

Examination of Temperature Variability over Lahore (Pakistan) and Dhaka (Bangladesh): A Comparative Study

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Abstract: Lahore and Dhaka are rapid expanding and over populated cities of South Asia located in Pakistan and Bangladesh respectively. The present study focuses on the evaluation of temperature variability in comparison of both cities. This study primarily aims at the assessment and examination of temperature variations in both mega cities of South Asia which are seasonal as well as the annual. The time series data were analysed by using statistical techniques Autoregressive Moving Average Model (ARMA) and Autoregressive Integrated Average Model (ARIMA). The results reveal that the minimum temperature is increasing much faster than that of the maximum temperature of both cities. However, the temperature rise (in maximum and minimum) has been observed highest during the spring seasons in both cities.

Keywords: Temperature variability, urban, mega cities, Lahore, Dhaka.

Introduction

Since 1860, the analysis of global scale data of air temperature regarding climate change documented a rise of 0.4-0.8°C. Rise in temperature leading to warming is recorded since mid-1970s. But it has been peculiarly speedy since 1983, reported the warmest 8 years (Feidas et al., 2004). According to Yue and Hashino (2003) rise in temperature is globally vacillating with significant regional variations, while substantial spatio temporal changes may prevail in various climatic zones. A thorough and extensive research has been conducted globally on climate change and temperature variability pattern due to elevated greenhouse gases, industrialization and urbanization. Trends in seasonal temperature pattern (Jeganathan et al., 2013, Punia et al., 2013, Sonali et al., 2008) impacts of urbanization, decrease in rainfall and perspective evapotranspiration, affecting cloud cover and suspended aerosols (Gadgil and Dhorde 2005; Kumar and Hingane 1998) temperature variations ranging from minimum to maximum (Tabari et al., 2011, Duhan et al., 2013) and diurnal temperature variability (Turk et al., 2004, Roy et al., 2015) have been studied in economic hubs and metropolitans. All these studies concluded that human activities have great impact on ecosystem leading to climate variability.

In Turkey, trends in spatial and temporal pattern ranging from minimum to maximum temperature and range of diurnal temperature, from 1929-1999 was recorded by Turker and Sumer (2004). In most of the regions and seasons of the country lesser warmth and cooling was noticed at maximum temperature as compared to the significant warmth at minimum temperature. Marked temporal temperature changes, in mean minimum and

maximum annual temperature, in Pune city, India from 1901-2000 was investigated by Gadgil and Dhorde (2005). Siddik and Rahman (2014) assessed the climatic sensitivity of Bangladesh and analysed a conspicuous agreeable trend per annum in minimum and maximum temperature during June–November and November–February respectively. The microclimate and minimum temperature of urban localities was initially influenced by urbanization and land use. However changes in annual temperature in urban areas were pronounced as compared to rural areas (Jeganathan, et al., 2013, Gadgil 2005; Kumar; 1988, Sajjad et al., 2009). South Asian urban areas are more in danger to global warming and climate change than any other city on earth.

Hence, analysis of the local temperature in the outgrowing urban areas, due to urbanization and industrialization, in order to compute the climatic changes is an important factor. Since temperature is the major contributing factor towards the climatic changes, temporal temperature variability trend in urban areas is an area of major interest. This study has provided a comparative assessment, analysis and investigation of temporal temperature variability in urban areas of two major cities of South Asia i.e., Lahore (Pakistan) and Dhaka (Bangladesh) on the basis of average temperature statistics at low and high extremes. In addition, it will also help to improve our understanding about factors responsible for change in urban areas temperature.

Study Area

Lahore is a fast-expanding urban city of the country and 2nd largest city in terms of population size. Geographically, the city extends between 74° 10' to

