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CLIMATIC CHANGE OF BANGLADESH OVER A CYCLE OF PERIOD 35 YEARS

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ABATRACT

Bangladesh has been undergoing hazardous climatic changes. Monsoon is changing its pattern. Variations of temperature, humidity, rainfall are remarkable. The seasonal changes of Bangladesh such as the transition from winter to spring, summer to autumn in temperate zone, and from wet to dry in the tropics are remarkable to take into consideration. The climatic changes have great influence on the distribution of plants and animals and in the formation of soils through the weathering of geological materials and the decomposition or preservation of organic matter. Various weather parameters over a cycle were studied and determined the coefficient of variations to compare the past, present and future situation in Bangladesh. The frequency distribution and the shift in distribution of monsoon rainfall were determined and analyzed to show the trend of climate changes and their impact on environment. The important findings are the surface temperature rise by 0.6^0C and the rainfall in monsoon likely to be increased by 12% in the year 2030. However, the seasonal rainfall trend is decreasing.

Key words: Temperature, Rainfall pattern, 35 years

INTRODUCTION

Once a verse was running “Bangladesh is a land of rivers.” It being monsoon area, there had been raining heavily all over the year. Nowadays, that condition had been changed since a pretty long ago. Climate is a key factor which determines the distribution of plants and animals and in the formation of soil through the weathering of geological materials and the decomposition or preservation of organic matter. Climate change means a change of climatic parameters which is attributed directly or indirectly to human activity that alters the composition of the atmosphere and which is in addition to natural climate variability observed over comparable time periods.

In order to assess the meaning of climate change for Bangladesh, it is first necessary to understand the present climate, and then ask how that climate could be altered through different constraints (BUP 1994).

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Bangladesh enjoys a tropical climate, although the tropic of cancer (23.5°N) passes through the middle of the country, dividing Bangladesh almost into two equal halves. The climate is characterized by high temperatures, heavy rainfall, and often excessive humidity and fairly marked seasonal variations throughout the year. The country is well guarded by the Himalayas on the north, and is within the domain of a very active monsoon with a reversal of seasonal wind. The region used to be known as the "land of six seasons" with regard to crop sowing and harvesting times, and cultural festivities. The nation lost some of its relevance with the initiation of various development programmes, particularly in the water resource sector during the early sixties. Now, the seasonal cycle is often divided into three main periods, namely the summer (March-May), the monsoon (June-October), and the winter (November-February). Other important aspects of climate in Bangladesh include weather-related extreme events, e.g. tropical cyclones, tornadoes, nor'westers and droughts.

Weather records of 15 stations for 35 years (1972-2006) are included in the present analysis. Stations are chosen on the basis of their represent activeness for different localities having relatively fewer missing data. Temperature means and coefficients of variation (CV) are shown in Table 1. The calculated mean winter temperature for 35 years is 21°C with 1·7 per cent coefficient of variation. A steady fall in maximum and minimum temperatures from November makes the beginning of winter season, and by the end of December the north-western corner of the country records a mean minimum of 9°C. The same trend is also visible in the Sylhet hills at the north-east corner. At that time, Cox's Bazar experiences a mean minimum of 15·5°C. January is the coldest month in Bangladesh with a minimum of temperatures recorded in northern Dinajpur and southern Sylhet.

Table 1. Bangladesh (area-averaged) mean annual and seasonal temperatures, 1972-2006.

Period	Winter		Summer		Monsoon		Annual	
	Mean (°C)	CV* (%)	Mean (°C)	CV* (%)	Mean (°C)	CV* (%)	Mean (°C)	CV* (%)
1972-1981	21·1	1·92	27·7	1·64	28·2	0·72	25·7	2·17
1982-1991	21·1	1·87	27·3	2·05	28·3	0·89	25·8	1·19
1992-2001	20.8	1.28	27.5	2.07	28.1	0.85	25.6	0.91
2002-2006	21·0	1·69	27·5	1·92	28·2	0·82	25·7	1·42

Source: The table is based on Warrick *et al.* (1994).

