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TREND analysis of changing temperature in Bangladesh due to global warming

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Abstract

Long term changes in near-surface air temperature over Bangladesh was studied using the available historical data of maximum and minimum daily temperature for the last 60 years (1949-2008) collected by the Bangladesh Meteorological Department (BMD). Analysis was done by using MAKESENS trend model. It has been observed that the temperature increased significantly at the rate of 0.00569 ^{o}C Yr^{-1} for AMXT, 0.014498 ^{o}C Yr^{-1} for AMNT and 0.010262 ^{o}C Yr^{-1} for AMT. It is evident that AMXT and AMT raised to maximum levels during November by 0.023 ^{o}C Yr^{-1} and 0.02597 ^{o}C Yr^{-1} respectively. However, AMNT increased to its maximum during February at 0.0308 ^{o}C Yr^{-1}. It was also found that maximum increase in AMXT occurred at Shitakundu (0.058102^{o}C Yr^{-1}), in AMNT at Madaripur (0.042 ^{o}C Yr^{-1}) and in AMT at Kutubdia (0.031113 ^{o}C Yr^{-1}). Southern parts of the country showed higher increasing trends of daily AMXT than other parts. Northern and north-western parts had higher rate of increase in daily AMNT, whereas the daily AMT has increased more in the southern and south-western parts. During Rabi season AMNT increased by 0.023 ^{o}C Yr^{-1} and AMT by 0.013 ^{o}C Yr^{-1}. In Kharif-1 AMNT increased by 0.012 ^{o}C Yr^{-1} and AMT by 0.006 ^{o}C Yr^{-1}, whereas in Kharif-2 AMXT increased at 0.011^{o}C Yr^{-1}, AMNT at 0.005 ^{o}C Yr^{-1} and AMT at 0.008 ^{o}C Yr^{-1}. Besides, the temperature of winter season (December to February) has been raised at much higher rate than summer season (June to August). This study also showed that temperature has been increased to much higher levels over the last 30 years (1979-2008) than the last 60 years (1949-2008).

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Introduction

Climatic parameters such as rainfall, temperature, humidity, sunshine hour etc. may be vary with time and space. Scientific studies indicate significant changes in various climatic parameters in various regions of the world. Global warming is mainly caused by the increase in greenhouse gases like as carbon dioxide, methane and nitrous oxide etc. of the atmosphere and increased amount of greenhouse gases act as a blanket to store infrared radiation of solar energy. Stored energy is radiated as heat and makes warmer the cooler parts of the atmosphere as well as land surface. Intergovernmental Panel on Climate Change (IPCC) reported in their fourth assessment report that global surface temperature increased by 0.74 ± 0.18 °C during the 100 years ending in 2005 (IPCC 2007). It was also noted by IPCC (2007) that the rise of mean annual temperature will be 3.3 °C per century. In the past, a number of studies have been carried out on trend of change in climatic parameters over Bangladesh. By using historical data of some selected meteorological stations, Chowdhury and Debsharma (1992) and Mia (2003) pointed out that temperature has been changed. Parathasarathy *et al.* (1987) and Divya and Mehrotra (1995) reported that mean annual temperature of Bangladesh has increased during the period of 1895-1980 at 0.31 °C. Karmakar and Shrestha (2000), using the 1961-1990 data for Bangladesh, projected that annual mean maximum temperature will increase by 0.4 °C and 0.73 °C by the year 2050 and 2100 respectively. Mondal *et al.* (2008) also tried to find out trend of temperature based on the recent data, rather than the long-term data, and also there was lack of modern statistical techniques. Most of the trend analysis was done by using simple regression techniques, not even the normality and stationarity of residuals were checked in those studies. In this context, it has become essential to quantify the trend of changes in temperature in recent years based on the historical data, by using modern data analysis model. This model is also useful in analyzing atmospheric chemistry data. This study was conducted to investigate the long term changes and prediction of future status of near surface air temperature, by using data from historic period up to recent year, with the MAKESENS trend model.

