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IMPACT OF CLIMATE CHANGE ON RICE PRODUCTION AT NAOGAON DISTRICT IN BANGLADESH

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Abstract

The study was conducted to evaluate the impact of climatic variables on rice production at Naogaon district in Bangladesh. The trend of climatic parameters such as temperature, rainfall and the rice (*Aman* and *Aus*) yield showed that both the annual average maximum and minimum temperatures were increased during 1981 to 2009 while the amount of annual rainfall from 1980 to 2009 was decreased. However the variation in rainfall was not statistically significant at 1 or 5% level. The surface water level of both Atrai and Chotto Jamuna rivers was decreasing during 2000 to 2009. In 1991 to 2008, the annual production of *Aman* was increasing significantly at 1% level. The highest (903815 Mt) and lowest (576970 Mt) production was recorded in 2008 and 1997, respectively. The annual *Aus* production was decreasing over the period 1989 to 2008. The highest (156050 Mt) and lowest (36760 Mt) production was recorded in 1989 and 1999, respectively. This study suggested that the *Aman* production is increasing with the climatic variations, whereas the *Aus* production is decreasing.

Keywords: Climate change, Temperature, Rainfall, Rice production

Introduction

The global warming induced changes in temperature and rainfall are already evident in many parts of the world, as well as in our country (Ahmed, 1999). Agriculture is highly susceptible to variations in climate change and the great majority of the people of Bangladesh are dependent on agriculture for their livelihood (McCarthy *et al.*, 2001; Karim *et al.*, 1996). The differences in harvest are largely due to variations in temperature and rainfall. Climate change as estimated will reduce overall rice production in Bangladesh by an average of 7.4% every year over the period 2005-2050 (Yu *et al.*, 2010). The increase of temperature will decrease the life span, grain yield, maximum leaf area index, biomass, and straw of the rice (Mathauda *et al.*, 2000). Changes in rainfall patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security (Karim *et al.*, 1996).

Drought is one of the worst effects of climate change, mostly affects Bangladesh in pre-monsoon and post-monsoon periods. During the last 50 years, Bangladesh suffered about 20 drought conditions (Banglapedia, 2008). According to IPCC (2007), the moderately drought affected areas will be turned into severely drought prone areas within next 20-30

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years. As plants are sensitive to high temperatures during critical stages (flowering and seed development), high temperatures can mean disaster to farmers' fields often combined with drought (Desiraju *et al.*, 2011). The drought condition in the northwestern Bangladesh in recent decades had led to a shortfall of rice production of 3.5 million tons in the 1990s. Due to drought severity, crop loss ranges between 20 to 60% or even may be more for transplanted *Aman* and other rice varieties. Naogaon district, one of the northwestern districts of Bangladesh, has already been known as drought prone area of the country (Banglapedia, 2008).

Crop plays a vital role in the economy of Bangladesh. The contribution of agriculture was 20% of GDP and the crop subsector alone contributed 12% to GDP at constant prices in 2009 to 2010. Of all crops, rice plays the leading role by contributing 95% of total food production (GoB, 2010). Climate information is now used to advise farmers about their choice of crops and methods of cultivation, which in turn was provided major benefits in terms of increased yields and preventing food shortages (Hulme, 1996). The objective of this study is to assess the climatic variations and to describe the impact on rice (*Aman* and *Aus*) production.

Materials and Methods

Study area

The Naogaon district is situated at northwestern Bangladesh, and is one of the drought prone areas of the country. It is about 3435 km^2 in area and is bounded by West Bengal (India) on the north, Natore and Rajshahi districts on the south, Joypurhat and Bogra districts on the east, Nawabganj district and West Bengal (India) on the west. The annual maximum and minimum temperature is 37.8 and 11.2°C, respectively and the annual rainfall is 1862 mm. Main rivers include Atrai, Punarnaba, Chotto Jamuna, Nagar, Chiri and Tulsi Ganga. Guta, Mansur and Dighali beels are also notable. The total population of the district is 2377314, where 49.01% of the population is direcly involved in agriculture and 26.96% is agricultural labourer. The total cultivable land covers 2777573 ha, where fallow land includes 68715 ha; with 25, 55 and 20% of single, double and triple crop land, respectively (Banglapedia, 2008).

