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Variation of Climatic Parameters (Rainfall and Temperature) over Ganges-Brahmaputra-Meghna River Basin in Bangladesh

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Key words: Ganges–Brahmaputra–Meghna (GBM) delta, Geographical Information System (GIS), Rainfall, Temperature.

Abstract

Bangladesh is vulnerable to third order impact of climate change, due to its geographical position, over population and economic condition. The research aimed to focus on the variation of rainfall and temperature over an area of agricultural importance zone of GBM (Ganges–Brahmaputra–Meghna) delta system in Bangladesh. Arc GIS 10.1 software (spatial analyst tool) was used to present the spatial distribution and variation of temperature and rainfall over G-B-M delta. Microsoft excel was used to conduct the percentage change calculation. Highest total average rainfall was observed in the Meghna river system area 52917 mm from 1985 to 1994 and lowest total average rainfall was in Brahmaputra river system 20185mm from 2005 to 2014. Beside highest and lowest temperature was 31.9°C and 29.51°C from 2005 to 2014 in Ganges and Brahmaputra river system respectively. Highest percentage change in rainfall was in Khepupar -0.016069504mm and temperature was in Sylhet 0.038435604°C in Ganges-Padma and Meghna-Surma river system respectively in Bangladesh. Lowest percentage change in rainfall was in Mymensign -0.264142107mm and temperature was in Madaripur 0.003861004°C in Meghna-Surma and Brahmaputra-Jumna river system respectively. Due to the change in climatic variable GBM delta's agricultural system faces some severe problem as drought. As a result Bangladesh reaches to a question of food security.

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Introduction

Bangladesh is situated at the confluence of three mighty river as Ganges-Brahmaputra-Meghna also known as GBM delta. The Ganges–Brahmaputra–Meghna/Barak (GBM) Basin comprises over 1.758 million km², of which 8% lies in Bangladesh (Bernsohn *et al.,* 2007). The three rivers making up the basin meet in Bangladesh and flow to the Bay of Bengal as the Meghna River (Wolf *et al.,* 1999; Nishat and Faisal, 2000). Climate change is no longer something to happen in future but rather an ongoing phenomenon (Basak *et al.,* 2013). The climatic factors of the country were in changing pattern. Bangladesh is one of the top most nations vulnerable to climate change (Harmeling, 2008). This study focused on the two climatic factors rainfall and temperature that change over the GBM delta. Rainfall is considered as the most significant variable to recognize global warming as well as changes in the state of climate (Chowdhury *et al.,* 2016). Rainfall is extensively used to study the advanced climate sciences (Chowdhury *et al.,* 2016). Rainfall over the GBM river system has been changed. Temperature in GBM river system in Bangladesh also changed. Monthly average minimum temperature data also showed increasing trends (Basak *et al.,* 2013).Bangladesh is in now reaches to the climate hotspot region. Bangladesh is one of the severe vulnerable countries to rainfall unpredictability and major 'hotspot' for upcoming influences of climate change (IPCC, 2007). Changing pattern of the climatic factors has a great impact on the agricultural system of GBM river system area. Many most of the agricultural land of Bangladesh are water dependent ,beside the GBM river system carry a huge fertile soil, that are blessed for agriculture. But the climate change and upstream barrage destroy the agricultural system of GBM riverine area. The objective of the study is to reveal the Variations and changing pattern of temperature and rainfall over GBM delta system in Bangladesh.

Materials and methods

Study area

Bangladesh is situated at 21°47'12" N and 92°36'36" E (Wikipedia, 2014).

