

## SPATIAL AND TEMPORAL VARIATIONS OF TEMPERATURE IN BANGLADESH: AN ANALYSIS FROM 1950 TO 2012

Asib Ahmed\*  
Mohammad Jakir Hossen\*\*

**Abstract:** The current research is an endeavor to analyse the spatial and temporal trends of temperature in Bangladesh based on available data from 1950 to 2012 obtained from Bangladesh Meteorological Department. Collected data have been analysed through Arc GIS software and the statistical software 'R' for mapping and time series analysis. The study found that monthly maximum temperature has increased to 0.12°C while the monthly mean temperature has increased to 0.56°C for the last 63 years. On the other hand, the monthly minimum temperature reveals the increase of 0.08°C for the above mentioned years. Maximum increase of monthly maximum temperature has occurred to 1.3°C in the month of November and minimum temperature has decreased to 0.37°C in the month of February during the last 63 years. It is found that maximum temperature has been increased dramatically over the last 40 years period. During the last 63 years the highest temperature of 44°C recorded at Bogra and Ishwardi in April 1956 and May 1970 respectively. The recorded lowest temperature of 3.2°C was observed at Rajshahi in January 2003. Regionally, Rajshahi was the warmest area during summer season and Khulna was the coldest area during winter season.

**Keywords:** Climate, Meteorology, Seasonal Expansion, Temperature, Time Series

### INTRODUCTION

Most of climatic phenomena in Bangladesh are intimately related to temperature because of its location in subtropical region. Atmospheric turbulence is common in the country which is mainly controlled by temperature (Quader *et al.*, 2001; Singh 2002).

---

\* Asib Ahmed, Assistant Professor, Department of Geography and Environment, University of Dhaka, Dhaka 1000, Bangladesh

\*\* Mohammad Jakir Hossen, Doctoral Student, Department of Geography and Environment, University of Dhaka, Dhaka 1000, Bangladesh

The presence of great Himalaya is also a major driving force in determining the temperature and other related climatic phenomena in Bangladesh (Quader and Prasad, 2002). A number of studies on the variability of climate in Bangladesh have been conducted so far (Rahman et al., 1997; Jones, 1995; Singh, 2001; Shahid, 2008; Shahid and Khairulmaini, 2009; Shahid, 2010a; Shahid, 2010b; Shahid, 2011). Some studies also carried out on Diurnal Temperature Range (DTR) in Bangladesh and India (Shahid, S., 2012; Rupa Kumar *et al.*, 1994; Yadav *et al.*, 2004; Roy and Balling, 2005; Fowler and Archer, 2006; Jhajharia and Singh, 2011). Some studies have been conducted previously that partly cover the spatial and temporal variation of temperature. Previous studies on the variations of temperature in Bangladesh suggest that the trend of annual maximum temperature from 1961-1990 is 0.029°C per year which is statistically significant at 1% level (Singh and Khan, 2000). It is estimated that mean maximum temperature would be increased to 0.40°C and 0.73°C by 2050 and 2100 respectively. Mean annual minimum temperature would be increased to 0.04°C and 0.08°C by 2050 and 2100 respectively. It is also predicted that the average temperature in Bangladesh would be increased to 0.22°C and 0.41°C by 2050 and 2100 respectively (Karmakar *et al.*, 2000).

### **STUDY AREA**

The research accounted 34 weather observation stations of Bangladesh Meteorological Department (BMD) as the study area. The temperature data collected from these stations are considered more or less representative for the whole country.

### **OBJECTIVES OF THE STUDY**

Recent meteorological observations suggest that there is a significant fluctuation occurred in atmospheric temperature gradient of the country (Khan et al., 2002). The study aims at finding the recent trends of temperature and regional variations of temperature in Bangladesh for the last 63 years from 1950 to 2012. More specifically, the study attempts to analyse the trends of lowest, highest and average temperature where special emphasis has been given to analyse the monthly average temperature in Bangladesh for the last 63 years. The study also synthesized the seasonal as well as regional variations of temperature in Bangladesh for the selected time period.

### METHODOLOGY OF THE STUDY

The research followed an empirical way of investigation to analyse the temporal and regional trends of temperature in Bangladesh for the last 63 years. The study used raw secondary data of 34 weather observing stations collected from Bangladesh Meteorological Department (BMD) (figure 1). Secondary data on the variations of past temperature in Bangladesh have been used for the study from available published and unpublished studies. Raw data of monthly highest, lowest and average temperature for the years from 1950 to 2012 recorded at 34 stations of BMD have been collected from the archive of Bangladesh Meteorological Department. Raw data were then processed and mapped through using MS Excel, statistical software 'R' and Arc GIS. Most of the graphs are presented as line and bar charts as these are suitable for presenting trend analysis of lowest, highest and average temperature for the selected years. The regional variations of temperature of BMD stations and some spots of recorded highest and lowest temperature throughout the country have shown by using GIS software.

The following formula has been used for finding the trend of a time series data.

$$b = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2}$$

Where  $x_i$  is the independent variable,  $\bar{x}$  is the average of the independent variable,  $y_i$  is the dependent variable and  $\bar{y}$  is the average of dependent variable. One way of testing significance of trends of temperature is the calculation of the coefficient of determination,  $R^2$  of the trend. Values of  $R^2$  vary between 0 and 1. The following formula has been used to find out the value of  $R^2$ .

$$R^2 = \frac{[\sum (x_i - \bar{x})(y_i - \bar{y})]^2}{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}$$

Highest correlation of the dataset can be found at 1 and it gradually reduces towards zero. Values less than 0.5 have been considered as less significant correlation.

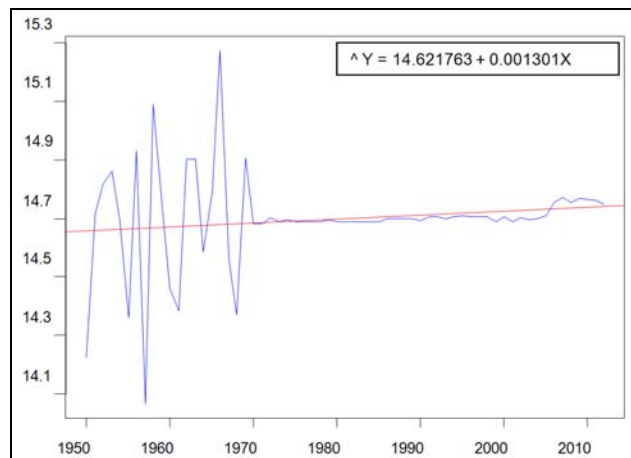
## RESULTS AND DISCUSSION

### Temporal Trends of Temperature in Bangladesh

Temporal trends of temperature exhibit an important index of climate (Shahid, 2012). Monthly and diurnal temperature ranges validate the changes of climate (Plummer et al., 1995; Kaas and Frich, 1995; Razuvaev et al., 1995; Price et al., 1999; Roy and Balling, 2005; Englehart and Douglas, 2005; Makowski et al., 2008; Jhajharia and Singh, 2011; Sang, 2012). It is also predicted that the changes in monthly and diurnal temperature range has regional and seasonal characteristics (Shahid, 2012).

### Trend of Lowest Average Temperature

Data on monthly lowest temperature for the period from 1950-2012 have shown an increasing trend of 0.08°C during the last 63 years in Bangladesh (Figure 2). The constant temperature was at 14.62°C for the mentioned years. During 1950-1970 lowest temperature curve fluctuates at a high rate while the lowest temperature curve represents nearly horizontal increase from 1970 to 2012.



**Figure 2:** Trend of lowest average temperature (1950-2012). Vertical axis indicates temperature in degree Celsius where horizontal axis indicates corresponding years.

