Effects Of Rainfall And Maximum Temperature On Aman Rice Production Of Bangladesh: A Case Study For Last Decade

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Abstract: The study is conducted for the effect of climate variables (rainfall, maximum temperature) on Aman rice production and mapping in Bangladesh. We used time series data for the last decade (2003-2012) for rainfall and maximum temperature from BMD (Bangladesh Meteorological Department) and BBS (Bangladesh Bureau of Statistics) respectively. From the combined trend of rainfall and maximum temperature intensity (determined by GIS mapping), geographically Bangladesh is divided into four regions such as; North-Eastern Region, South-Eastern Region, South-Western Region and North-Western Region, in this research. In North-Eastern regions Aman production is proportional to rainfall and maximum temperature does not prominent variables which indicate the rainfall effect the rice production prominently. In the South-Eastern region rainfall and maximum temperature both are in repetitive and show less effect on production which indicates other variables are prominent in this region. There may have salinity and soil condition effect on the Aman rice production of this region. In South-Western region the both variables are prominent in this region. We know that most the area of the region is situated under tidal effect which may be the cause of production decrease. In North-Western region Aman production increased though rainfall decreased so significantly also average maximum temperature was high in this region. It implies that maximum temperature is the dominant factor in this region which increases the Aman rice production significantly. So, effect of maximum temperature becoming the dominant variable continuously for Aman rice production in the last decade of Bangladesh.

Keywords: Climate variable, GIS, Rainfall, Maximum Temperature, Aman rice.

1. Introduction

The dominant food crop of Bangladesh is rice, accounting for about 75 percent of agricultural land use. Agriculture in Bangladesh is already under pressure both from huge and increasing demands for food, and from problems of agricultural land and water resources depletion (Ahmed *et al*., 2000). Bangladesh is facing challenges in tackling and managing the effect of uncertain climate change. According to the Third Assessment Report of IPCC, South Asia is the most vulnerable to climate change impacts (McCarthy, 2001). The international community also recognizes that Bangladesh ranks high in the list of most vulnerable countries (Climate Change Cell, 2008c). Climatic factors such as temperature, rainfall, atmospheric carbon dioxide, solar radiation etc are closely link with agriculture production. Therefore, rice production would be major concern in recent years due to changing climatic conditions, because there is a significant amount of rice yield may hamper for only fluctuations of those climatic parameters (Basak, 2010).

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Aman is almost completely rain-fed rice that grows in the months of monsoons, although it requires supplementary irrigation during planting and sometimes in the flowering stage depending on the availability of rainfall. Aman productions are also influenced by temperature as temperature and rainfall have good connection. For these reasons to increase Aman production it needs to adequate knowledge about climatic condition of Bangladesh and its changing pattern. For this purpose, GIS technology needs to be deployed which is capable of handling both spatial and attributes data to provide tools to present information in maps for better visualization, understanding and decision making. Therefore, the present study was undertaken at farm level with the following specific objectives:

1. To understand the impact of rainfall and maximum temperature on rice (Aman) production.
2. To identify the vulnerable rice growing area in Bangladesh for changing rainfall and maximum temperature condition and adaptation process.
3. To assess the change in rice (Aman) production under historical assumption.
4. Policy recommendation to increase rice production under upcoming diver's climatic condition.

2 METHODOLOGY

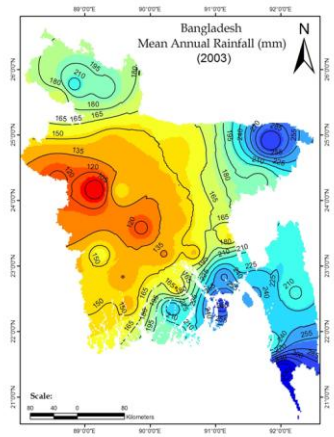
The information furnished in the study based on different database. Data and information were collected from DAE (Department of Agriculture Extension) personnel through informal interview and Meteorological data were collected from Bangladesh Meteorological Department (BMD, 2002-12). Rice production data were also collected from the Yearbook of Agricultural Statistics of Bangladesh of BBS. Data was entering and processing in the computer by using MS-Excel and MS-access programs. GIS unit of BRRI (Bangladesh Rice Research Institute) was used for contour mapping and documentation. All data were converted into standard units (Metric tons, mm, °C). A GIS (Geographic Information System) is a computer based technology for sorting,

