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Status of climatic variations in North Western region of Bangladesh

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Abstract: North-Western region of Bangladesh is just north to the tropic of cancer. The effect of Himalayan mountain chain makes the climate tropical throughout the year. Considerable variations in climate are a continuous process over time and space here. Irregularity of rainfall and temperature affects on different aspects of the entire part. For this reason the study has attempted to examine the spatio-temporal climatic variations in this region. To perform the study, climatic data are collected from different meteorological centers of this region. The data on elements of climate i.e. temperature, wind and rainfall then analyzed and interrelated. The study revels that different climatic parameters had significant variations in this study duration at North West region of Bangladesh due to some significant factors. Finally, the study suggested the climatic variations in the north-western region are really an added up to the irregular climate change situation over the world.
Key words: Climate, variation, North Western region, Bangladesh.

Introduction

Climate is simply the weather that is dominant or normal in a particular region. The term climate includes temperature, rainfall and wind patterns. Geography, global air and sea currents, tree cover, global temperatures and other factors influence the climate of an area, which causes the local weather (Pender, 2008). The climate of the Rajshahi division i.e., the north western region of Bangladesh is dominated by tropical monsoons. It is characterized by high temperature, moderate rainfall with often excessive humidity and fairly marked seasonal variations (Rashid, 1991). The most striking feature of this climate is the reversal of the wind circulation between winter and rainy season, which is an integral part of the circulation system of the Indian subcontinent. From the climatic point of view, four distinct seasons are recognized in Bangladesh i.e., the winter season covering from mid-December through February, the pre-monsoon summer season from March through May, the rainy monsoon season from June through mid-October and the autumn season from mid-October through mid-December (Ahmed, 1997).

A number of studies about climate change in the north western region of Bangladesh exist (Asaduzzaman, 1995; Motin, 1996; Rashid, 1991; Reid and Sims, 2007; Sayem, 2000; Warrick et.al., 1996). Climate over the region has been the subject of scientific investigations for well over a century. Sayem (2000) examined monsoon rainfall series from 1961 to 1998 in his study. The emphasis is upon changing annual cycle of rainfall using selected stations from various parts of Rajshahi and Rangpur divisions along with increasing trend of annual rainfall and relative humidity in this region. Rashid (1991) in his book 'Geography of Bangladesh' attempted to describe the climatic zones of Bangladesh. The zone of Rajshahi is considered as an area of extremes (Rashid, 1991). In summer the highest maximum temperature is well above 40°C whereas in winter the lowest minimum is below 5°C in this area. Motin (1996) in his study on 'Rainfall characteristics in the north western part of Bangladesh' attempted to explain the spatial variations of rainfall. Asaduzzaman (1995) analysed the climate of Barind region including rainfall, temperature etc. He reported that the mean annual rainfall of this region is lower (below 2000 mm). The lower rainfall makes the area atmospherically drier. Warrick *et al.* (1996) presented that the mean annual temperature and rainfall in former Rajshahi division has been changed. He showed significant changes in the spatial extent and increasing trend of temperature and rainfall pattern in the studied area. The sources of climate changes in the north western region show an increasing trend in atmospheric temperature. Climatic variations in this region are associated with hotter summers and colder winters. Reid and Sims (2007) observed temperatures in this region have increased about 1°C in May and 0.5°C in November between 1985 and 1998, and further increase of temperature are also expected. However, although the overall climate is warming, temperature extremes are increasing, and winter temperatures as low as 3.4°C have been recorded in January 2003, reportedly the lowest in 40 years. The study has been conducted to examine the climatic conditions and to analyze its spatio-temporal variations in the north western region of Bangladesh. Recent trends on climate change can be best understood by an analysis of its components.

Materials and Methods

Study site: The study regions are Rajshahi and Rangpur divisions located in the north western part of Bangladesh and extends from 23◦ 80' to 26◦ 38' N latitude and from 88◦ 01' to 89◦ 70' E longitude with an area of about 34513 sq. km. Except the Barind Tract, most of this region is a low-laying plain land. It is surrounded by India in the west and north, Dhaka division in the east and Khulna division in the south. The north western region consists of five former greater districts. Five weather stations in all, one from each greater district were selected for this study. The stations are scattered around the division.