Source: BMD, 2013

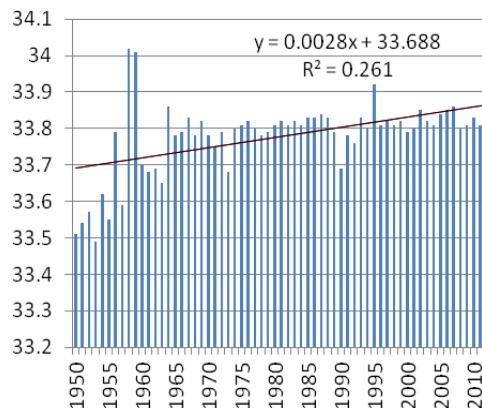
### Trend of Highest Average Temperature

Monthly highest temperature data exhibit a significant trend of 0.12°C for the last 63 years (Figure 3). It is found that maximum temperature has been increased dramatically over the last 63 years. Although the highest temperature were recorded during 1960s there also some lowest records. From 1965 to present the gradual increase of temperature has been observed and some significant fluctuations of highest average temperature from 1950s to 1970s have been identified. After 1970s a more or

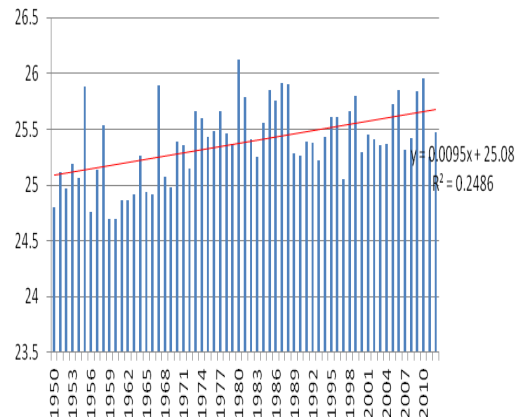
less constant highest average temperature observed that indicates the recent constant changes of temperature in atmosphere.

**Trend of Average Temperature**

Literature suggests that the Indian subcontinent faced a rate of 0.3°C change of temperature per hundred years (Quader *et al.*, 2005). The monthly mean temperature has increased at a rate of 0.56°C for the last 63 years (Figure 4). It is also evident that the rate of change has been accelerated during the last 40 years.



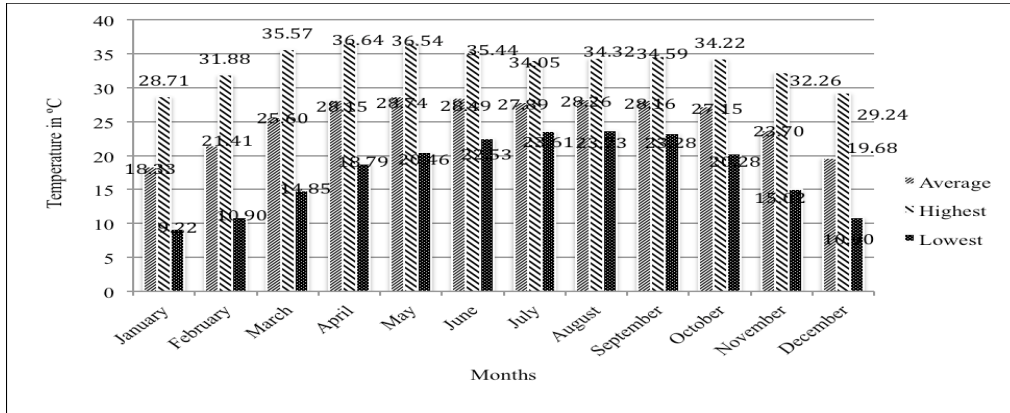
**Figure 3:** Trend of highest average temperature (1950-2012)



**Figure 4:** Trend of average temperature (1950-2012)

Source: BMD, 2013 (Vertical axis indicates temperature in degree Celsius where horizontal axis indicates corresponding years.)

The comparative presentation (Figure 5) of monthly average, maximum average and minimum average temperature of Bangladesh during the period from 1950 to 2012 shows the highest rise of monthly mean temperature of 28.74°C during the month of May. Monthly maximum temperature has increased to 36.64 °C in April. However, data on monthly minimum temperature have shown the highest rise of 9.22°C during the month of January while the highest rise of temperature for that month recorded to 18.33°C.

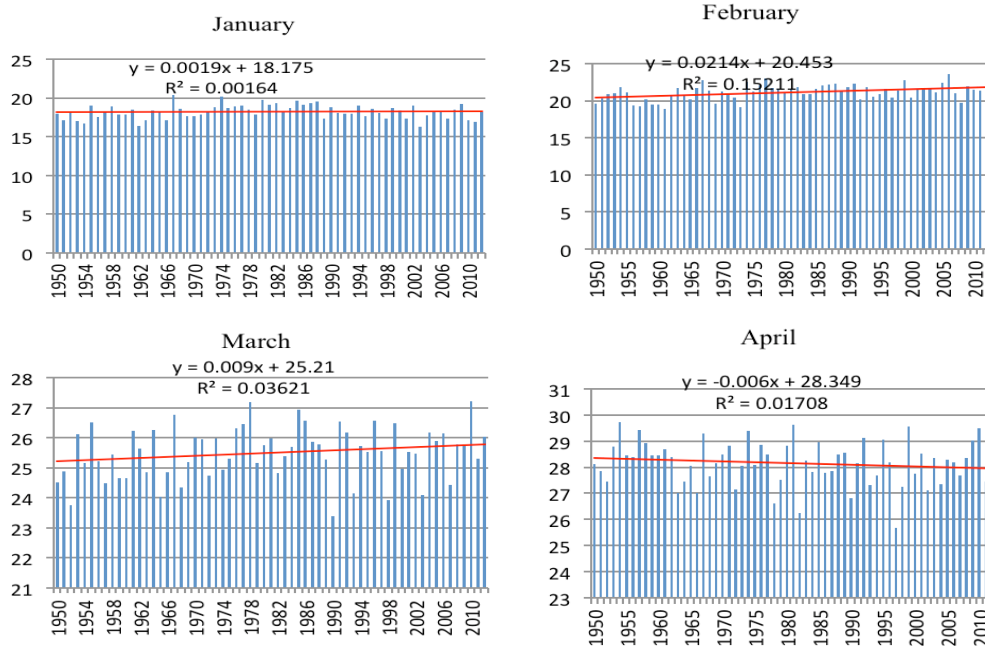


**Figure 5:** Mean, Highest and Lowest Temperature in Bangladesh (1950-2012)

Source: BMD, 2013

**Trend of Monthly Average Temperature**

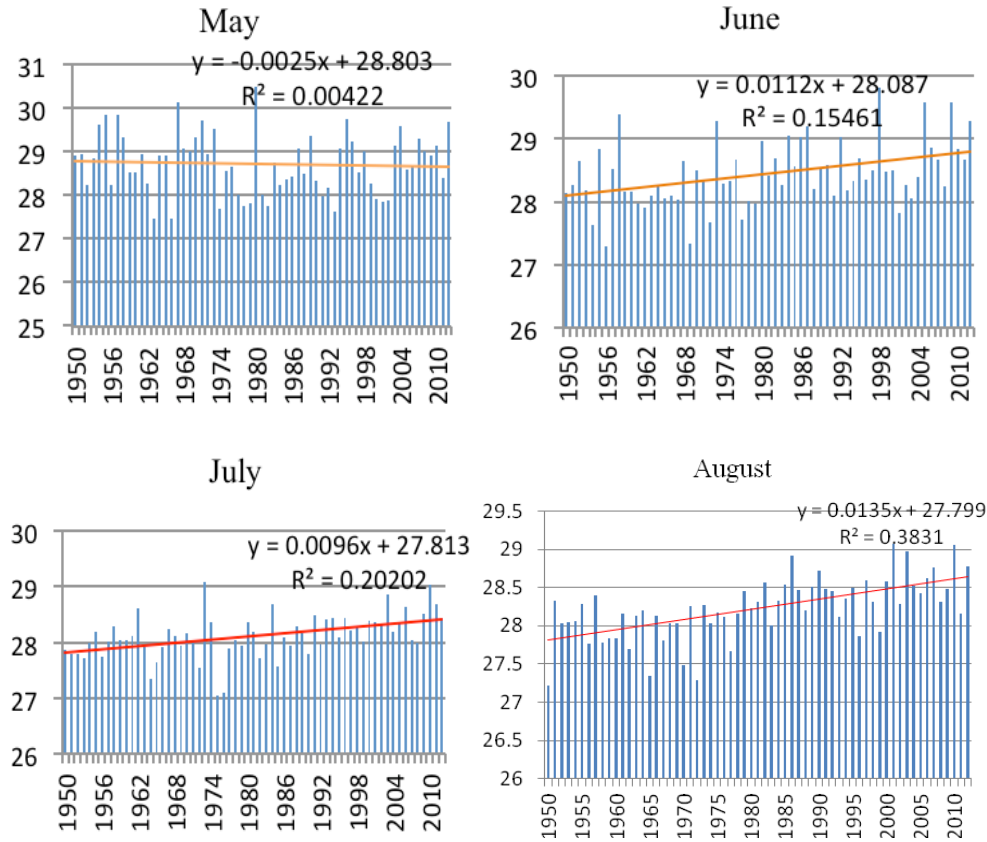
The monthly trends of temperature have shown in the figure 6, 7 and 8. The month January represents a positive trend of increase at a rate of 0.1°C for the last 63 years.