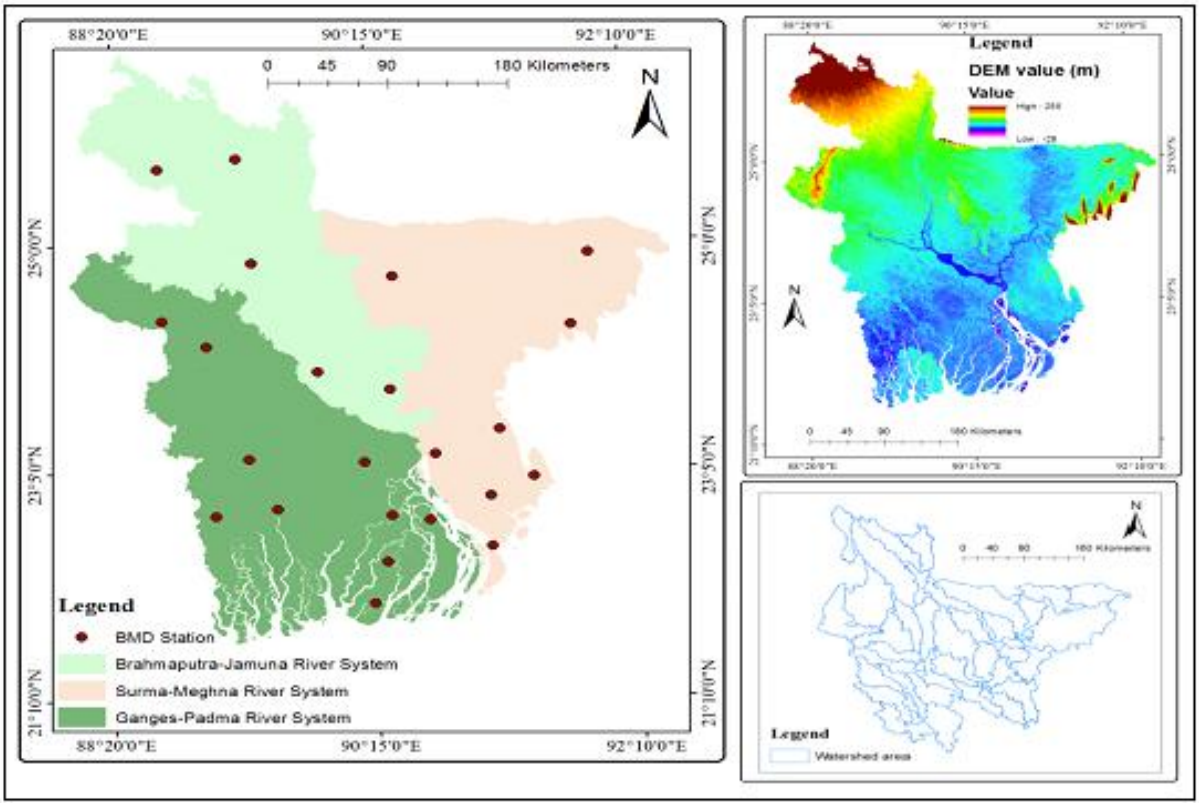

Fig. 1. Study area with watershed and Digital Elevation Model.

The mighty river Ganges originated from the Himalayan hill ranges and travel through India and enter by Nawabgong district in Bangladesh. Brahmaputra river originate from Tibet and travel through India and reaches to Bangladesh in Kurigram district. Megna River rises in the Manipur Hills of northeast India as the Barak River and flows west becoming the Surma River and then flows south as the Meghna River (Wikipedia, 2015). The Meghna River flows southwest and joins the Ganges and Brahmaputra rivers before flowing into the Bay of Bengal (McEwen, 2008).The total length of study area was 85521 square kilometers. The (Fig. 1) is exposing the study area with Digital Elevation Model and Watershed area.

Data and software

Data that were used in the study were collected from the BMD (Bangladesh Meteorological Department). 23 weather station data over the GBM delta was used in the study. These weather stations are unevenly distributed over the GBM river system. The data that were collected from BMD were 1985 to 2014 and study period were selected as 10 years interval. GIS is an extraordinary ultimate tool for natural resource modeling (Chowdhury *et al.,* 2016). For the processing of data and final representation of data Microsoft-excel and a version of Arc GIS 10.1 was used. Now a day Arc GIS (Geographical Information System) is widely used for various purposes (Chowdhury *et al.,* 2016). GIS is a useful tool to input, store, retrieve, manipulate, analyze and output geographically referenced data (Siddik *et al.,* 2013).