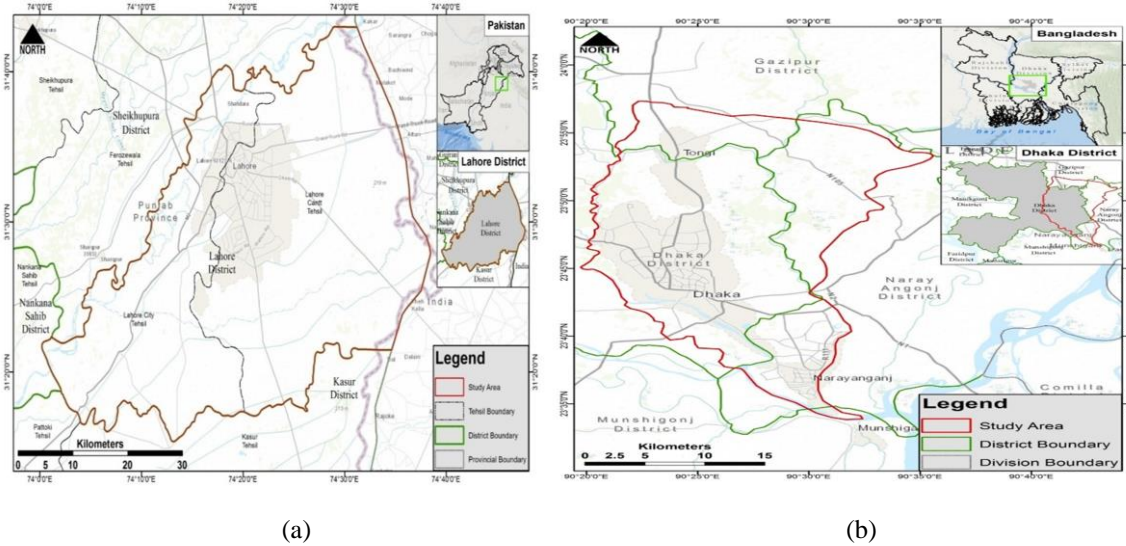


Fig.1 The location of (a) Lahore (Pakistan) and (b) Dhaka (Bangladesh) cities.

74° 39' E longitude and 31° 15' to 31° 43' N latitude in the north east of the Punjab province spread over an area of 1,772 square kilometres. Semi-arid climate leads to the hottest months of summer which are May and June. While December till February are considered the coldest months. On the basis of population size, Dhaka, the capital of Bangladesh located between 24°40' to 24°54' North latitude to 90°20' to 90° 30' East longitudes is considered the largest urban centre. The spread of Dhaka is over a 1,463.6 sq.km area. (GoB, 2011). It is located on the Bay of Bengal, where hot, humid and tropical monsoon climate conditions prevail over Dhaka. The mean monthly temperature generally remains 25 °C. However, mean monthly temperature of the coldest month (January) is 18.5 °C and it is 29 °C for the hottest month (April). The period from May - October is generally hot and humid and cold to dry since the beginning of winter in the region (November -February). The average temperature for the months of winter is 21.1°C and 7.2 °C respectively.

Material and Methods

Data Source

Present study relies on monthly mean of daily maximum and minimum temperature data for the cities of Lahore and Dhaka. The data have been gathered from Pakistan Meteorological Department (PMD-Lahore), while for the Dhaka city it has been collected from Bangladesh Meteorological Department (BMD). These data contain seasonal and annual time series without skipping any value during 1980 to 2015 for Lahore and for Dhaka from 1980 to 2013. For Lahore, the average of monthly minimum and maximum temperature data have been recorded for 36 years while in the case of Dhaka it is for over 34 years. For both fast expanding metropolis cities of South Asia (Lahore and Dhaka), Time series data have been calculated by adopting Regression method. The time

series data for these categories are employed for linear trend analysis. Standard Normal Homogeneity Test (SNHT) has been used for the homogenization of time series data before running the test for analysis. The results showed no significant or error during study period. The seasonal data of both cities are based on standardized scheme which is international season scheme

In order to observe the temperature fluctuations and variability for the selected cities: the ARMA (Autoregressive Moving Average Model) and the ARIMA (Autoregressive Integrated Average Model) has been carried out using the equation below:

$$y = c + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + e$$

“y” is the dependent variable and x_1, x_2, x_3, x_4 and x_5 are the independent variables used to find the minimum temperature in four observed seasons and annual for the Lahore and Dhaka. Further, the time series data analysis and use of Regression Model; SPSS (Statistical Package for Social Sciences) have been applied.