Data sets and methods

Maximum and minimum daily temperature data of last 60 years (1949-2008) were collected from different stations of BMD. These stations are mainly located at the city centres of urban districts. The trend of changes in temperature was computed monthly, yearly and crop yearly and analyzed by using MAKESENS trend model for all the stations. User's manual of MAKESENS model was introduced Timo Salmi *et al.* (2002). The MAKESENS is a software computer model which was developed using Microsoft Excel 97 and macros were coded with Microsoft Visual Basic. MAKESENS performed two types of statistical analyses. First, the presence of monotonic increasing and decreasing trend was tested with the nonparametric Mann-Kendall test and secondly, the slope of linear trend was estimated with the nonparametric Sen's method (Gilbert 1987). These methods are used in their basic forms; the Mann-Kendall test is suitable for cases where the trend may be assumed to be monotonic and thus no seasonal or other cycle is present in the data. The Sen's method uses a linear model to estimate the slope of the trend and the variance of the residuals should be constant in time. These methods offer many advantages that have made them useful in analyzing atmospheric chemistry data. Missing values are allowed and the data need not to be conformed to any particular distribution. Besides, the Sen's method is not greatly affected by single data errors or outliers. In MAKESENS test, the significant levels alphas (α) were 0.001, 0.01, 0.05 and 0.10. For the four tested significance levels the following symbols were used in the template: *** if trend at $\alpha = 0.001$ level of significance, ** if trend at $\alpha = 0.01$ level of significance, * if trend at $\alpha = 0.05$ level of significance, + if trend at $\alpha = 0.1$ level of significance. If the cell is blank, the significance level is greater than 0.1. Changes were calculated based on trend analysis results as Change = (last data yr – first data yr) *Q. Actual values were calculated by the

equation, Actual value = (change + B) and Prediction was calculated based on trend analysis results as equation of the lines: f (year) = Q*(last data yr-first data yr) + B. Here, B = Intercept, Q = Rate of change per year.

Table 1. Temperature change and prediction.

	Calendar Year Wise				Crop Year Wise					
Parameters	Change (°C Yr-1)	Change °C per 60Yrs	Actual Value °C	After 60Yrs °C	Change per Year (°C)			Actual Value (°C)		
					Rabi	K_1	K_2	Rabi	K_1	K_2
AMXT	0.00569**	0.33571	30.5	30.85	0.004	0.003	0.011***	28.79	32.31	31.65
AMNT	0.014498***	0.855382	21.44	22.32	0.023***	0.012**	0.005**	17.82	23.96	25.24
AMT	0.010262***	0.605458	25.98	26.60	0.013***	0.006*	0.008**	23.28	28.11	28.41

(K_1 = Kharif-1, K_2 = Kharif-2)

Table 2. Month wise change (°C yr-1).

Month	Change °C yr-1 (1st 30yrs)			Change °C yr-1 (2nd 30yrs)			Change yr-1 °C (60yrs)		
	AMXT	AMNT	AMT	AMXT	AMNT	AMT	AMXT	AMNT	AMT
January	-0.0089	0.01465	0.0051	-0.0179	-0.0062	-0.015	-0.004	0.0149**	0.0056
February	0.0172*	0.02012	0.0187**	0.0377**	0.03147+	0.0359**	0.004**	0.0308***	0.01745**
March	-0.0091	0.02742	0.0042	0.00963	0.01491	0.0214	-0.010+	0.0263***	0.00803
April	-0.022	0.00339	-0.0112	0.00737	0.01206	0.0075	-0.008	0.0108*	0.0015
May	-0.0192	-0.017	-0.0196	0.03488+	0.02203	0.03231+	0.004	0.0040	0.00455**
June	-0.0122	-0.0063	-0.007	0.0192+	0.0025	0.01035	0.012*	0.0079***	0.00933**
July	-0.007	-0.0012	-0.0036	0.02206**	0.01089*	0.01890**	0.008**	0.0069***	0.00738***
August	-0.006	-0.00612	-0.0057	0.0351**	0.0138**	0.02347***	0.015***	0.0066***	0.01093**
September	-0.0108	-0.0076	-0.0108	0.02761*	0.00795	0.01853*	0.006	0.00273	0.00466
October	0.0016+	0.00177	0.00388*	0.00995	0.01965	0.0171+	0.015***	0.0055	0.01076**
November	0.0236+	0.06646**	0.0462**	0.01172	0.01497	0.01485	0.023***	0.0283***	0.02597***
December	-0.00212	0.01558	0.0073	0.02667+	0.0277	0.02632+	0.014**	0.0269***	0.02023***

Results and Discussion

The maximum and minimum temperature data within last 60 years period (1949-2008) from all the 32 stations of BMD were used to determine trend and prediction.

