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Climate change and its impact on agricultural cropping pattern of the Old Brahmaputra floodplain in Bangladesh

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ABSTRACT

Bangladesh is highly vulnerable to climate change which has become a challenging issue for agriculture. Agricultural crops of Bangladesh are especially sensitive to the different variables of climate such as temperature, rainfall, humidity, day-length etc. as well as different natural disasters like floods, drought, salinity and storm surges etc. From the analysis the changing trends of climatic variability in the Old Brahmaputra floodplain, it is clear that temperature is increasing from 1975 to 2015. On the other hand rainfall and humidity has decreased. Consequently, the climate of the Old Brahmaputra floodplain is changing which has adverse effects on ecosystem, agricultural activities and also cropping pattern. Crops are destroying due to periods of extreme heat and less rains. Farmer has been losing their crops for increasing temperature, less rainfall, semi-drought, flood which are occurring for climate

change. As a result farmer of the Old Brahmaputra floodplain face economic loss. Adaption strategy can consider these problems. Farmers have been adapting for changing conditions and this study suggests some adaptation strategies to climate change.

Keywords: Climate, Impact, Agriculture, Cropping Pattern, Floodplain, Old Brahmaputra.

1. INTRODUCTION

Climate change is quickly becoming one of the most pressing global challenges and a threat to many critical sectors of civilization (EEN, 2005; Houghton, 2004; IPCC, 2012). Agriculture is one of the most climate-sensitive sectors, as it is continuously and directly affected by temperature and precipitation (Huffman et al., 2001; Syeda, 2012). Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, and climate extremes; changes in pests and diseases; and changes in the nutritional quality of some foods (Ahmed, 1989; Hoffmann, 2013; Huq et al., 1996). It could affect livestock health, crop growth, and farming practices which will probably increase the risk of food insecurity for some vulnerable groups, such as the poor (HLPE, 2012; Shamsuddin et al., 2015; Navaratne, 2007). The impact of global climate change on agriculture has been studied extensively for various crops at different scales in many countries of the world (Bals et al., 2008; Porter et al., 2014). IPCC report 2007, predicts that monsoon rainfall will increase, resulting in higher flows during monsoon season in the river system. IPCC also estimates that, by 2050, changing rainfall patterns with increasing temperatures, flooding, droughts, and salinity (in coastal belt) could cause the decline in rice production in Bangladesh by 8% and wheat by 32%, against 1990 as the base year.

Bangladesh is one of the most vulnerable countries facing the adverse impacts of climate change (Alam, 2004; Broadus, 1993; Climate Change Cell, 2006; Huque, & Ayers, 2007; Islam, & Neelim, 2010; Islam, 1994; Roy and Hossain, 2015; Edris Alam, 2017). Due to its unique geographic location, the dominance of floodplains and low-lying topography, high population density, high levels of poverty, and overwhelming dependence on natural resources and services, many of which is climate sensitive (Ahmed, 2006; Alam, & Rabbani, 2007; Douma, 2007). Seventy-six percent of the total cultivable land of Bangladesh lies in the floodplains and five percent lies in the Old Brahmaputra floodplain (Brammer, 2012). Different types of crops are practiced in the Old Brahmaputra floodplain. Rice, wheat, and potato are major food crops growing at different cropping seasons with various temperature and rainfall requirements. The farmers of the Old Brahmaputra floodplain are facing various problems of their cropping patterns due to climatic variability. Keeping all these issues in consideration, an investigation has conducted to know the climate change and its impact on agricultural cropping pattern of the old Brahmaputra floodplain in Bangladesh.

2. PURPOSE OF THE STUDY

The main aim of this study is to investigate the impacts of climate change on agricultural cropping pattern in the Old Brahmaputra floodplain. In order to come up with a reasonable analysis to the study following specific objectives is set to be performed:

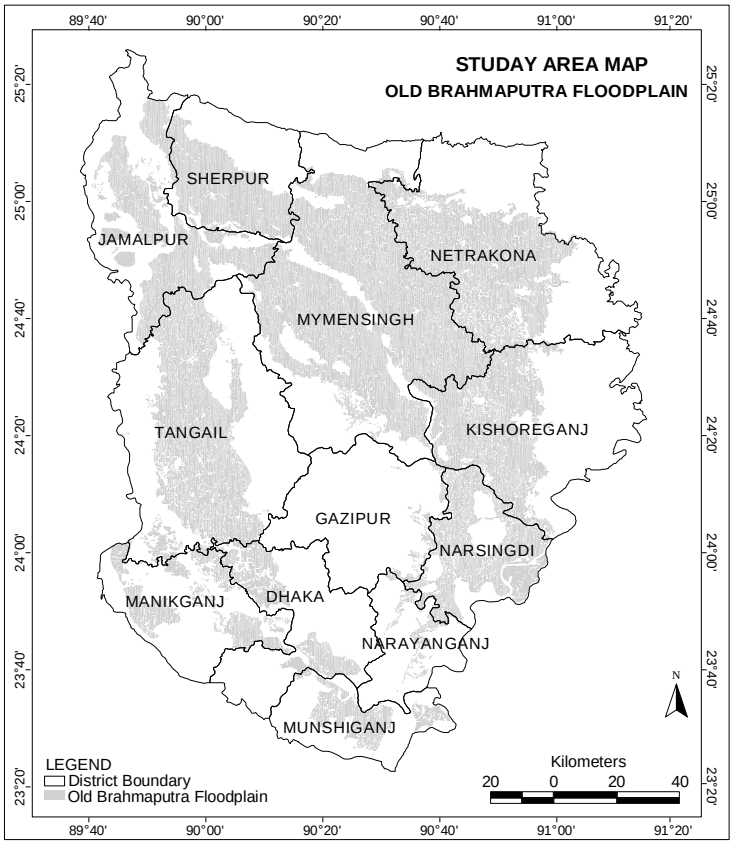
a) To measure the temperature, rainfall, and humidity variation and their relation to climate change in the Old Brahmaputra floodplain; and
b) To find out the impact of climate change on agricultural cropping pattern of the study area.

3. DATA SOURCES AND METHODOLOGY

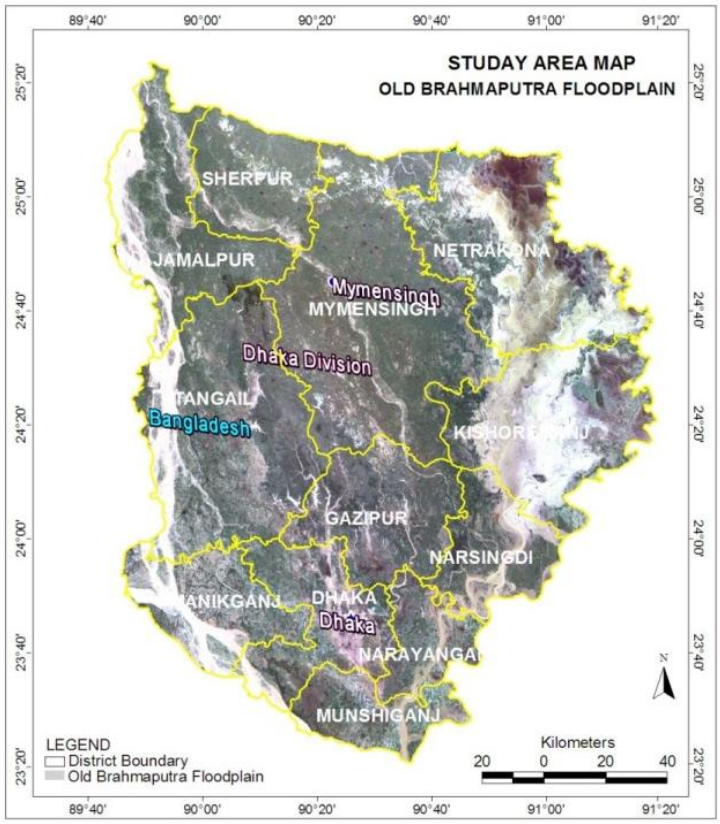
This study has conducted on the basis of primary and secondary data. Primary data is collected from the field by using formal questionnaire survey, informal interview and informal group discussions. Most of the secondary data on climatic variable such as temperature, rainfall and humidity collected from the Bangladesh Meteorological Department (BMD) and agricultural crops data are collected from Bangladesh Bureau of Statistics, Bangladesh Agricultural research Institute etc. Consequently, for the fruitful completion of the study statistical, hydrological and some geographical approaches has analyzed. Using descriptive statistics, data was analyzed in terms of frequency distribution and the percentage using SPSS as raw data was difficult to understand for meaningful conclusions to be made. Finally, data were presented using tables, frequencies, figures, and percentages.

4. STUDY AREA

The Old Brahmaputra floodplain is selected as the study area (Map 1). This study area consists of 12 districts and 186 Upazila with a total area of 7,787 square kilometers (Banglapedia, 2016). It is stretching from the southwestern corner of the Garo Hills along the eastern rim of the Madhupur Tract down to the Meghna River exhibits a gentle morphology composed of broad ridges and depressions (Map 2). The Old Brahmaputra, the Sutia, and the Negeshwari are main rivers in this floodplain (Banglapedia, 2016).