Data collection

Twenty nine (1981 to 2009) years annual average maximum and minimum temperature data as temperature-related climatic variable and thirty (1980 to 2009) years' annual rainfall data were collected from Bangladesh Meteorological Department (BMD). Records of ten (2000 to 2009) year's surface water fluctuations of Atrai and Chotto Jamuna were collected from Bangladesh Water Development Board (BWDB). Record of eighteen (1991 to 2008) and nineteen (1989 to 2008) years annual *Aman* and *Aus* rice production, respectively, with respective cultivated areas (ha) were collected from the Bangladesh Rice Research Institute (BRRI).

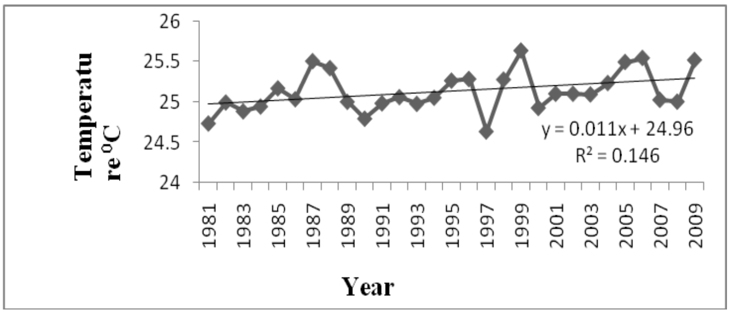
Data analysis

The data were analyzed by using SPSS 17 and Microsoft Office Excel 2007 to perform regression analysis and to investigate the probable relation between the climatic variability and trend of rice (*Aman* and *Aus*) production, so that the impact on rice production can be assessed.

Results and Discussions

Trend of annual average temperature

The air temperature is one of the main properties of climate which is very easy to measure, directly observable, and geographically consistent indicator of the climate change. It is observed that the trend of annual average maximum temperature, over the period 1981 to 2009, was increasing but not statistically significant (at 1 or 5% level). Similar result was also found by Karmakar and Shrestha (2000) and Mathauda *et al.* (2000). The highest annual maximum temperature was recorded at 25.6°C in 1999, while the lowest annual maximum temperature was 24.5°C in 1997 (Fig. 1a). The highest annual average minimum temperature of the study area was recorded 19.5°C in 2001 and the lowest annual average minimum temperature was 15.3°C in 2003 (Fig. 1b). The annual average minimum temperature during 1981 to 2009, indicated an increasing trend but not statistically significant (at 1 or 5% level). Similar result was also observed by Debsarma (2003) and Karmakar and Shrestha (2000).



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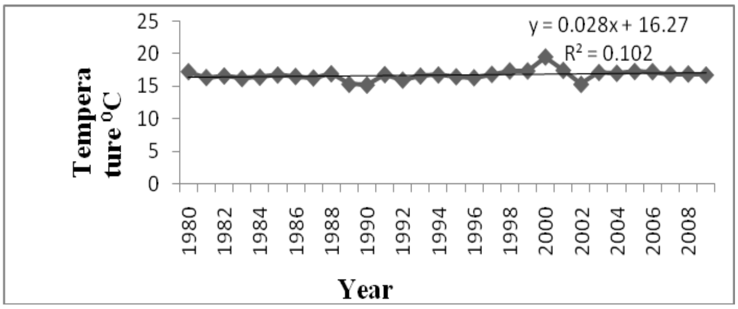


(b)

Fig. 1. Annual average temperature of the study area from 1981 to 2009: (a) maximum, and (b) minimum.

Trend of total annual rainfall

Rainfall is also one of the primary indicators for climate change. Rainfall distribution of the study area showed that the total amount of annual rainfall for the year 1980 to 2009 varied significantly and indicated a decreasing trend but not statistically significant (at 1 or 5% level). The highest amount (2262 mm) of rainfall was observed in 1981 and the lowest (463 mm) was in 1992. The average annual rainfall of the study area was 1934.4 mm (Fig. 2).