manipulating, analyzing and retrieving data such as digital maps, images or other information with spatial reference such as latitude and longitude (BARC, 2001). GIS and their associated Map and database can serve general and multiple purposes with limited database. A key feature of the GIS is that, separate data sets may be related through a common spatial reference. Rainfall maps and maximum temperature maps are prepared using spatial analyst tool of ArcGIS 10, where kriging in interpolation of the spatial analyst tool is used by examine of semi-variance analysis with GS+ software. From the rainfall and maximum temperature contour maps, the whole country divided into four regions such as; North-Eastern Region, South-Eastern Region, South-Western Region and North-Western Region with different geographical position and characteristics. In every region, Aman rice production graphs prepared for last decade and then made comparison with rainfall and maximum temperature data. Then effect of the rainfall and maximum temperature are analyzed for Aman rice production regionally.

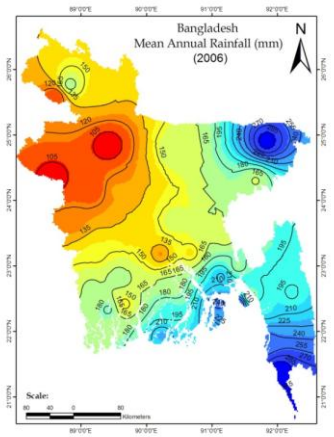
3 RESULT AND DISCUSSION

3.1 Average rainfall (Trend and maps)

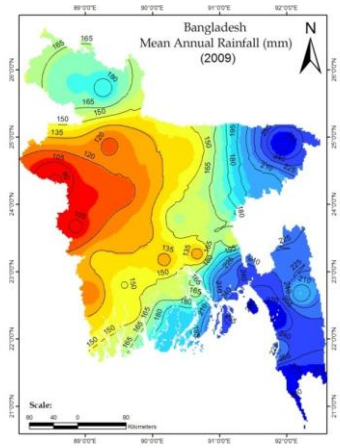
Rainfall has a statistically significant effect on Aus and Aman rice (Sarker *et al*., 2012). There have prepared average annual rainfall maps (Map 3.1.1 to Map 3.1.4) of Bangladesh for last decade from 2003 to 2012 with three years gap. The rainfall unit is in mm scale. There are observed many changes in average rainfall in different place of Bangladesh. The average rainfall diagram (Figure 3.1.5) from 2003-2012 shows the continuous fluctuation of rainfall of Bangladesh. But the regional diagrams shows different scenario of change in rainfall. From the contour map of 2003 (Map 3.1.1), maximum rainfall was located in the south and north-east part of Bangladesh. In the greater Sylhet area the rainfall was 210 mm to 300 mm where in Kutubdia and Chittagong area the rainfall were as much as 375 mm and in Cox's Bazar area it was up to 300 mm. From the contour map of 2012 (Map 3.1.4) the Sylhet and Chittagong region shows increase of rainfall where in the Sylhet area it is 240-375 mm and in Chittagong-Cox's Bazar area the rainfall is up to 450 mm. In those region shows an increasing graph of rainfall change, but in this time the total average rainfall of whole Bangladesh is lower than the year of 2003. It is occurred because the decrease of rainfall in other area of Bangladesh. Now, in the north and north-western part of Bangladesh the changes are very prominent. From the average data of rainfall station of Rangpur, Dinajpur, Bogra, and Rajshahi which are situated in north and north-western part of Bangladesh, the contour maps gives the scenario of changes in rainfall in this area.