Map 1 Location of the study area (*Source: BCA, complied by Author, 2016*)



Map 2 Location of the study area in Satellite image (*Source: Google Earth image, 2010, complied by Author, 2015*)

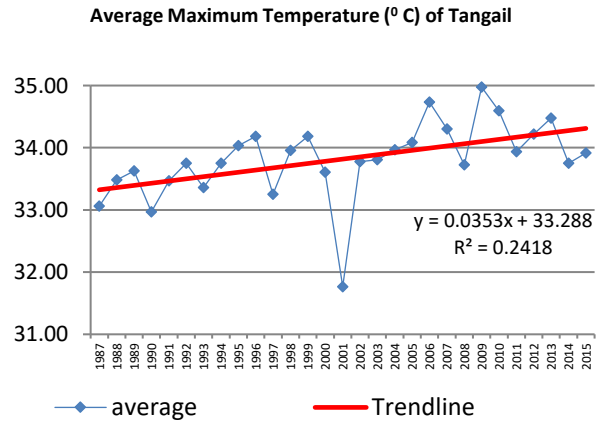
5. RESULT AND DISCUSSION

Climate change is a change in average weather conditions, or in the time variation of weather around longer-term average conditions (Solomon et al., 2007; Ahrens, 2009; Klein, 2005). The Old Brahmaputra floodplain has warm temperatures throughout the year, with relatively little variation from month to month. January (average 19°c) tends to be the coolest month and May (average 29°c) the warmest (Rashid, 1991). Different types of crops are grown in this area on the basis of crop seasons such as (a) Rabi crops (Mid-September to Mid-March), (b) Kharif crops which is divided into two sub division as Kharif-I (Mid-February to Mid-July) and Kharif-II (Mid-June to Mid-November) (BARI, 2014).

Climatic Variability Analysis in the Old Brahmaputra Floodplain

Variation of Maximum and Minimum Temperature (1975-2015)

The maximum temperature is the compilation of the summer and winter temperature records together in the Old Brahmaputra floodplain. In general, there is an increasing trend of the average maximum temperature of the Old Brahmaputra floodplain. The average maximum temperature of Tangail district has increased gradually but it became lowest in 2001 and highest in 2010 (fig. 1). Although, there was a tendency to increase the temperature in the Old Brahmaputra floodplain from 2011 to 2015, the average maximum temperature of Mymensingh district was steadily uniform (fig. 2). However, in Dhaka district, the average highest temperature recorded in 1987 (fig. 3). On the other hand, the average minimum temperature of Dhaka, Mymensingh, and Tangail district has been increasing year to year (fig. 4). The changing trend of Dhaka is higher than other two districts (fig. 5). In 1975 the minimum temperature of Dhaka was about 16.5°c which was above 20°c in 2015. But, minimum temperature of Tangail is increased slowly whereas the temperature trend was broadly uniform and minimum temperature of Mymensingh has fluctuated with increasing trend (fig. 6).



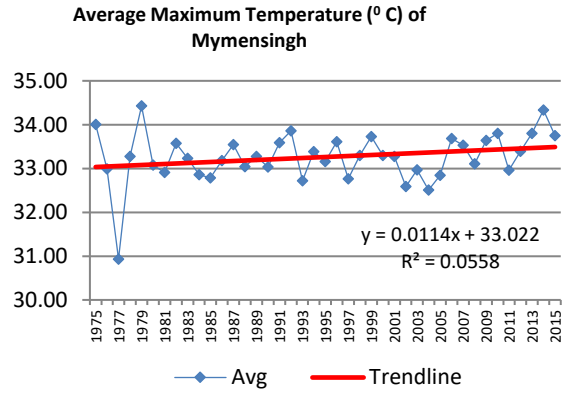
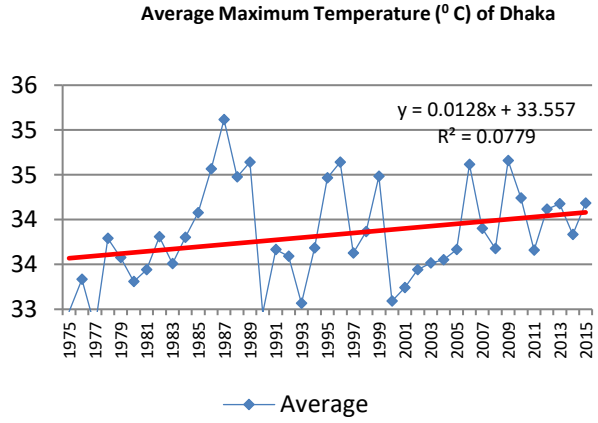


Figure 1 Year-wise average maximum temperature (^{0}C) of Tangail *(Source: BMD, 2015)*; **Figure 2** Year-wise average maximum temperature (^{0}C) of Mymensingh *(Source: BMD, 2015)*



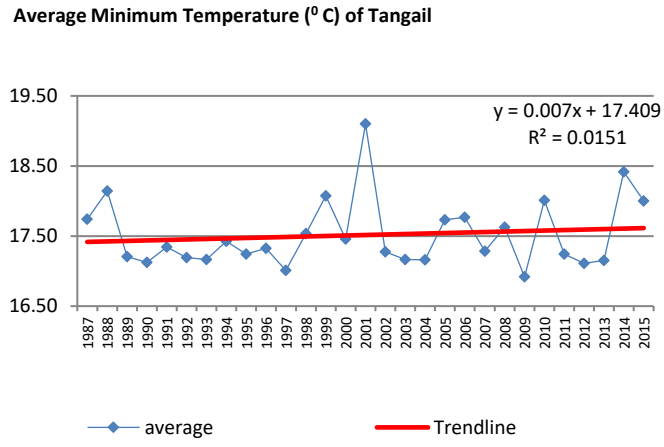
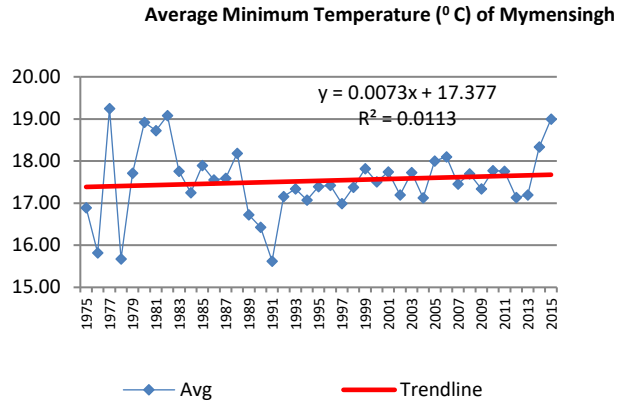


Figure 3 Year-wise average maximum temperature (^{0}C) of Dhaka *(Source: BMD, 2015)*; **Figure 4** Year-wise average minimum temperature (^{0}C) of Tangail *(Source: BMD, 2015)*



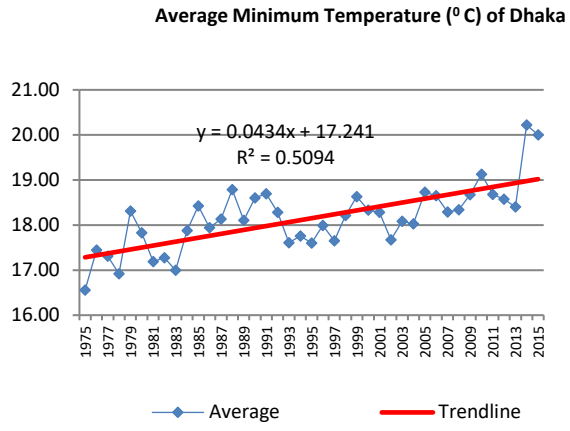
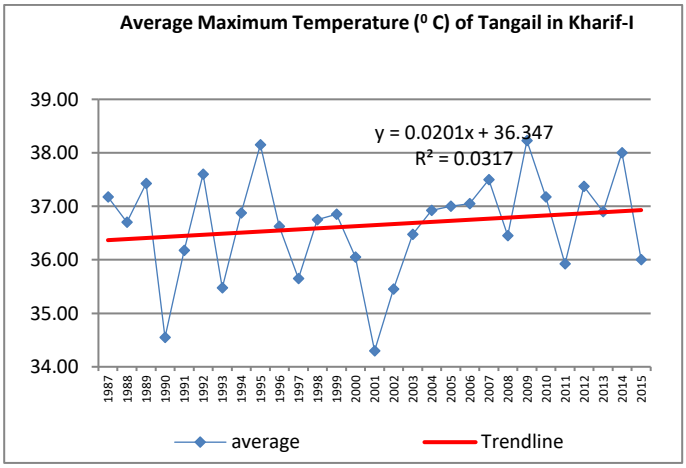


Figure 5 Year-wise average minimum temperature (^{0}C) of Mymensingh *(Source: BMD, 2015)*; **Figure 6** Year-wise average minimum temperature (^{0}C) of Dhaka *(Source: BMD, 2015)*

Variation of Average Maximum and Minimum Temperature with Crop Seasons

The changing trend of maximum temperature of Tangail district gradually increased in Kharif-I season but it decreases in Dhaka and Mymensingh district (fig. 7). The highest maximum temperature of Dhaka and Mymensingh district recorded in 2014 (fig. 8 & 9). On the other hand, over all, there is an increasing trend on the average minimum temperature of Dhaka, Mymensingh and Tangail districts in Kharif-I Season (fig. 10, 11 & 12). In contrast to Kharif-I season, there is an increasing trend in the average maximum temperature in Kharif-II Season of Dhaka, Mymensingh and Tangail Districts (fig. 13, 14 & 15). The average maximum temperature of Tangail, Mymensingh and Dhaka district has increased about 2^{0}C, 1^{0}C and 1^{0}C respectively over the last 30 years and the average minimum temperature trend is also increasing (fig. 16, 17 & 18) in the Kharif-II season. As like as Kharif-II seasons, the Old Brahmaputra floodplain has an increasing trend in the average maximum temperature in Rabi Season and increasing trend of maximum temperature of Tangail is higher than other two districts (fig. 19, 20 & 21). On the other hand, there is a decreasing trend on average minimum temperature records of Mymensingh and Tangail Districts and increasing trend on Dhaka district (fig. 22, 23 & 24). The average minimum temperature of Dhaka district was increasing from 1995 to 2015.