**Figure 6:** Average trend of temperature (in °C) for the months of January, February, March and April (1950-2012). Vertical axis indicates temperature in degree Celsius where horizontal axis indicates corresponding years.

Source: BMD, 2013

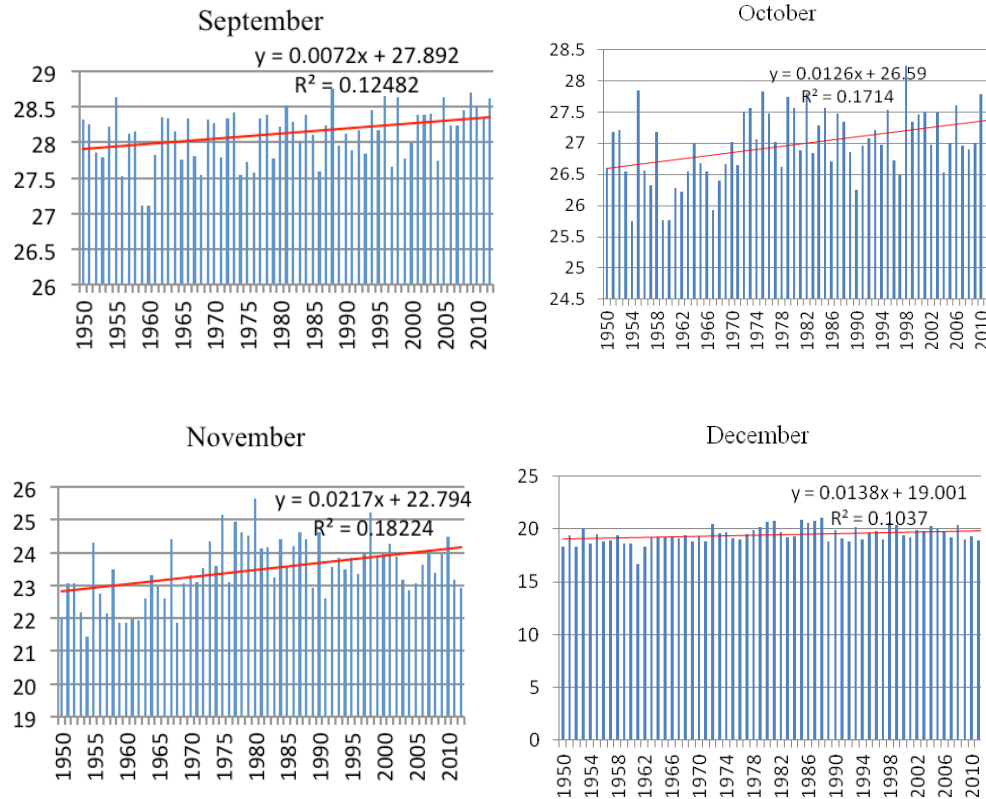
The months February and March show a positive trend of increase at a rate of 1.3°C and 0.56°C respectively. April shows a negative trend of increase during the last 63 years that indicates the increasing trend of temperature during winter season in Bangladesh.



**Figure 7:** Average trends of temperature (in °C) for the months of May, June, July & August (1950-2012). Vertical axis indicates temperature in degree Celsius where horizontal axis indicates corresponding years.

Source: BMD, 2013

In Bangladesh March, April and May comprise the summer season where June, July and August comprise the Rainy season. The study indicates the decreasing rate of temperature during summer season and increasing rate of temperature during rainy season. The month of May represents a negative trend of increase at a rate of 0.2°C for the last 63 years. The months June, July and August indicate positive trends of increase at a rate of 0.68°C, 0.56°C and 0.8°C respectively.



**Figure 8:** Average trend of temperature (in °C) for September, October, November & December (1950-2012). Vertical axis indicates temperature in degree Celsius where horizontal axis indicates corresponding years.