In the summer, the yearly maximum temperatures are reached in the month of April, when the western part of the country experiences temperatures that are sometimes over 40°C. The mean maximum temperature ranges from 30·4°C in Cox's Bazar to 36°C in Rajshahi. A hot dry westerly wind springs up almost everyday and blows hard for at least 5 hours in the western part of the country. Infrequent thunderstorms bring some relief. In the eastern part, there are more frequent thunderstorms (nor'westers) and the intense heat

of the west is rare. The 35-year mean summer temperature is 27·5°C. The south-west monsoon normally reaches the North West Bay of Bengal (20°N) and Myanmar coast by June 1. It enters Bangladesh by the end of first week of June at the earliest and withdraws by the start of the fourth week in October at the latest. On the average, the monsoon in Bangladesh lasts for 121 days within a range of 112 to 139 days.

The monsoon begins with a marked fall in temperature, because of the rainfall. Throughout the season the mean maximum temperature over most of the country remains around 31°C and the mean minimum about 6°C less. During the monsoon season, the mean temperature for the 35 year period is around 28°C and the variability is 0·8 per cent (Table 1). The mean temperature is relatively higher during the monsoon than during summer. This is because the range between maximum and minimum temperatures is very high during summer; the minimum temperature during summer is relatively very low.

Increase of 0·6°C over a 35 years period (1972-2006) from 39·0°C is observed. We see that in 1972, 1980 and 1985 are highest maximum temperature year. These temperature are 45·1, 44·4 and 43·8°C which are the record temperature from 1972 to 2006. The lowest minimum temperature demonstrated a clear trend of decrease over the same period by 1·8 to 6·5°C. In other words, the gap between the highest maximum and lowest minimum temperature has narrowed over three decades from 1977 to 2006.

In order to identify the trend mean seasonally decadal temperature data for three decades (1977-1986, 1987-1996, 1997-2006) have been examined and reproduced in Table 2.

Table 2. Change in mean seasonal temperature (three decades).

Season	Absolute mean seasonal temperature (°C)	Seasonal mean temperature variation (°C)
Dec.-Jan.	18·07	
Feb.-Mar.	22·80	4·73
Apr.-May	29·34	6·54
June-July	29·91	0·57
Aug.-Sept.	29·21	0·70
Oct.-Nov.	24·62	4·60

Source: Hossain and Ansary (2012).

Here the authors divided six seasons which are December - January, February - March, April - May, June - July, August - September and October - November. The average temperature of the season December - January is 18·07°C, February - March is 22·80°C April - May is 29·34°C, June - July is 29·91°C, August - September is 29·21°C and October - November is 24·61°C. The seasonal mean temperature variation is 4·73°C

from December - January to February - March, 6·54°C from February - March to April - May, 0·57°C from April - May to June - July. Decrease 0·70°C from June - July to August - September and Much decrease 4·60°C from August - September to October - November. The authors observed that from December - January to February - March and April - May temperature increased rapidly, but the season April - May, June - July and August - September's temperature increase or decrease was very slow. Again the temperature rapidly decreases from August - September to October - November. Actually Bangladesh citizen feels hot season from April - May to August - September and feels cold season from December to February with October and November as no hot no cold.

Seasonal mean maximum and mean minimum temperature and seasonal mean temperature variations (every five years) are shown in Tables 3 and 4.

Table 3. Seasonally mean maximum temperature and seasonal mean temperature variations (every five years).

Season	1972-1976	1977-1986	1987-1996	1997-2006	Seasonal mean maximum temperature (°C)	Seasonal mean temperature variations (°C)
Dec.-Jan.	28·55	28·11	28·34	27·23	27·89	
Feb.-Mar.	35·98	35·28	34·96	34·72	34·99	7·10
April-May	41·08	39·65	41·07	39·63	40·12	5·13
June-July	36·64	36·51	36·2	36·86	36·52	3·60
Aug.-Sept.	33·41	34·85	35·36	35·22	35·14	1·38
Oct.-Nov.	33·33	32·73	33·43	33·16	33·11	2·03

Source: Hossain and Ansary (2012).