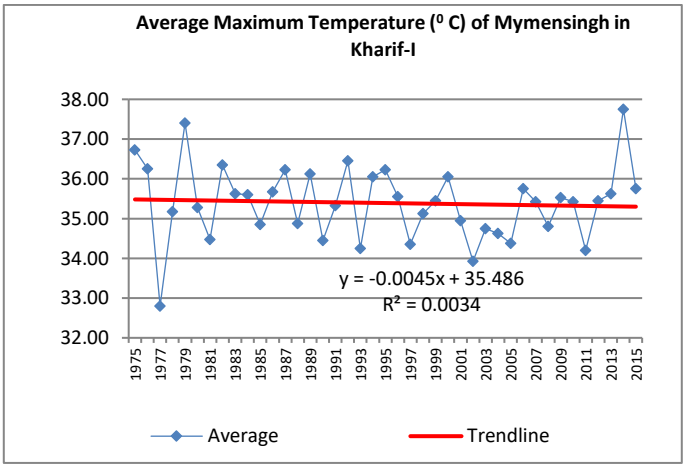
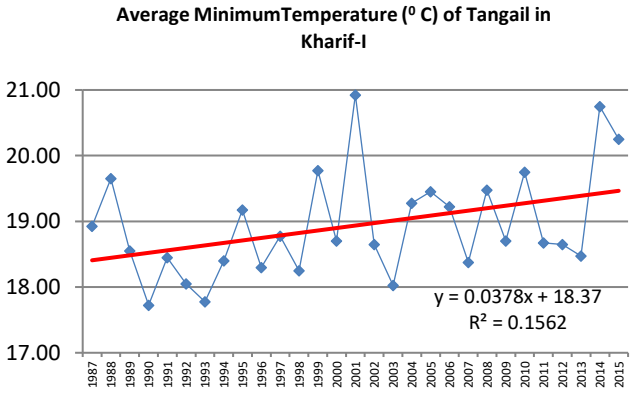


Figure 7 Year-wise average maximum temperature (^{0}C) of Tangail in Kharif-I Season *(Source: BMD, 2015)*; **Figure 8** Year-wise average maximum temperature (^{0} C) of Mymensingh in Kharif-I Season *(Source: BMD, 2015)*



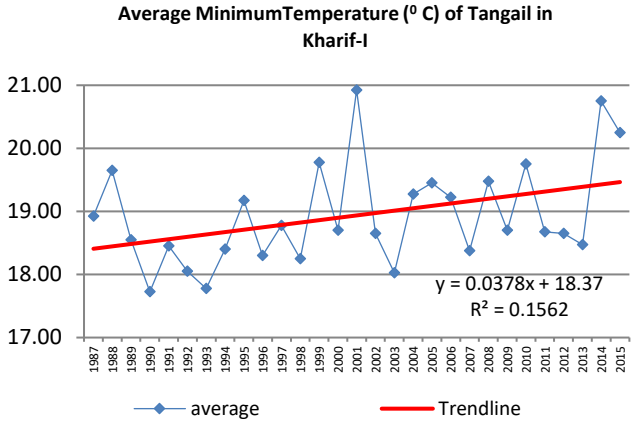
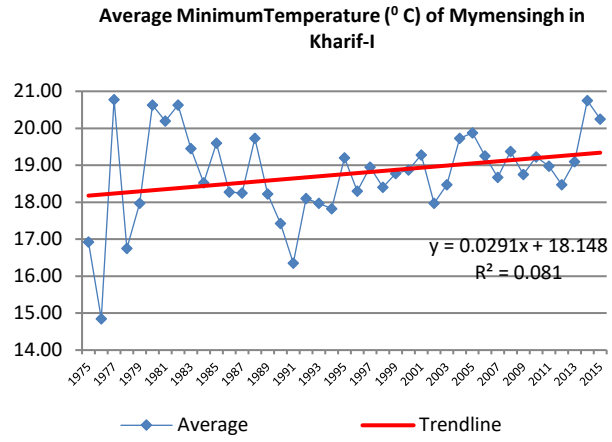


Figure 9 Year-wise average maximum temperature (^{0}C) of Dhaka in Kharif-I Season *(Source: BMD, 2015)*; **Figure 10** Year-wise average minimum temperature (^{0}C) of Tangail in Kharif-I Season *(Source: BMD, 2015)*



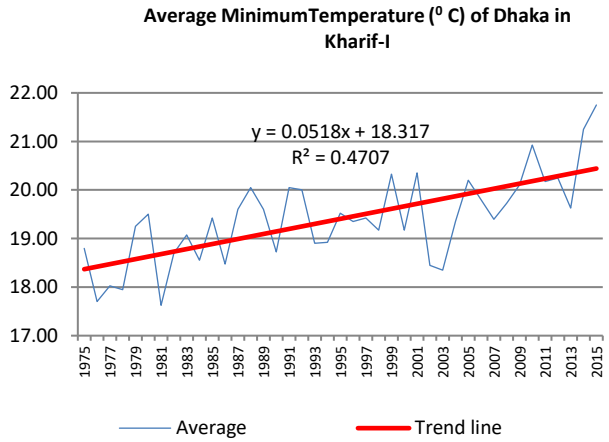
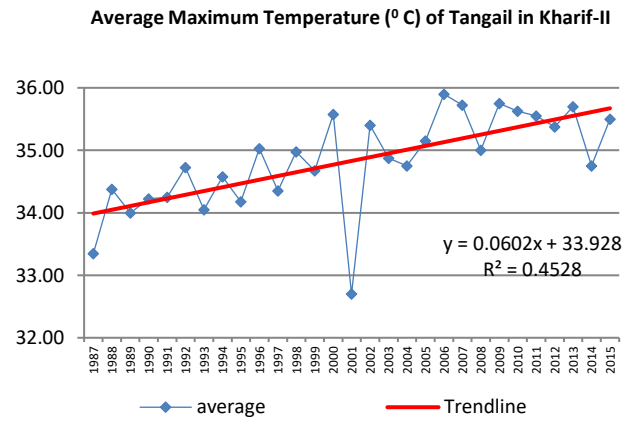


Figure 11 Year-wise average minimum temperature (^{0}C) of Mymensingh in Kharif-I Season *(Source: BMD, 2015)*; **Figure 12** Year-wise average minimum temperature (^{0}C) of Dhaka in Kharif-I Season *(Source: BMD, 2015)*



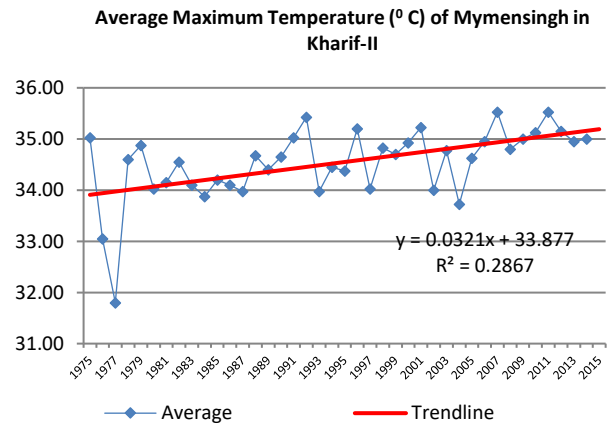
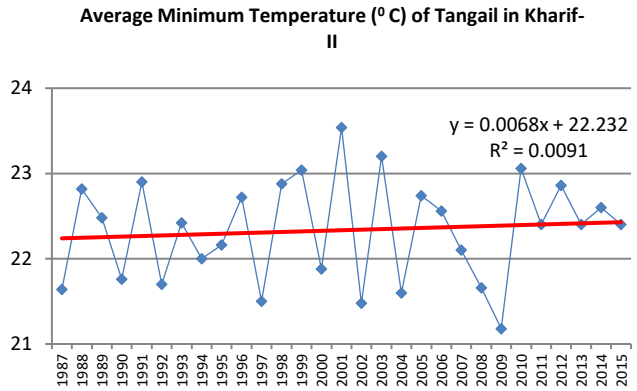


