temperature [16]. When temperature falls below the range or exceeded the upper limit, crop production faces constraints. With the climatic conditions of Bangladesh these are very much conducive. A study found that 10°C increase in maximum temperature at vegetative, reproductive and ripening stages there was a decrease in Aman rice production by 2.94, 53.06 and 17.28 tons respectively [17]. With the change in temperature (by 20 °C and 40 °C), the prospect of growing wheat and potato would be severely impaired. Production loss may exceed 60 percent of the achievable yields [18].

b) Effect of Sea Level Rise

The rise in sea level is another threat for agricultural production that affects agriculture in three ways, i.e., by salinity intrusion, by flooding and by increasing cyclone frequency and its depth of damage. Combined effects of these three factors decrease agriculture production in the coastal zone. Salinity intrusion due to sea level rise will decrease agricultural production by unavailability of fresh water and soil degradation [19]. Salinity also decreases the terminative energy and germination rate of some plants [20, 21]. For example, the loss of rice production in a village of Satkhira district was investigated and it found that rice production in 2003 was 1,151 metric tons less than the year 1985, corresponding to a loss of 69 percent. Out of the total decreased production, 77 percent was found due to conversion of rice field into shrimp pond and 23 percent was because of yield loss [22].

As the sea level rises, this allows the saltwater to makes it ways on dry land. Salinity intrusion is already a significant hindrance to Bangladesh's agriculture. Currently, more than half of the agricultural land is tainted with saltwater. In southern parts of Bangladesh, the intrusion of salinity is seriously affecting the arable land. Salinity hinders agricultural output. In addition to such crippling effect, rising population and declining agricultural land due to rising sea level, the nation's food security is at risk. In fact, the nation's most popular food commodity has been tremendously affected by salinity. During the Boro season in the southern region, it is not possible to grow rice. Though, there has been advancement with saline tolerant rice varieties, the technology will take time to extend to farmers. Thus, salinity is a very apparent problem to the nation's agriculture and puts the nation's food security at risk.

Sea level rise has considerable effects on fisheries and aquaculture, causing a great change in fish habitat and breeding ground. There are 60 shrimp hatcheries and 124 shrimp processing plants in the coastal zone [23]. And coastal zone are mostly vulnerable to sea level rise, shrimp hatcheries and shrimp fields are also vulnerable to this phenomena. However, sea level rise is helping shrimp culture by bringing in salt water into it but if water overflows it can cause a serious flood condition and have a massive harm to this sector. Fisheries are the main protein source for us. So, decreased coastal fisheries would cause protein insufficiency among the coastal population in Bangladesh and ultimately causes health problem. Many people in the coastal zone are earning their livelihood by fisheries but if the fisheries sector is damaged due to climate change it may cause a great threat to not the coastal people only but the national economy is also severely hampered, ultimately Bangladesh may go down to earn foreign exchange.

Rising sea levels also affect the forestry industry of Bangladesh. The sea level will rise between 18 cm and 59 cm by 2100 [24]. In effect, the Sundarbans will be completely wiped out which is the single largest forestry producer in this region. It is responsible for providing raw materials to wood-based businesses as well as supplying non-forest products such as beeswax and honey. In additions to its agricultural value, the forest also plays a vital role in providing employment, serves as protection to natural disasters and generates significant forestry revenue. All these opportunities will completely be lost if predictions of sea level rise become reality.

Another impact of sea level rise on agriculture is soil degradation. Due to degradation, soil may loss its productive capability, as salinity may decrease the soil temperature and germination rate of some plants too. So, agriculture, essentially the rice production in the coastal region is severely declined due to soil degradation.

iii) Climate Change and Food Security

Food security has been one of the major national priorities in last few decades in Bangladesh. Ensuring food security has been one of the major goals of Bangladesh since its independence in 1971 when most of the people were living under the poverty line [25]. Climate change will affect food security. The impacts of climate change on food security therefore should consider both direct impacts on local food production and also the fuller set of interactions with the whole food system [26]. Impact of climate change on crop production raises questions about ability to adaptation to achieve food security in Bangladesh because of the uneven allocation or distribution of resources and damages of crops due to recurrent climatic incidents of floods, drought and salinity. Flood has most deleterious effect on crop production of Bangladesh. In fact, in the year 1988 the flood caused reduction of agricultural production by 45 percent [27]. Northwestern regions of Bangladesh are particularly vulnerable to the droughts. A severe drought can create more than 40% damage to the broadcast Aus [28].

4.1 Conclusion and Recommendation

The effects of climate change represent more than just hurdles for overall development of Bangladesh rather it creates a great challenge for the agricultural sustainability. Bangladesh economy is highly reliant on agriculture. And agriculture is very much vulnerable due to sudden climate change. Agriculture and food security are always being threatened due to the pressure of massive population which is accounted for more than 160 million in 2014 [8]. In addition, climate change issues have been increased the risk level too.

Food security refers to the availability of minimum diet at a reasonable price. In order to ensure food security for all, agricultural growth and expansion is one of the major challenges that Bangladesh faces today. Cultivable land is being decreased in Bangladesh day-by-day to meet demand of the huge population as the land use pattern is transformed from farming to non-farming sectors (industrial or residential

purposes). Besides, Sea level rise and salinity intrusion, increase in temperature, flood and other natural calamities hamper the agricultural production.

No doubt that Bangladesh has made a steady progress in the expansion of food production and due to the increasing population pressure there has been an extensive use of land to meet the growing demand for food. Despite the growth in food production and its availability, food insecurity is still a major concern mainly because of the lack of purchasing power and thus of access to food, especially for the ultra poor community.

Impacts on regional and local food supplies in some low latitude regions could amount to large percentage changes in the production [29]. Climate change may therefore impose significant costs in our area. In addition, warming beyond that reflected in current studies may impose greater costs in terms of aggregate food supply. Projections from most economic studies show substantial economic losses as temperature increases beyond the equivalent of a CO_2 doubling. So it may suggest incurring a closer focus on more agricultural research to adapt and mitigate with changing climate patterns.

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