Data preparation and Analysis

23 weather station data that are unevenly distributed over GBM river system in Bangladesh are firstly process according to their geographical co-ordination using Microsoft-excel. Then the data were input to Arc GIS software. (Fig. 2) exposed the data preparation and analysis procedure. After input into the GIS software, the data were projections. The projections were done by WGS 1984 and UTM. Then the values were interpolated using the spatial distribution tools. GIS is a tool to show the spatial distribution of the effect of climatic parameters (Siddik *et al.,* 2013).For interpolation, IDW (Inverse Distance Weighting) were used. The IDW is a function of inverse distance. The IDW is a simple and intuitive deterministic interpolation method based on the principle that sample values closer to the prediction location (Uddin *et al.,* 2014).

Results and discussion

Changes in Rainfall and Temperature

The study focused on the rainfall and temperature changes over the G-B-M river system consisting area of 85521 square kilometers. After interpolation using GIS (Fig. 3) to5 it was exposed that the total rainfall decreased and Temperature is increased.

Table 1. Changing percentage of Temperature and Rainfall from 1985-2014.

Station Name	Changing percentage(temperature) from 1985 to 2014	Changing percentage (rainfall) from 1985 to 2014
Meghna-Surma river system		
Sherimongol	0.020840225	-0.170034007
Sylhet	0.038435604	-0.263681028
Mymensing	0.015711948	-0.264142107
Comilla	0.009574117	-0.114986554
Feni	0.006303915	-0.183891288
M.court	0.033512064	-0.216326221
Hatiya	0.02535497	-0.100921614
Chadpur	0.024793388	-0.242141346
Ganges-Padma river system		
Ishordi	0.014225671	-0.133997785
Rajshahi	0.01153107	-0.078619089
Jessor	0.013341804	-0.164699107
Khulna	0.01092194	-0.125417039
Satkhira	0.013099042	-0.13250478
Barisal	0.016732283	-0.168458088

Bhola	0.00591133	-0.189097104
Khepupar	0.024883875	-0.016069504
Patuakhali	0.033719008	-0.142091153
Madaripur	0.003861004	-0.193834657
Jamuna-Brahmaputra river system		
Dinajpur	0.006352391	-0.109269913
Rongpur	0.006777364	-0.176189989
Bogra	0.010794897	-0.184909811
Dhaka	0.007482108	-0.252486353
Faridpu	0.015711948	-0.20758363

In 1985-1994 the total average rainfall in Brahmaputra-Jamuna riverine area in Bangladesh was 25358 mm but in 2005-2014 the total average is 17664mm. In 1985-1994 the total average rainfall for Ganges-Padma and Meghna-Surma river system in Bangladesh was 24038 and 33923 respectively but in 2005-2014 the total average is 18444 and 26430mm respectively. In recent years, it is quite visible that rainfall reduced all over the 22 regions in Bangladesh (Siddik *et al.*, 2013).

