Original Research Article

Plausible Impacts on Crop Production Under Climate Change in Bangladesh: An Analysis of the Denitrification-Decomposition (DNDC) Model

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Abstract: This paper first analyzes the changing pattern of temperature and precipitation and then constructs a Denitrification-Decomposition (DNDC) model to better understand the climate change impact on crop yields in Bangladesh. In the DNDC model, historical daily precipitation and temperature data used for baseline scenario and projected data have been taken from general circulation model (GCM). Different general circulation models (GCM) have been employed to analyze and estimate future temperatures and precipitations. The result of the general circulation model (GCM) study finds that the overall temperature in Bangladesh tends to increase by 1.5 ℃ and 2.8 ℃ in the years 2030 and 2050. Precipitation patterns are also projected to increase in 2030 and 2050. The result from the Denitrification-Decomposition (DNDC) model finds that overall rice, corn, winter wheat, potato, vegetable, and pulses yields decrease both in 2030 and 2050, and decrease more rapidly in 2050. In the year 2050, the output of rice, potatoes, and pulses falls by -33%, -35%, and -54%, respectively, while the production of corn and wheat falls by -22% collectively. Since rice is the main food consumed in Bangladesh, a decline in rice output will pose a serious threat to the country's ability to feed itself.

Keywords: Bangladesh, Climate change, Crop yield, Denitrification-Decomposition (DNDC) model.

1. Introduction

Climate change refers to long-term shifts in temperature, weather patterns, and other environmental conditions on Earth. It is primarily driven by the increase in greenhouse gas emissions, primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), resulting from human activities such as burning fossil fuels, deforestation, and industrial processes. Average global temperatures have been increasing steadily. The Intergovernmental Panel on Climate Change (IPCC) reported that global temperatures had risen approximately 1.2 degrees Celsius (2.2 degrees Fahrenheit) above pre-industrial levels by the early 21st century (Masson-Delmotte et al., 2021). The polar ice caps and glaciers in various regions, including the Arctic and Antarctica, have been melting at accelerated rates. This contributes to rising sea levels and poses risks to coastal communities. There has been an increase in the frequency and intensity of extreme weather events, including hurricanes, droughts, wildfires, and heavy rainfall events. These events have significant impacts on communities, ecosystems, and economies. Rising global temperatures cause seawater to expand, leading to higher sea levels. This poses a threat to low-lying coastal areas and can result in saltwater intrusion into freshwater sources. Increased CO2 levels are causing the world's oceans to become more acidic, which can harm marine life, particularly coral reefs and shellfish. Climate change is disrupting ecosystems and affecting plant and animal species. Some species are shifting their ranges, while others face increased risks of extinction. The Paris Agreement, adopted in 2015, remains a central international effort to combat climate change. Many countries have pledged to reduce their greenhouse gas emissions to limit global warming to well below 2 degrees Celsius above pre-industrial levels.

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Climate change has a significant impact on Bangladesh economy and agriculture. Bangladesh has a total area of 1,47,570 square kilometers, or 56,977 square miles, and is located in the northeastern region of South Asia. Bangladesh is frequently referred to as a riverine nation, and it has one of the world's largest deltas, with a significant portion of the delta being less than three meters above sea level. Bangladesh is primarily an agricultural nation and majority of the labor force was employed in the agricultural industry. The most significant agricultural crop produced in Bangladesh is rice, which accounts for about half of the country's labor force. Agriculture in Bangladesh is extremely susceptible to climate change; it is particularly sensitive to changes in temperature, precipitation, and rainfall pattern, and climate change is intensifying these changes. Bangladesh is a nation whose agricultural activities are largely dependent on nature, and climate change is further deteriorating this scenario. Bangladesh is already experiencing significant effects from climate change, including those on livelihoods, food and water security, ecosystems, infrastructure, etc. Future climate-related dangers will also be severe. Bangladesh has already experienced a slow rise in temperature and precipitation, with more unpredictable and variable weather patterns than in the past. Crop productivity in Bangladesh is declining due to climate change, according to earlier research (Hossain et al., 2023; Hossain et al., 2022; Rahman et al., 2018; Karim et al., 1996, 2012; Basak et al., 2010. Sarker et al., 2012).

This paper illustrates how Bangladesh's agricultural crop productivity has been impacted by climate change. The total climate scenario for Bangladesh has been projected in this research by first examining the output from climate models, and then all of the climate data are passed on to the DNDC model to calculate the overall influence on crop production. The DNDC model has been used to compare the output of the baseline climate and future climate scenario for 2030 and 2050 in order to reveal the influence of climate change on agricultural yield. This comparison offers insight into how future climate scenarios may change crop yields in Bangladesh. The rest of this paper will analyze methodology, database, result analysis and conclusion.

2. Methodology

The denitrification-decomposition (DNDC) model is used in this study to examine how Bangladesh's changing climate has an impact on crop production. The DNDC model is a process-oriented computer simulation model of carbon and nitrogen biogeochemistry in agro ecosystems. The model's specifics are described below.

