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Analysis of Temperature Change in Capital City of Bangladesh

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Abstract

Bangladesh faces multiple manifestations of climatic change and is one of the most vulnerable countries in the world. The study was carried out based on secondary information to assess the temperature trend in Dhaka city. The study revealed that average annual and seasonal temperature in Dhaka city is in an increasing trend during last couple of decades. From 1950s to 1960s average annual temperature was remained stable (25.1^0C) which is 0.6^0C lower than baseline temperature (25.7^0C). Then, temperature increased gradually (25.4^0C in 1970s and 25.8^0C in 1980s). During 1990s annual temperature remained stable but it was 0.1^0C higher than the baseline temperature. However, during 2000s annual temperature increased 0.2^0C which is 0.3^0C higher than the baseline temperature. Proper mitigation plans and adaptation policies are inevitable to minimize the impacts of climate change.

Key words: Climatic variability, temperature change, seasonal variation, climate change

1 Introduction

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer [1]. It is a change in any statistical property of the atmosphere, such as change in mean temperature [2]. Climate change has significant impacts on the global environment and human society [3]. It is necessary to predict and understand global climate change as it is doubtlessly the single most pressing environmental issue of the world in the 21st century [4]. In order to predict these changes in climate in the future, it is unavoidable to comprehensively understand the history of climate change not only on global scale but also regionally [3]. These changes will have impact on every part of the world including different mega cities [5, 6, 7, 8]. The expansion of low density, automobile centric communities in cities throughout the world is widely recognized as a major driver of local environmental change and degradation, as well as having implications for global greenhouse emissions forcing [7]. Srivanit and Kazunori [9] argue that urban climate is a critical factor which effects regional and global climate and consequently urban liveability. So, the relationship between urban area and climate change is reciprocal. Climate change will deteriorate standard of living of residents of urban areas and increasing commercial development, increasing demand of housing and increasing number of automobiles will change global climate [10]. Anthropogenic causes responsible for global warming are expected to continue to contribute to an increase in global-mean sea level rise during this century and beyond [1, 11, 12].

Bangladesh is one of the most climate vulnerable countries in the world [13]. Located between the Himalayas and the Bay of Bengal, the country is very prone to natural disasters [14]. Climate change accelerated the intensity and frequency of occurrences of salinity, storms, drought, irregular rainfall, high temperature, flash floods, etc. that resulted from global warming [15]. There are various estimates of temperature rise in Bangladesh. Ahmed and Alam [16] reported that the average increase in temperature in Bangladesh would be 1.3^0C and 2.6^0C by the year 2030 and 2075 respectively with respect to the base year 1990. The seasonal variation of temperature will be more in winter 1.3^0C than in summer 0.7^0C for 2030 and 2.1^0C for winter and 1.7^0C for summer for 2075. Using the 1961-1990 baseline data for Bangladesh it was shown that annual mean maximum temperature will increase by 0.40^0C and 0.73^0C by the years 2050 and 2100 respectively. The mean minimum temperature will correspondingly rise by 0.04^0C and 0.08^0C. But the mean annual temperature will increase by 0.22^0C and 0.41^0C respectively [17]. The implications of the impacts of global warming for Bangladesh are highly significant because of the probability of sea level rise in the total climate change scenario [4]. During past couple of years several comprehensive studies have been done in Bangladesh on climate change issues and their potential impacts in the country [4]. These studies are complimented by the Yamane *et al.*, [3] where it is argued that climate

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change can affect the variability, frequency and magnitude of meteorological disasters. Therefore, it is especially important to understand the potential climate change in Bangladesh. But there have been very little researches focusing on climate change and impacts on Dhaka city. Most of the researches are based on whole Bangladesh or on coastal areas of Bangladesh. Yamane *et al.,* [3] have conducted a research to analyze the trend of temperature and rainfall in Dhaka city. Dhaka City has experienced extreme growth in its population, infrastructure, commerce etc. in the recent decades [18]. This rapid growth of population and unplanned infrastructural growth linked up themselves with the formation of microclimate and urban heat island and thus contribute to global climate change. The present study deals with long term temperature data from 1953 to 2010. The study focuses on daily mean temperature as Michael *et al.,* [19] argue that daily mean temperature is generally used as a universal measurement for climate change. Moreover the present study tries to show decade wise change of annual and seasonal temperature to understand and predict climate change in Dhaka city.