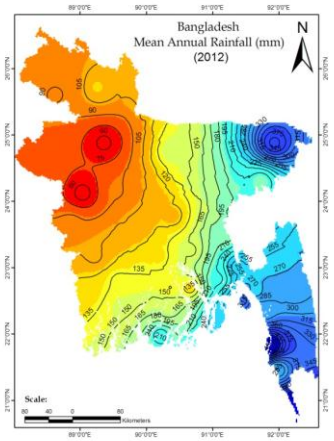
Map 3.1.1: Average Annual Rainfall (mm) contour map of Bangladesh (2003).



Map 3.1.2: Average Annual Rainfall (mm) contour map of Bangladesh (2006).



Map 3.1.3: Average Annual Rainfall (mm) contour map of Bangladesh (2009).



Map 3.1.4: Average Annual Rainfall (mm) contour map of Bangladesh (2012).

In 2003 (Map 3.1.1) average rainfall decreases to 210 mm in Rangpur and its surrounding area. Although in 2006 (Map 3.1.3) the average rainfall is decreases consistently. In the year 2009 the average rainfall decreases to 150 mm and we observed the in 2012 (Map 3.1.4) the maximum average rainfall decreases to 105 mm. So, from 2003 to 2012, the amount of rainfall decreases about 150 mm. From the analysis of 10 years average rainfall contour maps, it is found that the rainfall in this area decreases continuously. The trend of change is prominent and indicates continuous desertification of this area. The trend of change in rainfall also shows in the bar diagram (Figure 3.1.1 to Figure 3.1.4) of average rainfall in this area. Rainfalls data are plotted in bar diagram in mm. Data are plotted for 11 years average rainfall by dividing total Bangladesh into four regions based on rainfall contour maps (Map 3.1.1 to Map 3.1.4) as: North-Eastern Region, South-Eastern Region, South-Western Region and North-western Region diagrams are given below.

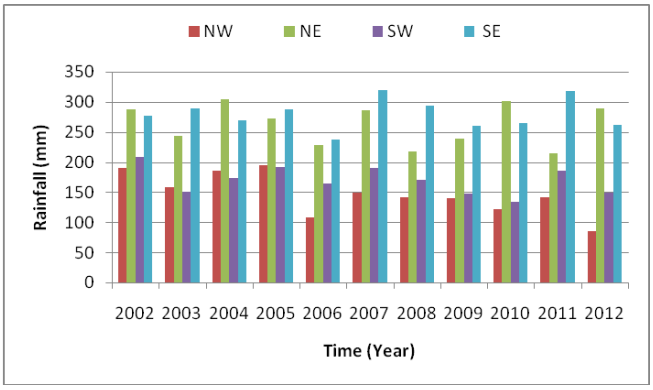
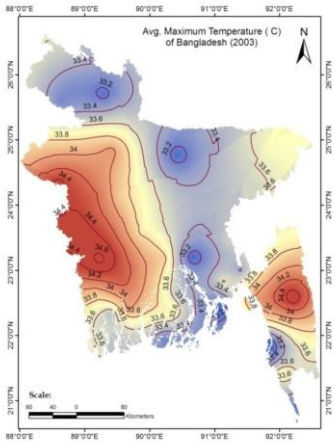


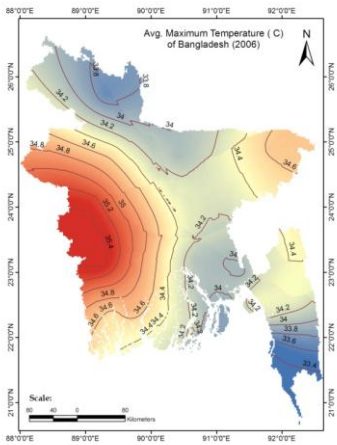
Figure 3.1.5: Rainfall of the North-Eastern, South-Eastern, South-Western, and North-Western Region of Bangladesh.