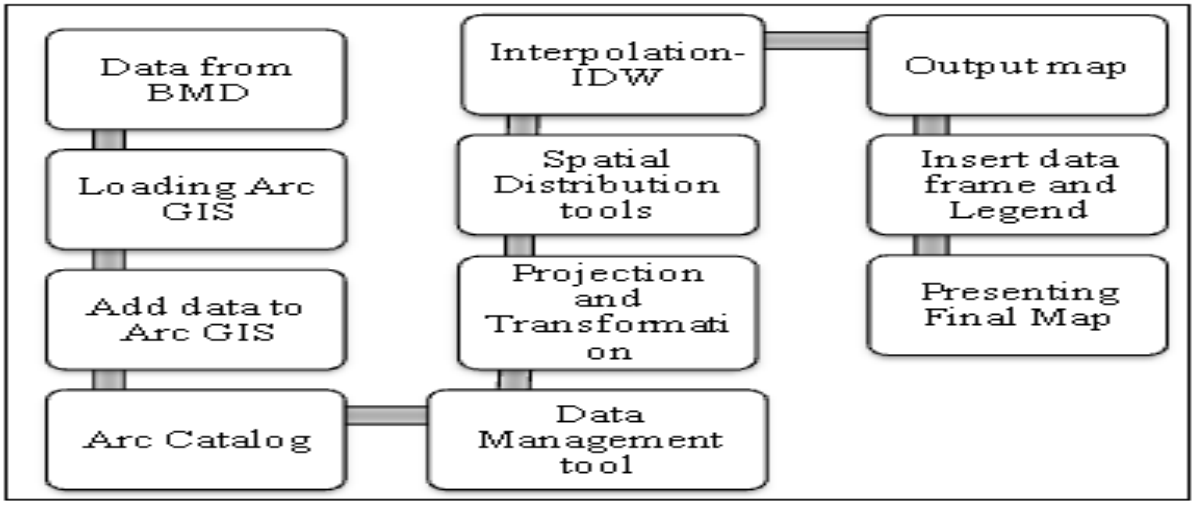

Fig. 2. Data Preparation and Analysis.

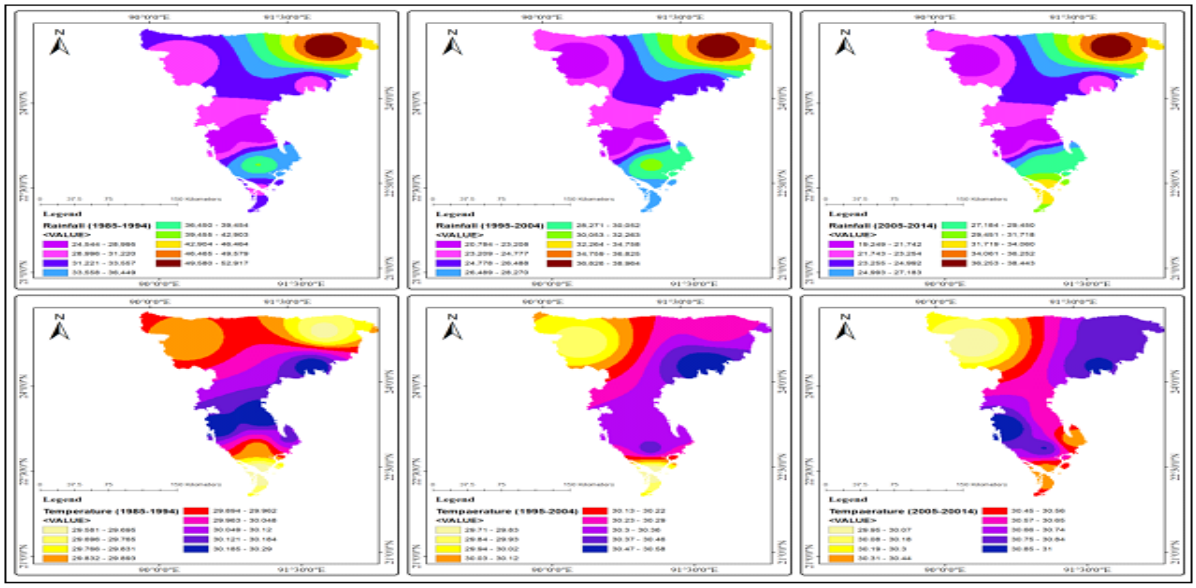

Fig. 3. Rainfall (upper 1, 2, 3) and Temperature (lower 1, 2, 3) variation in Meghna- Surma river system in Bangladesh.

From this study it also reveals that the highest amount of rainfall observe in the Meghna-Surma River basin area. This is because the highest amount of rainfall in the monsoon, pre-monsoon and post-monsoon occurs in Meghna-Surma river system Sremongol and Sylhet region. Sylhet situate in the Meghna-Surma river system had the greatest recorded total single year rainfall 5620 mm in 1988 and the greatest one month total rainfall was recorded 1294.7 mm in July 2004 (Choudhury *et al.,* 2012).