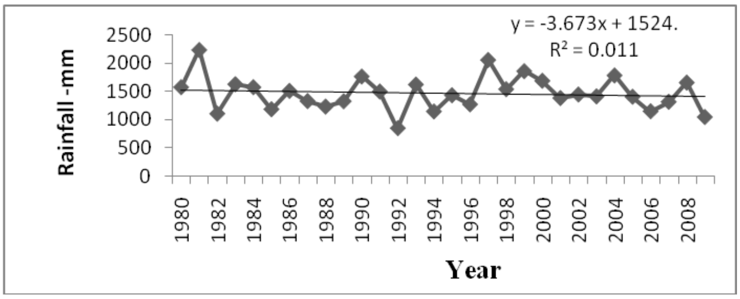
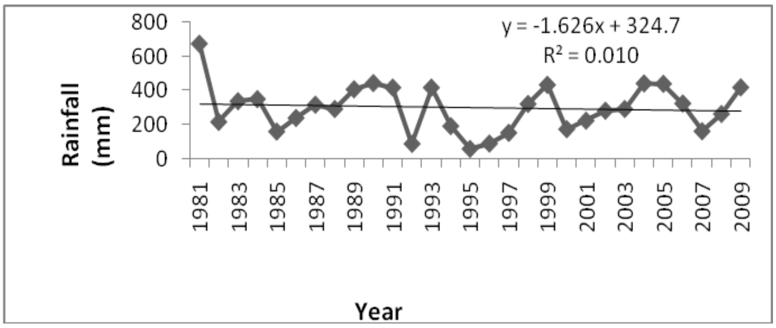


Fig. 2. Annual total rainfall of the study area (1980 to 2009).

Trend of total annual rainfall in different periods

The total amount of rainfall in pre-monsoon (March to May) period over the year from 1981 to 2009 had a decreasing trend. The highest (673 mm) and the lowest (95 mm) amount of rainfall were found in 1981 and 1995, respectively (Fig. 3a). The total amount of rainfall in monsoon (June to October) period for the year 1981 to 2009 showed a decreasing trend, with a highest amount (2500 mm) observed in 2005 and the lowest (915 mm) in 1994 (Fig. 3b). The total amount of rainfall in post-monsoon (November to December) period during 1981 to 2009, had also a decreasing trend. The highest (123 mm) and the lowest (1 mm) amount of rainfall were found in 1981 and 2009, respectively (Fig. 3c).



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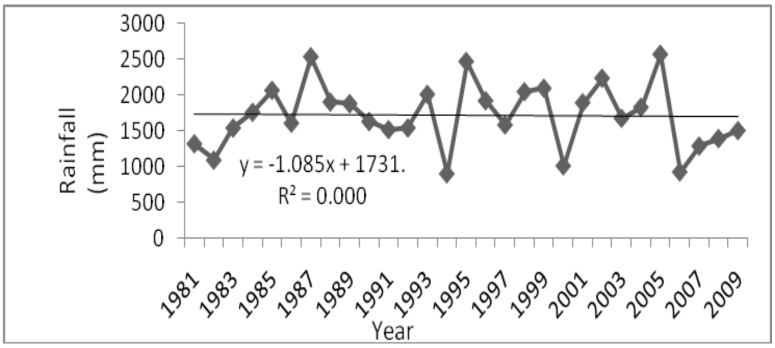

