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Climate Change Effects on the Major Crops of Bangladesh and the Adaptation Measures- A Review of Literature

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Abstract

Bangladesh is a vast and resourceful nation, yet natural calamities often afflict it due to climate change (CC). Agriculture is the most vulnerable sector of the Bangladeshi economy due to CC. The North and Northwest areas of Bangladesh are severely impacted by CC-related natural calamities such as drought and high temperatures. The Southern and Southeast coastal areas are especially susceptible to rising sea levels, salt intrusions, and cyclones. Flooding stands as the principal natural disaster wreaking havoc on agriculture throughout Bangladesh, impacting almost every division each year with its devastating effects. Due to the rising sea levels, the Southern region of Bangladesh would produce 30 percent less Boro rice. Rice output would fall by 28 percent and wheat production by 68 percent if the temperature were to climb. Climate Change would lower the average output of rain-fed maize by 3.3 percent to 6.4 percent by 2030 and by 5.2 percent to 12.0 percent by 2050. Potato yields would likely decrease by 8.7 percent in 2075 because of soil moisture stress. From 2015 to 2020, the Khulna division in Bangladesh faced the most significant crop losses caused by climate-related disasters, while the Chattogram division recorded the least amount of crop damage during the same period. Bangladesh's most prevalent adaptation systems are agricultural and infrastructural management, whereas farm management is the least prevalent. Irrigation, obtaining loans, using tractors, and pesticides are farmer's most effective adaptation strategies in Bangladesh.

Keywords: Agriculture, Climate change, Char, Natural calamities

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Introduction

Bangladesh is one of the most climate-vulnerable countries on the planet, where natural catastrophes are common because of its vulnerable position between the Himalayas and the Bay of Bengal (Baten et al., 2015; Faroque et al., 2013). Located in South Asia, Bangladesh has a coastline of 720 km (447 miles) along the Northern littoral of the Bay of Bengal. Seventy-nine percent of the territory consists of the delta plain formed by the rivers Ganges (Padma), Brahmaputra (Jamuna), and Meghna and their tributaries (Mondal, 2010) (Figure: 1). Every year, thousands of people are displaced in coastal parts of Bangladesh due to natural disasters linked to climate change (CC) (Chowdhury et al., 2020). Erosion from the Padma, Jamuna, and Meghna rivers has destroyed 1,60,000 hectares of land, forcing 3,00,000 to 4,00,000 people to move to the capital city Dhaka annually (Rahman, 2022). By 2050, CC is expected to displace one out of every seven Bangladeshi residents (Khan, 2019).

Fig. 1. Main rivers map of Bangladesh (Source: Furfur, 2016)

Bangladesh has seen more than 200 natural disasters during the last three decades. Floods, cyclones, and hailstorms disproportionately affect most Bangladeshi families in disaster-prone areas. From 2015 to 2020, a total of 7.516 million households were affected by natural disasters, of which 4.111 million households (54.69 percent) were impacted by floods, followed by cyclones affecting 2.555 million households (34.0 percent) and hailstorms affecting 1.340 million households (17.83 percent). Around 4.067 million households were affected by disasters once during 2015-20 in Bangladesh, 54.11 percent of the total affected households.

Similarly, 2.355 million households were impacted twice, while the remaining 1.094 million were affected three or more times, accounting for 14.56 percent of all affected households (Table 1). Bangladesh is experiencing what can only be described as extreme climate injustice. The country is paying the price for the GHG emissions in the past and the present from high GHG-emitting countries like the United States and China, although it emits only 0.21 percent of global GHG emissions (Rahman, 2022).

Table 1. Total number of affected households by various types of disaster, 2015-2020

Type of disaster	Total	One time	Two times	Three times or more
Drought	354739	195461	117099	42178
Flood	4110532	1952914	1416900	740718
Water Logging	763676	332199	260184	171293
Cyclone	2555137	1324839	861592	368706
Tornado	396614	269063	83527	44024
Storm/tidal surge	169759	87035	59382	23342
Thunderstorm/Lightning	1068659	632539	317285	118835
River/Coastal Erosion	754979	419466	230269	105244
Landslide	30379	20156	6835	3387
Salinity	245845	103329	93224	49292
Hailstorm	1339898	995142	269855	74900
Others	7061	3956	2035	1070
Total number of disasters affected households (one affected household counted for onetime, non-overlapping total)				
Total	7515977	4066895	2354756	1094326
Percent distribution	100	54.11	31.33	14.56

Source: BBS, 2022.

