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**An analysis of the temperature change of Dhaka city**

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**Abstract**

The study analyses the pattern of change of temperature of Dhaka city using the data of maximum and minimum monthly temperature of 1995 -2010 period collected from Bangladesh Meteorological Department. This study reveals that minimum average monthly temperature is showing significantly increasing pattern. The most significant and highest changes occurring in winter (December-February) and trend of increasing is 13 °C in 100 years. The highest increase occurred in trend is 13.6 °C increase in 100 years in December. Although pre-monsoon maximum and minimum temperature is increasing but the rate is lower than winter.

**INTRODUCTION**

Dhaka is the capital of Bangladesh and one of the largest and densely populated mega cities of the world. It is now a fact that climate change is happening due to the increase in the green house gas such as carbon dioxide, methane etc which acts as a partial blanket for the earth and store the radiation of the solar energy. This has increased the surface temperature of the earth. According to Intergovernmental panel on climate change (IPCC) the global surface temperature has increased  $0.74 \pm 0.18$  °C during the last 100 years ending in 2005 [1]. The effect of climate change will be very much severe for the mega cities mainly in the Asian mega cities of the developing world due to the large number of population concentration. Number of studies has been conducted on the effect of climate change on the rainfall, temperature and other climatic variables on Bangladesh using historical data. Divya and Mehritra (1995) using historical data of 1895-1980 reported that the mean annual temperature of Bangladesh has increased 0.31°C over the past two decades [2]. Another study done by Karmakar and Shresta using the historical data of 1961-1990 for Bangladesh projected that the annual mean maximum temperature will be increased to 0.4 °C and 0.73 °C in the year 2050 and 2100 respectively[3]. This study have concentrated on the change in the temperature pattern on the historical data of Dhaka the only mega city of Bangladesh from 1995-2010 to know the recent changes of the temperature pattern of Dhaka city.

**MATERIALS AND METHODS**

Temperature data is collected by Bangladesh Meteorological Department for 34 different stations. As the analysis concentrated on the Dhaka city, the historical data of minimum and maximum temperature of Dhaka station from 1995-2010 has been used for this analysis because within this period Dhaka city has experienced massive urbanization which is a prime cause of temperature rise is urban areas[1,4]. Mean Average temperature data has been collected from World Bank Website [5]. Statistical trend analysis has been conducted in the study by using maximum and minimum monthly temperature data of Dhaka. Trend analysis has been done using simple linear regression equation.

$$y = bx + c \tag{1}$$

In the equation y is temperature of specific year, x is the specific year and c is the intercept of the straight line represented by equation. “b” can be determined from the following equation.

$$b = \frac{\sum (xi - \bar{x})(yi - \bar{y})}{\sum (xi - \bar{x})^2} \tag{2}$$

Where xi is the independent variable representing the year and yi is depended variable representing temperature for the year.

Whereas  $\bar{x}$  and  $\bar{y}$  is average of the variable. Significance of trend has been judged by using R<sup>2</sup> value. The value of R<sup>2</sup> is positive and varies from 0 to 1. R<sup>2</sup> is calculated from equation 3.

$$R^2 = \frac{(\sum (xi - \bar{x})(yi - \bar{y}))^2}{\sum (xi - \bar{x})^2 \sum (yi - \bar{y})^2} \tag{3}$$

If the value of R<sup>2</sup> is relatively small such as less than 0.50, the trend will be insignificant [6].

The data set of each year has been divided into four seasonal periods for analysis. These are Pre monsoon (March – may), Monsoon (June – September), Post Monsoon (October – November) and winter (December – February). The data series has been applied for linear trend analysis for these categories to determine whether there are any significant trends in the data series.

**RESULTS**

The monthly variation of temperature has been analyzed with the time series data. Monthly variation of temperature has been analyzed on the basis of average maximum and minimum temperature of last 16 years from 1995- 2010.

From Fig.1 Average monthly maximum temperature is low in the winter period: December, November and January. Lowest maximum and minimum average monthly temperature has been found in the January. Higher monthly average temperature has been observed in the pre-monsoon period: March, April and May. Monthly average maximum data has the highest value for the month of April. It can be interoperated from the data that, January is the coolest month and April is the warmest month for Dhaka city. From Fig. 2 the change of monthly mean temperature is not significant from 1960-2009 for any months of the year except October and November. Temperature has rise significantly within 1990-2009 periods from 1960-1990 periods.