Data analysis: The analyzed variables of this study included wind, rainfall and temperature. The time series data of these variables were obtained from the Bangladesh Meteorological Department (BMD), Dhaka. Information of climate have been collected from various sources i.e., books, journals, research bodies and official records. Qualitative and quantitative analysis with map have been made for the collected data and interpreted using geographical information systems (GIS) and statistical techniques. Simple mean (M) have been used in this work. For analyze the climatic data of this study, there have

widely used standard deviation (SD) which was calculated here by summing the square of the deviation of each value from the mean, dividing the number of cases and than taking the square root. The selected stations did not have any missing values. Wherever monthly data was missing, it was completed with the average value for that month.

Results and Discussion

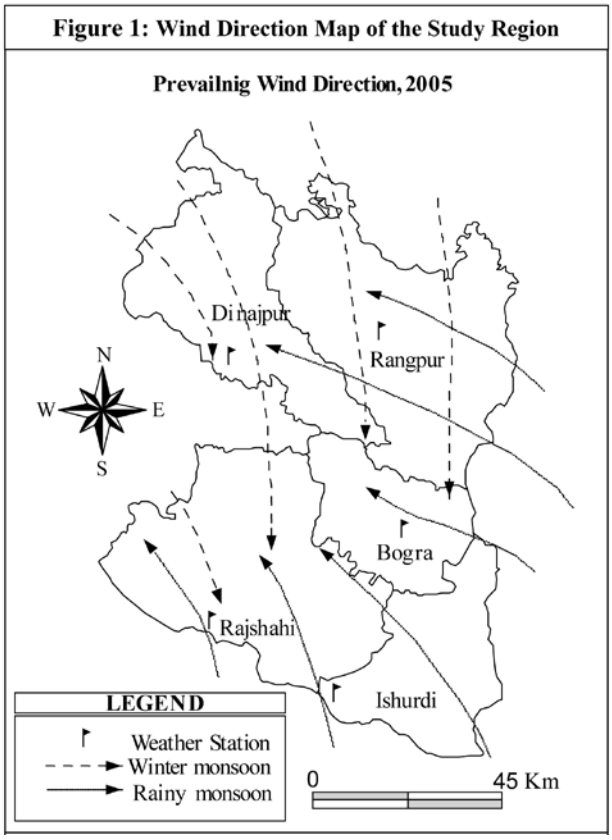
Winds: Winds are characterized by seasonal reversals between winter and rainy monsoon season in the north western region of Bangladesh (Fig.1). During winter, due to the disruptive effect of the Himalayan barrier on the airflow, upper westerly jet stream divided into two branches- northern and southern (Barry and Chorley, 1982). Air subsiding beneath westerly jet stream (southern) causes subtropical high pressure and gives dry out-blowing north-westerly winds over Rajshahi and Rangpur divisions. This wind changes its course clockwise (Fig.1). This wind is the part of the winter monsoon circulation of the Indian subcontinent. The influence of the north westerly over this region is weak and limited in spatial extent. Normally monthly prevailing wind speed in this region is 1.2 to 4.6 Knots (Table 1).

Table 1. Monthly prevailing wind speed (in knots) in the study region , 2005

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bogra	3.0	4.7	3.7	3.7	4.3	4.1	3.9	3.9	3.8	4.4	3.4	2.9
Dinajpur	1.8	2.0	1.6	1.6	1.7	1.8	1.5	1.6	1.7	1.9	1.2	1.3
Rajshahi	1.9	2.8	2.5	2.4	2.7	3.0	3.0	2.4	3.3	1.9	1.8	2.3
Rangpur	3.1	4.0	4.4	4.6	3.5	3.7	3.5	3.4	2.8	4.5	3.2	3.2
Ishurdi	3.0	4.2	3.1	3.5	3.6	3.3	3.2	2.4	4.3	2.2	2.4	2.6

Source: Bangladesh Meteorological Department, 2007.

Figure 1: Wind Direction Map of the Study Region



During the rainy monsoon season, a center of low pressure and monsoon trough develops over the west-central part of the India because of intense surface heat (Trewartha, 1968). As a result, a stream of warm and moist air from the Bay of Bengal flows toward the above-mentioned low pressure through the Rajshahi and Rangpur divisions. The direction of the wind is south or south-westerly in the southern part of Bangladesh. It changes slightly her course anti-clockwise. However, the wind direction of the north western region during this season has generally a southerly and easterly component (Table 2). This wind is the part of the monsoon circulation of the Indian subcontinent. During the early part of the season, it is neither strong nor persistent. With the progression of this season wind speed increases and the direction becomes more persistent. Generally, wind is stronger in rainy monsoon season. The onset of the monsoon is normally on June 2 (Day 153) over the southern part of Bangladesh. By June 10 (Day 161) it affects the southern part of the region. This monsoon advances at an uneven pace, reaching north western part of the region by June 15 (Day 166). The withdrawal of the south-east/south monsoon is a far more gradual process than its onset. It usually withdraws from the north western region by September 30 (Day 273) and from the remaining parts of this region by October 7 (Day 280). Pre-monsoon summer and autumn are the transition season which is characterized by lighter wind speed and more complicated flow patterns (Islam, *et al*, 2003).