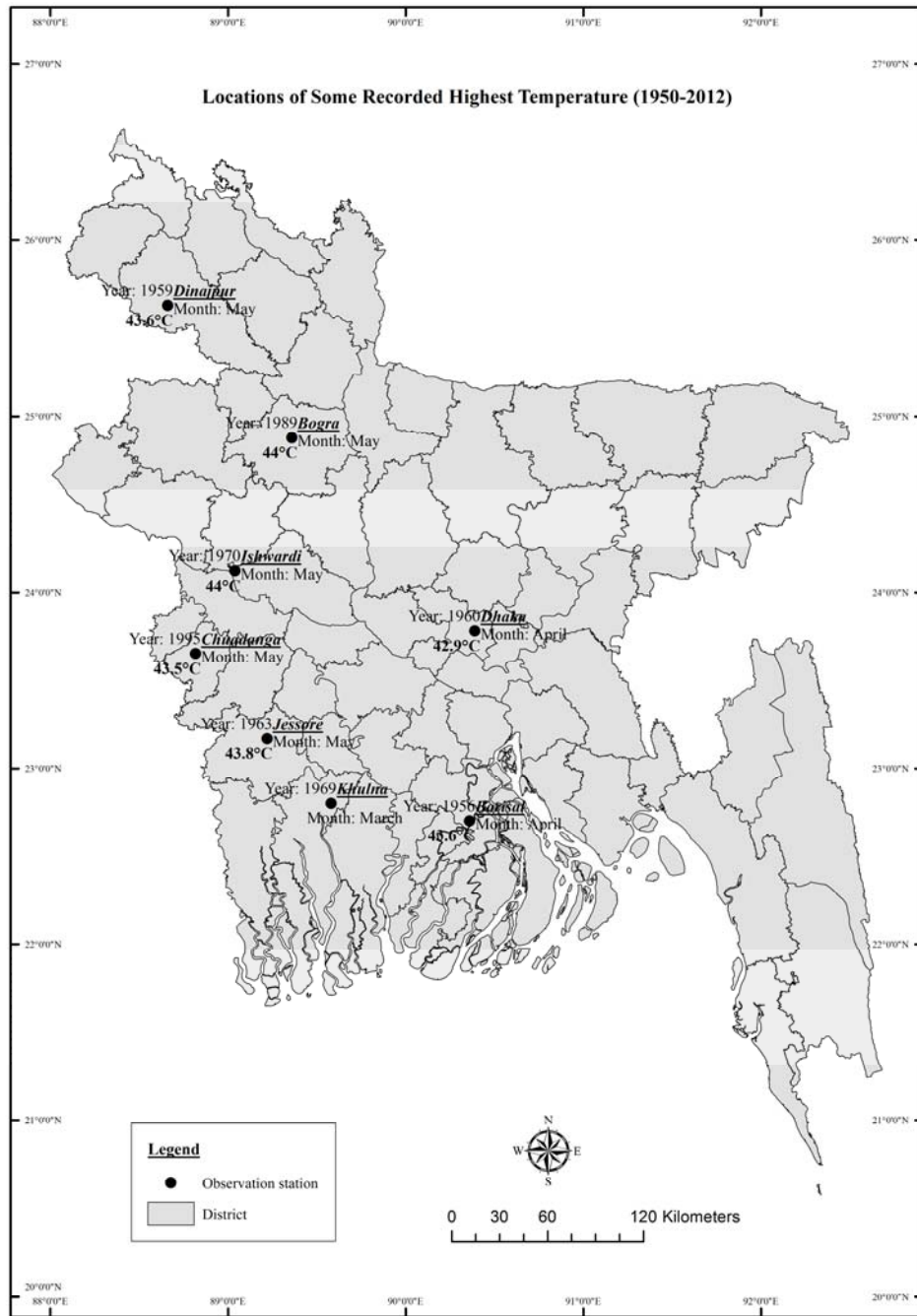
Source: BMD, 2013

The analysis shows a positive trend of increase of temperature for the months of September, October, November and December at a rate of 0.43°C, 0.74°C, 1.3°C and 0.8°C respectively during last 63 years which exhibits the rise of temperature during winter season in Bangladesh. The month November shows the highest positive trend of increase than all other months of the year during the last 63 years.

### Recorded Highest Temperature

The figure 9 shows locations of some highest temperature recorded during the period from 1950 to 2012 in the country (Figure 9). Records show that the highest temperature observed at Bogra station in April 1989 which is 44°C (Table 1). The temperature 43.6°C, 43.7°C, 43.9°C also recorded at Bogra in 1960 and 1970 during the months of April and May. Ishwardi experienced 44°C for the month of May 1970. This weather station also experienced a temperature of 43.6°C in 1963 and 1975.





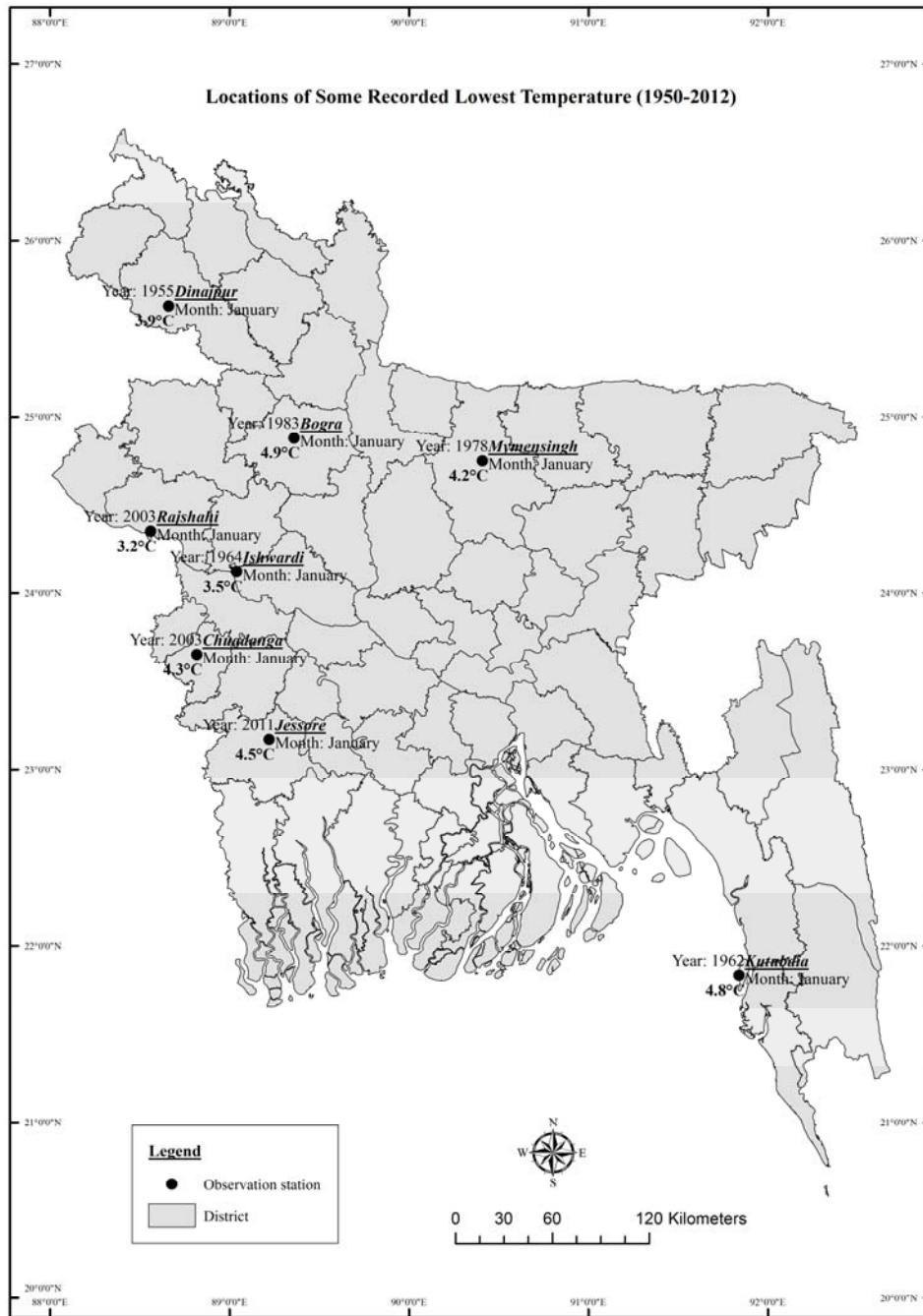
**Figure 9:** Recorded Highest Temperature (in °C) in Bangladesh (1950-2012)  
 Source: Compilation from BMD, 2013

The weather stations in southern part the country recorded peak temperature of 43.6°C in April 1956. Capital Dhaka experienced a highest temperature of 42.3°C in April 1960. The weather stations at Dinajpur, Khulna and Jessore also experienced highest temperature for different years.

**Table 1:** Some recorded highest and lowest temperature in Bangladesh (1950-2012)

Recorded Highest Temperature				Recorded Lowest Temperature			
Year	Station	Temperature in °C	Station	Year	Station	Temperature in °C	Station
1956	Barisal	43.6	April	1950	Srimangal	3.9	January
1958	Bogra	43.5	March	1950	Dinajpur	4.4	February
1958	Jessore	43.3	March	1950	Dinajpur	4.6	December
1958	Bogra	43.9	May	1953	Dinajpur	4.4	February
1959	Dinajpur	43.3	April	1955	Dinajpur	3.9	January
1959	Dinajpur	43.6	May	1955	Srimangal	3.8	January
1960	Dhaka	42.3	April	1962	Kutubdia	4.8	January
1961	Jessore	43.3	May	1963	Ishwardi	3.8	January
1963	Ishwardi	43.6	April	1964	Faridpur	4.1	January
1963	Jessore	43.8	April	1964	Dinajpur	4.4	January
1965	Dhaka	42	April	1964	Dhaka	5.6	January
1969	Khulna	43.5	March	1964	Ishwardi	3.5	January
1970	Dinajpur	43	March	1964	Srimangal	3.3	January
1970	Bogra	43.4	March	1968	Ishwardi	3.8	February
1970	Bogra	43.6	May	1974	Faridpur	4.4	January
1970	Ishwardi	44	May	1974	Ishwardi	3.9	February
1972	Jessore	43.6	June	1974	Srimangal	4.3	December
1975	Ishwardi	43.5	April	1975	Ishwardi	4.4	January
1975	Ishwardi	43.6	May	1977	Srimangal	4.4	January
1975	Ishwardi	43.4	June	1978	Srimangal	3.9	January
1976	Khulna	43.4	April	1980	Ishwardi	4	January
1976	Bogra	43.6	April	1983	Bogra	4.9	January
1976	Khulna	43.4	May	1989	Rajshahi	4.6	January
1989	Bogra	44	April	1995	Dinajpur	4.2	January
1995	Chuadanga	43	April	2003	Rajshahi	3.2	January
1995	Chuadanga	43.5	May	2007	Srimangal	4	January
2005	Chuadanga	43	June	2011	Jessore	4.5	January