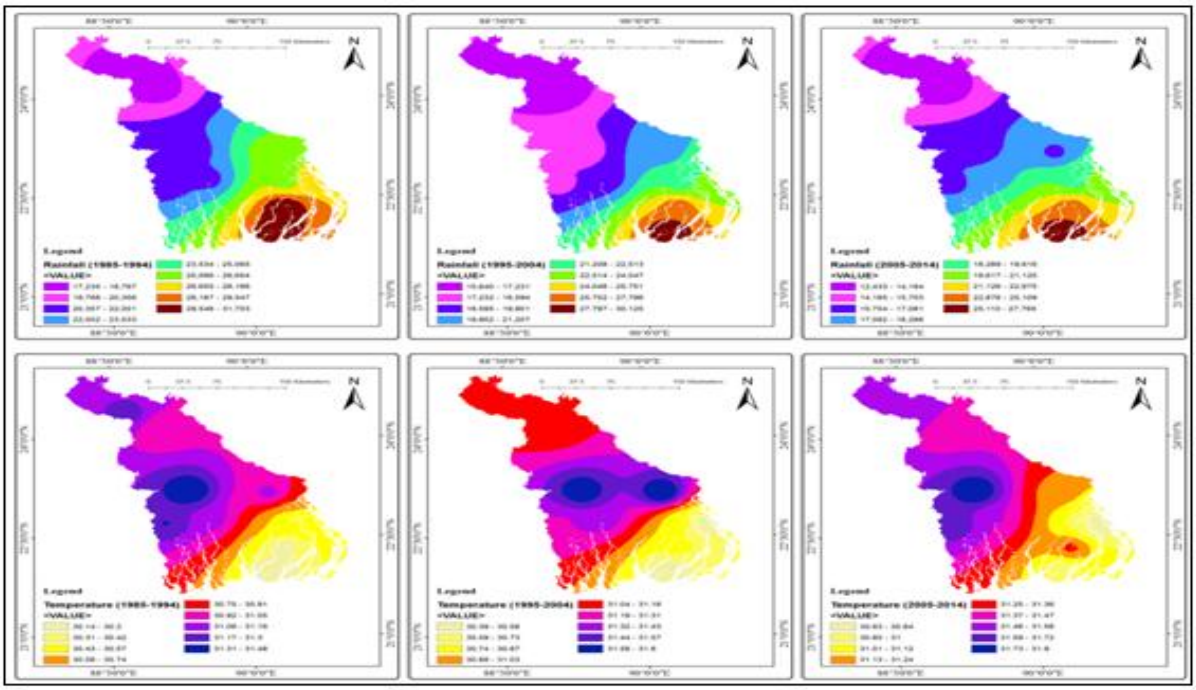

Fig. 4. Rainfall (upper 1, 2, 3) and Temperature (lower 1, 2, 3) variation in Ganges-Padma river system in Bangladesh.