3.2 Maximum temperature (Trend and maps)

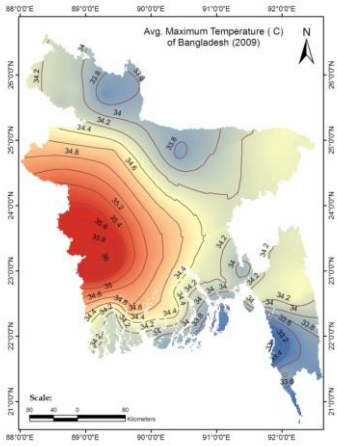
Maximum temperature is statistically significant for all rice yields with positive effects on Aus and Aman rice. The influences of maximum temperature and minimum temperature are more pronounced compared with that of rainfall (Sarker *et al*., 2012). Optimum temperatures for maximum photosynthesis range from 25 °C to 30 °C for rice under the climatic conditions of Bangladesh (Basak, 2010). The temperature contour map of 2003 (Map 3.2.1) shows maximum temperature in Khulna, Satkhira region where max value was 34.6°C -35.2 °C. Beside this Chittagong and Sylhet shows also greater than 34.4 °C maximum temperature. In 2006 (Map 3.2.2), the scenario is changed where maximum temperature of the Khulna and surrounding region is 35.4 °C. The maximum temperature line moved toward the eastern side gradually for the maps of 2006 and 2009. But, in 2011 (Map 3.2.4) maximum temperature lines moved toward the north. The relation graph of temperature and rainfall (Figure 3.2.6) shows a representative change in their parameter. Where rainfall shows lower, the temp curve shows higher value. So, from the graph it can be said that the temperature and rainfall are inversely related to each other. According to the Maximum Temperature contour map of Bangladesh for the last decade, there is also divided Bangladesh into four regions with temperature variation. These are: North-Eastern Region, South-Eastern Region, South-Western Region and North-western Region.



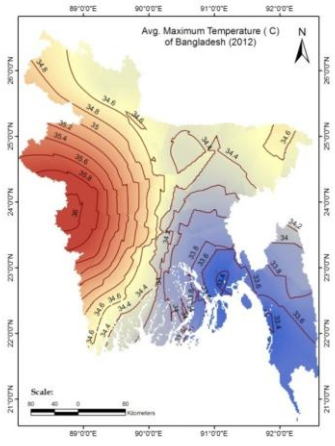
Map 3.2.1: Maximum Temperature (°C) contour map of Bangladesh (2003).



Map 3.2.2: Maximum Temperature (°C) contour map of Bangladesh (2006).



Map 3.2.3: Maximum Temperature (°C) contour map of Bangladesh (2009).



Map 3.2.4: Maximum Temperature (°C) contour map of Bangladesh (2012).

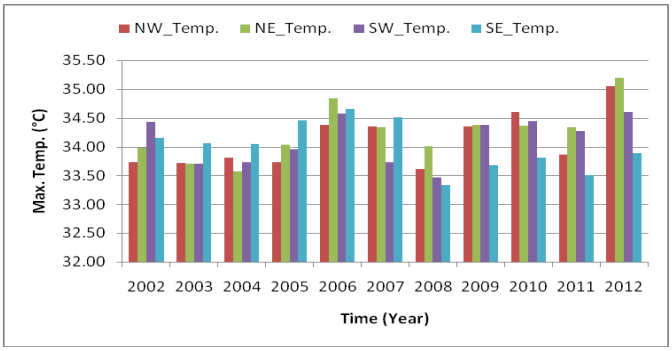


Figure 3.2.5: Maximum Temperature of the North-Eastern, South-Eastern, South-Western, and North-Western Region of Bangladesh.