Among the numerous sectors of the Bangladeshi economy, agriculture is the most susceptible to CC. Climate change impacts many facets of agriculture, including yield, allocation, food availability, and costs (Tai et al., 2014). As a consequence of CC, agriculture has been ravaged, and food security is in jeopardy in South Asia, which has become a severe worry (Rasul, 2021). Climate change is increasing the frequency and severity of floods, droughts, and heat stress, all of which pose a danger to the agricultural system's basis (Rasul, 2021).

The Southern and Southeastern coastal region of Bangladesh is especially susceptible to CC due to its location near the tip of the Bay of Bengal's inverted funnel form (Hossain and Joshi, 2025). Northern Bangladeshi Char inhabitants depend significantly on agricultural harvests for sustenance. Regarding climate-related natural disasters, Char inhabitants are among the most vulnerable. Similarly, the findings of a climate sensitivity index reveal that Char respondents are more vulnerable to various climate-related threats (Ahmed et al., 2021).

The direct and indirect consequences of CC on the biophysical and socioeconomic conditions of the coastlines will result in unreliable access to food. Due to financial and political disadvantages, women are more vulnerable to CC and food insecurity than men. In addition, a study revealed that the propensity to feminize food poverty is not addressed by existing policies or adaptive mechanisms (Hossain and Majumder, 2018).

Adaptation in agriculture requires increased productivity through a broader array of technologies, more sustainable land management practices, and supportive legal and institutional frameworks (Aryal et al., 2020). To face the problems of CC in the following decades, adaptation strategies and agricultural or economic policies must include regional climate models and their diverse forecasts. In addition, further physical and statistical research is necessary to comprehend better the behavior pattern of extreme climatic events (Dastagir, 2015).

Adaptation is highly reliant on people's susceptibility to CC. In addition, seasonal weather forecasts should be included in agricultural techniques' data (Piya et al., 2013). Under these backdrops, this study aims to understand the present situation of CC and its impact on main crops and farmer-level adaptation, as well as farmers' opinions of future coping strategies to face the challenges of future CC in Bangladesh through a literature review.

Methodology

The information gleaned from reviewing pertinent theses, journals, reports, and books served as the foundation for this study. Similarly, working with farmers and attending several seminars and research presentations on agriculture and CC contributed to the development of valuable, practical knowledge in this paper. The necessary data was gathered from several sources, including journal articles, theses, reports, books, and Bangladeshi statistics yearbooks. It was also discussed with

various researchers involved in continuing the study and consulting with other researchers and consultants. Research conducted in the same field but coming from various parts of the world was also considered.

Climate change and agriculture in Bangladesh

Agriculture underpins the country and has a direct impact on food availability. The biggest challenge we face is meeting the relentless demand for food as we strive to support a growing population. Issues on food security and the ability to earn a living from agriculture, which the vast majority of people on earth rely on, may result from CC's impact on agriculture (Faroque et al., 2013).

Frequent droughts in the Northwest have detrimental effects on agriculture. The drought has disrupted the food supply chain, food reserves, and agricultural production system in the Barind region (Hossain et al., 2016). Therefore, the Central and Southwest areas might benefit from improved irrigation efficiency and groundwater conservation from a water management perspective. The impacts of CC have not only always raised the water demand for crops, but it has also reduced owing to positive changes in relative humidity and negative changes in wind speed and sunshine hours, as opposed to continuous climatic change (Islam et al., 2019).