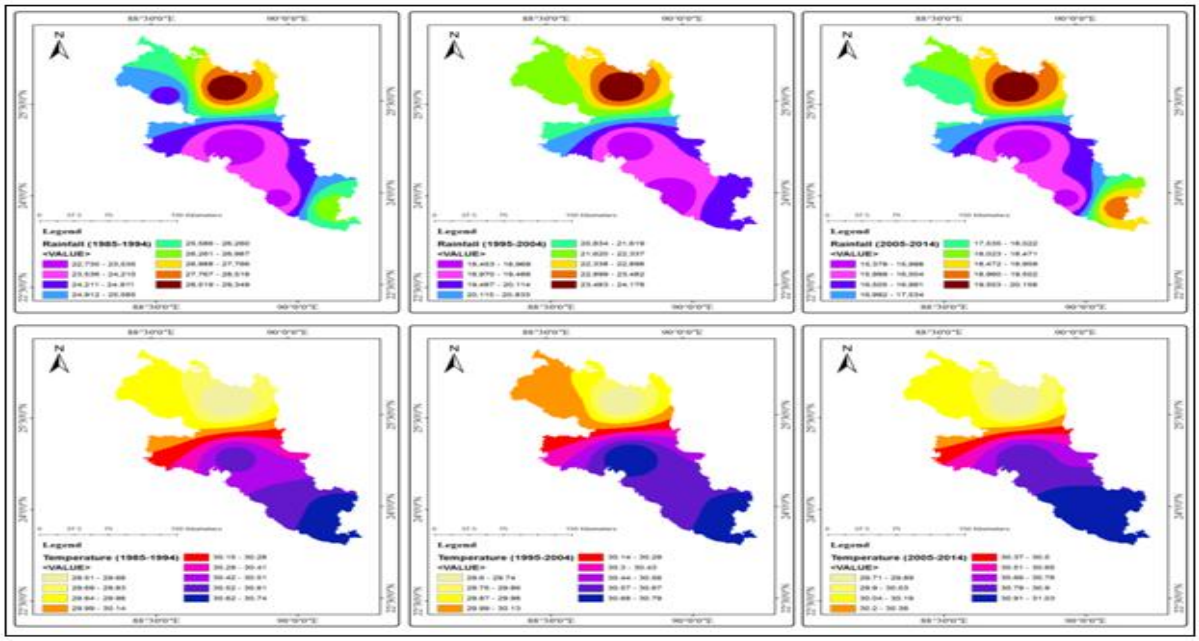

Fig. 5. Rainfall (upper 1, 2, 3) and Temperature (lower 1, 2, 3) variation in Brahmaputra-Jamuna river system in Bangladesh.

After then Ganges-Padma river system area, which is mainly western, north-west, south-west and southern part of Bangladesh. The whole north-west part of the country gets minimum rainfall (Siddik *et al.,* 2013).Lowest amount of rainfall was observed in the Brahmaputra-Jamuna river system which is mainly some part of north-west, northern, north-central, central part of Bangladesh. Rainfall varies from 1500 mm in the western part to more than 5000 mm in the north-eastern part of the country (Hasan *et al.,* 2015).

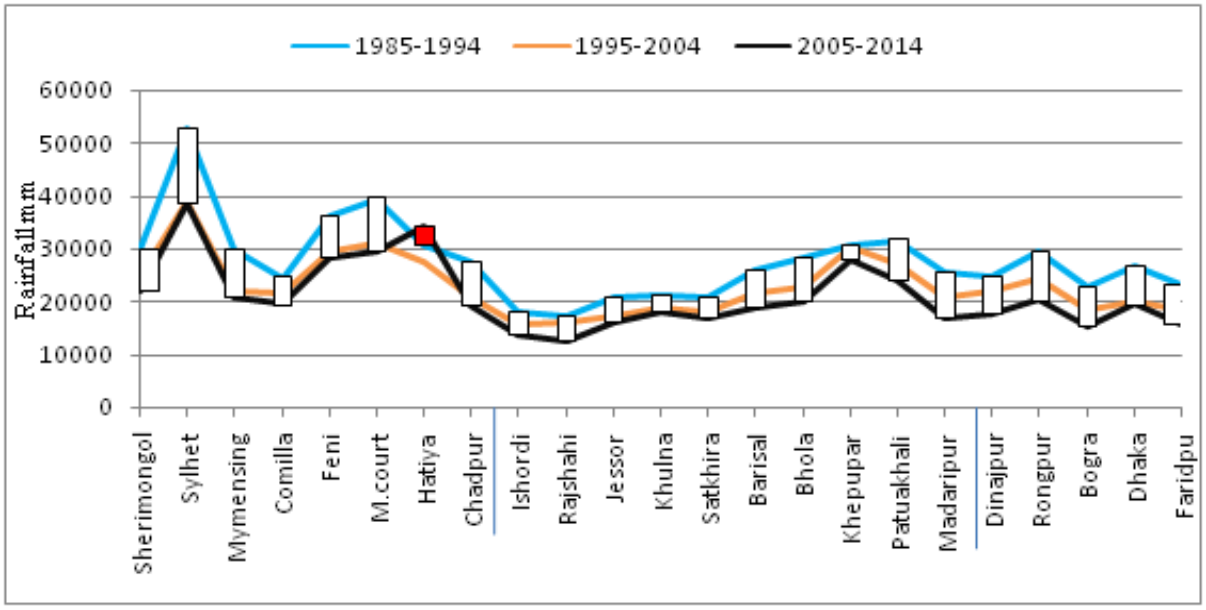

Fig. 6. Rainfall conditions in GBM River System.

(Fig. 3, 4 and 5) expose the rainfall variation in different region of Ganges- Brahmaputra-Meghna river system in Bangladesh. For (Fig. 3, 4 and 5) (upper 1, 2, 3) the highest value is decrease means rainfall in different region also decrease. The highest value for Ganges- Brahmaputra-Meghna in 1985-1994 was17235, 22730 and 24,544 mm respectively but now in 2005-2014 the value is decrease and replace as 12433, 15379 and 19249 mm respectively. (Fig. 6) graphically presents the rainfall condition of GBM (Ganges- Brahmaputra-Meghna) river system area in Bangladesh.