Source: BMD, 2013



**Figure 10:** Recorded lowest temperature (in °C) in Bangladesh (1950-2012)

Source: Compilation from data of BMD, 2013

### Recorded Lowest Temperature

The weather stations located in the northern part of the country mostly exhibit recorded lowest temperature. The stations are comparatively close to the Himalayas. The weather station located in Rajshahi experienced 3.2°C in January 2003 which is being considered official the lowest temperature record in Bangladesh for the period from 1950 to 2012. The observed low temperature of 3.8°C and 3.9°C recorded at Srimangal and Ishwardi in 1955 and 1968 for the month of January. Dinajpur experienced 3.8°C in January 1955. Weather stations located at southern part of the country experienced lowest temperature of 4.8°C in January 1962. Capital Dhaka experienced a temperature of 5.6°C in April 1964.

### Station-wise Trend Analysis

Trends of monthly average temperature have been analyzed for each 32 station of BMD (two stations namely Bogra and Madaripur have been excluded from the analysis due to the existence of a large number of missing data). A summary of the trend analysis is presented in Table 2.

**Table 2:** Average Trend (in degree Celsius) of 32 stations (1950-2012)

Station	Trend	Station	Trend
Ambagan	0.7	Khulna	0.3
Barisal	-0.8	Kutubdia	1.4
Bhola	0.3	M.court	1.9
Chandpur	-0.1	Mongla	0.3
Chittagong	1.1	Mymensingh	0.2
Chuadanga	-2.4	Patuakhali	-1.5
Comilla	-0.1	Rajshahi	-0.7
Cox'sbajar	1.1	Rangpur	0.9
Dhaka	-1.2	Rangamati	-2.9
Dinajpur	-0.1	Sandwip	-0.8
Faridpur	1.2	Satkhira	0.9
Feni	-0.3	Sitakundo	-1.4
Hatiya	-0.3	Srimangal	2.3
Ishwardi	0.1	Syedpur	3.4
Jessore	1.3	Sylhet	0.3
Khepupara	-1.7	Tangail	-0.2

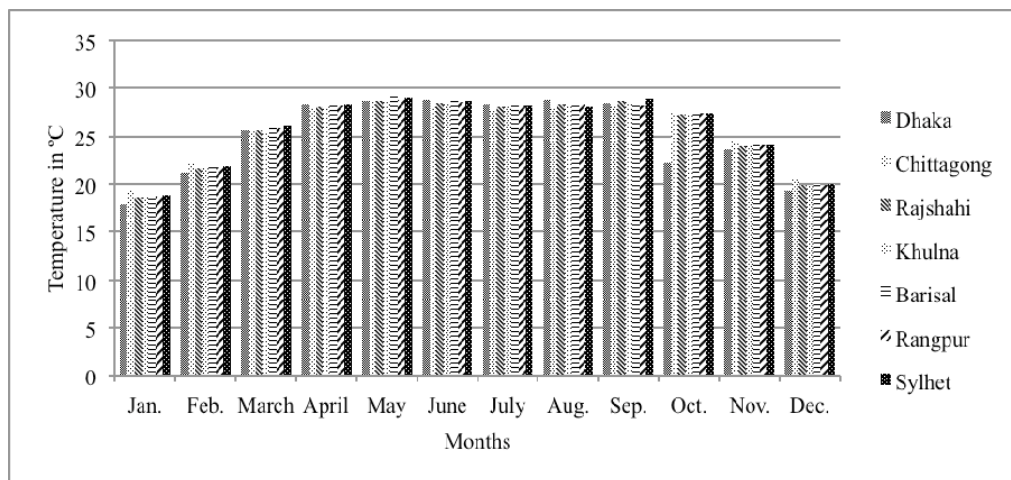
Source: BMD, 2013

Station-wise trend analysis shows that monthly maximum temperature vary from -2.9 C to 3.4 C per 100 year. Maximum value of trends of monthly maximum temperature has found at Syedpur which is 3.4 C per 100 year. Station Rangamati exhibits the lowest value of trend of -2.9 C per 100 years. Coefficient of determination,  $R^2$  of the trend analysis of monthly mean temperature varies from 0 to 0.65.  $R^2$  value less than 0.5 has found at some stations which represents poor statistical significance of the trend.

### Regional Variations of Temperature

#### Regional Average Temperature

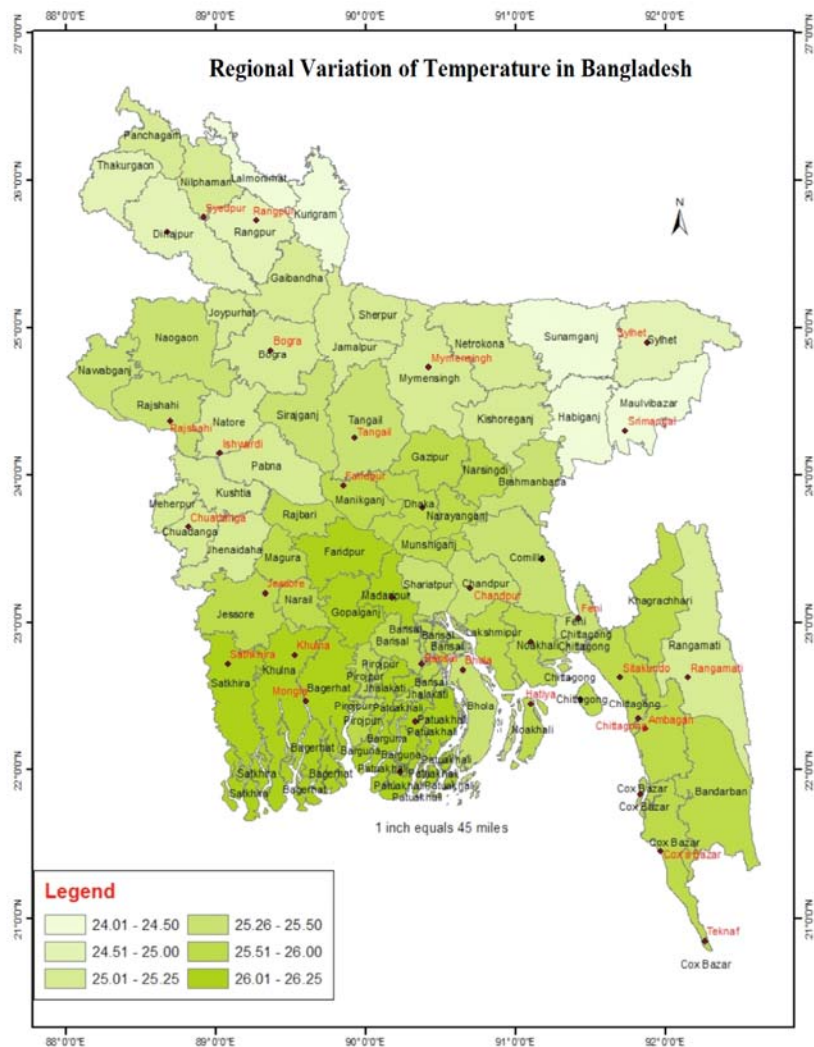
Division-wise temperature data have been gathered from the stations fall within each of the then seven divisions of Bangladesh and termed as regional temperature in the study. Analysis of regional average temperature shows that Dhaka experiences lowest average temperature during November, December, January and February than other regions (Figure 11). On the other hand, Chittagong experiences highest temperature during the above mentioned months while the values for other station are almost equal. In March, April, May and June Barisal has a highest temperature than other regions. During July, August and September highest mean temperature is recorded in Dhaka while Chittagong shows lowest temperature. Khulna and Rajshahi regions exhibit consistent mean temperature throughout the years. Sylhet shows an increasing trend in March, April, May and June.