2.1 Model Background

The DNDC model was initially used to simulate N_2O emissions from cropped soils in the USA, and it has subsequently been improved upon. Since the model's creation, other academics have adjusted it to fit various production systems. The DNDC model has so far been extensively utilized for regional modeling research in Europe, China, Canada, India, and the United States. In different soil systems and forested wetlands, such as agricultural fields, wetlands, grazed land, tropical rainforests, and temperate forests, the DNDC model has been used for various purposes to model GHG emissions, SOC management, grain yield, water-filled soil pore space, gross photosynthesis, percent of undecomposed residues, etc (Giltrap et al., 2010). The DNDC model's simulation capabilities are constrained by the data used to parameterize the model, and thus is sensitive to input data. To evaluate the potential influence of land management practices on climate change, however, DNDC model may be used. DNDC (Decomposition-Denitrification) model is a biogeochemical model and used to simulate SOC dynamics in agricultural lands by implementing functional relationships between important parameters and gas emissions. To measure soil C and N cycles in agro-ecosystems, the DNDC model uses soil carbon and nitrogen (N) biogeochemistry. A detailed description of the model and the equations are already explained in different studies (Li, 2007; Pathak et al., 2005; Pathak et al., 2006). Under different kinds of agricultural management practices, the DNDC model offers a scientific basis to estimate CO_2, CH_4, and N_2O emissions (Li, 2007). This model simulates soil-based biochemical interactions that result in CO_2, CH_4, and N_2O emissions. The initial goal of the DNDC model was to replicate greenhouse gas emissions. The DNDC model has been applied in practice by several research teams for a variety of objectives. This model has been applied to the modeling of grasslands and grazing land systems in various agricultural systems, as well as one- or two-crop rotations (rice and wheat) (Babu et al., 2006; Beheydt et al., 2007; Saggar et al., 2004). In the Indian crop field, the DNDC model has been used to simulate greenhouse gas emissions to monitor the N balance in rice cropping systems (Babu et al., 2006; Pathak et al., 2005; Pathak et al., 2005). Several other studies short or long-term simulations of SOC content of CO_2 and CH_4 emissions that have been validated against empirical data in several other studies (Liu et al., 2006; Qiu et al., 2005, 2009; Smith et al., 1997; Wang et al., 2008). This model was used to simulate anticipated SOC changes as well as CO_2 and CH_4 emissions under various farm management techniques.

2.2 Model Description

This research uses the DNDC model to analyze the effects of climate change on main agricultural crops in Bangladesh. The DNDC model is a computer simulation model for the biogeochemistry of carbon and nitrogen in agroecosystems that is process-oriented. The University of New Hampshire created the model that was employed in this study. This model was primarily created to measure greenhouse gas emissions from agricultural ecosystems, but it has since been widely utilized for yield prediction in subsequent studies (e.g., Babu et al., 2005; Tonitto et al., 2007; Fumoto et al., 2008). In the DNDC model, crop growth is monitored by simulating the process of crop nitrogen (N) intake from the environment while taking temperature and water stress into account. Biological nitrogen fixation, nitrification, denitrification, the breakdown of organic matter, atmospheric nitrogen deposition, atmospheric NH3 concentration, and fertilization from human inputs are among the dynamic biogeochemical processes of the DNDC. An ideal biomass accumulation curve is employed in accordance with user-defined parameters to calculate the maximum rate of daily biomass increase as well as the possible nitrogen and water demands (Kröbel et al., 2011). The highest yields, crop water requirements (CWR), the optimal temperature for growth, the necessary cumulative temperature (or TDD: the thermal degree days), the partitioning of the biomass, and their C/N (carbon/nitrogen) ratios are a few examples of such characteristics. By taking into account the input meteorological data, the thermal degree days (TDD) are used to define the growing period and the plant growth index (PGI).

In addition to the availability of N from various sources, the daily biomass increase is influenced by the availability of water. Using the Penman-Monteith equation, the DNDC model simulates the transport of water across several soil layers in accordance with soil characteristics, changes in soil moisture, and evapotranspiration. The accumulation of crop biomass will be limited from the ideal curve if the N or H_2O taken up is insufficient to meet the various daily anticipated demands. The user-specified ideal temperature and the tolerance range are used in the model to define temperature stress.

The potential grain increase as well as the stressors from nitrogen, water, and temperature control the daily rise in grain biomass. Numerous papers contain the model's technical specifications (Zhang et al., 2002; Li, 2012). The Crop Potential Maximum Grain Yield variable is used in the DNDC model to compute projected Crop Yield. Crop potential maximum grain yield (PMGY) is the highest grain yield (in kilograms of carbon per hectare) possible for a crop that receives enough water and nitrogen to thrive (the model assumes all other nutrients and light are always inadequate supply). Crop variety development has historically led to a rise in PMGY value, which is related to crop variety development. A generalized crop growth curve is utilized for all the crops in the model (Watts and Hanks, 1978). The following are the several steps used to calculate crop growth. The PMGY value and the crop biomass partitioning ratios are used to determine the potential maximum biomass yield (PMBY), as

$$PMBY = PMGY / G_f \quad \text{(Eq.1)}$$

Where: G_f is the fraction of crop biomass C that is in the grain C pool at harvest.

Crop potential maximum N uptake (PMNU) is the potential maximum biomass yield divided by the crop C:N ratio, as

$$PMNU = PMBY / RCN \quad \text{(Eq.2)}$$

On a given day the potential N uptake (Nup*) is determined by the difference between the optimal crop biomass N at that time and the actual crop N content, as

$$N_{up}^{*} = FG.PMNU - N_{crop} \quad \text{(Eq.3)}$$

Where: FG is the crop fractional growth.