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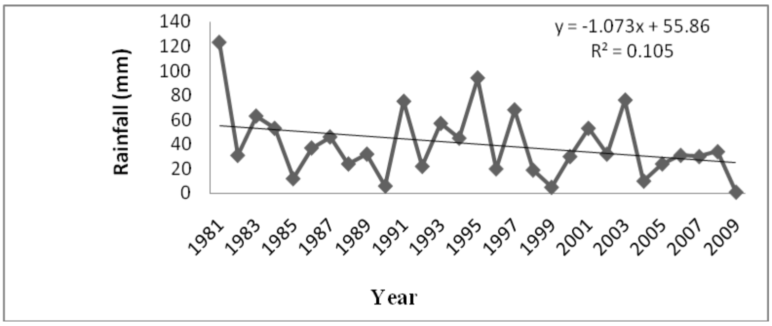
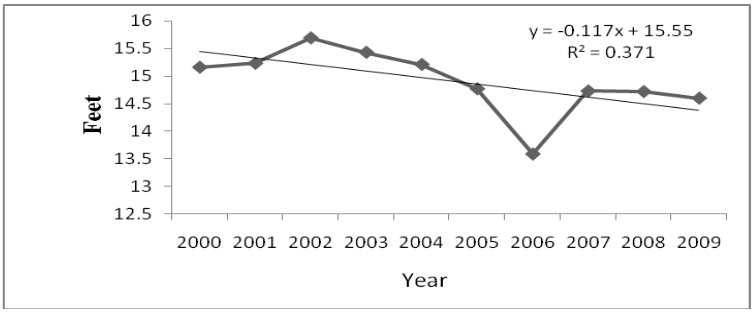


(c)

Fig. 3. Total amount of rainfall in different periods from 1981 to 2009:
(a) pre-monsoon, (b) monsoon, and (c) post-monsoon.

Trend of river water fluctuation level

The water level of Atrai River had a decreasing trend over the period 2000 to 2009, which might be due to the climatic variability in the study area (Fig. 4a). Desiraju *et al.* (2011) observed that climate change will not only affect the crop water use but also affect water availability. The annual highest (15.69 ft) and the lowest (13.59 ft) water level of Atrai river were recorded in 2002 and 2006, respectively (Fig. 4a). The surface water level of Chotto Jamuna river had also a decreasing trend over the period 2000 to 2009, resulting from climatic variability (Desiraju *et al.*, 2011). The annual highest (12.29 ft) and the lowest **(**9.49 ft) water level of Chotto Jamuna river in the study area were recorded in 2004 and 2009, respectively (Fig. 4b).



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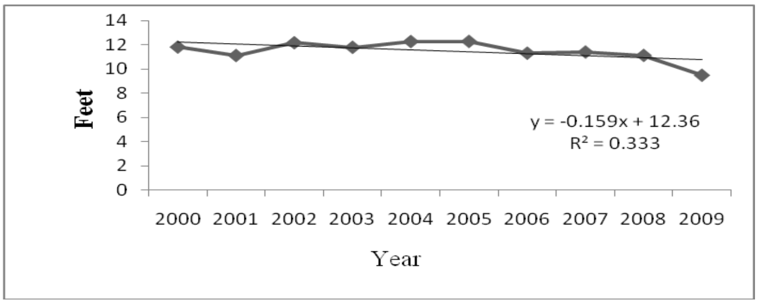


(b)

Fig. 4. River water fluctuation level in the study area from 2000 to 2009:
(a) Atrai river, and (b) Chotto Jamuna river.

Annual production of Aman (1991-2008)

The annual production of *Aman* rice along with the plot used from 1991 to 2008 is presented in Fig. 5. The highest production (903815 Mt) was found in 2008, whereas the lowest (576970 Mt) was in 1997. The highest plot areas (1008425 ha) were used in 1991 and the lowest (919506 ha) were in 2005. The *Aman* production had an increasing trend which was statistically significant and the area had a decreasing trend which was also statistically significant at 1% level (Fig. 5). The study also revealed that the annual production of *Aman* rice was increasing with increasing temperature (maximum and minimum) and decreasing rainfall, during the year 1991 to 2008 (Figs. 6a, 6b and 7).