Figure 13 Year-wise average maximum temperature (^{0}C) of Tangail in Kharif-II Season *(Source: BMD, 2015)*; **Figure 14** Year-wise average maximum temperature (^{0}C) of Mymensingh in Kharif-II Season *(Source: BMD, 2015)*



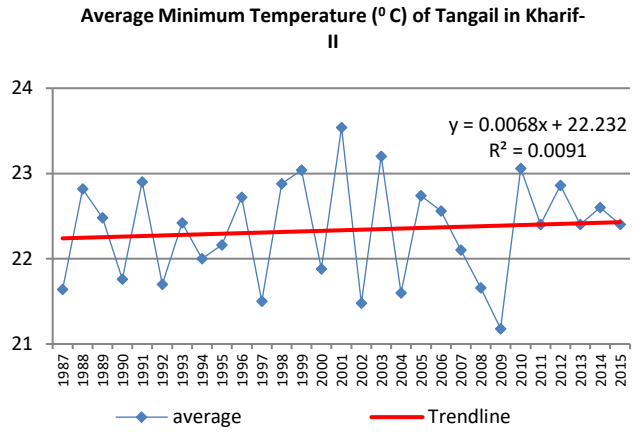
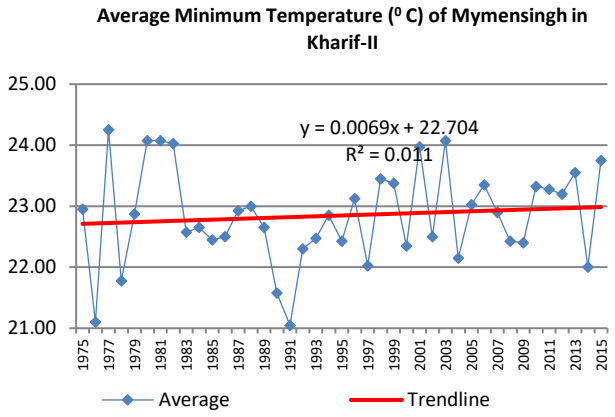


Figure 15 Year-wise average maximum temperature (^{0}C) of Dhaka in Kharif-II Season *(Source: BMD, 2015)*; **Figure 16** Year-wise average minimum temperature (^{0}C) of Tangail in Kharif-II Season *(Source: BMD, 2015)*



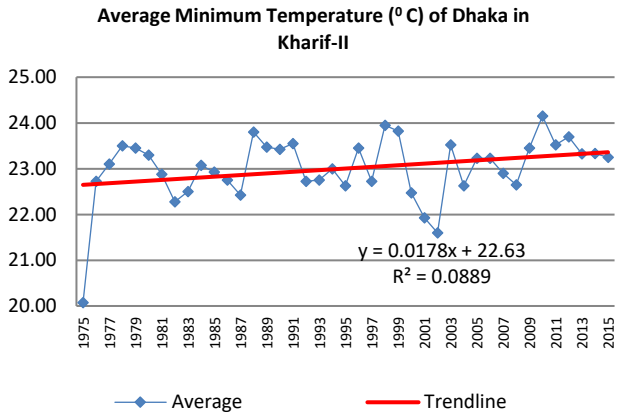
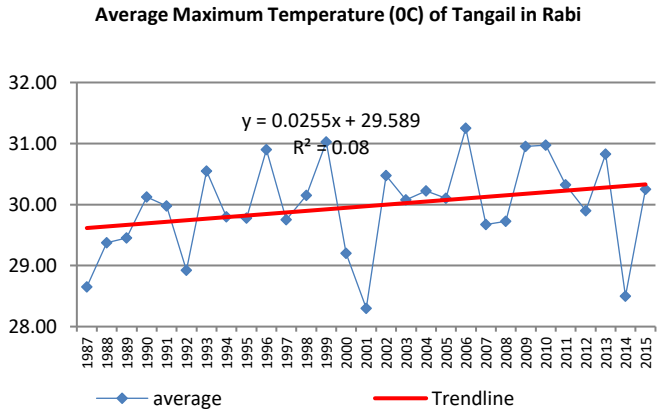


Figure 17 Year-wise average minimum temperature (^{0}C) of Mymensingh in Kharif-II Season *(Source: BMD, 2015)*; **Figure 18** Year-wise average minimum temperature (^{0}C) of Dhaka in Kharif-II Season *(Source: BMD, 2015)*



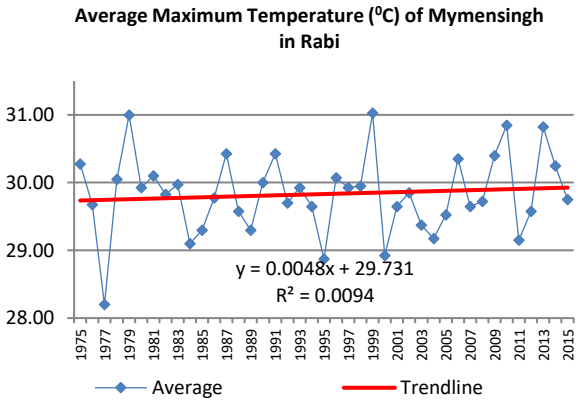
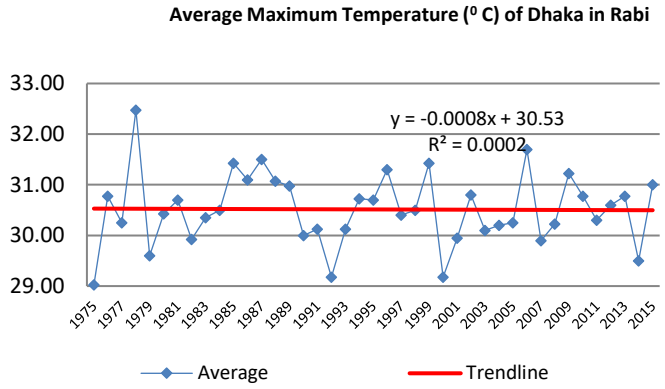


Figure 19 Year-wise average maximum temperature (^{0}C) of Tangail in Rabi Season *(Source: BMD, 2015)*; **Figure 20** Year-wise average maximum temperature (^{0}C) of Mymensingh in Rabi Season *(Source: BMD, 2015)*



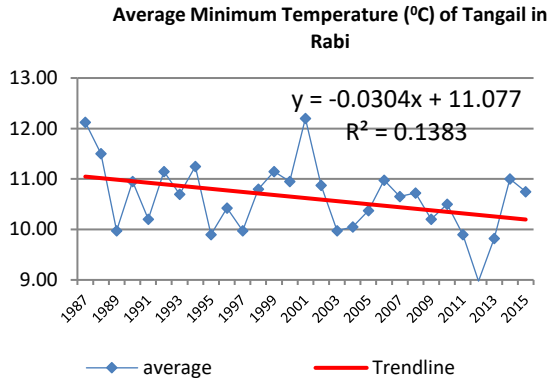
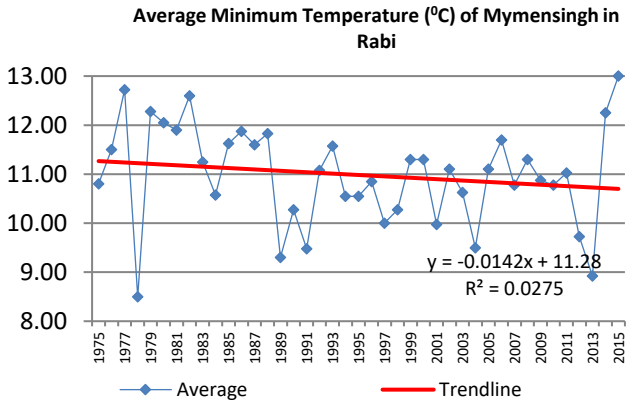


Figure 21 Year-wise Average Maximum Temperature (^{0} C) of Dhaka in Rabi Season *(Source: BMD, 2015)*; **Figure 22** Year-wise average minimum temperature (^{0}C) of Dhaka in Rabi Season *(Source: BMD, 2015)*



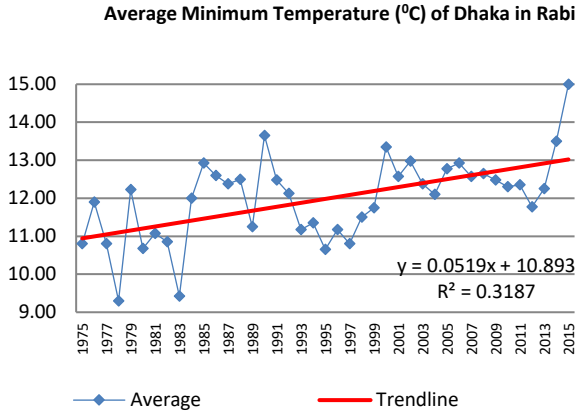
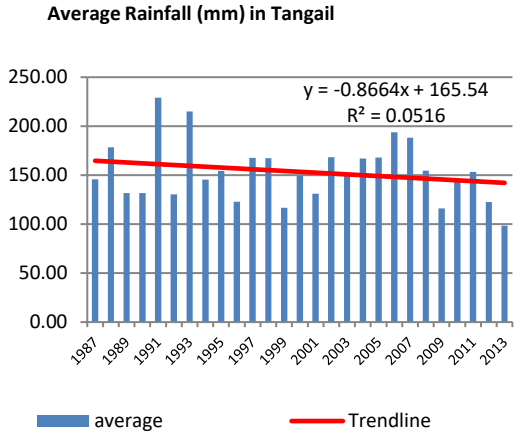