For modeling soil climate, plant growth, decomposition, nitrification, denitrification, and fermentation, DNDC has six sub-models. Daily meteorological information (maximum and minimum temperatures, precipitation), soil characteristics (SOC content, clay content, pH, and bulk density), and farming management measurements are among the input elements needed by the DNDC (tillage, mineral fertilization, manure, and crop rotation). The model does not account for fuel use. The model used in this study was built using actual data from various climate stations in Bangladesh. Numerous research teams have employed the DNDC model thus far for a variety of purposes. The calibration of the DNDC model was done using actual data. The DNDC model estimates agricultural production in Bangladesh over a number of divisions with various planting dates and times. The DNDC model calculates the impact of climate change on crop yields for both rain-fed and irrigated crops, as well as changes in irrigation demand. There are two parts to the model. The first component includes profiles of substrate fixation driven by ecological forces, soil climate, crop growth, and decomposition sub-models, soil temperature, moisture, pH, and redox potential (Eh) (e.g., climate, soil, vegetation, and anthropogenic movement). TThe second part, made up of the sub-models for nitrification, denitrification, and fermentation, forecasts emissions from plant-soil systems of carbon dioxide (CO_2), methane (CH_4), ammonia (NH_3), nitric oxide (NO), nitrous oxide (N_2O), and dinitrogen (N_2). Each unique geochemical or biochemical reaction has been parameterized in the model using classical physical, chemical, and biological laws as well as empirical equations derived from laboratory experiments. The complete model builds a link between the main ecological forces and the C and N biogeochemical cycles. Four fundamental natural factors—namely, climate, soil, vegetation, and management practices—drive the entire concept (see Figure 1).

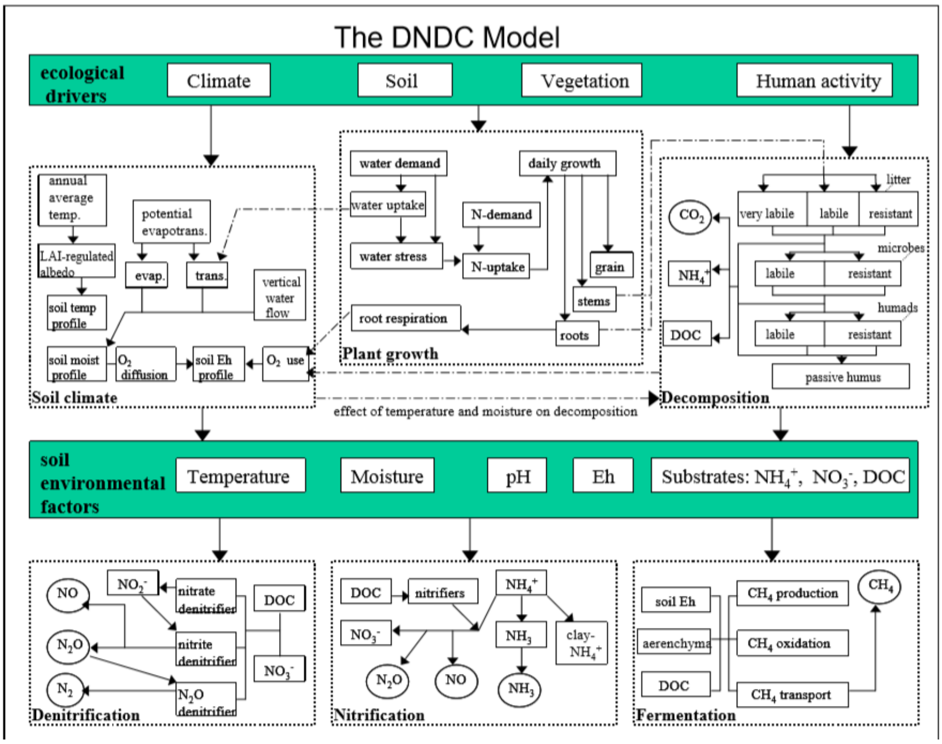

Figure 1 Structure of the DNDC model.

Source: *DNDC manual.*

Obtaining sufficient and reliable input data regarding the four main factors is essential for a successful simulation. Various climate model outputs are utilized in this research to examine how the climate will change over time in the model. The reason why climate projections vary between modeling institutes is because different climate modeling institutions employ various plausible models of the climate system. Climate models allow making understand what amount of temperature and precipitation changes under future climate scenarios. Numerous elements are taken into account by climate models, including historical data and emission conditions. A DNDC model is created in this study to simulate crop growth. The model, which examines the effects of agricultural yield on climate change, is a general crop model. Maximum yield, biomass portioning, C/N ratio, season-accumulating temperature, water requirement, and N fixation capacity are among the crop factors employed in this model.

3. Model Database and Study Area

3.1 Database

The inputs into DNDC model are daily weather data (max and min temperature and precipitation), soil parameters (N concentration in precipitation, Maximum SOC content, Minimum SOC content, Maximum soil clay fraction, Minimum soil clay fraction, Maximum soil pH, Minimum soil pH, Maximum soil bulk density, Minimum soil bulk density, and soil surface slope). Other related data like date of planting and harvesting, dates of irrigation, and the number of irrigation, quantities, and types of mineral fertilizers are used in the model calibration. Data on soil characteristics, such as texture, number of soil layers and depth of each layer, organic matter (in percent), groundwater table depth (in centimeters), etc., were collected from the Soil Resources Development Institute, Bangladesh. Climate parameters contained mean values of maximum and minimum surface air temperatures (in degrees Celsius), total precipitation (in centimeters) all on a daily basis. Daily climate data for the major parameters were collected from the nearby 8 meteorological stations, from January 2020 to December 2020. Daily rainfall and daily maximum and minimum temperature data were acquired from the Bangladesh Meteorological Department.