Rainfall: The word 'monsoon' is derived from the Arabic word 'mawsim' which means Seasons. The monsoon cycle is believed to have started about 12 million years ago with the uplift of the Himalayas (Islam, *et al*, 2003). Monsoon is the wind system that dominates the climate of South Asia and the area around the Indian Ocean with seasonal reversals of direction caused by the differential heating and cooling of landmass and oceans between summer and winter. The wind blows from the northeast (towards the sea) in winter (the dry-monsoon) and from the southwest (towards the land) in summer (the wet-monsoon). It describes atmospheric circulation pattern of the Subcontinent and seasonality of its rainfall is the hallmark and most well-known characteristic of the monsoon climate. Rainfall in the north western region of Bangladesh is basically regular each year. The rainy monsoon season is mainly June through mid-October. More than 80 percent of the annual rainfall normally occurs during this period (Fig.2).

The moisture-laden southerly monsoon is drawn to the Rajshahi division by the intense heat consequent low pressure. This wind blows across the Indian Ocean and the Bay of Bengal. With the progression of this season, the perceptible water increases. During rainy monsoon the cloud cover is very widespread. In the month of July and August it varies from 70 to 80 percent all over the region. After the withdrawal of the monsoon, the cloud cover

decreases rapidly, dropping to 20 percent in the western parts (BMD, 2007).

Table 2. Monthly prevailing wind direction in the study region, 2005

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bogra	NW	W	SE	E	E	E	SE	SE	E	E	NW	NW
Dinajpur	W	W	E	E	E	E	E	E	E	E	N	W
Rajshahi	W	W	E	S	E	E	E	E	E	N	N	N
Rangpur	NE	W	NE	NE	E	SE	SE	SE	E	NE	NE	NE
Ishurdi	NW	W	S	S	S	SE	SE	S	E	NE	N	N

Source: Bangladesh Meteorological Department, 2007, Note: Winter Monsoon (mid-December to February), Rainy monsoon (June to mid-October)

Table 3 shows a variation from 1461 millimeters of rainfall in the Rajshahi division to more than 2300 millimeters in the Rangpur division. So Rajshahi is the driest area in this region. Mayer's NSQ (Normal saturation Quantity) is below 250 (Rashid, 1991). The value of standard deviation (204.39) is lower at all the stations. The dry season begins here by the end of December where its duration is about four months. Rangpur is close to the wind-ward side of the Himalayan range. Its rainfall is relatively higher like semi-wet zone of Bangladesh.

The analysis of this study using data from 1970 to 2005 shows that there are mixed result of upward shift in annual rainfall. In the north western region of Bangladesh, rainfall has increased from 1985 to 1990 (Table 4).

Table 3. Annual total rainfall (in mm) at selected stations of the study region

Stations	1970	1975	1980	1985	1990	1995	2000	2005	Mean	SD	CV
Bogra	1761	1432	1630	1708	2080	2248	1830	2091	1847	255.18	13.81
Dinajpur	1423	2050	1960	2094	2080	2609	1524	2975	2089	479.12	22.93
Rajshahi	1377	1154	1576	1249	1805	1432	1690	1405	1461	204.39	13.99
Rangpur	1998	1767	2120	2872	2488	2811	1755	2853	2333	450.76	19.32
Ishurdi•	1810	1505	1456	1779	2091	1182	1808	1819	1681	264.60	15.74

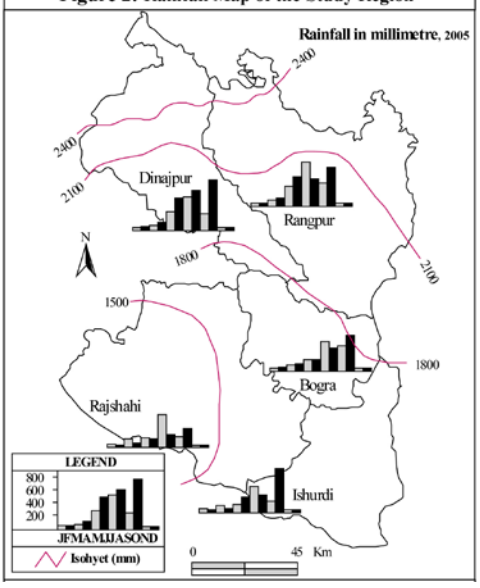
Source: Bangladesh Meteorological Department, 2007.