Figure 23 Year-wise average minimum temperature (^{0}C) of Mymensingh in Rabi Season *(Source: BMD, 2015)*; **Figure 24**: Year-wise average minimum temperature (^{0}C) of Dhaka in Rabi Season *(Source: BMD, 2015)*



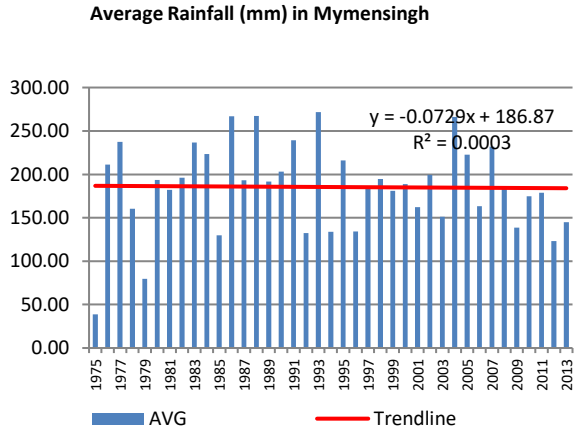


Figure 25 Year-wise average rainfall (cm) in Tangail (1987-2013) *(Source: BMD, 2015)*; **Figure 26** Year-wise average rainfall (cm) in Mymensingh (1975-2013) *(Source: BMD, 2015)*

Variation of Rainfall (1975-2013)

Among the various individual climatic parameters, which influence the growth of crops water or rainfall is considered most important (Brammer, 2000). The reservoir of water from which crops draw their moisture supply through the soil derived mainly in the form of rainfall, with relatively minor contributions in Tangail district from dew and fog. The Old Brahmaputra floodplain's rainfall trend is decreasing from 1987 to 2013. The minimum rainfall recorded is about 99 cm whereas the maximum is about 260 cm. The rainfall trend was nearly steady from 1972 to 1983. There is an interrelationship between temperature and rainfall in this area which has uniform characteristics. However, some year rainfall decreases and some years rainfall occurs more by the impact of climatic variation.

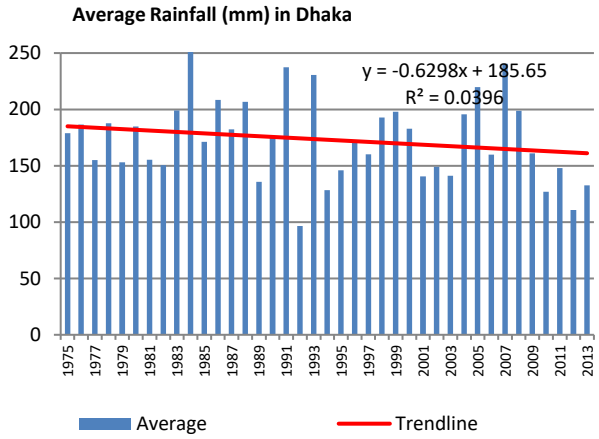
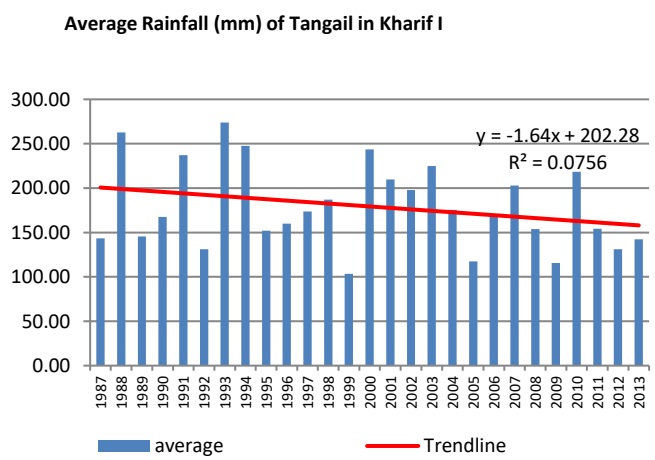


Figure 27 Year-wise average rainfall (cm) in Dhaka (1975-2013) *(Source: BMD, 2015)*

Variation of Rainfall with Crop Seasons

The distribution and selection of crops and the sustainability of yield or the period in which most runoff generated, depend not only on annual amounts, variability, or seasonality but also on the duration of the rainy season (Habibullah, et. al, 1999). Figure 28, 29 and 30 reveal the more climatic impact of Rabi season among the three seasons. Crop production decreases in the years of 1993, 1999, 2004, 2005, 2006, 2009, 2011 and 2013 in Rabi season (BBS, 2015). On the other hand, extreme rainfall is harmful for the crop production, for this reason in 1988, 1995, and 2007 Rabi season was highly hampered by the climatic change. So rainfall is not same in every year it is changing by time in Rabi season. Variation of rainfall is responsible for the cropping pattern change. On the other hand, the average amount of precipitation need not necessarily be a constraint to successfully carrying out agricultural activities. However, More rainfall occurs in Kharif-I season, little more rainfall occurs in Kharif-II season and less rainfall in Rabi season. In addition to, there is a decreasing trend of average rainfall in Rabi season in the last 30 years. Rain fall of Tangail district is more decreased than other two districts (fig. 34, 35 and 36).



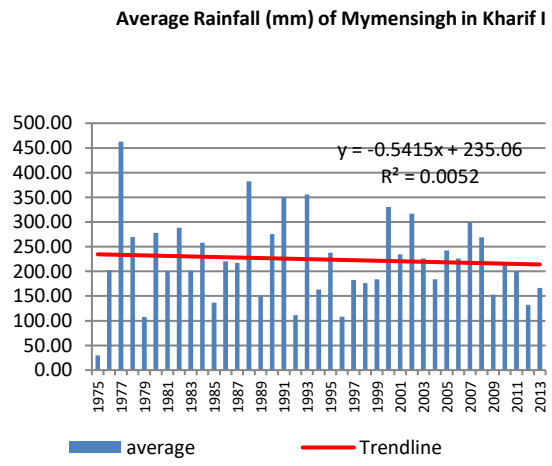
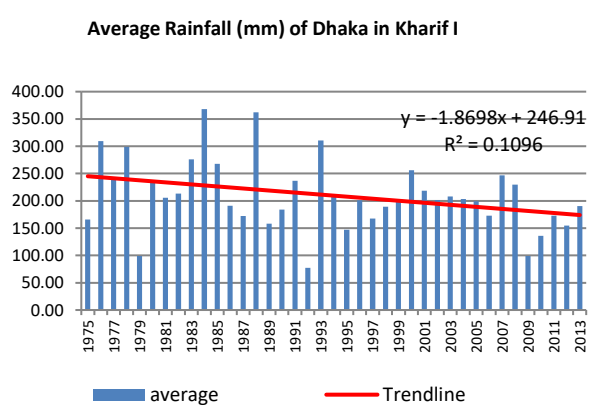


Figure 28 Year-wise Average Rainfall (cm) in Tangail in Kharif I Season (1987-2013) *(Source: BMD, 2015)*; **Figure 29** Year-wise Average Rainfall (cm) in Mymensingh in Kharif I Season (1975-2013) *(Source: BMD, 2015)*



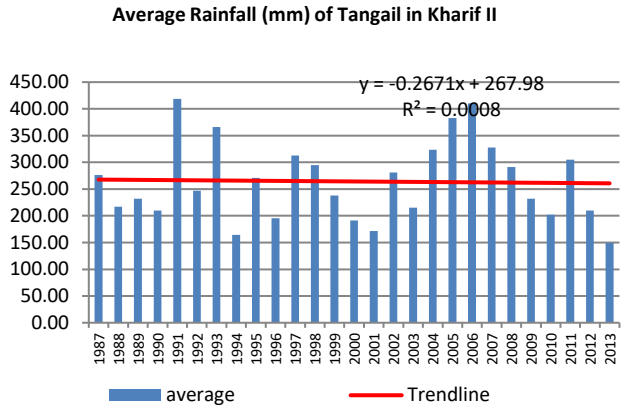
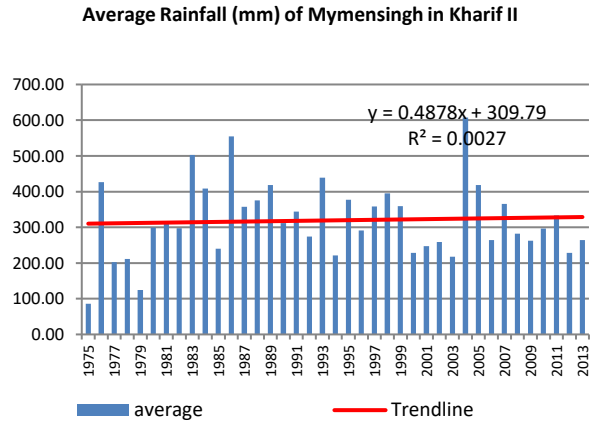