Table 4. Seasonally mean minimum temperature and seasonal mean temperature variations (every five years).

Season	1972-1976	1977-1986	1987-1996	1997-2006	Seasonal mean minimum temperature (°C)	Seasonal mean temperature variations (°C)
Dec.-Jan.	9·17	8·60	7·45	8·09	8·05	
Feb.-Mar.	11·63	10·30	10·49	10·98	10·59	2·54
April-May	19·76	18·70	18·12	19·44	18·75	8·16
June-July	22·94	22·94	23·09	23·48	23·29	4·54
Aug.-Sept.	23·22	23·19	22·95	24·03	23·29	0·10
Oct.-Nov.	17·38	16·47	15·05	16·77	16·10	7·29

Source: Hossain and Ansary (2012).

As shown in Table 5, Bangladesh receive heavy rainfall; mean annual rainfall increases rapidly towards the north-east to an average of about 4060 mm at Sylhet. Rainfall also increases towards the south-east to a mean about 3600 mm near Cox's

Bazar. Lower rainfall occurs in the west with an average annual of 1415 mm at Rajshahi. The distribution of the average annual rainfall makes the isohyets swing round in a curve from the south toward the east and then towards the north-east. The mean annual rainfall for 35 years is over 2200 mm.

About 82 per cent of annual rainfall occurs in the five months of the monsoon period, June through October. The 35 years mean monsoon rainfall amounts to about 1800 mm, with variability of around 11 per cent, which is less than the annual. This fact indicates that monsoon rainfall is reactively stable with variability ranging from around 8 to 13 per cent between the 10-years time periods. Winter is the driest season in Bangladesh. The 35-years mean winter rainfall amounts to about 64 mm with a variability of around 53 per cent.

Table 5. Bangladesh (area-averaged) mean annual and seasonal rainfall, 1972-2006.

Period	Winter		Summer		Monsoon		Annual	
	Mean (mm)	CV* (%)	Mean (mm)	CV* (%)	Mean (mm)	CV* (%)	Mean (mm)	CV* (%)
1972 - 1981	46	45·31	351	23·03	1835	11·47	2181	13·19
1982 - 1991	76	49·30	398	38·84	1751	8·56	2179	20·62
1992 - 2001	71	48·38	482	24·50	1797	12·85	2305	14·80
2002 - 2006	64	53.40	410	33.15	1795	11.28	2202	13.14

Source: The table is based on Warrick *et al.* (1994).

Among the weather-related extreme events (ADB 1994, Ahmed 2006), tropical cyclones occur frequently in Bangladesh and cause severe human casualties, widespread damage to property and constant set backs to economic development. During the period 1976-88, the frequency of cyclones (wind speed greater than 35 knots) was 4·0 per month, as compared to 2·7 per month during 1891-1960. Bangladesh is also subjected to devastating tornadoes and nor'westers every year during summer, but little is known about their frequency of occurrence. Droughts are usually considered climatically controlled extreme events in Bangladesh.

Over the past 35 years, the broad region encompassing Bangladesh has been warmed by about 0·6°C. The warming trend is consistent with that of the northern hemisphere as a whole. There has been no discernible trend in average rainfall, although rainfall variability appears to have increased in recent decades.

In future, Bangladesh may get warmer and wetter (IPCC 2007). Bangladesh is projected to be 0·6 to 2·0°C warmer than today by the year 2030, based on a range of GCM results. Rainfall is more difficult to predict.

However, climate models generally agree that regional monsoon rainfall should increase in a warmer world. The best estimate is a 10 to 15% increase in average monsoon rainfall by the year 2030, although the uncertainties are very large (Warrick *et al.*1994).