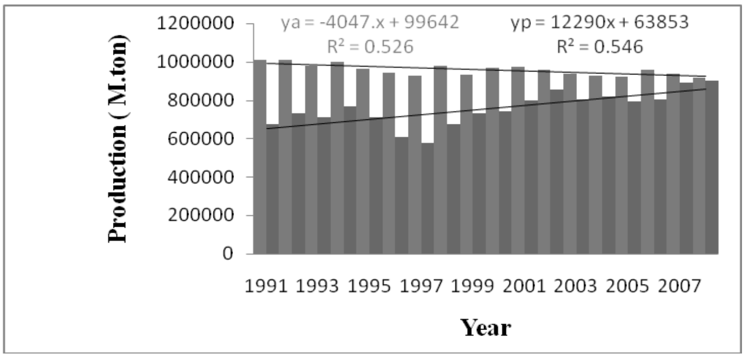
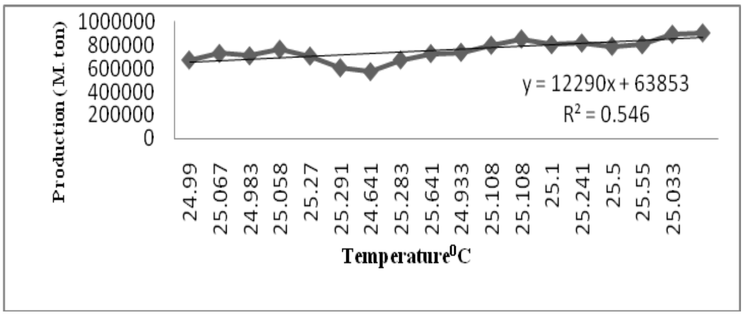


Fig. 5. Annual production of *Aman* with plot area from 1991 to 2008.



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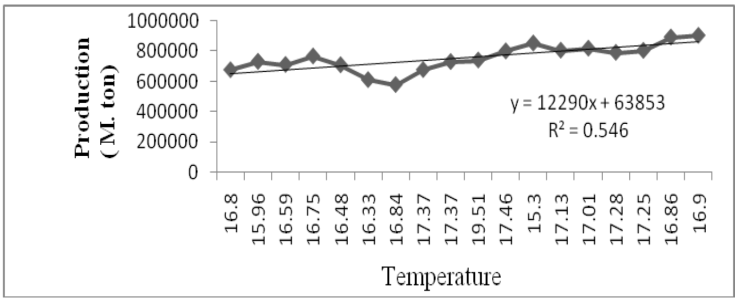

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Fig. 6. Annual *Aman* production in response to annual temperature from 1991 to 2008: (a) maximum, and (b) minimum.

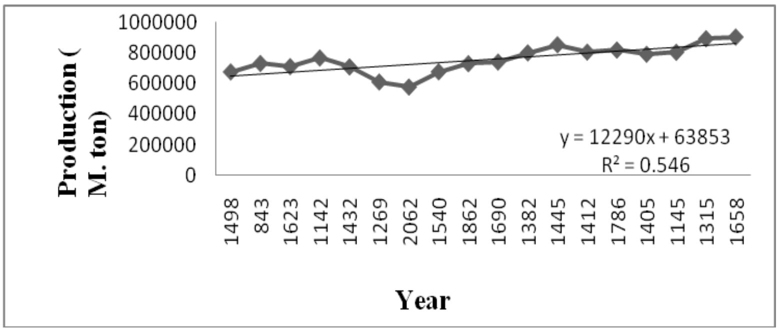


Fig. 7. Annual production of *Aman* in response to annual rainfall from 1991 to 2008.

Annual production of Aus (1989-2008)

The annual production of *Aus* rice had a decreasing trend which was not statistically significant at 1 or 5% level. The highest production (156050 Mt) was found in 1989, whereas the lowest (36760 Mt) was in 1999 (Fig. 8). The annual production of *Aus* rice was decreasing with increasing temperature (maximum and minimum) and decreasing with rainfall, from the year 1989 to 2008 (Figs. 9a, 9b and 10). Similar result was also found by Rimi *et al.* (2009) in Satkhira district of Bangladesh. Peng *et al.* (2004) found that the grain yield declined by 10% for each 1°C increase in growing-season minimum temperature in the dry season. It also might be due to the decreasing trend of water level in the study area as Atrai and Chotto Jamuna rivers are among the major sources of water irrigation.