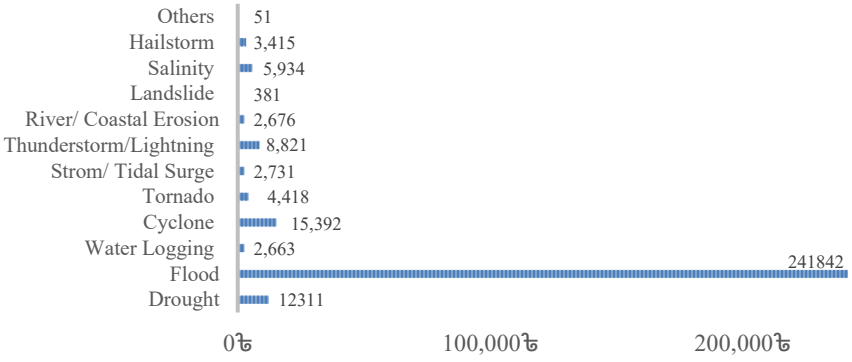

Fig. 2. Crop damaged (Million Taka) by natural disasters in Bangladesh, 2015-2020.
Source: BBS, 2022.

Floods are solely responsible for crop damage totaling TK. 2,41,842 million, which is the most severe crop damage from 2015 to 2020, as shown in Figure 2. From 2015 to 2020, cyclones and drought destroyed crops worth TK.15,392 million and TK.12,311 million, respectively. In addition, thunderstorms/lightning and salinity damaged crops to TK.8,821 million and TK.5,934 million, respectively (Figure 2).

Table 2. Crops damaged (Million Taka) by division and disaster categories in Bangladesh, 2015-2020.

Types of disaster	Barisal	Chattogram	Dhaka	Khulna	Mymensingh	Rajshahi	Rangpur	Sylhet
Total	73585	35708	76606	94947	59475	78122	55518	44000
Drought	94	1054	2701	1116	1303	1740	552	3750
Flood	7568	14181	52401	1514	46539	43124	41117	35399
Water Logging	9592	3795	1709	6869	1680	2625	266	97
Cyclone	50551	11095	9360	71703	1468	8888	659	197
Tornado	68	96	374	361	143	2264	1032	80
Strom/Tidal Surge	2617	52	0	61	0	0	0	0
Thunderstorm/ Lightning	79	319	627	1557	432	4015	1107	686
River/ Coastal Erosion	1108	1882	5119	4337	1431	6496	6072	321
Landslide	0	380	0	0	0	0	0	1
Salinity	1880	1331	7	2716	0	0	0	0
Hailstorm	29	1523	4301	4711	6479	8927	4714	3470
Others	0	0	6	0	1	44	0	0

Source: BBS, 2022.

Khulna suffered the most crop loss with TK.94,947 million (18.33 percent), followed by Rajshahi and Dhaka with TK.78,122 million and TK.76,606 million, respectively, whereas Chattogram had the least amount of crop damage, totaling TK. 35,708 million (Table 2). Except for the landslide, almost all-natural disasters impacted the crops in Khulna division. Crops damage and loss due to cyclone and salinity erosion were the greatest in the Khulna Division, TK.71,703 million and TK.2,716 million, respectively. Flood is the main natural disaster that causes agricultural loss in Bangladesh, affecting almost all divisions on regular basis. Flood caused crop damage and loss of TK.52,401 million in Dhaka alone, followed by TK.46,539 million in Mymensingh. The highest number of crops are damaged by drought in Sylhet, accounting for TK.3,750 million (BBS, 2022). Among the natural disaster's floods, severe rain, pests, and diseases are the primary threats faced by Bangladeshi farmers (Adnan et al., 2021).

Climate change impact on the major crops of Bangladesh

Rice production

In Bangladesh, which has a long history of agricultural production, rice is the main staple crop. Rice is cultivated in most parts of the nation, except for the steep regions in the Southeast. Rice is the essential grain for Bangladesh's primarily agricultural economy and principal source of nourishment in this country, as seen by the high rice

consumption per capita (Shelley et al., 2016). In Bangladesh, *Aus* rice is cultivated throughout the summer (March-August), *Aman* rice during the monsoon season (March-December), and *Boro* rice during the winter season (December-June).

Rice harvests have undergone significant influences from climatic change impacts, although the observed consequences vary across three distinct rice cultivars. The rise in temperature positively affects *Aus* and *Aman* rice yields and adversely affects *Boro* rice yields. High temperatures and precipitation benefit crop production, whereas low temperatures have the opposite impact (Sarker et al., 2012, 2014).