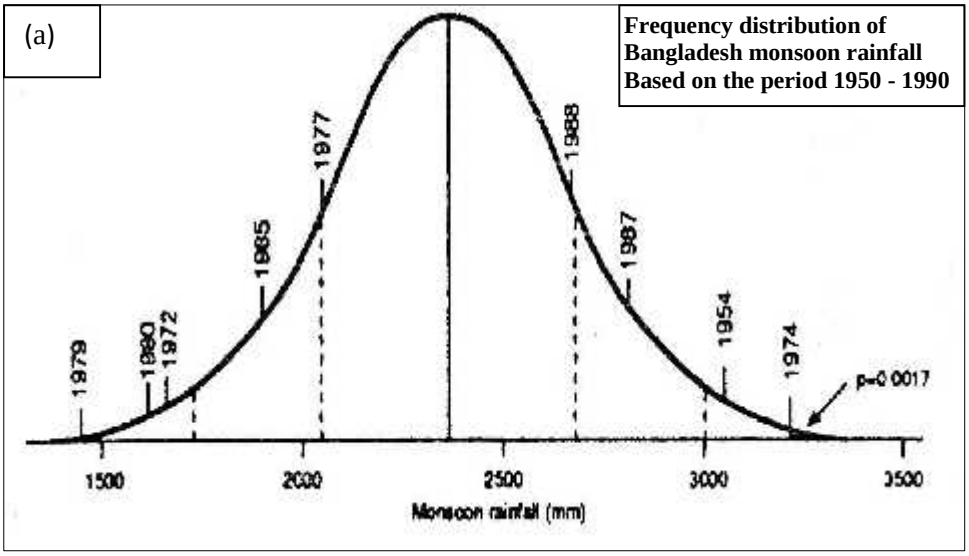


Fig. 1(a). Frequency distribution of Bangladesh monsoon rainfall (June-Oct).

Present distribution is based on the period 1950-1990, with selected extreme wet and dry seasons noted. The shaded area denotes the probability of the extremely wet monsoon of 1974 being equaled (or exceeded) in any given year.

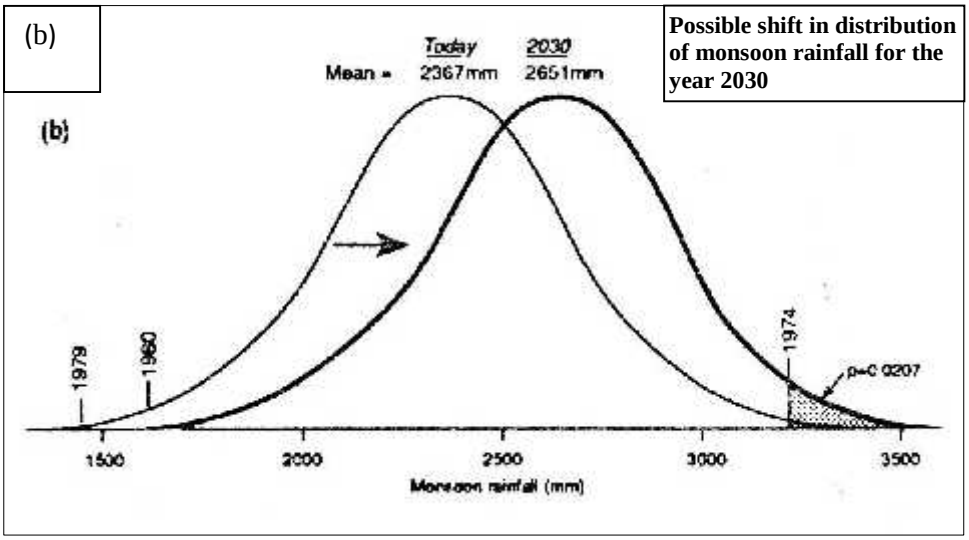
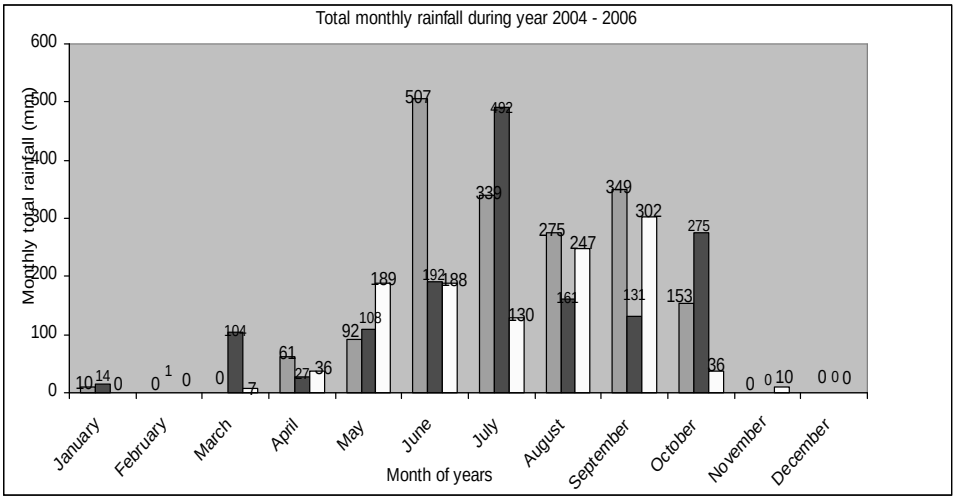