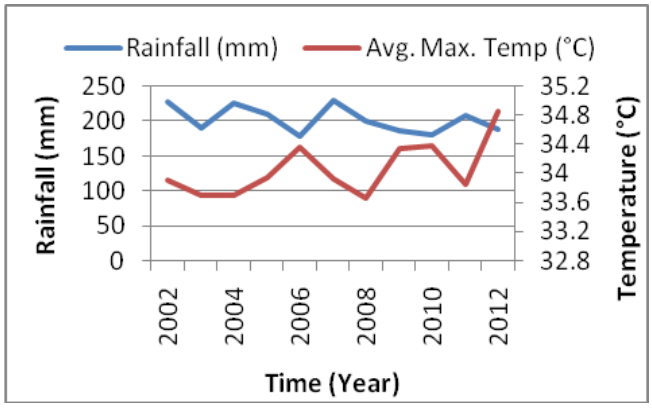


Figure 3.2.6: Relation between Temperature & Rainfall.

3.3 Aman Rice Production

The cultivation of rice in Bangladesh varies according to seasonal changes in the water supply. Rice is cultivated in Bangladesh throughout the year as *Aus*, *Aman* or *Boro* constitute about 100% of total rice production and grow in three different seasons. Aman is generally sown in June-July and harvested in November- December (Adhunik Dhaner Chas, 2011, Islam, 1988, BBS, 2009). According to the four dividing regions based on rainfall and temperature, there are calculated and plotted the Aman rice production for each region. Although Aman rice productions are depends on

various parameter. Ali (1999) discussed the influence of climate change by considering extreme climate events, such as cyclones, storm surges, coastal erosion and backwater effects. His study revealed that sea level rises on the eastern part of Bangladesh would result in large agricultural land losses fuelled by beach erosion. The study also identified some adaptive measures, such as the construction of embankments and cyclone shelters and the introduction of new rice varieties that are suited to higher salinity and temperatures; however, he did not estimate the effects of temperature and rainfall on the coastal agriculture. Rashid and Islam (2007) identified droughts, floods, soil salinity and cyclones as the major extreme climatic events that have affected agricultural production adversely. Changes in behavioral patterns, human practices and international actions are suggested as anticipatory adaptive measures in the study. The research discussion focused only on the climatic variables which are the most dominant factor for positive effect of Aman rice production. The rainfall and Average maximum Temperature are considered for this research work. The rainfall and temperature are inversely related to each other shown previously (Figure 3.2.6). According to Sarker *et al*., (2012) the influences of maximum temperature and minimum temperature are more pronounced compared with that of rainfall. The effects of rainfall and average maximum temperature on Aman rice productions are discussed based on previously divided four regions. Figure 3.3.1 to figure 3.3.4 shows the Aman rice production in four regions. The rice productions were very low during 2004 and 2007 because of flood hazards during those years. So, those times are not taken for consideration in rainfall and maximum temperature effect. A linear trend lines are drawn for each graph to understand the linear change in production.

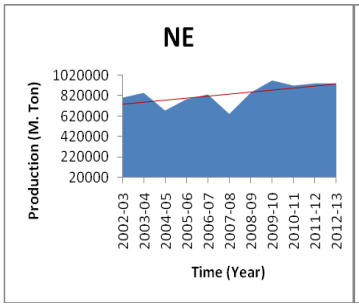


Figure 3.3.1: Aman rice production and linear trend of North-Eastern Region for last decade.

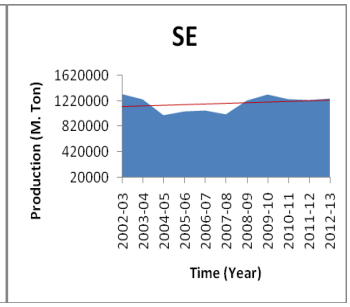


Figure 3.3.2: Aman rice production and linear trend of South-Eastern Region for last decade.