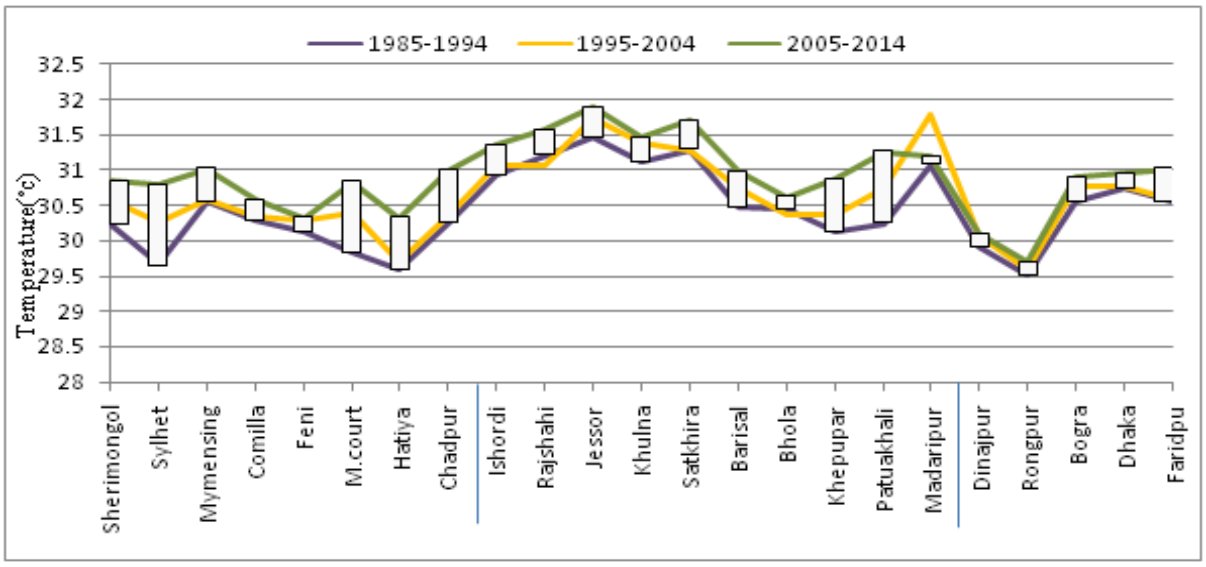

Fig. 7. Temperature conditions of different location in GBM River System.

In (Fig. 6) white color bars indicate the decreasing pattern of rainfall and red color indicates the increasing pattern of rainfall. Rainfall of GBM river system in Bangladesh is decrease only exceptional is Hatiya region which is in Meghna-Surma River system, where rainfall is increase. Besides decreasing rainfall temperature of GBM riverine area is increases. (Fig. 3 to 5) (Lower 1, 2, 3) exposed the temperature condition. For Meghna river system, in 1985-1994, 1995-2004 and 2005-2014 the highest temperature was 29.58°, 29.71° and 29.95° C respectively. Not only Meghna river system but also Ganges-Brahmaputra river system are also experience the highest temperature from 1985-2014. The yearly average maximum temperature increased at all regions in Bangladesh during the period of 1976-2008 (Basak *et al.,* 2013).