Calendar and crop year wise changes of temperature: It is evident that (Table 1) over all 32 stations that the Bangladesh temperature increased significantly at the rate of 0.00569** °C Yr-1 (AMXT), 0.014498*** °C Yr-1 (AMNT) and 0.010262*** °C Yr-1 (AMT) during calendar year. After 60 yrs (2068) the predicted temperature will be 30.85 °C (AMXT), 22.32 °C (AMNT) and 26.60 °C (AMT). The magnitudes of the trends are dependent on the period of analysis and analysis technique. The rise in mean annual temperatures projected by IPCC (2007) for South Asia is 3.3 °C with a range of 2.0-4.7 °C. Mondal *et al.* (2008) found that AMXT rising trend is 0.63 °C per century, AMNT is 1.44 °C per century and AMT rise in +0.10 °C per decade (equivalent to +0.01 °C per year) for data periods of 1948-2007. However, from this study it is clear that MAKESENS trend model provides results, which are closer to the IPCC (2007) projection and identical to Mondal *et al* (2008).

Table 1 also shows that at Rabi season (21st October-20th March) AMNT and AMT increased at the rate of 0.023*** °C Yr-1 and 0.013*** °C Yr-1 respectively. At Kharif-1 season (21st March- 20th July) AMNT increased by 0.012** °C Yr-1 and AMT by 0.006* °C Yr-1. At Kharif-2 season (21st July-20th October) AMXT increased by 0.011*** °C Yr-1, AMNT by 0.005** °C Yr-1 and AMT by 0.008*** °C Yr-1. The rate of increase in temperature during Rabi season was higher than other crop seasons.

Table 3. Station wise temperature change.

Station Name	No. of Yrs	First Year	Change (°C Yr-1)			Actual Value (°C)		
			AMXT	AMNT	AMT	AMXT	AMNT	AM
Dinajpur	60	1948	0.013***	0.011***	0.012**	31.38	20.16	25.7
Rangpur	52	1957	-0.01417***	0.019444***	0.001695	29.32	20.45	24.8
Rajshahi	45	1964	0.011111**	0.000768	0.004373+	31.27	20.61	25.9
Bogra	60	1948	-0.001+	0.008**	0.004*	30.60	21.06	25.8
Ishordi	52	1957	0.014684**	0.020777***	0.016564***	31.28	20.78	25.9
Tangail	24	1985	0.022266*	0.013329	0.018119**	30.68	20.93	25.8
Mymensingh	60	1948	-0.007**	0.008***	0.0005**	29.75	20.93	25.3
Sylhet	52	1957	0.024216***	0.019304***	0.021559***	30.32	20.82	25.5
Srimongal	60	1948	0.001	0.021***	0.011***	30.41	19.79	25.1
Dhaka	60	1948	0.011**	0.025***	0.018***	30.72	22.06	26.3
Comilla	60	1948	0.004	0.001	0.003	30.32	20.95	25.6
Chandpur	45	1964	0.00989*	0.009306*	0.011694**	30.53	22.01	26.2
Jessore	60	1948	0.017***	0.010***	0.013***	31.92	20.98	26.4
Faridpur	60	1948	0.021***	0.017***	0.021***	30.89	21.56	26.2
Madaripur	36	1973	0.005*	0.042***	0.024***	30.67	21.90	26.3
Khulna	60	1948	0.005	-0.004	0.0005	31.38	21.73	26.4
Shatkhira	60	1948	0.006	0.009**	0.007**	31.49	21.71	26.5
Mongla	24	1985	0.045711***	0.017522*	0.033214***	31.44	22.65	27.0
Barisal	60	1948	0.008**	-0.005*	0.0015+	30.73	21.18	25.9
Bhola	45	1964	0.018109***	0.021667***	0.020833***	30.56	21.98	26.3
Patuakhali	36	1973	0.027316***	-0.00109	0.013996**	31.00	21.16	26.4
Khepupara	36	1973	0.027316***	0.005556	0.015104***	31.00	22.27	26.5
Feni	36	1973	0.000629	0.005985	0.003087	30.24	21.35	25.7
Maizdicort	60	1948	0.016***	0.021***	0.018***	30.40	22.19	26.2
Hatia	45	1964	0.019558***	-0.00909	0.006795+	29.85	21.90	25.8
Shitakundu	36	1973	0.058102***	-0.0054	0.026403***	31.28	20.95	26.1
Sowndip	45	1964	0.014286*	0.00119	0.007927+	29.84	22.11	25.9
Chittagong	60	1948	0.020***	0.010***	0.014***	30.80	21.93	26.2
Kutubdia	24	1985	0.03471**	0.020833*	0.031113**	30.33	22.54	26.4
Cox's bazar	60	1948	0.032***	0.022***	0.025***	30.92	22.57	26.7
Teknaf	36	1973	0.031399***	0.033072***	0.030224***	30.72	22.47	26.5
Rangamati	52	1957	0.000976	-0.0283**	-0.01122*	30.59	20.72	25.6