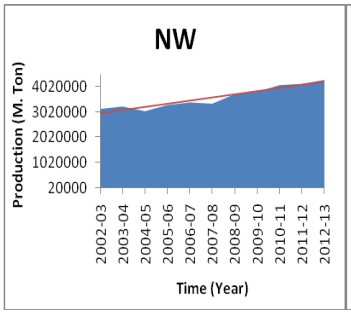


Figure 3.3.3: Aman rice production and linear trend of North-Western Region for last decade.

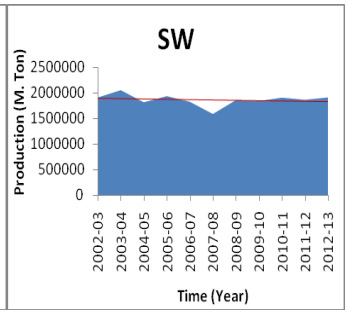


Figure 3.3.4: Aman rice production and linear trend of South-Western Region for last decade.

3.3.1 North-Eastern Region

The region comprises the area of Sylhet, Maulavibazar, Sunamgonj, and Hobigonj district. From the graph of rice production for the last decade, it shows an increasing trend in this region. According to the Figure 3.3.1.1, the rice production vs. rainfall of this region is plotted which shows the trend of rice production changing with the trend of rainfall. Beside this, the temperature graph (Figure 3.3.1.2) shows an inverse trend in 2002-2004 and 2009-2010 years for rice production. So in this region rainfall is the dominating variable for Aman rice production.

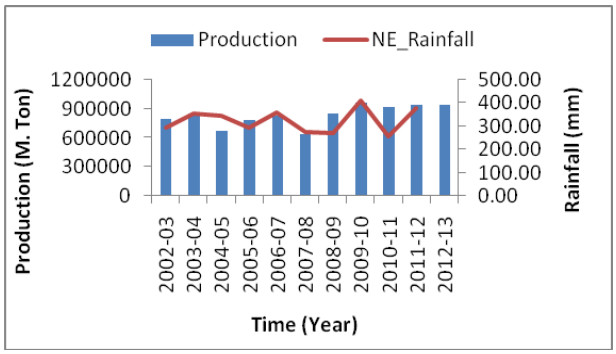


Figure 3.3.1.1: Combined graph of Aman rice production and Rainfall production in North-Eastern Region of Bangladesh for last decade.

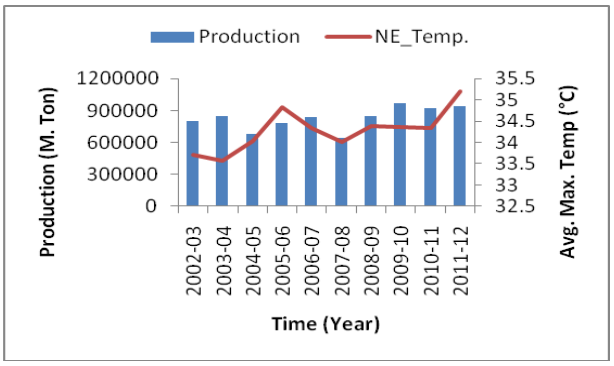


Figure 3.3.1.2: Combined graph of Aman rice and Maximum Temperature (°C) in North-Eastern Region of Bangladesh for last decade.

3.3.2 South-Eastern Region

This region comprises the district of Chittagong, Cox's Bazar, Comilla, Brahmanbaria, and Chandpur. The production trend (Figure 3.3.2) in this region shows unchanged with some exception (2004, 2007) where rainfall and maximum temperature graphs do not shows effective trend in this region (Figure 3.3.2.1 and Figure 3.3.2.2).