Results and Discussion

The annual average temperature data has shown a positive variation in annual dT_{min} in both cities. The change was quite visible in Lahore and Dhaka with temperature increase of 2.14°C for Lahore and 0.61°C for Dhaka. The dT_{max} temperature for Lahore shows a maximum temperature decrease of -0.77°C while Dhaka shows an increase of 0.34°C temperature. The dT_{min} temperature of both cities show the gradual rise in winter season. The increase in dT_{min} temperature of Lahore is observed as 1.72°C while the dT_{min} temperature Dhaka is observed as 0.95°C. Moreover, the decrease in temperature is observed during winter in Lahore and Dhaka (-0.51 °C and -1.75 °C)

respectively. The situation of spring season is entirely different which is showing the marked rise in dT_{min} and dT_{max} . The dT_{min} temperature of Lahore was observed as 3.40°C during spring and Dhaka also showed rise of 1.02°C . As the monsoon spell is experienced in both cities during summer season so the dT_{min} temperature of Lahore is showing a rise of 0.82°C , while the dT_{min} temperature of Dhaka exhibits the temperature drop off -0.24°C . The dT_{max} of Lahore is showing the drop off

1.19°C and dT_{max} of Dhaka is increasing with 0.82°C and in autumn season the dT_{min} temperature of Lahore and Dhaka are also experiencing the rise in temperature 2.63°C and 0.37°C respectively. The dT_{max} of Lahore is declining with -1.40°C but the dT_{min} of Dhaka is rising with 0.31°C . Overall in three seasons (winter, autumn and spring) the dT_{min} temperature is showing the increase inclination. So, the rise in dT_{min} indicates the temperature in urban areas