**Figure 11:** Regional average temperature in degree Celsius (1950-2012)

Source: BMD, 2013

The analysis shows that there is a sharp contrast observed between the lowest and highest temperature. The temperature in the country never falls below the freezing point during the time from 1950 to 2012. The district-wise regional average temperature shows that the south-western districts have highest average temperature ranging from 25.5°C to 26.25°C (figure 12). The same range prevailed in the southern and some parts of hill tracts of Chittagong division. Literature also suggests that the mean temperature has increased in the southern and south-western parts of the county (Islam, 2003). The northern and eastern districts show average temperature ranging from 24°C to 25.25°C.



**Figure 12:** Regional average temperature (in degree Celsius) in Bangladesh

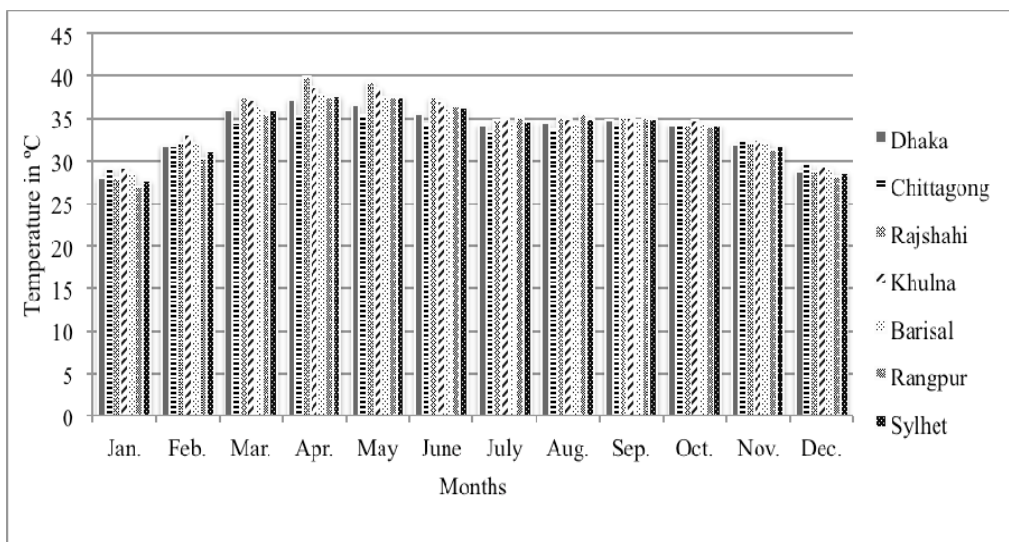
**Table 3:** Division-wise monthly (average from 1962 to 2012) lowest, highest and average temperature (in degree Celsius) in Bangladesh

Month	Range	Division-wise Temperature in ° C						
		Dhaka	Chittagong	Rajshahi	Khulna	Barisal	Rangpur	Sylhet
January	Lowest	8.48	10.63	9.56	8.35	9.74	9.22	9.48
	Highest	28.04	29.05	28	29.11	28.55	26.91	27.72
	Average	17.95	19.38	18.66	18.66	18.86	18.73	18.8
February	Lowest	10.31	12.16	11.23	10.6	11.36	11.06	11.21
	Highest	31.79	31.6	32.09	33.08	32.15	30.26	31.21
	Average	21.13	22.03	21.58	21.58	22.02	21.73	21.88
March	Lowest	14.31	15.96	15.14	14.88	15.61	15.21	15.41
	Highest	36.03	34.52	37.55	37.22	36.33	35.57	35.95
	Average	25.67	25.69	25.68	25.48	26.28	25.88	26.08
April	Lowest	18.47	19.29	18.88	19.3	19.57	19.25	19.41
	Highest	37.29	35.22	39.95	38.74	37.8	37.55	37.68
	Average	28.26	27.93	28.1	28.21	28.46	28.22	28.34
May	Lowest	19.99	20.79	20.39	20.94	20.87	20.73	20.8
	Highest	36.71	35.61	39.41	38.55	37.51	36.68	37.55
	Average	28.61	28.61	28.61	28.61	29.17	28.79	28.98
June	Lowest	22.52	22.55	22.53	23.1	22.75	22.8	22.77
	Highest	35.54	34.44	37.45	37.13	36.14	36.32	36.23
	Average	28.8	28.11	28.4	28.4	28.79	28.59	28.66
July	Lowest	23.85	23.4	23.62	24.03	23.61	23.76	23.68
	Highest	34.24	33.35	34.85	34.95	34.35	35.15	34.75
	Average	28.33	27.71	28.12	28.12	28.22	28.19	28.19
August	Lowest	24.02	23.5	23.74	24.66	23.88	23.89	23.88
	Highest	34.54	33.66	34.17	34.99	34.58	35.48	35.03
	Average	28.74	27.86	28.33	28.36	28.36	28.3	28.1
September	Lowest	23.47	23.33	23.4	23.64	23.41	23.48	23.45
	Highest	34.77	34.17	34.78	35.15	34.8	35.11	35.01
	Average	28.47	28.03	28.62	28.62	28.42	28.2	28.86
October	Lowest	20.1	21.17	20.63	19.96	20.6	20.4	20.5
	Highest	34.31	34.04	34.25	34.77	34.35	33.92	34.13
	Average	22.2	27.4	27.3	27.23	27.42	27.34	27.38
November	Lowest	14.62	16.13	15.38	14.46	15.55	15.13	15.34
	Highest	32.05	32.46	32.08	32.51	32.27	31.27	31.77
	Average	23.54	24.34	23.94	23.91	24.09	23.99	24.04
December	Lowest	10.36	12.26	11.31	10.04	11.07	10.81	10.94
	Highest	28.78	29.61	28.73	29.38	29.12	28.17	28.64
	Average	19.29	20.59	19.94	19.8	19.95	19.89	19.95

Source: BMD, 2013

### Regional Highest Average Temperature

Rajshahi experiences highest average temperature during March, April, May and June than other regions of the country (Figure 13). On the other hand, Chittagong experiences highest temperature during November, December and January while the fluctuations are very low for the other stations. In March, April, May and June Khulna also experienced highest temperature. During July and August highest mean temperature recorded in Rangpur while lowest temperature observed in Chittagong. Dhaka and Sylhet exhibit almost consistent mean temperature throughout the years.



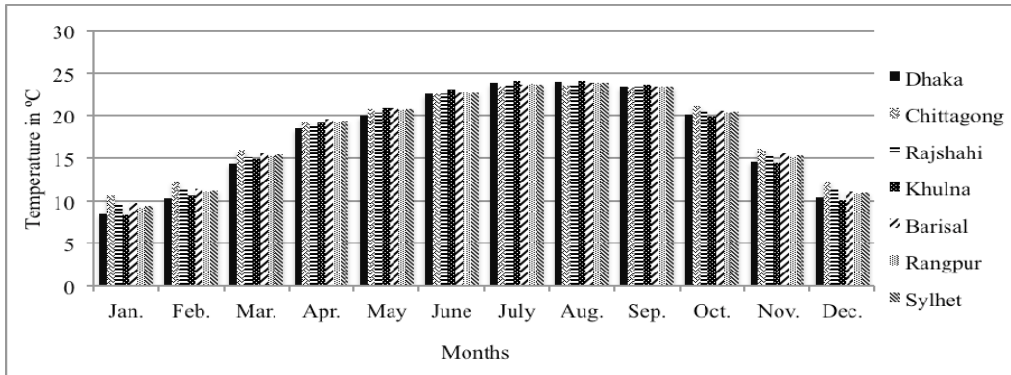
**Figure 13:** Regional Highest Temperature (in degree Celsius) in Bangladesh (1950-2012)

Source: BMD, 2013

### Regional Lowest Average Temperature

Khulna and Dhaka experienced lowest average temperature during the months of December and January than other regions of the country (Figure 14). On the other hand, Chittagong experiences highest temperature during November, December and January. In March, April, May and June Khulna also experienced highest temperature. During December and January lowest mean temperature was recorded in Khulna.