The future climate projection (2030 and 2050) data such as temperature and precipitation has been taken from various general circulation models (GCM) results considering CO_2 emission scenarios to analyze the total possible future variability. The data indicate that maximum temperature is in increasing trend all divisions and remains high in Rajshahi, Khulna, Dhaka and Sylhet division by 34.5℃, 33.5℃, 33.4℃ and 33.2℃ in the year 2050. It is evident from the data that the overall temperature in Bangladesh will increase up to 2.8℃ in 2050 and 1.5℃ in 2030.

The weather file database in the DNDC model includes Julian day, maximum daily air temperature (℃), minimum daily air temperature (℃), and daily precipitation (cm) data. Soil physical properties such as soil texture, clay content, bulk density, field capacity, wilting point, saturated hydraulic conductivity, soil pH, porosity, and initial soil organic carbon content were required for simulation. Information regarding soil texture, bulk density, and pH was collected from the Bangladesh Fertilizer Recommendation Guide (Ministry of Agriculture, 2010). Several kinds of farm management practices, including crop rotation, land preparation, water management, fertilizer application, and harvesting date, are mainly controlled by seasonal temperature and rainfall patterns. Information regarding climate and farming management practices, such as tillage, manure, fertilizer, irrigation, and flooding dates, was collected from either published journal articles or books.

3.2 Study Area

To unfold the impact of climate change on crop yield in Bangladesh, the entire country was chosen as the study area. The entire country is divided into 8 divisions named Dhaka Division (Latitude 23.9536° N; Longitude 90.1495° E), Barisal Division (Latitude 22.3811° N; Longitude 90.3372° E), Rangpur Division (Latitude 25.8483° N; Longitude 88.9414° E), Chittagong Division (Latitude 23.1793° N; Longitude 91.9882° E), Khulna Division (Latitude 22.8088° N; Longitude 89.2467° E), Rajshahi Division (Latitude 24.7106° N; Longitude 88.9414° E), Mymensingh Division (Latitude 24.7136° N; Longitude 90.4502° E) and Sylhet Division (Latitude 24.7050° N; Longitude 91.6761° E).

4. Result and Discussion

Figure 2 shows the maximum temperature trends in Bangladesh division wise. This portion of this paper analyze climate scenario in Bangladesh to investigate overall climate changes division wise. The result indicates in the year 2050 mean annual temperature tends to increase by 2℃ and daily maximum temperature will be intense in future and a slow increase in temperature is observed in the year 2030. Maximum temperature is in increasing trend all divisions. A significant increase in temperature (average 2℃) is observed in the year 2050 compared to baseline year 2020. Rajshahi, Khulna, Dhaka and Sylhet division temperature increases sharply by 34.5℃, 33.5℃, 33.4 ℃ and 33.2℃ in the year 2050. It is evident from the figure that the overall temperature in all divisions tends to increase up to 1°C in 2030 and 2°C in 2050.

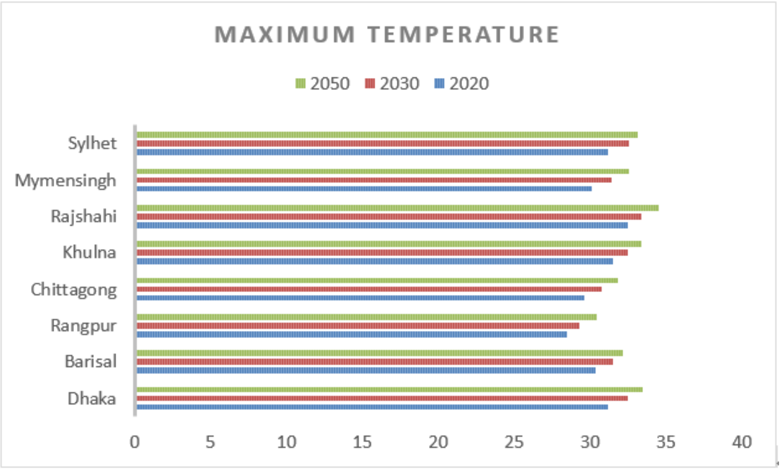

Figure 2 Maximum temperature projection of bangladesh.

Source: *Model simulation result*

Figure 3 gives details about minimum temperature increase in all division in Bangladesh. Minimum temperature increases in all division compared to baseline year 2020. Dhaka, Rangpur, Mymensingh and Barisal division are the major rice producing area in Bangladesh and the minimum temperature increases in those divisions. It is clear from the figure that the minimum average temperature in all division increases almost 1℃ in 2030 and 2℃ in 2050.