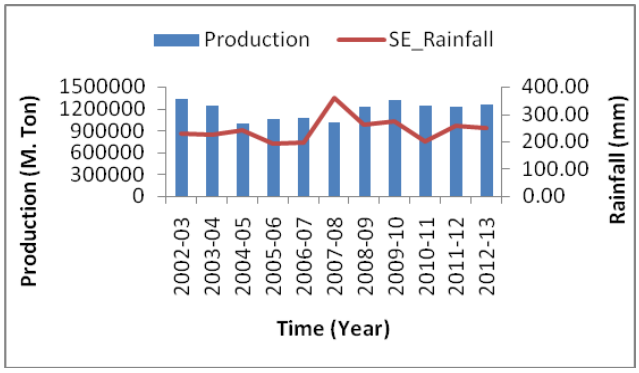


Figure 3.3.2.1: Combined graph of Aman rice production and Rainfall production in South-Eastern Region of Bangladesh for last decade.

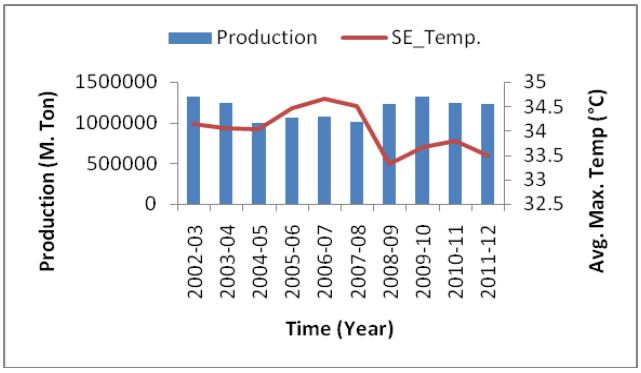


Figure 3.3.2.2: Combined graph of Aman rice and Maximum Temperature (°C) in South-Eastern Region of Bangladesh for last decade.

3.3.3 South-Western Region

This region comprises the area of Khulna, Bagerhat, Satkhira, Jessore, Jhenaidah, Magura, Narail, Patuakhali and Barguna districts. In this region, the production decrease with time (Figure 3.3.3.1) where rainfall and temperature shows mostly repetitive trend but have combined effect on production (Figure 3.3.3.1 and Figure 3.3.3.2). Temperature graph shows distinct relation with production where the effect of rainfall is not much prominent.

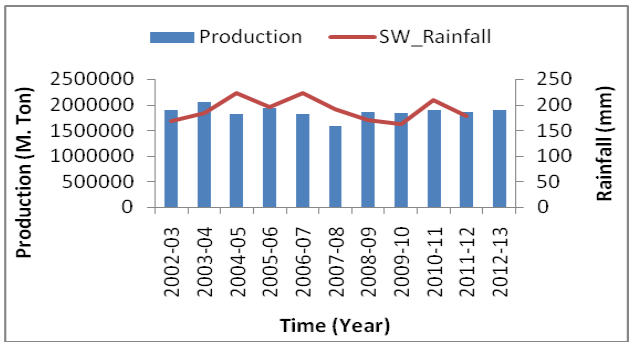


Figure 3.3.3.1: Combined graph of rice production and Rainfall production in South-Western Region of Bangladesh for last decade.

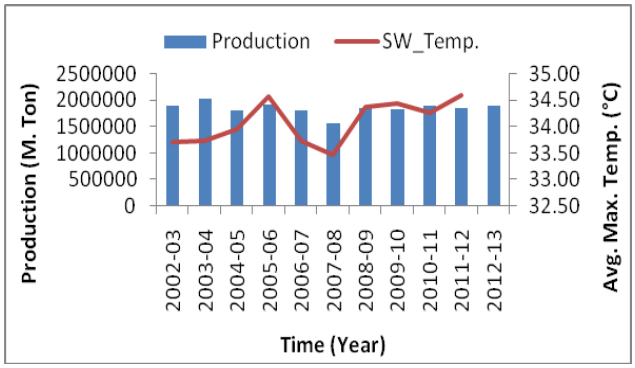


Figure 3.3.3.2: Combined graph of Aman rice and Maximum Temperature (°C) in South-Western Region of Bangladesh for last decade.