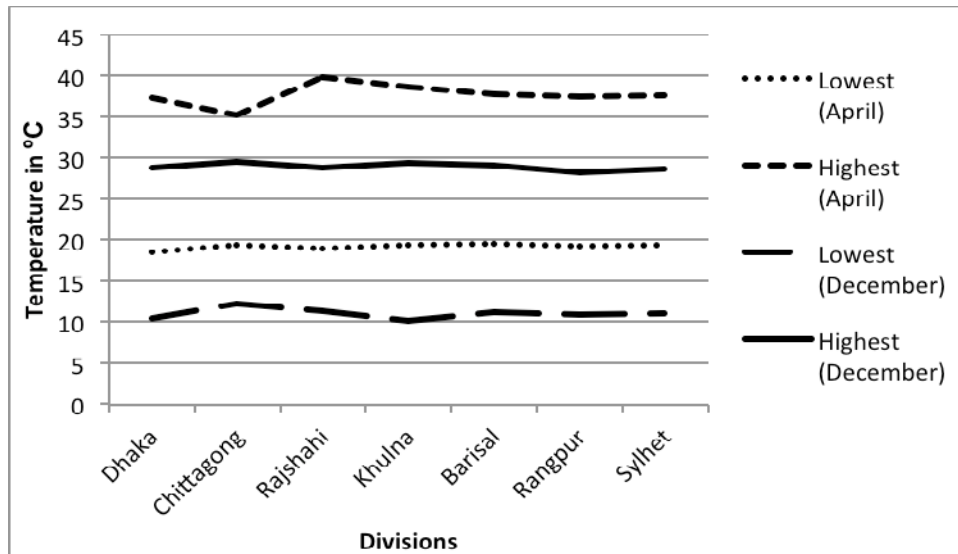




**Figure 14:** Regional lowest temperature (in degree Celsius) in Bangladesh (1950-2012)

Source: BMD, 2013

It is observed from the records of lowest temperature for the months of April and May at Cox’s Bazar, Bhola, M.court, Sitakundo, sathkhira, Barisal, Chandpur, Khulna weather stations that the lowest temperature rising steadily in almost all the stations during summer and late winter season.



**Figure 15:** Division-wise highest and lowest temperature for the months of April and December in Bangladesh from 1962 to 2012

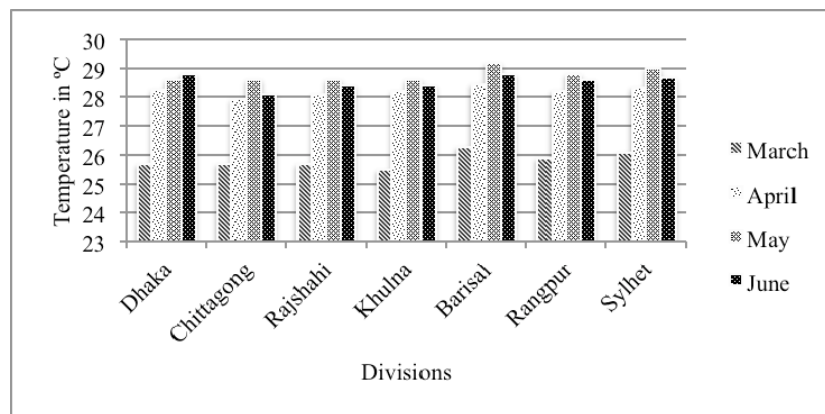
Source: BMD, 2013

It is also noticeable that the highest temperature also increasing especially in Chittagong and Rajshahi regions. As a result, atmospheric turbulences are occurring during the months of April and May. Occurrences of tornado in Sauria and

Brahmanbaria in 1989 and 2013 respectively are the best examples of recent atmospheric turbulences. On the other hand, lowest temperature in December is increasing in Barisal, Rangpur and Chittagong division that results the shrinking of winter season and expanding of summer season gradually.

### Seasonal Variation of Temperature

In Bangladesh winter season comprises of the months of December, January and February. The study shows an increasing trend of temperature in November, December and February which are 1.3°C, 0.8°C and 1.3°C respectively. It has been found that daily maximum temperature shows a positive increase at a rate of  $0.621 \pm 0.491^\circ\text{C}$  per 100 year (Islam, 2008). The maximum increase occurred during November at a rate of 2.7°C per 100 year and the maximum increase occurred during February at a rate of 3.4°C per 100 year. The months November and February are the transition periods of winter season in the country. The increasing trends of temperature of these months clearly indicate the expansion of summer season and shrinking of winter season. March, April, May and June comprise the summer season in Bangladesh. During March average temperature in all the divisions range mostly between 25°C to 26°C (Figure 16).

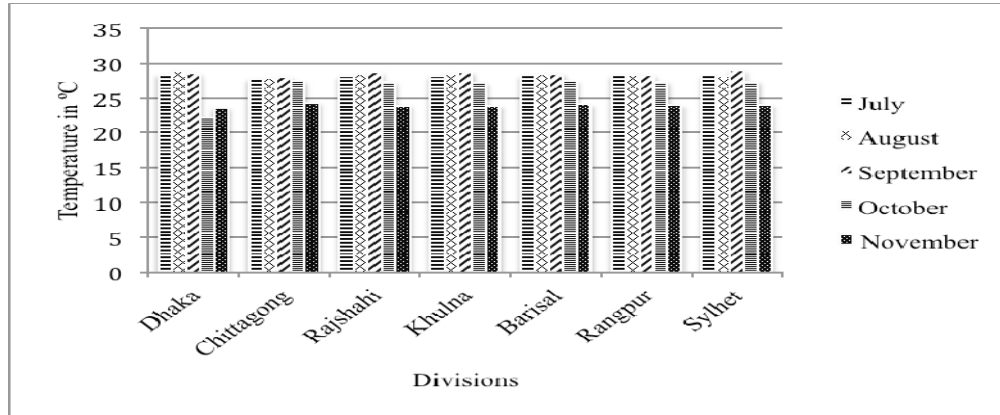


**Figure 16:** Division-wise variation of average temperature during summer (March to June) in Bangladesh from 1962 to 2012.

Source: BMD, 2013

It is observed from the data that there is a drastic rise of temperature during the months of April, May and June in the country. During the months of April and May Barisal and Sylhet divisions show the highest rise of temperature in comparing with other divisions in the country. For the month of June highest temperature recorded in Dhaka division comparing with others divisions. In Bangladesh Rainy season

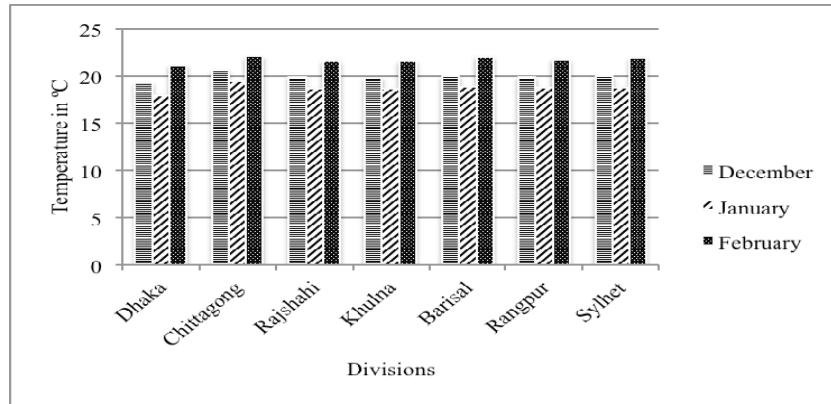
comprises of the months of July, August and September when about 80% of total annual rainfall occur. As a result, the variations of temperature are less for the divisions during these months. The trend of high temperature shows in Sylhet division (figure 17).