Fig. 1(b). Frequency distribution of Bangladesh monsoon rainfall (June-Oct).

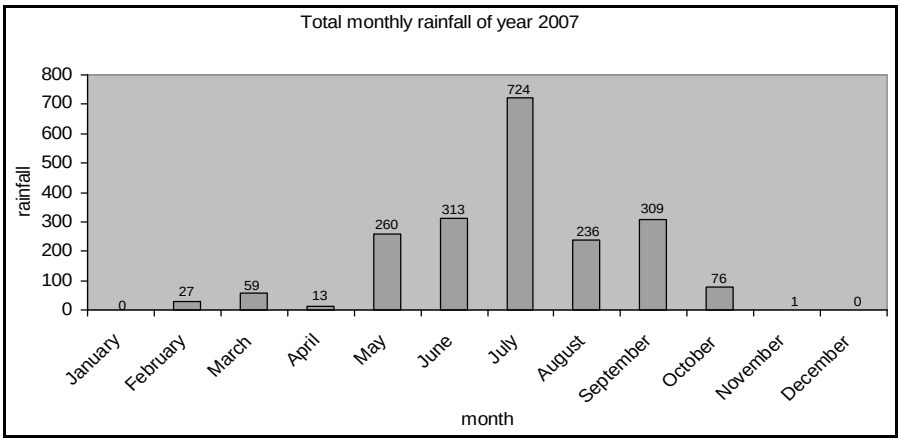
The shift in distribution for a 12% increase in mean rainfall is projected for the year 2030, assuming no change in variability. The stippled area under the curve indicates the increase in probability of occurrence of an extremely wet monsoon like 1974.



Source: Hossain and Ansary (2012). Modified by Fig. 3.4

Fig. 2. Comparing three years rainfall (2004-2006).
(MS Excel method has been used to analyze the data)

The authors noted that there are some nil rainfall months in almost every year. Data are furnished by Bangladesh Meteorological Departments.



Source: Hossain and Ansary (2012). Modified by Fig. 3.4

Fig. 3. Total rainfall of each month in the year 2007.
(MS Excel method has been used to analyze the data)

Here authors discuss comparing three years monthly rainfall during year 2004-2006. The total rainfall was 1786 mm in 2004, the total rainfall was 1405 mm in 2005, and also

the total rainfall was less in 2006 which was only 1145 mm. Again the authors saw that, the maximum rainfall was 507 mm at June and 349 mm at September in year 2004.

The maximum rainfall was 492 mm at July and 275 mm at October in the year 2005. The maximum rainfall was 302 mm at September and 247 mm at August in the year 2006. So clearly, the authors noted that, day by day the rainfall has been decreasing.