Month wise change of temperature:

Table 2 shows month wise changes in temperature per year. During 1st 30 years (1949-1978) AMXT and AMT increased in February, October and November but AMNT increased in November only. During 2nd 30 years (1979-2008) AMXT increased in May - September, December and February; AMNT increased in February, July and August; AMT increased in May, July - October, December and February. During 60 years (1949-2008) AMXT increased in June - August, October - December and February but decreased only in March. The increase in AMNT was observed in January-April, June-August and November - December, While AMT increased in May - August, October - December and February.

It has been found that the maximum increase of AMXT occurred in November (1st 30 yrs and last 60 yrs) and February (2nd 30 yrs), and AMNT in November (1st 30 yrs) and February (2nd 30 yrs and last 60 yrs). AMT increase was found maximum in November (1st 30 yrs and last 60 yrs) and February (2nd 30 yrs). It is clear that AMXT and AMT rose to maximum during November at 0.023*** ^{o}C Yr^{-1} and 0.02597*** ^{o}C Yr^{-1} respectively. However, AMNT increase was found maximum during February (0.0308***^{o}C Yr^{-1}).

Besides it has been observed that temperature of winter season (December to February) increased at much higher rate than the summer season (June to August). Table 2 also shows that the increase in temperature over the last 30 years (1979-2008) was much higher than the last 60 years (1949-2008). This result can be verified by the IPCC (2007) median projections for quarterly result, where temperature was predicted to rise 3.6 ^{o}C in December - February and 2.7 ^{o}C in June – August, by the end of the 21st century. Also, the IPCC projection described that the recent trends are higher than the past and it may strengthen in the future, which was also observed is this study.

Station wise temperature change:

Average Maximum Temperature (AMXT):

AMXT increased in all the stations with 0.005* ^{o}C Yr^{-1} (Madaripur) to 0.058102 ^{o}C *** Yr^{-1} (Shitakundu) except Rangpur, Bogra and Mymensingh. Decreased rate varied from 0.001 ^{o}C Yr^{-1}(Bogra) to 0.01417 ^{o}C *** Yr^{-1} (Rangpur). Maximum rising 0.031 to 0.058 ^{o}C Yr^{-1} occurred at Mongla, Shitakundu, Kutubdia, Cox's bazar and Teknaf.

Average minimum temperature (AMNT):

AMNT increased in all the stations at the rate of 0.008** ^{o}C Yr^{-1} (Bogra) to 0.042 ^{o}C Yr^{-1} (Madaripur) except Barisal and Rangamati, where the temperature decreased at the rate of 0.017522* ^{o}C Yr^{-1} and 0.0283** ^{o}C Yr^{-1}, respectively.

Average mean temperature (AMT):

Increased rate of AMT varied from 0.0005** ^{o}C Yr^{-1} in Mymensingh to 0.033214*** ^{o}C Yr^{-1} in Mongla but decreased only Rangamati at 0.01122* ^{o}C Yr^{-1}. Maximum rising also occurred in Kutubdia at 0.031113** ^{o}C Yr^{-1} and in Teknaf at 0.030224*** ^{o}C Yr^{-1}. In Rangpur, Comilla, Khulna and Feni AMT trend was positive but not significant. Most of the stations in Bangladesh exhibit increasing trends in AMT, which was also investigated by Mondal *et al.* (2008).

Significant increase in temperature at 0.02 ^{o}C Yr^{-1} or above was observed for *AMXT* in Tangail, Sylhet, Faridpur, Mongla, Patuakhali, Khepupara, Shitakundu, Chittagong, Kutubdia, Cox's bazar and Teknaf for *AMNT* in Ishurdi, Srimongal, Dhaka, Madaripur, Bhola, Maizdicort, Kutubdia, Cox's bazar and Teknaf and for AMT in Sylhet, Faridpur, Madaripur, Mongla, Bhola, Shitakundu, Kutubdia, Cox's bazar, and Teknaf. However increase in temperature of 0.02 ^{o}C Yr^{-1} or above for *AMXT, AMNT and AMT* was recorded at Kutubdia, Cox's bazar and Teknaf.