Table 4. Variations from average rainfall and their percentage

Year	Bogra(1847)		Dinajpur(2089)		Rajshahi(1461)		Rangpur(2333)		Ishwardi(1681)	
	Var.	%	Var.	%	Var.	%	Var.	%	Var.	%
1970	↓086	4.66	↓666	31.88	↓084	5.75	↓335	14.36	↑129	7.67
1975	↓415	22.47	↓039	1.87	↓307	21.01	↓566	24.26	↓176	10.47
1980	↓217	11.75	↓129	6.18	↑115	7.87	↓213	9.13	↓225	13.38
1985	↓139	7.53	↑005	0.24	↓212	14.51	↑539	23.10	↑098	5.83
1990	↑233	12.62	↓009	0.43	↑344	23.55	↑155	6.64	↑410	24.39
1995	↑401	21.71	↑520	24.89	↓029	1.98	↑478	20.49	↓499	29.68
2000	↓017	0.92	↓565	27.05	↑229	15.67	↓578	24.77	↑127	7.56
2005	↑244	13.21	↑886	42.41	↓056	3.83	↑520	22.29	↑138	8.21

Note: ↑ Rainfall increase, ↓ Rainfall decrease.

Figure 2: Rainfall Map of the Study Region



The statistics of monthly rainfall illustrates that June is the month of maximum rainfall. In this month Rangpur receives 480 millimeters (Table 5). After the 15th of October the monsoon rainfall meters out rapidly. Very little rain occurs from November to March. Table-5 shows that, all the stations get no rainfall in the month of December, January and February. In 2005, the normal rainfall pattern has changed. Here October is the month of maximum rainfall (Table 6).

Temperature: The north western region of Bangladesh has a tropical monsoon climate characterized by moderately warm temperature. Significant differences in seasonal temperature occur across the area. It is influenced by latitude and monsoon activities (Brammer, 1996).

The mean maximum temperatures over most of the area of this region are about 30°**C** and mean minimums are less than 20°**C**. Around Rajshahi the mean maximum temperature is higher than the surrounding regions (Table 7). It is also the hottest part of Bangladesh. On the other hand the mean minimum temperature of Rangpur is relatively lower. The cold winter air that moves into this region from the northwestern part of India loses much of its intensity by the time.

Table5. Monthly rainfall (in mm) at selected station during 2001

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bogra	000	000	000	024	234	288	183	130	328	224	003	000
Dinajpur	000	000	000	005	185	479	152	316	472	479	026	000
Rajshahi	000	000	009	025	201	339	311	207	072	185	001	000
Rangpur	000	000	023	041	202	480	357	329	466	455	007	000
Ishurdi	000	000	021	059	230	406	169	164	333	074	001	000

Source: Bangladesh Meteorological Department, 2007.

Table 6, Monthly rainfall (in mm) at selected station during 2005

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bogra	005	009	058	072	138	130	417	328	356	523	000	001
Dinajpur	009	015	037	089	255	474	507	597	222	770	000	000
Rajshahi	014	001	104	027	108	092	492	161	131	275	000	000
Rangpur	011	009	061	093	271	428	671	400	328	581	000	000
Ishurdi	014	003	075	013	089	199	378	246	137	664	000	001

Source: Bangladesh Meteorological Department, 2007.

January is the coldest month in this region (Ahmed, 1997). Mean monthly maximum and minimum temperatures in January vary from 23.1°**C** to 24.2°**C** and 11.3°**C** to 12.1°**C,** respectively (Table 9). As the winter season progresses in to the pre-monsoon summer, temperature rises, reaching the maximum in April which is the middle of the pre-monsoon hot season. In some places (Rajshahi) of the division mean maximum temperature rises up to 35°**C** or more. After April, it decreases slightly which coincides with the rainy monsoon season. Widespread cloud cover causes dampening of temperature. Mean maximum temperature in July varies from about 31.6°**C** to 32.4°**C** (Table 8).