Figure 30 Year-wise Average Rainfall (cm) in Dhaka in Kharif I Season (1975-2013) *(Source: BMD, 2015)*; **Figure 31** Average Rainfall (cm) of Tangail in Kharif II Season (1987-2013) *(Source: BMD, 2015)*



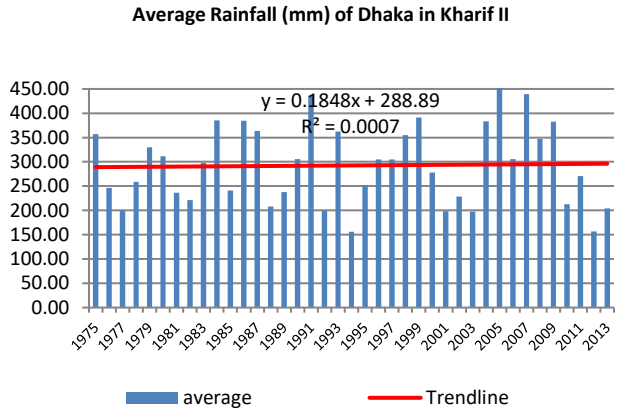
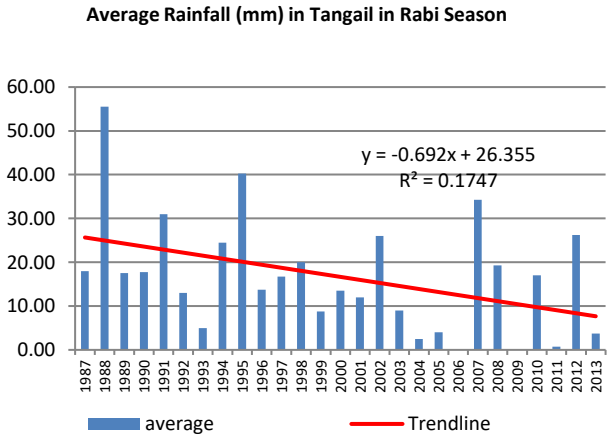


Figure 32 Average Rainfall (cm) in Mymensingh in Kharif II Season (1975-2013) *(Source: BMD, 2015)*; **Figure 33** Average Rainfall (cm) in Dhaka in Kharif II Season (1975-2013) *(Source: BMD, 2015)*



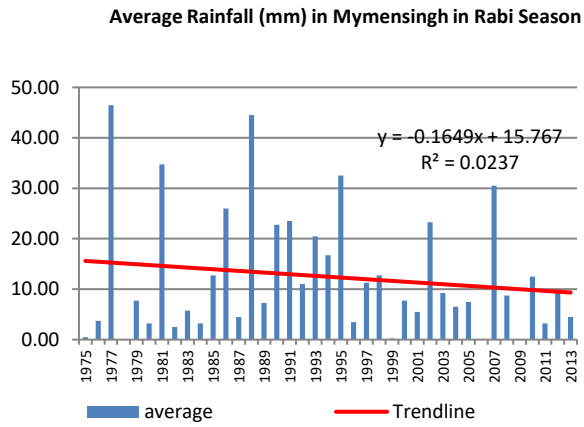


Figure 34 Average Rainfall (cm) in Tangail in RabiSeason (1975-2013) *(Source: BMD, 2015)*; **Figure 35** Average Rainfall (cm) in Tangail in Rabi Season (1975-2013) *(Source: BMD, 2015)*

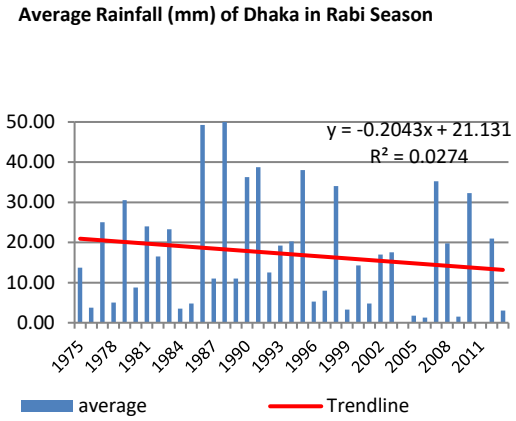
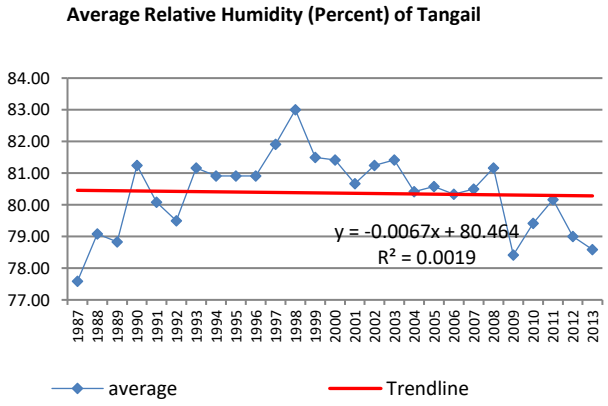


Figure 36 Average Rainfall (cm) of Dhaka in Rabi Season (1975-2013) *(Source: BMD, 2015)*

Variation of Humidity (1975-2013)

The percentage of average relative humidity of Old Brahmaputra floodplain (1975-2013) represents that there is a decreasing trend of relative humidity in Dhaka and Tangail district where as increasing trend in Mymensingh (fig. 37, 38 and 39). In Tangail the lowest average humidity was recorded in 1987 and highest humidity in 1997 then it started to decrease from 1998 and continued to 2013. In Mymensingh district the lowest average humidity was recorded in 1983 which was the result of decreasing humidity from 1975 to 1983 after that Average humidity of this district had increased. There was fluctuation in average humidity of Dhaka district from 1975 to 1998 and 1998 was the year of highest average humidity. From 1998-2009 humidity had decreased gradually and 2009-2023 it was stable in Dhaka.



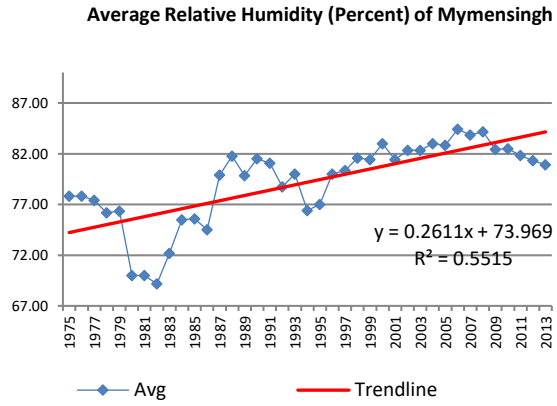


Figure 37 Average Relative Humidity (Percent) of Tangail *(Source: BMD, 2015)*; **Figure 38** Average Relative Humidity (Percent) of Mymensingh *(Source: BMD, 2015)*

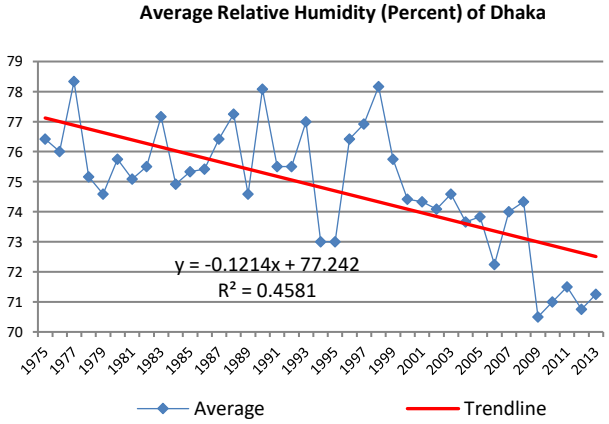
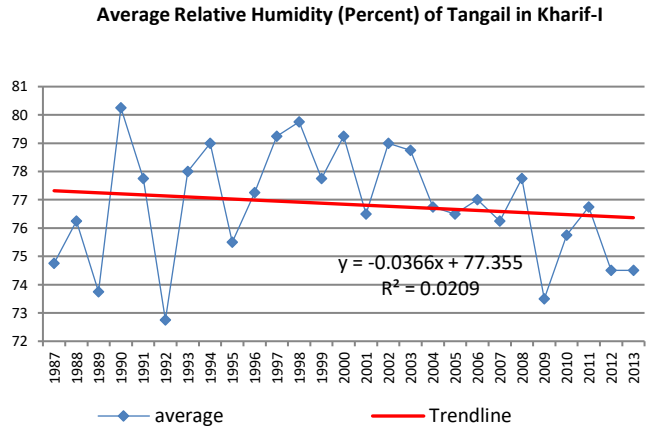


Figure 39 Average Relative Humidity (Percent) of Dhaka *(Source: BMD, 2015)*

Variation of Humidity with Crop Seasons

The percentage of average relative humidity of three districts in Kharif-I, where it is seen that there is a decreasing trend in Dhaka and Tangail district as well as increasing trend in Mymensingh (fig. 40, 41 42). Although the humidity of Mymensingh was low in 1979-1986 from 1987 it starts to increase. On the other hand, there is a decreasing trend in Dhaka and Tangail district average relative humidity where as increasing trend in Mymensingh in Kharif- II (fig. 43, 44 and 45). From 1987-1998 the average humidity increase after that humidity of this area was decreased which continued to 2013. In Mymensingh district lowest average humidity was recorded in 1981 and 1982 then humidity was increased from 1983 to till now. Moreover, the percentage of average relative humidity of Old Brahmaputra Floodplain (1975-2013) in Rabi season represent that there is a decreasing trend of relative humidity in Dhaka and Tangail districts while increasing trend in Mymensingh district (fig. 46, 47 and 48).