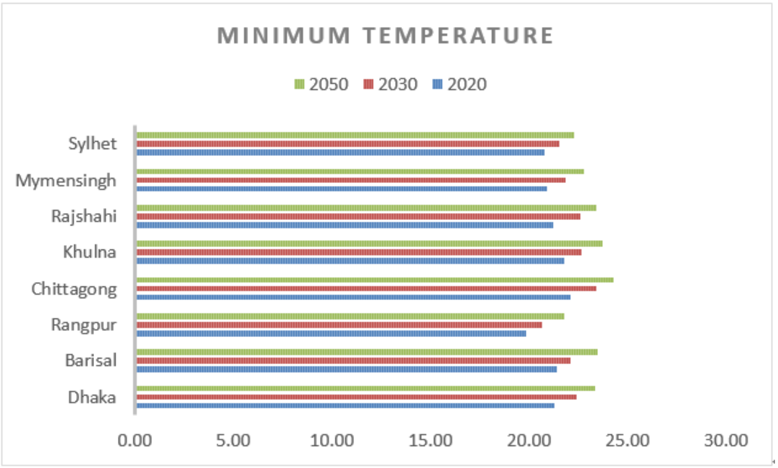

Figure 3 Minimum Temperature Projection of Bangladesh.

Source: *Model simulation result.*

Figure 4 shows the details about average precipitation pattern in all over Bangladesh. It is clear from the figure that the annual precipitation pattern is in increasing trend and projected to increase significantly in 2050, whereas the precipitation is projected to change a little in 2030 compared to baseline year 2020. This increasing trend of precipitation will increase rainfall intensity in Bangladesh. Thus it will directly affect crop production in Bangladesh.

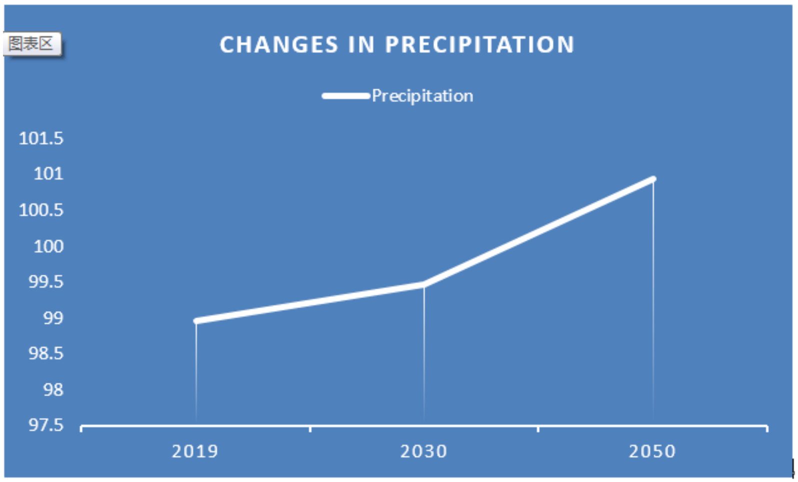

Figure 4 Precipitation Projection of Bangladesh.

Source: *Model simulation result.*

The DNDC model is used in this study to simulate changes in crop yields in different climate scenarios. The result of this study addresses the impact of climate change on the productivity of agricultural crops in Bangladesh during the periods 2020 to 2050 and did not extend to 2100 due to the limitation of data. Figure 5 provides information about crop yield in the Dhaka division. Results indicate that rice, wheat, corn, potato, vegetable, and pulses yield decrease in 2030 and 2050 compared to the base year 2020. Rice is the main staple food in Bangladesh and the majority of the people in Bangladesh take rice. Rice, potato, vegetable, and pulses production decreases significantly compared to corn and winter wheat. Rice production decreases to 1447 kg/ha in 2030 and 1194 kg/ha in the year 2050. Potato, vegetable, and pulses production decrease 4458 kg/ha, 2320 kg/ha, and 122 kg/ha in 2050.

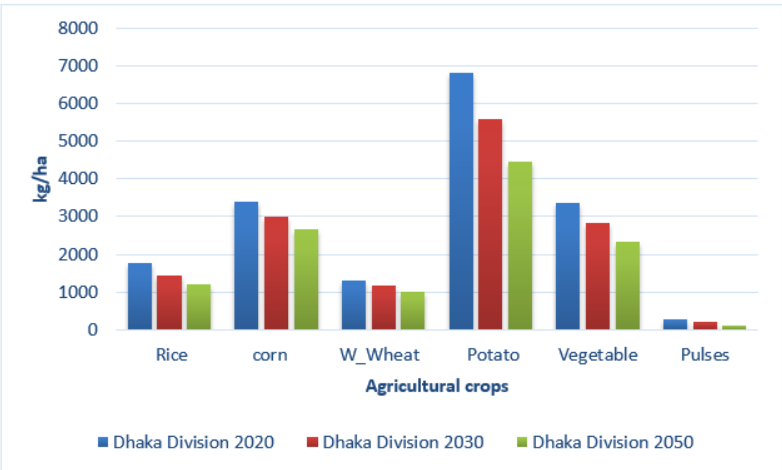

Figure 5 Impact of crop yield in dhaka division.

Source: *Model simulation result.*

Figure 6 shows the decreasing trend of crop yield in the Barisal division. Crop yield in this division drops due to climate change, where rice, potato, vegetables, and pulses decrease notably by 1583 kg/ha, 3453 kg/ha, 2013 kg/ha, and 175 kg/ha in the year 2050.