3.3.4 North-Western Region

This region comprises the area of Bogra, Joypurhat, Dinajpur, Thakurgaon, Panchagar, Rajshahi, Noagaon, Natore, Nawabgonj, Rangpur, Gaibandha, Kurigram, Nilphamari, and Lalmonirhat districts. In case of this region, the production increase with time but the rainfall trend shows decline trend but the temperature shows a prominent trend to production.

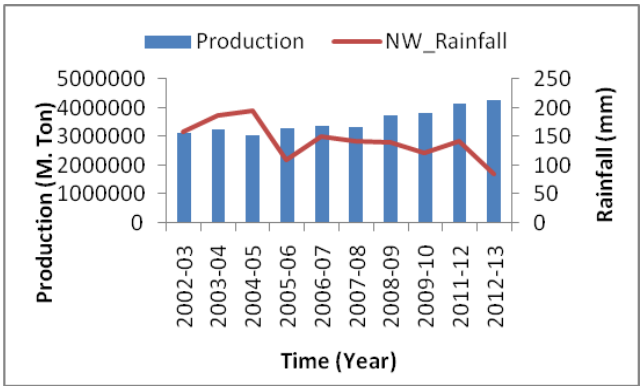


Figure 3.3.4.1: Combined graph of Aman rice production and Rainfall production in North-Western Region of Bangladesh for last decade.

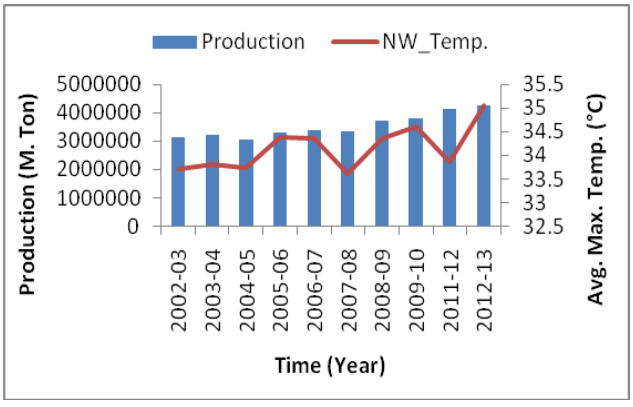


Figure 3.3.4.2: Combined graph of Aman rice and Maximum Temperature (°C) in North-Western Region of Bangladesh for last decade.

4 CONCLUSIONS AND RECOMMENDATION

Variations in rainfall pattern over the growing period have also been found to affect rice yield and water requirement. Increasing temperatures have been found to reduce the duration of physiological maturity of the rice varieties (Basak *et al*., 2010). From the above graphs, maps and analysis we found that in North-Eastern regions Aman production is proportional to rainfall and maximum temperature does not prominent variables which indicate the rainfall effect the rice production prominently. So, other parameters are less prominent to effect the production in this region. In the South-Eastern region rainfall and temperature both are in repetitive and show less effect on production which indicates other variables are prominent in this region. We know that maximum area of the region is covered by hills and coast line. So there may have salinity and soil condition effect on the Aman rice production of this region. In South-Western region the Aman production shows decreased trend through rainfall and temperature. But the both variables may prominent in this region. This scenario indicates rice productions in this region have combined prominent effects of rainfall and maximum temperature. We know that most the area of the region is situated under tidal effect which may be the cause of production decrease. In North-Western region Aman production increased though rainfall decreased so significantly also average maximum temperature was high in this region. According to Sarker *et al*. (2012) the influences of maximum temperature and minimum temperature are more pronounced compared with that of rainfall. It implies that maximum temperature is the dominant factor in this region which increases the Aman rice production significantly. So, effect of maximum temperature becoming the dominant variable continuously in the Aman rice production of Bangladesh in last decade. In South-west region, there also need further research for the salinity and tidal effect on the rice production in this region. Further research required to find the prominent factor in the South-Eastern region where rainfall and temperature play fewer rules in the region according to the findings of the research. There also need future research for the effect of soil quality and texture, groundwater quality and position and technology development in those regions.

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