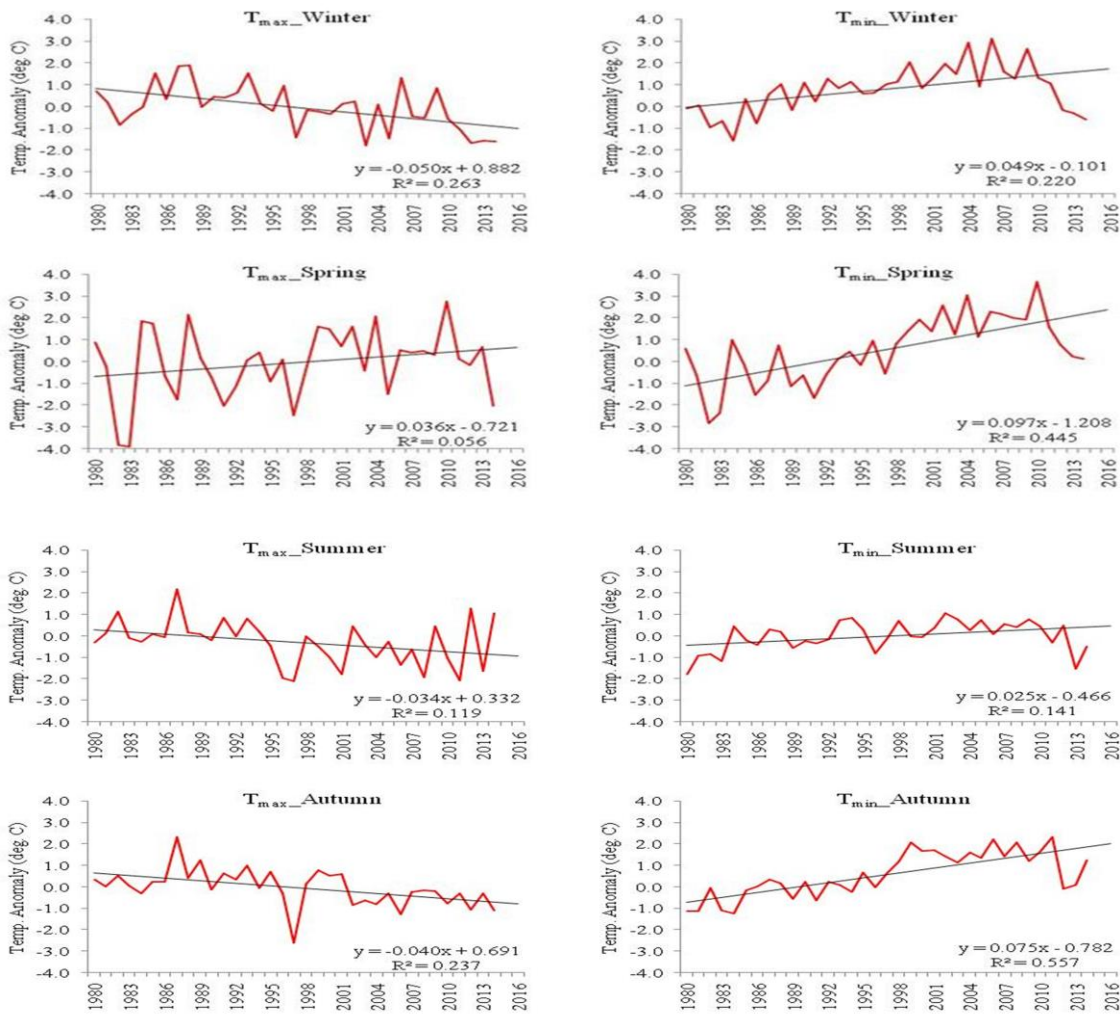


Fig. 2 Seasonal temperature of Lahore maximum (panel left) and minimum (panel right) four seasons; winter, spring, summer and autumn are computed for the period of 1980-2015.

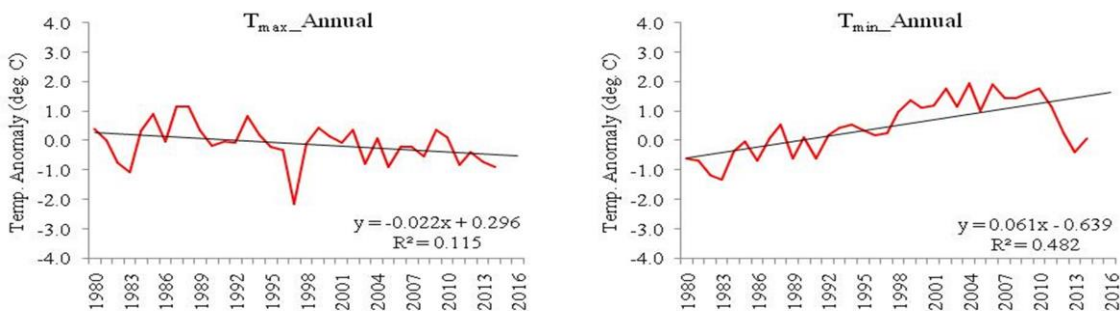


Fig. 3 Average annual daily temperature of Lahore from 1980 to 2015. Maximum temperature has been plotted on (panel left) while daily minimum on the (panel right).

is rising speedily due to rapid urbanization and anthropogenic activities. It has also been noticed that there is an overall increasing tendency of lowest minimum temperature across Lahore and Dhaka.

Table 1 Annual and seasonal variability in temperature in both study areas: Lahore and Dhaka

| Season | dT _{min} | | dT _{max} | |
|--------|-------------------|-------|-------------------|-------|
| | Lahore | Dhaka | Lahore | Dhaka |
| Annual | 2.14 | 0.61 | -0.77 | 0.34 |
| Winter | 1.72 | 0.95 | -1.75 | -0.51 |
| Spring | 3.4 | 1.02 | 1.26 | 0.85 |
| Summer | 0.88 | -0.24 | -1.19 | 0.82 |
| Autumn | 2.63 | 0.37 | -1.4 | 0.31 |

Conclusion

The results of this research highlighted the annual and seasonal average temperature which is showing a rising trend. The findings of this research are in line with analogous studies for example; Gadgil and Dhorde (2005), Sajjad et al., (2009), Sadiq and Qureshi (2010). The study showed that anthropogenic activities, and urban heat island are the major reasons of increasing daily and monthly average temperature rather than annual maximum temperature. Now-a-days, the phenomenon of climate change has become a reality. It is obvious from the results that Lahore and Dhaka show an increasing trend in annual average temperature. The annual dTmin temperature of Lahore