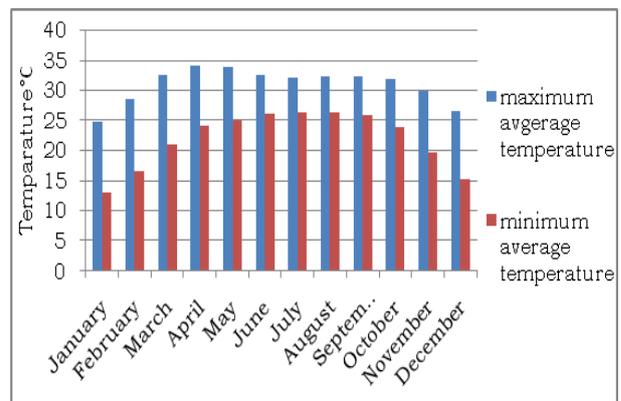


Fig. 1. Monthly average maximum minimum temperature (°C) during period 1995-2010.

In Fig. 3 minimum average temperature is revealing a significantly increasing trend. The trend analysis of monthly minimum temperature of 1995-2010 periods shows that average minimum temperature is increasing.

The trend line reveals the likelihood of increasing maximum temperature by 6.8 °C in the 100 years. Also the coefficient of determination value very high which is 0.521 which indicates a strong statistical significance of the trend.

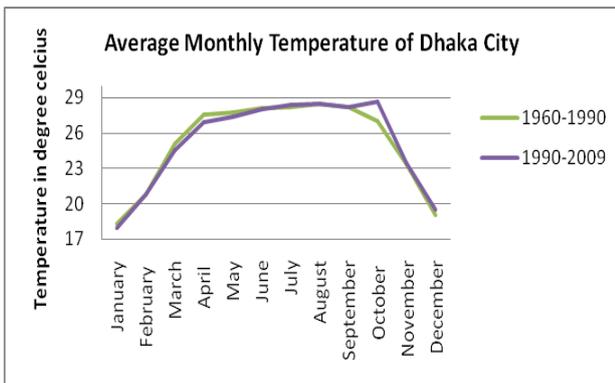


Fig. 2. Change in monthly mean temperature of Dhaka

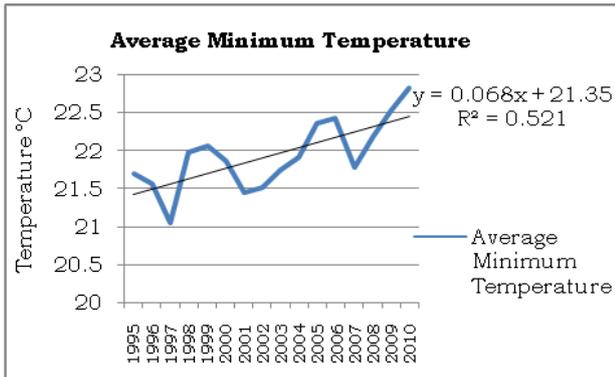


Fig. 3. Trend of monthly minimum temperature data of 1995-2010 periods.

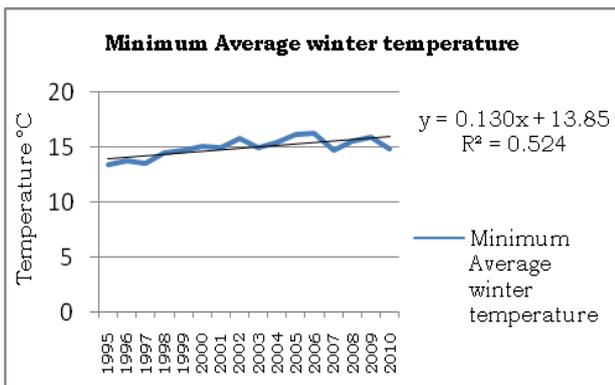


Fig. 4. Trend of minimum average winter temperature

In Fig.4, in the analysis of the minimum average temperature in the winter season it is seen that temperature is likely to increase. It is seen that trend of increasing temperature is 13°C in 100 years period for winter season.

In Fig. 5, the pre monsoon period it is seen that the average maximum temperature is likely to increase following a trend of 2.2 °C rise in 100 year period. But the R<sup>2</sup> value is very less indicates a poor statistical significance of the trend.

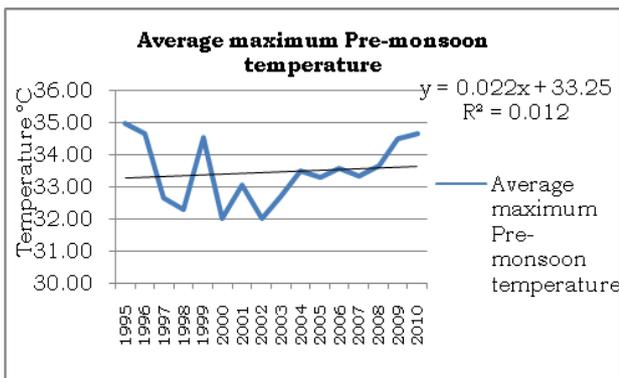


Fig. 5. Trend of monthly maximum temperature data of 1995-2010 in Pre- monsoon periods.