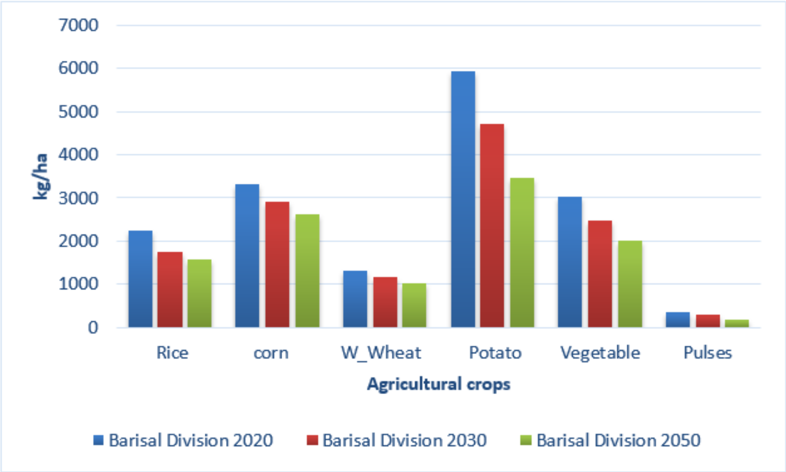

Figure 6 Impact of Crop Yield in Barisal Division.

Source: *Model simulation result.*

Figures 7 give a detailed projection of crop yields in the Rangpur division. Rangpur division located in the northern part of Bangladesh and this part is the major rice, corn, wheat, and sugarcane producing area. Crop yield in this area is highly vulnerable due to future climate change. Rice and pulses yield decrease significantly in 2050 stands 1431 kg/ha and 153 kg/ha, while corn and winter wheat yield decreases 2722 kg/ha and 1007 kg/ha.

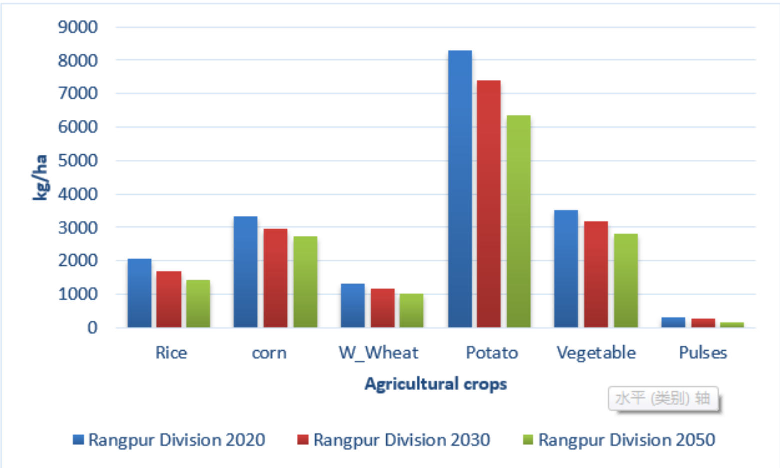

Figure 7 Impact of Crop Yield in Rangpur Division.

Source: *Model simulation result.*

Figure 8 explains the crop yield scenario in the Chittagong division. This division located in the southern part of Bangladesh. The southern part is often called the coastal area in Bangladesh. This part is highly vulnerable to climate change because of its geographic location. As shown in figure 8, rice, potato, and pulses yield decrease notably by 1497 kg/ha, 5512 kg/ha, and 160 kg/ha in 2050. At the same time corn and vegetable production decrease sharply by 2654 kg/ha and 2667 kg/ha in the year 2050.

Figure 9 shows crop yields in the Khulna division. This division also located in the southern part of Bangladesh. In this area rice, potato, corn, vegetables, winter wheat and pulses yields decreases both in 2030 and 2050. Potato production in this division decreases more rapidly by 4788 kg/ha and 3903 kg/ha in the year 2030 and 2050 compared to other agricultural crops.

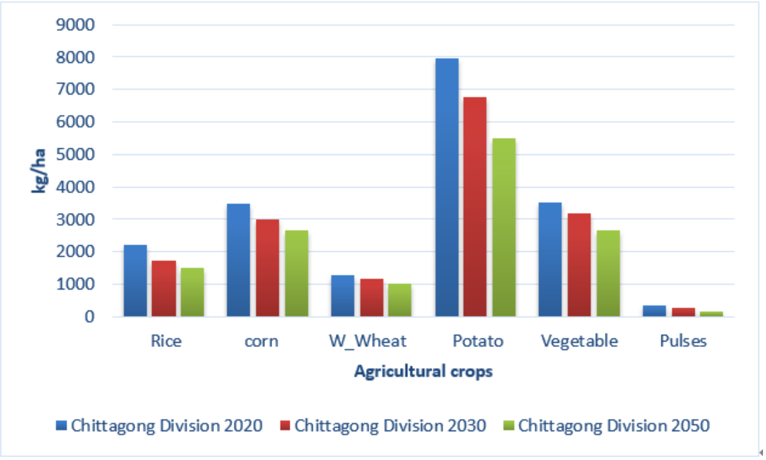

Figure 8 Impact of crop yield in chittagong division.