**Figure 17:** Division-wise variations of average temperature during rainy season (July to November) in Bangladesh from 1962 to 2012

Source: BMD, 2013

In Bangladesh winter season comprises of the months December, January and February. January is being considered as the coldest month in the country. The recorded coldest regions are Rajshahi, Khulna, Dhaka and Rangpur for the last 63 years from 1950 to 2012. During the month of February the temperature shows steady rise in all the divisions (figure 18) which is an indication of local climate change.



**Figure 18:** Division-wise variations of average temperature during Winter Season (December to February) in Bangladesh from 1962 to 2012

Source: BMD, 2013

## CONCLUSION

Climate change is a burning issue of recent days. The main concern is the change of temperature i.e. increase of temperature. To identify the changes in local climate both empirical and theoretical research is essential (Khan et al., 2002). The study analysed the past trends of temperature in Bangladesh from 1950 to 2012 that carry essence in finding changes in local temperature. The study analysed monthly maximum, minimum and mean temperature that show significant increasing trends over the country. Increase of monthly maximum temperature is 0.12°C, monthly minimum temperature is 0.08°C and monthly mean temperature is 0.56°C during the last 63 years. A maximum increase of monthly maximum temperature has occurred in November at 1.3°C and a minimum temperature has decreased in February at 0.37°C during the selected time period. The highest increase of monthly maximum temperature of 2.1°C has occurred at Syedpur and monthly minimum temperature has decreased to 1.8°C at Rangamati for the last 63 years. It is found that maximum temperature has increased dramatically over the last 40 years period. Analysis of regional average temperature shows that Dhaka experiences lowest average temperature during winter season than all other regions. Analysis of regional highest and average temperature shows that Rajshahi experiences highest average temperature during summer season and Chittagong shows lowest temperature during that season. Chittagong has the highest average temperature throughout the years than the other regions. Analysis of regional lowest temperature reveals that Khulna experiences both lowest and highest temperature during winter and summer respectively.

## REFERENCES

- Bangladesh Meteorological Department (BMD) (2013). *Daily Average Temperature Data from 1950 to 2012*. Ministry of Defense, Government of the Peoples' Republic of Bangladesh.
- Englehart, P. J. and Douglas, A. V. (2005). *Changing Behavior in the Diurnal Range of Surface air Temperatures over Mexico*. *Geophys. Res. Lett.*, 32, L01701, doi:10.1029/2004gl021139.
- Fowler, H. J. and Archer, D. R. (2006). *Conflicting Signals of Climatic Change in the Upper Indus Basin*. *Journal of Climate* 19: 4276–4293.
- Islam, A. K. M. S. (2008). *Analyzing Changes of Temperature over Bangladesh due to Global Warming using Historic Data*, Institute of Flood Management, BUET, Dhaka.
- Islam, M. N. (2003). *Long term forecasting of Rainfall & Temperature for the SAARC region using RCME Part-1 Calibration*, SAARC Meteorological Research Center (SMRC), Dhaka.

- Jhajharia, D. and Singh, V. P. (2011). Trends in Temperature, Diurnal Temperature Range and Sunshine Duration in Northeast India. *International Journal of Climatology* 31(9): 1353-1367.
- Jones P. D. (1995). Maximum and minimum temperature trends in Ireland, Italy, Thailand, Turkey and Bangladesh. *Atmos. Res* 37(1-3): 67-78.
- Kaas, E. and Frich, P. (1995). Diurnal Temperature Range and Cloud Cover in the Nordic Countries: Observed Trends and Estimates for the Future. *Atmospheric Research* 37: 211-228.
- Karmakar, S. S. and Lal, M. (2000). *Recent Climate Change in Bangladesh*, SAARC Meteorological Research Center (SMRC), Dhaka.
- Khan T. M., Quader, A. and Islam, A. (2002). *An Integrated Approach to Sea Level Changes, Coastal Erosion and Inundation and their Impacts on the Coastal Zone of Maldives*, SAARC Meteorological Research Center (SMRC), Dhaka.
- Makowski, K., Wild, M. and Ohmura, A. (2008). Diurnal Temperature Range over Europe between 1950 and 2005. *Atmos. Chem. Phys.*, 8: 6483–6498.
- Price, C., Michaelides, S., Pashiardis, S. and Alpert, P. (1999). *Long Term Changes in Diurnal Temperature Range in Cyprus*. *Atmospheric Research* 51(2): 85-98
- Quader, A., Hussain, D. and Islam, A. (2001). *Climate Variability and Its Trends in Maldives*, SAARC Meteorological Research Center (SMRC), Dhaka.
- Quader, A., Hussain, D. and Islam, A. (2005). *Inter-Annual & Intra-seasonal Variability of Temperature and Precipitation of Bhutan*, SAARC Meteorological Research Center (SMRC), Dhaka.
- Quader, A. and Prasad, K. (2002). *Climate Variability in South Asian Region and Its Impact*, SAARC Meteorological Research Center (SMRC), Dhaka.
- Rahman M. R., Salehin, M. and Matsumoto, J. (1997). Trends of Monsoon Rainfall Pattern in Bangladesh. *Bangladesh Journal of Water Resources* 14–18: 121–138.
- Razuvaev, V. N., Apasova, E. G., Bulygina, O. N. and Martuganov, R. A. (1995). Variations in the Diurnal Temperature Range in the European Region of the Former USSR during the Cold Season. *Atmospheric Research* 37:45-51
- Roy, S. S. and Balling, J. R. C. (2005). Analysis of Trends in Maximum and Minimum Temperature, Diurnal Temperature Range, and Cloud Cover over India. *Geophys. Res. Lett.*, 32, L12702, doi:10.1029/2004GL022201.
- Rupa Kumar, K., Krishna Kumar, K. and Pant, G. B. (1994). Diurnal Asymmetry of Surface Temperature Trends over India. *Geophysical Research Letters* 21: 677-680.
- Sang Y. F. (2012). Spatial and Temporal Variability of Daily Temperature in the Yangtze River Delta, China. *Atmospheric Research* 112: 12-24.
- Shahid, S. (2008). Spatial and Temporal Characteristics of Droughts in the Western Part of Bangladesh. *Hydrological Processes* 22(13): 2235-2247.

- Shahid, S. and Khairulmaini, O. S. (2009). Spatio-Temporal Variability of Rainfall over Bangladesh during the Time Period 1969-2003. *Asia-Pacific Journal of Atmospheric Sciences* 45(3): 375-389.
- Shahid, S. (2010a). Rainfall Variability and the Trends of Wet and Dry Periods in Bangladesh. *International Journal of Climatology* 30(15): 2299-2313
- Shahid, S. (2010b). Recent Trends in the Climate of Bangladesh. *Climate Research* 42:185-193
- Shahid, S. (2011). Trends in Extreme Rainfall Events in Bangladesh. *Theoretical and Applied Climatology* 104(3-4): 489-499
- Shahid, S. (2012). Vulnerability of the Power Sector of Bangladesh to Climate Change and Extreme Weather Events. *Regional Environmental Change*, 12(3): 595-606
- Singh O. P. and Khan T. M. (2000). *The Vulnerability Assessment of SAARC coastal region due to Sea level rise: Bangladesh Case*, SAARC Meteorological Research Center (SMRC), Dhaka.
- Singh, O. P. (2001). Cause-effect Relationships between Sea Surface Temperature, Precipitation and Sea Level along the Bangladesh Coast. *Theor Appl Climatol* 68: 233-243.
- Singh, O. P. (2002). *Sea Level Variability along Indian Coast*, SAARC Meteorological Research Center (SMRC), Dhaka.