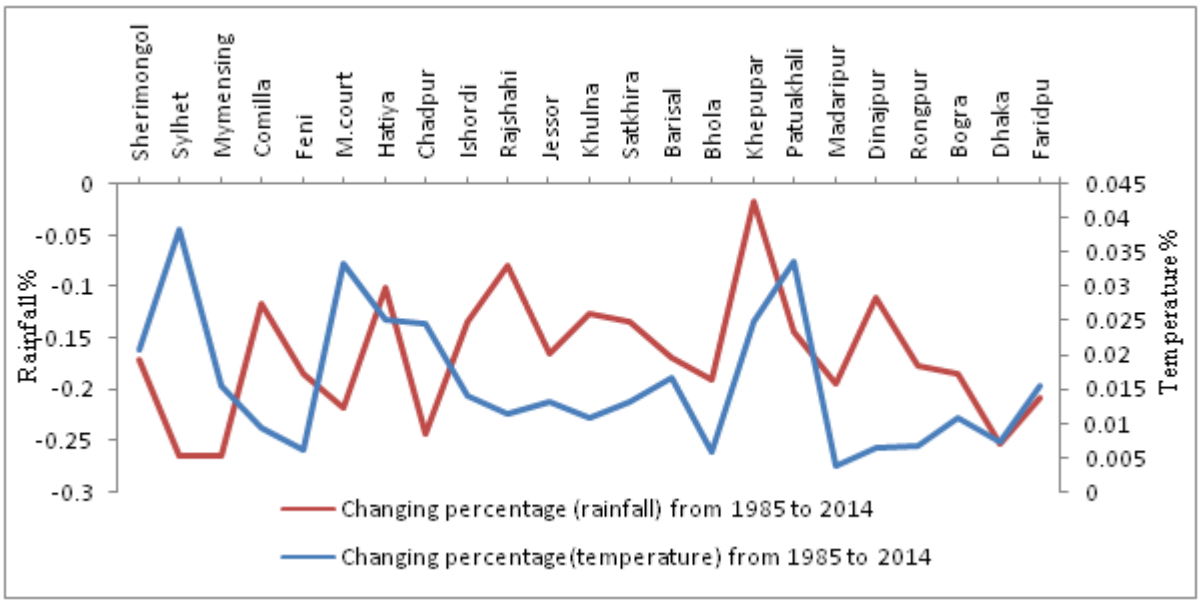

Fig. 8. Patterns of Rainfall and Temperature (1985-2014).

Ganges and Brahmaputra river system, in 1985-1994, 1995-2004 and 2005-2014 the highest temperature was 30.14°, 30.39°, 30.63° and 29.51°, 29.60°, 29.71° C respectively. The highest temperature experiences the Ganges river basin area in Bangladesh which is the mainly south, south-western and western part (Jessore, Khulna, Sathkhira and Rjshahi). The hottest regions of Bangladesh in the period 1948-2013 were Sitakunda, Jessore, Khulna and Sathkhira where the temperature varies between 31°C to 31.495°C (Uddin *et al.,* 2014). Fig 7 reveals the temperature condition of different weather station in G-B-M river system. The white bar
indicates the increasing pattern of temperature.

Percent of changes in Rainfall and Temperature

Table 1 and (Fig. 8) expose the changing percentage of rainfall and temperature among different location in G-B-M river system in Bangladesh at the time period of 1985-2014. In where highest rainfall percentage change observed in Khepupar -0.016069504mm (%) in Ganges-Padma river system beside the lowest change observed in Mymensign -0.264142107mm (%) in Meghna-Surma river system. Not only the rainfall is changed but also temperature was change. Temperature was changed in a positive manner. The highest temperature changes was observed in Sylhet 0.038435604°C (%), and lowest temperature change was observe in Madaripur 0.003861004°C (%) in Meghna and Brahmaputra river system in Bangladesh respectively.

(Fig. 8), where the rainfall percentage changes in exposed in left side and the temperature is in secondary axis in right side blue color. In (Fig. 8), rainfall value is negative indicating the decreasing

pattern and temperature value is positive indicate it is in increasing pattern.

Conclusion

Rainfall and temperature over GBM delta in Bangladesh is shifting to stiffer condition. Rainfall is in decreasing pattern and temperature is in increasing pattern. All over country experience this pattern of climatic condition of highest temperature and lowest rainfall, exception rare part rest of the country. The study strongly support that highest rainfall occurs in the north-eastern region (Meghna river system) and highest temperature is in south-western region (Ganges-Padma) river system.

The agricultural system likely depends on the upstream water flow and monsoon heavy rainfall. Because of the low rainfall and high temperature over the year some part of the country experience severe drought. Many different types of species of tropical monsoon climatic region have been extinct due to change in climatic variable (rainfall and temperature).In future it may cause the serious problem for the economic, environmental and food security.

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