Source: *Model simulation result.*

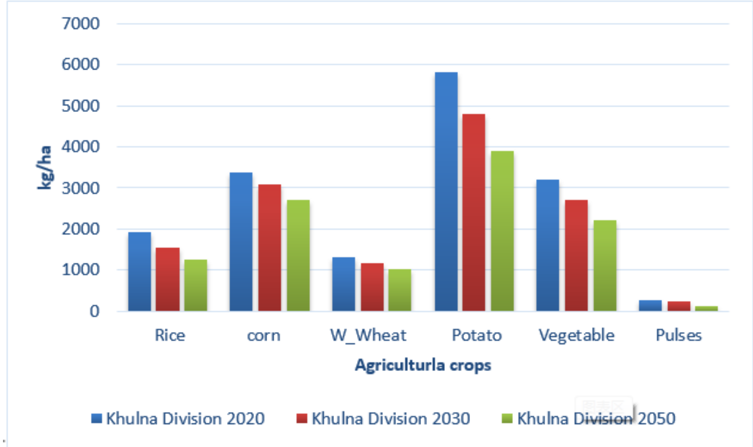

Figure 9 Impact of Crop Yield in Khulna Division.

Source: *Model simulation result.*

Figure 10 provides information about crop yield in the Mymensingh division and this division located in the central part of Bangladesh. Rice, potato, and pulses are the major crop produced in this area. It is clear from the figure that the rice production decreases by 1665 kg/ha and 1381 kg/ha, potato production decreases by 6048 kg/ha, and 4812 kg/ha, pulses production decreases by 249 kg/ha and 146 kg/ha in the year 2030 and 2050. On the other hand, the production of corn, winter wheat, and vegetables also decreases in 2030 and 2050.

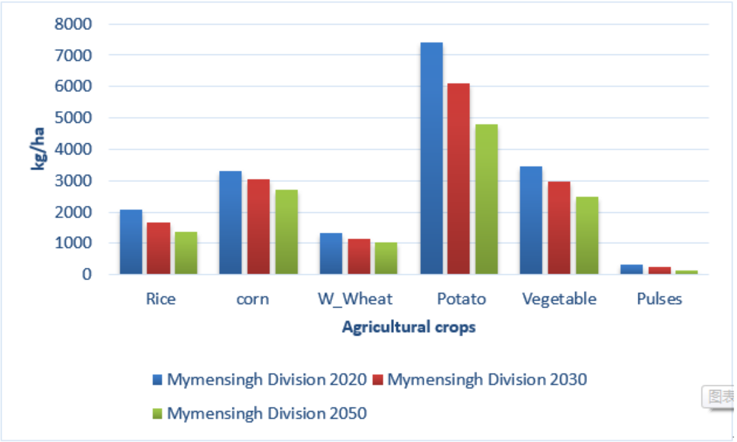

Figure 10 Impact of Crop Yield in Mymensingh Division.

Source: *Model simulation result.*

Figure 11 shows crop yields in the Sylhet division. Crop yields in this part decrease significantly in the year 2050. Wheat, potato, pulses and rice are the major crops in this division and the production of rice, potato, and pulses decrease significantly by 1202 kg/ha, 3728 kg/ha, and 123 kg/ha in 2050.

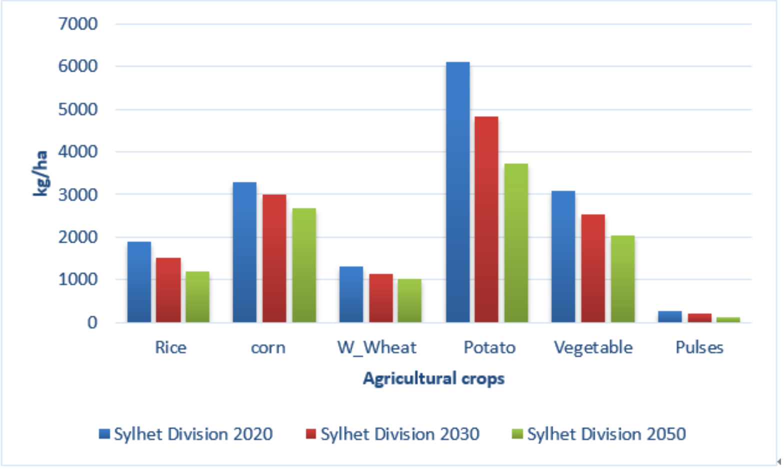

Figure 11 Impact of Crop Yield in Sylhet Division.

Source: *Model simulation result.*

Figure 12 provides information of crop yields in the Rajshahi division. Major crops in this area are corn, sugarcane, winter wheat, potato, and vegetable. Rice produced in this area in a very short amount compared to other divisions. As shown in figure 12, rice, potato, corn, vegetables and pulses production decrease significantly in the year 2050 amounts 997 kg/ha, 3410 kg/ha, 2408 kg/ha, 2179 kg/ha and 97 kg/ha.

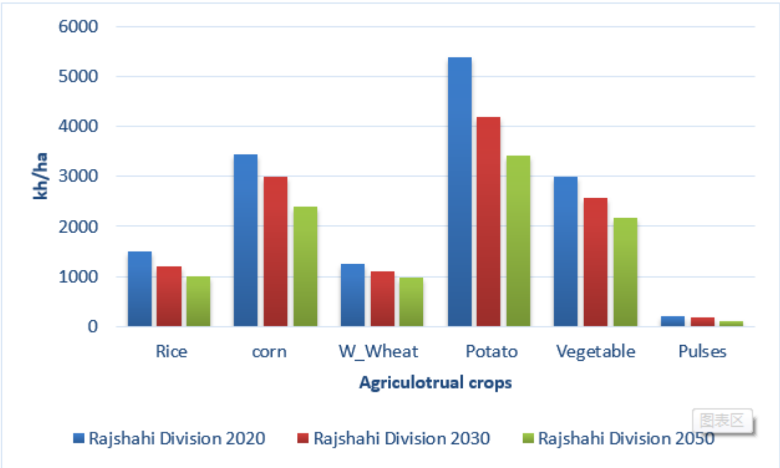

Figure 12 Impact of Crop Yield in Rajshahi Division.