Table 7. Mean maximum and minimum temperature (◦C) in Rajshahi Division

Year		Bogra	Dinajpur	Rajshahi	Rangpur	Ishurdi
1970	max	30.45	30.39	- -	31.12	- -
	min	20.95	20.95	- -	18.9	- -
1975	max	30.82	- -	31.17	- -	31.21
	min	20.45	20.45	21.01	- -	19.98
1980	max	30.79	- -	31.24	29.13	30.79
	min	20.93	20.93	20.98	20.56	20.68
1985	max	30.71	30.08	31.39	29.67	31.53
	min	20.82	20.82	20.29	19.66	20.36
1990	max	30.8	29.67	30.92	29.2	30.37
	min	20.61	20.61	19.6	20.05	20.34
1995	max	30.68	30.51	31.28	29.77	31.34
	min	21.19	21.19	20.69	20.16	20.53
2000	max	30.23	29.82	30.7	29.46	30.62
	min	21.11	21.11	20.65	20.09	20.74
2005	max	30.69	29.84	31.37	29.51	31.31
	min	21.3	21.3	20.97	20.47	21.12
Mean	max	30.65	30.05	31.15	29.69	31.04
	min	20.92	20.92	20.6	19.98	20.54

Source: Bangladesh Meteorological Department, 2007. Note: - - Missing data.

Table 8. Monthly average maximum temperature (in °C) by station, 2005

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	SD
Bogra	24.2	28.1	31.0	33.4	32.7	34.1	32.0	32.7	33.5	30.1	29.3	27.2	30.7	2.89
Dinajpur	23.1	26.9	30.2	32.1	31.6	33.1	31.8	32.1	33.5	29.3	28.5	25.9	29.8	3.07
Rajshahi	23.8	29.1	32.9	35.8	35.1	36.0	32.2	33.2	33.7	29.8	28.3	26.5	31.4	3.71
Rangpur	23.5	26.7	29.6	31.1	30.7	32.2	31.6	32.0	33.2	29.0	28.5	26.0	29.5	2.78
Ishurdi	23.6	28.5	32.9	35.5	35.0	35.6	32.4	33.2	33.5	30.2	28.8	26.5	31.3	3.65

Source: Bangladesh Meteorological Department, 2007.

Table 9. Monthly average minimum temperature (in °C) by station, 2005

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	M	SD
Bogra	12.1	16.0	20.6	22.8	23.2	26.3	26.2	26.7	26.2	23.5	18.1	13.9	21.3	4.93
Dinajpur	12.1	16.0	20.6	22.8	23.2	26.3	26.2	26.7	26.2	23.5	18.1	13.9	21.3	4.93
Rajshahi	11.3	15.0	19.7	23.5	24.4	26.1	26.1	26.7	26.0	23.2	16.6	13.0	20.9	5.38
Rangpur	11.7	14.8	19.0	21.7	22.6	24.6	25.8	26.2	25.9	22.6	17.2	13.5	20.5	4.91
Ishurdi	11.4	15.4	20.1	23.5	24.5	26.1	26.1	26.5	26.1	23.4	17.4	12.9	21.1	5.29

Source: Bangladesh Meteorological Department, 2007.

The climate of the north western region of Bangladesh is greatly influenced by Asiatic monsoons. The influence of monsoon was vigorously studied over Rajshahi and Rangpur divisions. Winds are characterized by seasonal

reversals between rainy monsoon and winter monsoon season. The Wind direction during the rainy monsoon is comparatively stronger which has generally an easterly (E) and south-easterly (SE) component. Monthly prevailing wind speed in this area varies from 1.2 to 4.6 knots. The winds in winter season over the studied area are relatively lighter and moves toward the westerly (W) and north-westerly (NW) direction. The rainy season over the region is due to south and southeast monsoon advancing across the Bay of Bengal from June to mid-October. In this study Rangpur has obtained highest rainfall and observed an increasing trend of rainfall is observed in Bogra, Dinajpur and Rangpur respectively. Decreasing pattern is also noticed in Rajshahi and Ishurdi region. With the exception of the relatively dry western region of Rajshahi division, where the annual rainfall is about 1461 mm, most parts of the division receive at least 1800mm of rainfall per year. The winter season is dry and accounts for only 2% of the total annual rainfall. The extreme temperature is observed in Rajshahi-Ishwardi belt. In some places of this area highest maximum temperature rises up to 42°**C** or more. On the other hand lowest minimum temperature goes down to 5°**C** or less. Around the division the mean maximum temperature of Rajshahi is higher (31.15°**C**) than the surrounding regions and the mean minimum temperature of Rangpur is relatively lower (19.98°**C**). January is the coldest and April is the hottest month in the region. Mean monthly maximum and minimum temperatures in January vary from 23.1°**C** to 24.2°**C** and 11.3°**C** to 12.1°**C** respectively. Therefore, these changing patterns give the clear evidence of climate change for this region and it will help to identify some emerging research issues for further exploration in climate of Bangladesh and its impacts on dif to get the results.

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