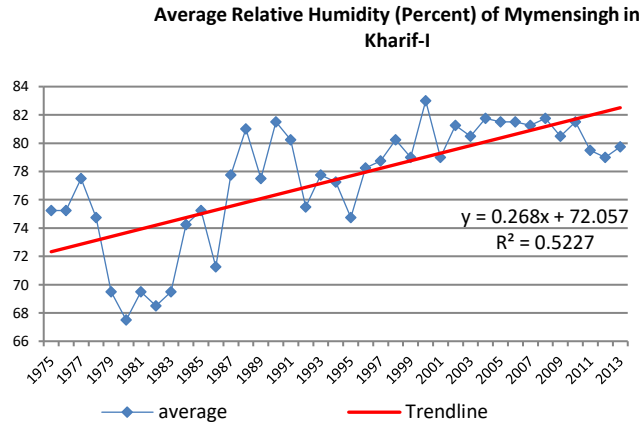
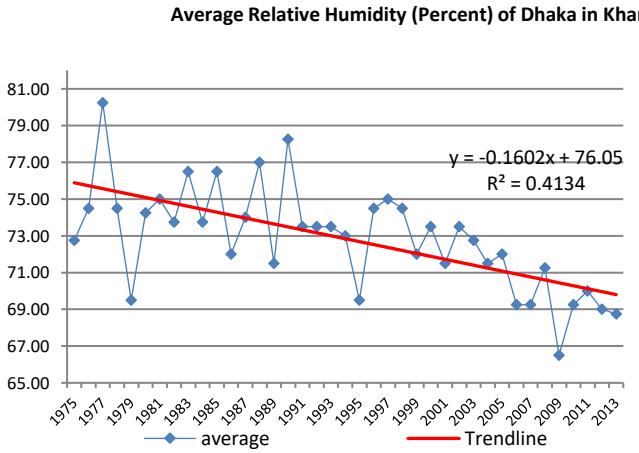


Figure 40 Average Relative Humidity (Percent) of Tangail in Kharif-I *(Source: BMD, 2015)*; **Figure 41** Average Relative Humidity (Percent) of Mymensingh in Kharif-I *(Source: BMD, 2015)*



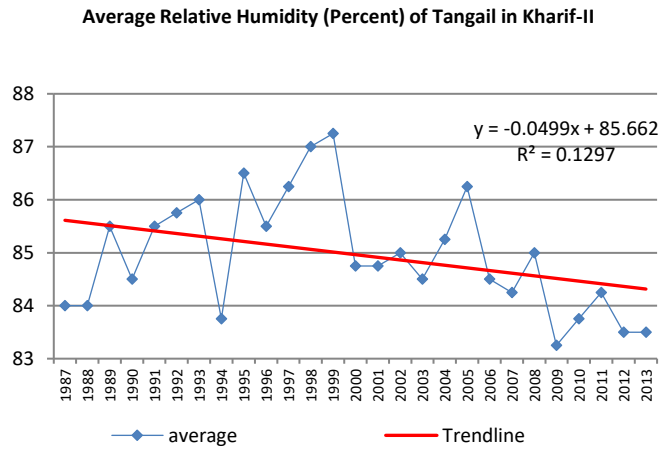
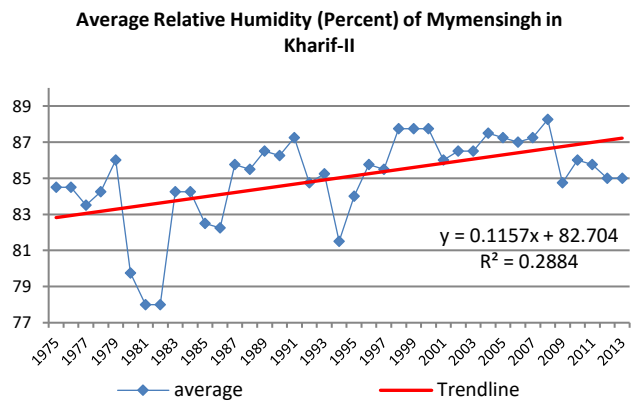


Figure 42 Average Relative Humidity (Percent) of Dhaka in Kharif-I *(Source: BMD, 2015)*; **Figure 43** Average Relative Humidity (Percent) of Tangail in Kharif-II *(Source: BMD, 2015)*



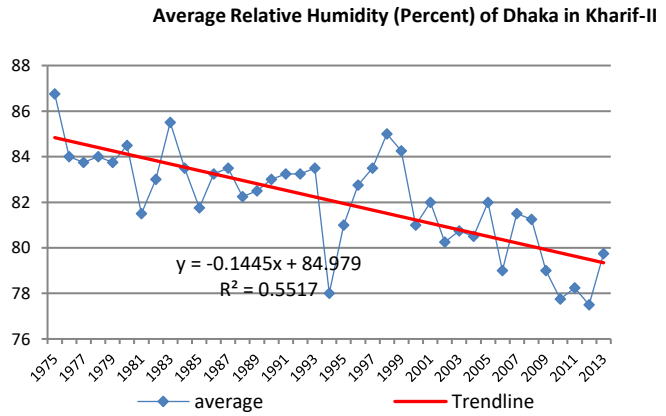
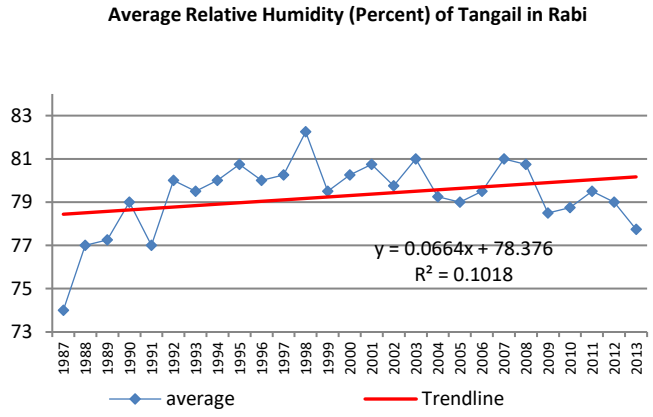


Figure 44 Average Relative Humidity (Percent) of Mymensingh in Kharif-II *(Source: BMD, 2015)*; **Figure 45** Average Relative Humidity (Percent) of Dhaka in Kharif-II *(Source: BMD, 2015)*



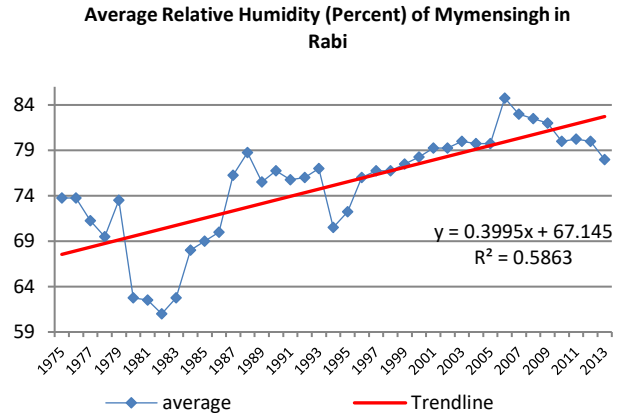


Figure 46 Average Relative Humidity (Percent) of Tangail in Rabi Season *(Source: BMD, 2015)*; **Figure 47** Average Relative Humidity (Percent) of Mymensingh Rabi Season *(Source: BMD, 2015)*