There was a statistically significant increase in temperature and precipitation but a decline in relative humidity. Karim et al., (2012) predicted that Bangladesh's rice yield would decrease by 33 percent by 2100 due to changing rainfall patterns accompanied by a rise in temperature that would increase evapotranspiration by boosting the rice cultivation's water requirement by 14 percent by using the biophysical simulation model ORYZA2000. In general, rice output would drop considerably by 28 percent if the temperature were to climb (Alamgir et al., 2018).

The second major climate disaster face by rice crop is drought as one of the most significant abiotic constraints in Bangladesh under rainfed conditions. Water stress during the reproductive stage may significantly reduce rice output, although it can be overcome if caught early enough in the crop's development (Shelley et al., 2016). Climate change represents a significant risk of soil salinization along the coast of Bangladesh. *Aus* crop yields drop precipitously in response to increasing salt (Lázár et al., 2015). Several areas of the Barisal, Chittagong, and Khulna divisions are anticipated to increase soil salinity in the upcoming decades substantially. In numerous *upazilas*, significant losses have already occurred, and they will deteriorate as salt levels rise in the following decades. If no new adaptation measures are implemented, the expected changes will result in a 7.7 and 5.6 percent loss in total rice output in Barisal and Chittagong, respectively, by 2050 (Dasgupta et al., 2018).

Another estimate has shown that rising sea levels will drop Boro rice production by 30 percent in the Southern region of Bangladesh. Similarly, CC would cause a major yield drop in the future owing to climatic unpredictability in Bangladesh, with a predicted 8–17 percent fall in rice output by 2050 (Alamgir et al., 2018).

Potato production

The potato is the nation's second-largest food crop and is mainly consumed as a vegetable. Bangladesh has extensive economic activity associated with potato production and commercialization, including economic relationships among farmers, dealers, stockholders, and cold storage operators (Akhand et al., 2016). As a result of CC, the degree of unpredictability of potato harvests in specific years has increased (Lázár et al., 2015). Climate change, which varies in speed across different locations and times, affects potato harvests. There is a chance that even a little temperature increase beyond the threshold will majorly affect potato tuber yields. The

temperature considerably influences the number of potatoes cultivated in Bangladesh; nevertheless, high summer temperatures may not be conducive to potato irrigation (Salan et al., 2022).

Temperatures beyond the recommended range (18–22˚C) decreased potato output. The simulation has shown a reduction of around 50 percent in potato yield due to an increase in temperature. Lack of precipitation and poor sun radiation restrict potato production regions during maturation. It was determined that, as a result of soil moisture stress, potato yields would likely decrease by 8.7 percent in 2075 (Roy et al., 2009).

Maize production

In Bangladesh, maize is cultivated throughout the Kharif (March-June) and Rabi (November-February) seasons. Potential maize output is contingent upon suitable climatic conditions. Changing climate patterns represent Bangladesh's most significant threat to maize production (Islam and Hoshain, 2022). Salinity is another challenge for maize production in the southern part of Bangladesh. Salinity in Bangladesh has increased by 26 percent during the last 35 years (Mahmuduzzaman et al., 2014). In many regions of Bangladesh, floods represent a formidable obstacle to growing maize (Adnan et al., 2023). Bangladesh's unpredictable rainfall and temperature are detrimental to maize growth (Islam and Hoshain, 2022).

Bangladesh will have a 10 percent decline in arable land by 2030 and a 20 percent decline by 2050 (Timsina et al., 2018). In addition to increasing irrigation expenses, delaying the planting of maize due to drought may reduce grain production (Kabir et al., 2017). Changes in diet, in Bangladesh, such as the substitution of wheat for rice or the consumption of meat, eggs, and fish, may be prompted by rising incomes and the concentration of populations in urban areas resulting in a substantial increase in demand for maize (Akanda, 2010; Timsina et al., 2018). While certain regions in Southern and eastern India and Bangladesh may have yield increases, the vast majority of South Asia regions are anticipated to experience average yields of up to a 15 percent decrease by 2030 and a 25 percent reduction by 2050. Regionally, CC would lower rainfed maize production by an average of 3.3 percent to 6.4 percent in 2030 and 5.2 percent to 12.2 percent in 2050 (Tesfaye et al., 2017).