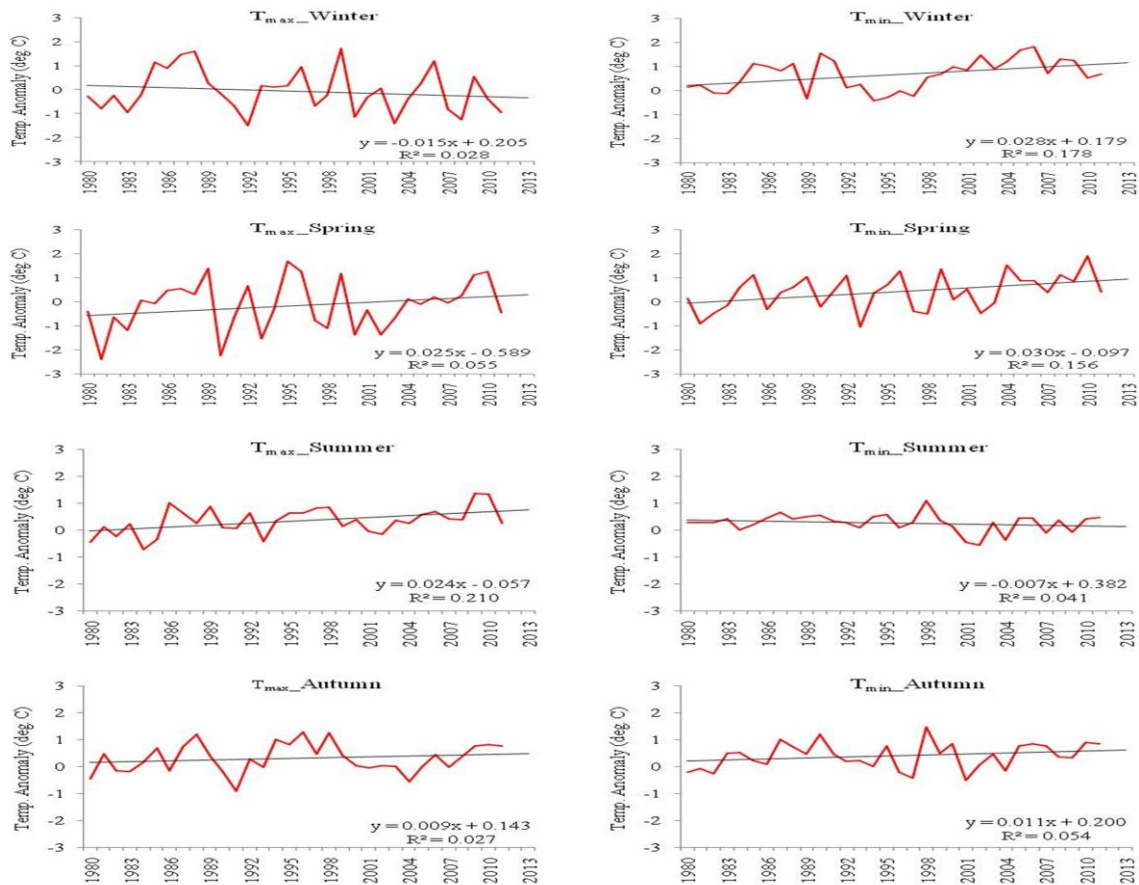


Fig. 4 Seasonal temperature of Dhaka maximum (Panel left) and minimum (Panel right) four seasons; winter, spring, summer and autumn are computed for the period of 1980-2013.

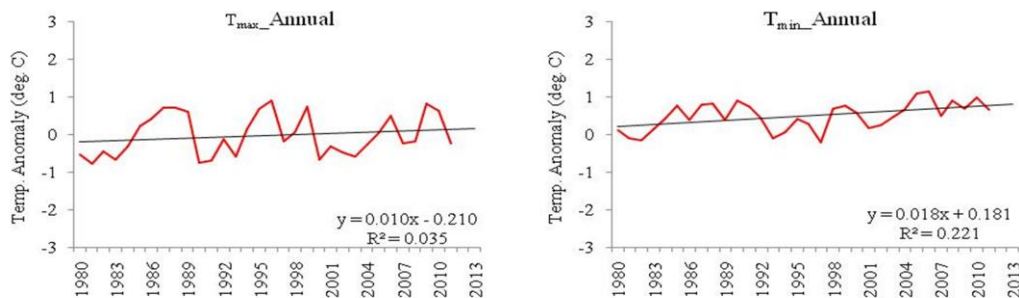


Fig. 5 Annual average daily temperature of Dhaka from 1980-2013. Maximum temperature has been plotted on (panel left) while daily minimum temperature (panel right).

is increasing as compare to dTmax.

While in Dhaka annual dTmax is showing the rising trend. In Lahore dTmin temperature is showing rise tendency in autumn season but in Dhaka dTmin temperature is showing rising trend in winter season.

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