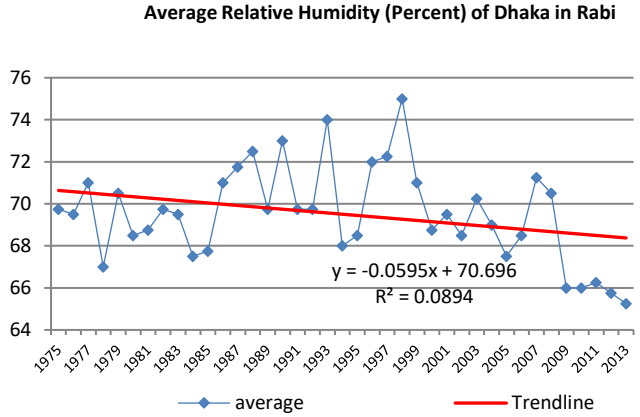
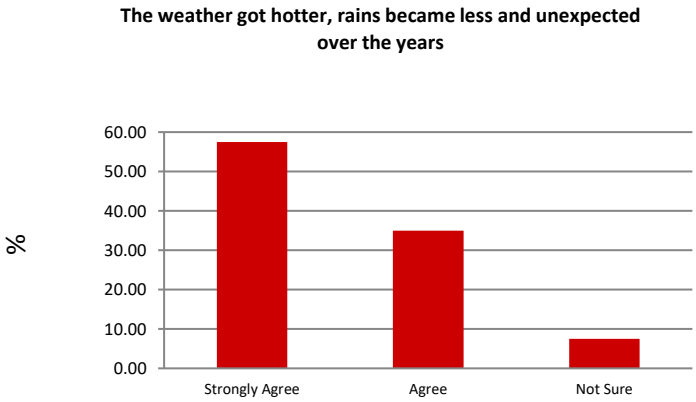


Figure 48 Average Relative Humidity (Percent) of Dhaka in Rabi Season *(Source: BMD, 2015)*

Farmer's Perception to Climate Change

Total 360 farmers were responding about climate change, cropping pattern, their income and other related perspectives. Majority of the respondents (47%) representing were in 40-50 years old and twenty two percent (20%) were in 50- 60 years old. Most of the respondents have a little academic learning (primary school 55%) and 32.5% have no education. The Old Brahmaputra floodplain is agriculturally rich area and most of the farmers (97%) cultivated land in the last crop season and they grew mainly paddy, jute, wheat etc. The farmers who responding about 57.50% strongly believe that the weather got hotter, rains became less and unexpected over the years (fig. 49). About 77.5% respondents strongly believe that weather is becoming more unpredictable year to year which also matters of concern. About 50% respondents believe temperature is increasing and 38.89% respondents believe the rainfall is becoming less due to climate change (fig. 51). As a result of increasing temperature and less rainfall some climatic hazards like drought, unpredictable weather and other attacked on agricultural activities every year in old Brahmaputra floodplain (Brammer, 1990; FAO, 2007). At present temperature is increasing, rainfall becomes less due to climate change.



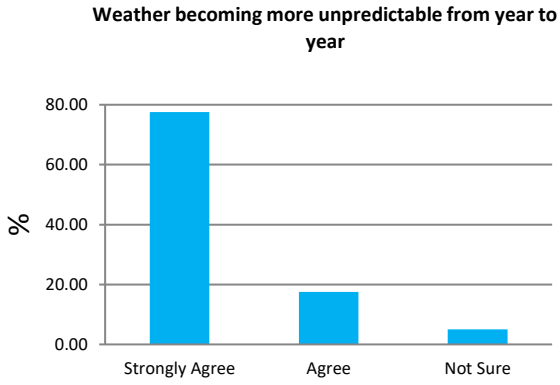


Figure 49 The weather got hotter, rains became less and unexpected over the years *(Source: Questionnaire Survey, 2016)*; **Figure 50** Weather is becoming more unpredictable from year to year *(Source: Questionnaire Survey, 2016)*

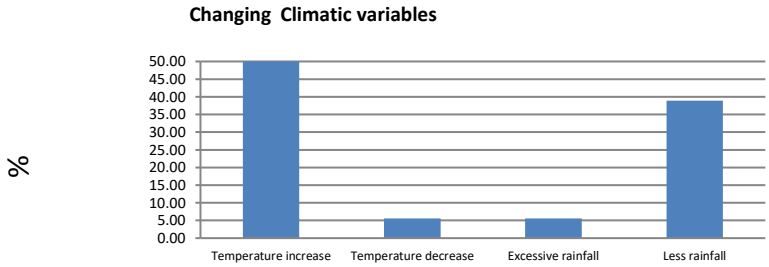


Figure 51 Changing variables of climate at present *(Source: Questionnaire Survey, 2016)*

Cropping Pattern Change Due to Climate Change

Variety of cropping patterns is generally practiced in Bangladesh as well as in the Old Brahmaputra floodplain (Brammer, 2000; BARC, 2014). Climate change impacts on the welfare of rural households depend on a number of interrelated factors especially agricultural sectors in the Old Brahmaputra floodplain face challenges with regard to the changes in weather (e.g. droughts, heavy

rain falls, floods etc.) which is moreover a result from climate change worldwide. The questions we addressed in this survey shall indicate how cropping pattern of the Old Brahmaputra floodplain has been changing due to climate change. About 72.50 % responded believe that the cropping pattern has changed for climate change and 28% disagree (fig. 52). In the old Brahmaputra floodplain production of rice, jute and other crops like sugarcane, pineapple etc have decreased and production of corn, wheat, vegetable have increased in present time(table 6.7). About 41.11% respondents had produced rice in past but in present only 35% respondents produce it. At present 3.33% respondents cultivate corn which was no cultivation in past. Wheat (3.33%) and vegetable (28.33%) production have increased as it needs less water than rice. Jute is one of the cash crops of Bangladesh but now a day its production is decreasing highly. About 22.50% respondents used to produce jute in past which decreasing in 3.33% (fig. 53). The main reasons for the change of production are less rainfall, high temperature, nearly drought, crop diseases etc. in the Old Brahmaputra floodplain (fig. 54).

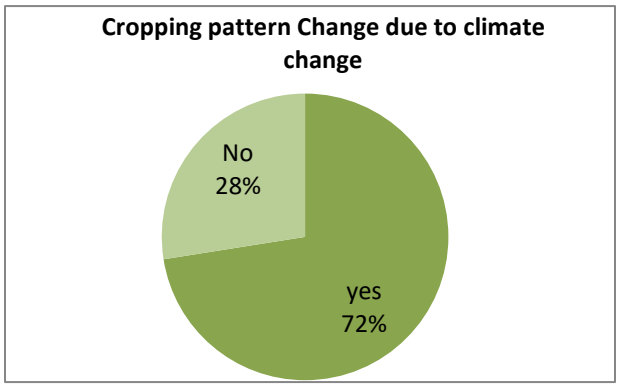
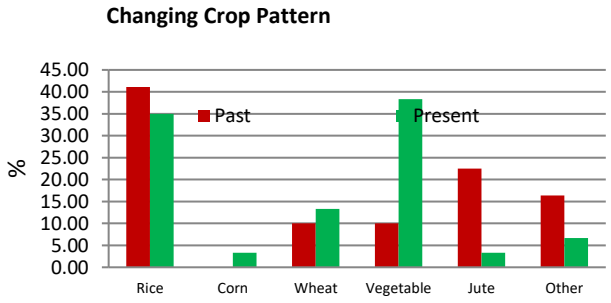


Figure 52 Changing Cropping Pattern in the Old Brahmaputra floodplain *(Source: Questionnaire Survey, 2016)*



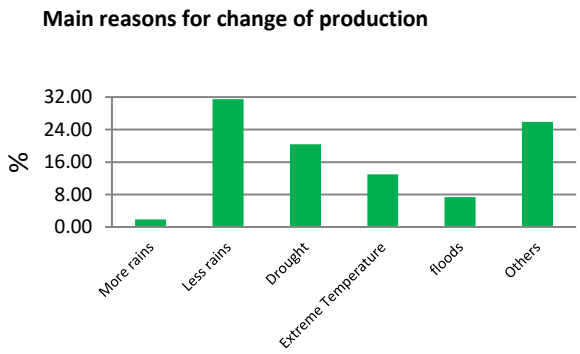


Figure 53 Changing Crop Pattern in the Old Brahmaputra floodplain *(Source: Questionnaire Survey, 2016)*; **Figure 54** The main reasons for change of production *(Source: Questionnaire Survey, 2016)*

6. CONCLUSION

The agricultural sector the Old Brahmaputra floodplain of Bangladesh is the traditional sector that existed over the thousands of years. It was largely subsistence oriented, based on family farming with some amount of paid work, and used traditional technology. Since last three decades, there is a significant transformation of the sub-sectoral structure of agriculture in the Old Brahmaputra floodplain. Per unit area and yield of cereal crops (Transplanted Aus and Aman to Boro and Vegetables) have been increasing gradually. On the other hand per unit area and yield of few cereal crops (Broadcast Aus and Aman) have been decreasing gradually. The wheat cultivating area is decreasing but the yield is increasing gradually. Use of modern appliances in agriculture reduced the cost of cultivation, production and saved management cost but it cannot help the farmers to get the fair price of their products for the middle-class trader. Again climatic parameters of the study area are changing especially average rainfall is declined and average

temperature is increasing gradually. Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as we have done in the past. These adverse trends are considered to be due to intensive cropping through indiscriminate use of fertilizers, pesticides, water for irrigation and total removal of biomass from the agriculture fields, which led to change in agricultural cropping pattern. Moreover, farmer could not get technical training by which they can improve their skill so that they can use input materials in proper proportion and on right time. Due to the fact that in the Old Brahmaputra floodplain is especially vulnerable to negative impacts of climate change, it is of great importance for the government to pay special attention to the consequences of climate change on agriculture and food security.

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