Here authors marked only the total rainfall of every month in the year 2007. The total rainfall in this year was 2018 mm. January and December were nil rainfall months, only 1 mm rainfall was recorded in the month of November. Maximum rain fall was 724 mm in July. Here the authors divide three seasons of the year 2007 and saw that, there were 4·91% rainfall in the first season, January to April in the year. This season had the total rainfall 99 mm. The second part of this year was mainly rainfall months. There were no nil rainfall months in May to August. This season had the total rainfall 1533 mm in the year 2007.

There are 75·97% rainfall in the second season, May to August in the year. The third season is September to December. The total rainfall of this season was 386 mm in the year 2007. There are 19·12% rainfall in the third season, September to December in the year. November and December are nil rainfall months. If we shall divide two seasons where June, July, August and September are first season. The rest of eight months are second season. Here it is noted that, there were 78·39% rainfall in the first season, June, July, August and September in the year. There were 21·61% rainfall in the second season. Here the authors identified three causes for decreasing rainfall. These are, (i) increasing population, (ii) land use pattern change and (iii) effects of Farakka Barrage (Banerjee 1999).

The problems that climate change is likely to pose for Bangladesh are not necessarily new. The Bangladesh legal system has a wealth experience in dealing, for example, with inundation, flooding and population displacement. In order to ensure effective implementation of policies and strategies related to climate change, more needs to be known about the ways in which legal rules and institutions actually work in practice. It should approach to effective controls of pollution as well as of green house gases, effective, possibly community-based, protection of crucial life-supporting ecosystems. Presently an international measure has been adopted by way of recovery from climatic change. Climate is changing all over the world for the reasons of developed countries; the reasons are their heavy industries. They are throwing a large amount of carbon dioxide (CO_2) from their industries in the air in one hand, and are leaving a lot of residue of the raw materials used in the industries in the rivers, the seas and the oceans on the other hand. As a result the natural environment is changing. But the matter of interest is that

the underdeveloped countries and the developing ones are falling in hazard more than the developed countries. In addition , the underdeveloped and the developing countries are also responsible more or less for climatic changes, because they are destroying forests, using river commercially, they are obstructing natural flow of water through rivers and channels by constructing barrage, dams etc.

RESULTS AND DISCUSSION

The influence of climatic changes over Bangladesh is that it increases temperature, it decreases rainfall and it changes the seasons of weather. These are the effects of climatic change. As a result the agriculture is being hindered; the plants and the trees are going to be diminished (Ciesia 1998).

Bangladesh is now identified as a number one hazardous country. One of the reasons is geographically Bangladesh is a delta. It is a downiest land area. The water of the Himalayas flows from it through India and flowing over this delta meeting lastly the Bay of Bengal. In addition, water from different parts of India flows through Bangladesh. So, Bangladesh is facing always risk of climate change (Huq *et al.* 1999). Off and on Bangladesh is facing cyclone and flood and these bring disaster to Bangladesh.

The authors may cite disaster Sidr (Cyclone Sidr 2008) over Bangladesh or Nargis 2008 over Myanmar and flood of 1988 and 2007 over Bangladesh. The reasons for floods are that the high rise of river bed due to slow current and sedimentation and the rivers become narrow due to its commercial use. As a result the rivers cannot keep water within in large amount and the excess water flows over the land area bringing flood disaster. The flood disaster causes a great loss to agriculture. The river sides are broken due to water pressure, as a result many people become homeless. Similarly, cyclones snatch even their last resource; the natural water shower in summer is scarce. This type of situation affects agriculture and tree plantation. It changes soil structure, because the required amount of water is absent in the soil. In the long run this soil condition will lead the soil to the sandy state and ultimately will go towards desertification.

CONCLUSION

The paper is concerned with the trend analysis of meteorological data on temperature and rainfall changes in Bangladesh over a period of 35 years. The main finding includes the surface temperature increase by 0.6°C in the period of 35 years. The seasonal rainfall decreased but it is predicted that the monsoon rainfall will be increased by 12% by the year 2030. Some effects were found in environment for the change of climatic parameters.

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