Wheat production

Wheat is a crucial cereal crop that affects global economic stability and food security due to its high caloric and protein content. Compared to 1980-2010 as a baseline, predicted worldwide wheat output will shift by -2.3 percent to -7.0 percent under the 1.5˚C scenario and by -2.4 percent to -10.5 percent under the 2.0˚C scenario (Liu et al., 2019). Despite this, wheat output in the region may remain to 76 percent below the demand in 2050 (Mainuddin and Kirby, 2015).

Bangladesh's wheat production is hampered by several factors, including extreme heat stress, drought, salinity, acidic soil, and numerous diseases (Barma et al., 2019). The wheat output would drop considerably, falling by 68 percent if the temperature were to climb (Alamgir et al., 2018). Bangladesh's wheat production will decrease by 61 percent even under a modest CC scenario (Roy et al., 2009). An increase in average temperature, the number of dry days, and the relative humidity negatively impacted wheat production. However, wheat production fell due to a shorter duration of the crop and a significant decline in the maximum leaf area index during flowering as the temperature rose (Sen et al., 2017).

Climate change and adaptation policy in Bangladesh

The agricultural adaptation approach comprises five components: crop management, farm management, water management, infrastructure, and social practice. Among the five adaptation methods, agricultural and infrastructure management strategies are the most essential, while farm management is the least used in Bangladesh (Ahmed and Fatema, 2022). Islam et al., (2021) found that using insecticides and taking out loans were farmers' most successful adaptation techniques. Income and farm size significantly influenced the essential criteria for selecting new adaptation techniques to CC in agriculture (Ahmed and Fatema, 2022). Irrigation has been considered Bangladesh's most significant agricultural adaptation technique, while crop insurance has been listed as the least. Adaptation methods, fertilizer, and enhanced seeds are often seen in crop management. Infrastructure management is only evident through the use of tractors in plowing and crop processing, but social practices are preserved through traditional agricultural processing techniques (Ahmed and Fatema, 2022).

In response to the threats faced by CC, the inhabitants of Char use several agricultural adaptation strategies, including adopting new or alternative farming techniques, adjusting planting schedules, and developing cultivars with short lifespans (Ahmed et al., 2021). Farmers attempted to adapt by modifying their agricultural techniques, calendars, varieties, agronomic operations, crop diversification, and animal care. Along with a dearth of suitable stress-tolerant crop species, extension services, and affordable agricultural financing, high production costs, unpredictable crop yields, and inconsistent output prices are the key obstacles to adaptation (Kabir et al., 2017).

Numerous farmers have used both on-farm and off-farm adaptation measures to mitigate the effects of CC and environmental stressors on their ability to care for their families, increase farm profitability, and diversify sources of income (Kabir et al., 2017). Important adaptation options include adopting new crop kinds, altering planting timing, household gardening, tree planting, and migration. Supporting local adaptation efforts and enhancing the resilience of vulnerable families seems to need improved access to financing and knowledge about relevant measures (Alam et al., 2017). It is evident that land, followed by labor and irrigation, is essential for

increasing agricultural production. Formal institutions must embrace cultural processes and forge collaborations with more community-based informal institutions to play a continuous and essential role in developing adaptive agriculture in Bangladesh (Islam and Nursey-Bray, 2017).

Conclusion

Crop agriculture across the underdeveloped world, particularly Bangladesh, is experiencing significant unfavorable consequences from CC. Residents of Char are among those most vulnerable to climate-related natural disasters as saline levels have already posed a danger to agricultural production, and a considerable yield decline has been seen during the dry season. Due to its proximity to the inverted funnel shape of the Bay of Bengal, the Southern and Southeastern coastal regions of Bangladesh are particularly vulnerable to CC. In the shifting environment of sea-level rise, it has been expected that increased salt concentration would increase the strain on farmers by lowering crop yields, therefore affecting their means of subsistence, income creation, and food security. Agricultural and infrastructure management is Bangladesh's most prominent adaptation method, while farm management is the least widespread. The availability of labor primarily determines adaptation to CC. Irrigation, acquiring loans, using tractors for plowing and crop processing, and using insecticides are highlighted as the most efficient adaptation measures used by farmers in Bangladesh. Formal institutions play a crucial role in the development of place-based mitigation and adaptation methods in agriculture via their different communities of practice.

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