Source: *Source: Model simulation result.*

Finally, table 1 shows the overall crop yields scenario in Bangladesh percentage-wise. It is clear from the table that the climate change severely affected rice, corn, winter wheat, potato, vegetables, and pulses yields in the year 2050 compared to 2030. Rice, potato, vegetables, and pulses yield decreases significantly in the year 2050 in all divisions in Bangladesh. Rice production decreases by -33%, -31%, -29%, and -34% in Dhaka, Rangpur, Barisal, and Mymensingh division. These divisions are the major rice producing area in Bangladesh. Rajshahi, Rangpur, and Chittagong divisions are the major corn-producing area. As shown in the table 1, corn production in those areas decreases by -30%, -18%, and -24% in the year 2050. Potato production also follows the same patterns and decreases in all divisions. In contrast, Rajshahi division is the major wheat-producing area and wheat yields in this division decrease by -20% and -21% in the year 2050. On the other hand, vegetables and pulses decrease significantly in all divisions in Bangladesh in the year 2050.

Table 1 Percentage change in crop yields.

Divisions	Year	Rice	corn	WWheat	Potato	Vegetable	Pulses
Dhaka	2030	-18	-12	-11	-18	-15	-19
	2050	-33	-21	-22	-35	-31	-54
Barisal	2030	-22	-12	-11	-21	-19	-19
	2050	-29	-21	-23	-42	-34	-52
Rangpur	2030	-18	-11	-11	-11	-10	-18
	2050	-31	-18	-22	-24	-20	-51
Chittagong	2030	-22	-13	-10	-15	-10	-19
	2050	-32	-24	-21	-31	-24	-54
Khulna	2030	-18	-9	-12	-18	-15	-19
	2050	-34	-20	-23	-33	-31	-55
Rajshahi	2030	-20	-13	-11	-22	-14	-17
	2050	-33	-30	-21	-37	-27	-54
Mymensing	2030	-20	-9	-13	-18	-14	-20
	2050	-34	-19	-22	-35	-28	-53
Sylhet	2030	-20	-10	-12	-21	-18	-22
	2050	-36	-19	-22	-39	-34	-57

Source: *Model simulation result.*

5. Conclusion

In this study, general circulation model (GCM) has been analyzed to investigate the changes in temperature and precipitation in 2030 and 2050. Then DNDC model has been analyzed to investigate the crop yield in Bangladesh. The GCM model result shows that temperature will increase up to 1.5℃ and 2.8℃ in the year 2030 and 2050. Major crops rice and other crops like corn, wheat, and vegetables are highly sensitive to temperature and will be more affected with increased temperature in the future. Crop failure due to either drought or excess rainfall is already putting a significant strain on the socioeconomic structure of Bangladesh. Looking at the results of the DNDC model simulations it can be seen that rice, wheat and corn yield decreases in all parts of Bangladesh. Rice, corn, wheat, and potato are the major crop in Bangladesh. It has been found from the result that the rice production decreases on average -20% in the year 2030 and -33% in the year 2050, corn production decreases -11% in the year 2030 and -21% in the year 2050, wheat production decreases -11% in the year 2030 and -22% in the year 2050. On the other hand, Potato production decreases by -18% in the year 2030 and -35% in the year 2050.

Bangladesh is dependent on agriculture and will continue to depend on her economic growth. Most of the rural area households depend on agriculture for their basic needs such as income and livelihoods. Agriculture is the main source of earning for the majority of people in Bangladesh. It evident from the analysis, that climate change will reduce crop production in Bangladesh. The reduction in crop production will significantly pose food security challenge in Bangladesh. Rice is the main crop in Bangladesh and accounts for 70% of daily caloric intake and climate change directly impact on rice production. The accompanying increased high temperatures will increase water demand for soil and this will lead to a food crisis in many parts of Bangladesh. Most importantly, the adverse impacts of climate change fall on the poorest people because a majority of them are dependent on agriculture as a source of food and income. In the future population in Bangladesh is projected to estimate a 200 million which means a more than 25% increase in food demand. Therefore, it is a crucial socio-economic and political issue in the economy of Bangladesh.

As Bangladesh is a developing country so it is necessary to put more emphasis on climate change issues such as increasing temperature, drought severity, changes in precipitation, and rainfall pattern. Besides, further studies regarding temperature, precipitation, and rainfall are still necessary. Adaptation to climate change is therefore the 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. Probably the most ideal approaches to adjust to climate change are to include individuals at the grass-root level. The people of Bangladesh are extremely venturesome and creative. They have been living with disasters for a long, long time (Ali, 1999). Adaptation is a great strategy to adjust to climate change. As Bangladesh is a developing country so Bangladesh should give more emphasis on the appropriate adaptation measures to combat climate change for ensuring food security. Finally, from the above analysis it can be said that climate variability and climate extremes are likely to pose greater challenges for food stability in Bangladesh in the long run.

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Author Contribution

S. S. Hossain performed the literature review, experimental design, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition.

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Conflict of Interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Code availability

The authors declare there is no code availability.

Ethics approval

The authors declare ethical approval for the publication of this research paper.

Consent to participate

The authors consent to participate.

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