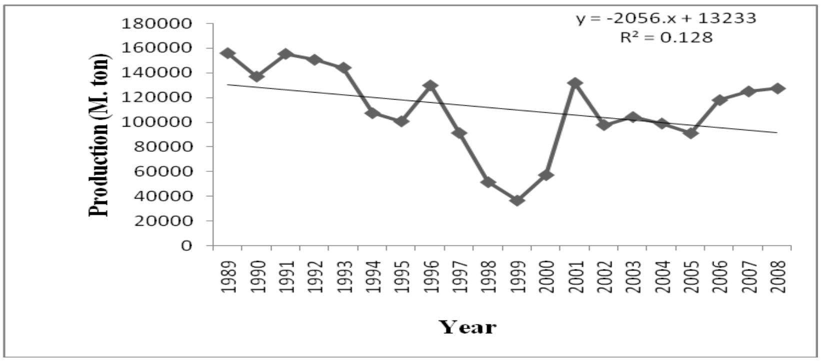
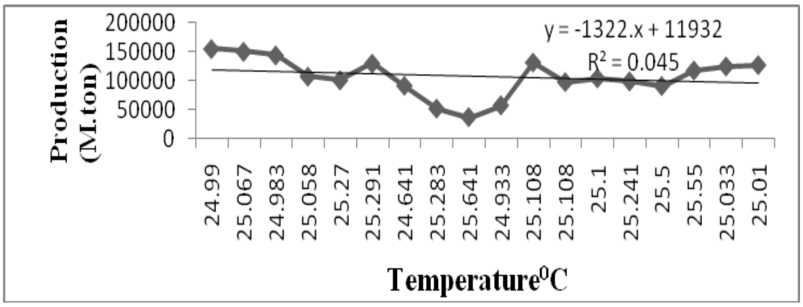


Fig. 8. Annual *Aus* rice production of the study area from 1989 to 2008.



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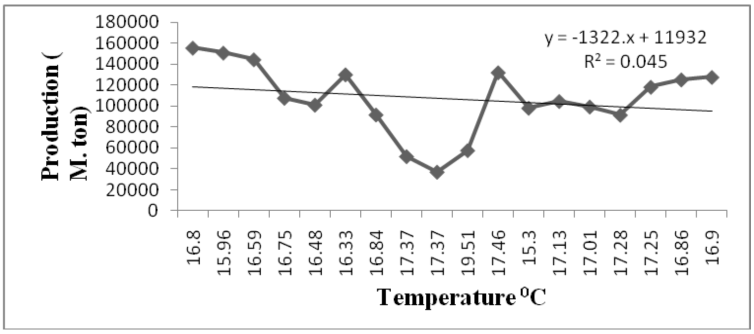

(b)

Fig. 9. Annual *Aus* production in response to annual temperature from 1989 to 2008: (a) maximum, and (b) minimum.

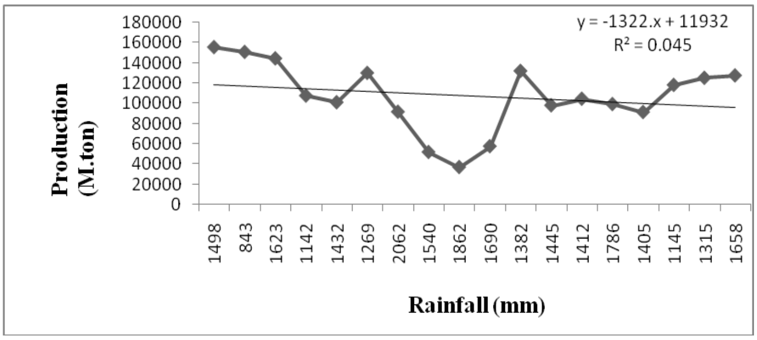

Fig. 10. Annual production of *Aus* in response to annual rainfall from 1989 to 2008.

Conclusions

With the increase in temperature and decrease in rainfall, the *Aman* and *Aus* production is increasing and decreasing, respectively. Low rainfall and increasing temperature are the main causes of drought in the study area which significantly affects the rice production. Although the farmers have taken copping strategies to mitigate the impact of climate change on rice production, the more frequent and intensified droughts will severely create adverse effects on the area, specifically on rice production, if the current trend of temperature and rainfall continues.

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