West and south-western parts showed higher *AMXT* than other parts of the country. Southern parts of the country showed higher increasing trends of *AMXT* than other parts. Northern and north-western parts

had higher rate of increase in *AMNT* than other parts of the country. Mean daily temperature *(AMT)* was found higher in the southern and eastern parts of the country compared to other parts of the country. It is clearly found that *AMT* has increased more in the southern and south-western parts of the country.

Impact of climate change on agriculture

Temperature is one of the most essential climatic parameters for agriculture as well as crop production. Rising in temperature is very dangerous for sustainable agriculture and it induces drought which affects agriculture, food production, water resources and human health. The present study will be helpful to design agricultural systems like greenhouses, irrigation devices, suitable variety and cropping pattern in order to mitigate the predicted adverse effect of climate change on crop production. The agro-climatic suitability of potential crops in a particular area depends on the prevailing climatic conditions. In winter season (November-February), the main crops of Bangladesh are Boro rice, wheat, potato and vegetables. Increase in winter temperature can reduce the environmental suitability for wheat (increased spikelet sterility, grain shrivelling and reduced yield), potato and other temperate crops grown in Rabi season. Not only crops, animal husbandry, forestry and fisheries are also adversely affected due to climate change. Increasing winter temperature offers less animal comfort and reduction in milk yield and higher infestation of pest and diseases to crops. Therefore, changes in climate will severely decline growth of various winter crops in the study area.

Conclusion

Daily average temperature (maximum, minimum and mean) showed positive trends over Bangladesh. Temperature increased significantly at the rate of 0.00569^{**} $^{o}C\ Yr^{-1}$ for AMXT, 0.014498^{***} $^{o}C\ Yr^{-1}$ for AMNT and 0.010262^{***} $^{o}C\ Yr^{-1}$ for AMT. After 60 years (2068) the predicted temperature will be 30.85 ^{o}C for AMXT, 22.32 ^{o}C for AMNT and 26.60 ^{o}C for AMT. The highest increase in AMXT occurred at Shitakundu (0.058102 ^{o}C *** Yr^{-1}), in AMNT at Madaripur (0.042 $^{o}C\ Yr^{-1}$) and in AMT at Kutubdia (0.031113^{**} $^{o}C\ Yr^{-1}$). It was also found that temperature increased dramatically over the last 30 years (1979-2008). Finally the study shows changes in climatic behaviour of the entire study area due to drastic changing temperature.

During winter season, cold loving Rabi crops are mainly planted in the northern parts of the county. It is evident that Rabi crops during winter will be highly affected because of global warming

References

Chowdhury MHK, Debsharma SK. 1992. Climate change in Bangladesh - A statistical review, Report on IOC-UNEP Workshop on Impacts of Sea Level Rise due to Global Warming, NOAMI, held during 16-19 November 1992, Bangladesh.

Divya, Mehrotra R. 1995. Climate Change and hydrology with emphasis on the Indian subcontinent, Hydrologic Sciences Journal; **40,** 231-241.

Gilbert RO. 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold , New York.

IPCC. 2007. Climate Change 2007: Impacts, adaptation and vulnerability". Fourth Assessment Report, Working Group II. Cambridge University Press, UK.

Karmakar S, Shrestha ML. 2000. Recent climate change in Bangladesh", SMRC No.4, SMRC, Dhaka.

Mia NM. 2003. Variations of temperature of Bangladesh", In Proceedings of SAARC Seminars on Climate Variability In the South Asian Region and its Impacts, SMRC, Dhaka.

Mondal MS, Mollah M, Hossain A. 2008. Characterizing Long-term Changes of Bangladesh

Climate in Context of Agriculture and Irrigation" Climate Change Cell, DoE, MoEF; Component 4b, CDMP, MoFDM. Month 2009, Dhaka.

Parthasarathy B, Sontake NA, Monot AA, Kothawale DR. 1987. Drought-flood in the summer monsoon season over different meteorological subdivisions of India for the period 1871-1984", Journal of Climatology **7**, 57-70.

Salmi T, Maatta A, Anttila P, Ruoho-Airola T, Amnell T. 2002. Detecting trends of annual values of atmospheric pollutants by the Mann-Kendall test and Sen's slope estimates - the Excel template application MAKESENS", Published by Finnish Meteorological Institute, Publications on Air Quality No. 31, Report code FMI-AQ-31 (August 2002), ISBN 951-697-563-1, ISSN 1456-789X, Painopaikka: Edita Oyj, Helsinki 2002.