In Fig. 6, the pre monsoon monthly minimum temperature also an increasing trend is observed and the trend is 8.6 °C per 100 year period. So in the pre monsoon season the trend in the maximum temperature is much higher than the minimum temperature. But the R<sup>2</sup> Value is 0.235 which indicates a moderate statistical significance of the trend.

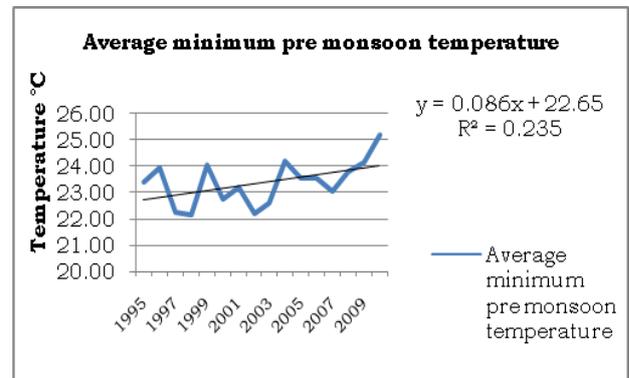


Fig. 6. Trend of monthly minimum temperature data of 1995-2010 in Pre- monsoon periods.

Also it is found the highest increasing trend in the temperature data is found in the winter season mainly in the month of December. From Fig.7 in December it is found that the in the increase trend of the temperature per 100 years is 13.6°C. R<sup>2</sup> value is of the trend line is very high which indicates a strong statistical significance of the trend. Mainly the in the winter season rise in the temperature is occurring in the month of December.

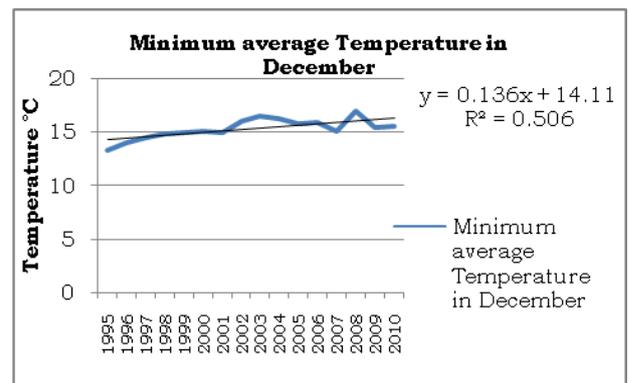


Fig. 7. Trend of monthly minimum temperature data of 1995-2010 in the month of December.

## DISCUSSIONS

The monthly average minimum temperature is showing a positive trend of increase in Dhaka city. The monthly average maximum temperature is showing a slightly negative trend of decreasing but due to a very low R<sup>2</sup> value this trend has less statistical significance. But the increase in the monthly minimum temperature trend is strongly significant and trend shows it is 6.8 °C increase per in 100 year period. Also the trend shows highest increase in the temperature with strong statistical significance in the winter period which is according to trend 13°C increase in 100 years. This increasing average minimum monthly temperature trend reveals a clear fact that the temperature trend is showing a rapid increasing pattern mainly in the winter in Dhaka city. Also both average minimum and maximum temperature have shown increasing trend in the pre monsoon periods mainly in the summer season. It is seen from the trend that average minimum temperature increase of 8.6°C and average maximum temperature increase of 2.2°C in 100 years periods. However, from the World Bank data it is seen that mean monthly temperature for the month of October and November is increasing significantly in 1990-2009 period from previous 1960- 1990 period. The causes of these increases

in the temperature may be many folds including urbanization, vegetation cover change, increased vehicle emission etc. Rate of urbanization in Dhaka is following increasing trend 54.42, 61.48 and 77.36% in 1991, 2001 and 2011 years respectively [4]. Emission of CO<sub>2</sub> of Bangladesh has increased 0.2 to 0.4 MT/capita from 1995 to 2010. [7]. Dhaka city is experiencing this CO<sub>2</sub> emission more than other parts of country due to rapid urbanization [1, 3, 6]. Also a significant portion of the CO<sub>2</sub> emission is occurring from motor vehicles which are also rapidly increasing in Dhaka city [8]. However, Vegetation cover has been also decreasing in Dhaka tremendously following as it lost 75.45 square kilometer green cover during 1989 to 2010 period [9].

### CONCLUSION

The increasing trend of temperature is evident in Dhaka city from analysis of historical data of the minimum and maximum temperature. In winter season the highest amount of increase of temperature is evident. Proper measure should be taken to reduce impact of temperature rise.

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