2 Methodology and data sources

Climatic study is a long term study. It usually requires the observations and collection of data for a period of about two to three decades for measuring actually what is going on in the climate condition. Hence, it is very difficult to use primary data for any scientific inference. In the present study, the secondary data has been extensively used to investigate the ongoing changes (although very infinitesimal) of the climate. The study area was selected purposively. The study was conducted based on secondary information. Seasonal temperature data are taken from a research conducted by Yamane *et al.,* [3]. They tried to identify climatic variability of Dhaka city by using 3 hourly daily temperature data from 1953 to 2008. Temperature data of 1974 were not available. For 2009 and 2010, temperature data are collected from Bangladesh Meteorological Department (BMD has one weather station in Dhaka city). Normal maximum temperature, normal minimum temperature and normal mean temperature data are collected from BMD.

The study has used the methodologies used by Yamane *et.al.,* [3]. These methods were used for the temperature data of 2009 and 2010. The study has showed decade wise change of seasonal and annual temperature from 1953 to 2010. The study has divided these years into six decades from 1950s to 2000s. Decadal average temperature is calculated if 7 year's data are available of a decade. IBM statistics 20 is used to calculate and this calculation considers the unavailable data as missing values. Base line climate values are defined to compare it with decadal average temperature. Yamane *et.al.,* [3] has defined base line climate of Dhaka city as the mean values between 1972 and 2000. The present study deals with seasons. Generally in Bangladesh we divide the 12 months in six seasons. But some of the seasons have very little distinguishable characteristics. So this study has considered four seasons, namely; pre-monsoon (March- May), monsoon (June-September), post-monsoon (October- November), and winter (December- February) [3].

3 Results and Discussion

3.1. Pattern of Seasonal Temperature in Dhaka City

Normal maximum temperature in pre monsoon season was 33.0^{0}C followed by 31.7^{0}C in monsoon, 30.6^{0}C in post monsoon and 26.6^{0}C in winter respectively. Normal minimum temperature in monsoon season was 26.1^{0}C followed by 22.8^{0}C in pre-monsoon, 21.5^{0}C in post monsoon and 14.1^{0}C in winter season respectively. Moreover, normal mean temperature in monsoon season was 28.6^{0}C followed by 27.5^{0}C in pre-monsoon, 26.0^{0}C in post monsoon and 20.2^{0}C in winter season respectively (Figure 1).

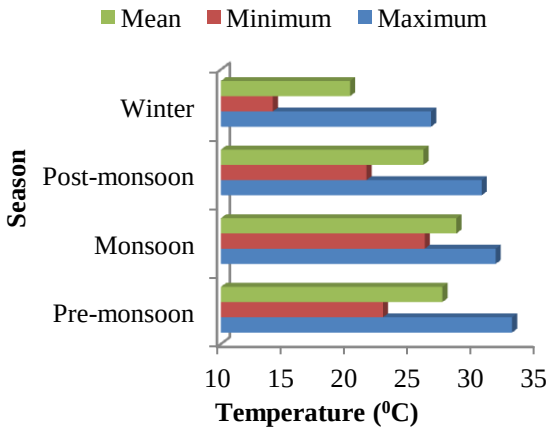

Figure 1: Seasonal variation of maximum, minimum and mean temperature of Dhaka city (Source: [20])

3.2. Decadal trend of seasonal temperature in Dhaka City

3.2.1. Pre-monsoon season

The study revealed that during last three decades the pre-monsoon temperature increased from 27.6^{0}C in 1981-1990 to 28^{o}C in 2001-2010 (Figure 2 & 3). The baseline temperature for pre monsoon season is 27.6 ^{0}C.

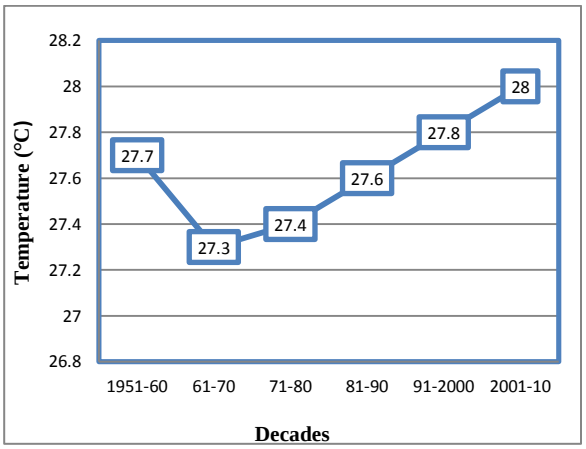

Figure 2: Decadal trend of pre monsoon temperature in Dhaka city (Source: [3, 20])

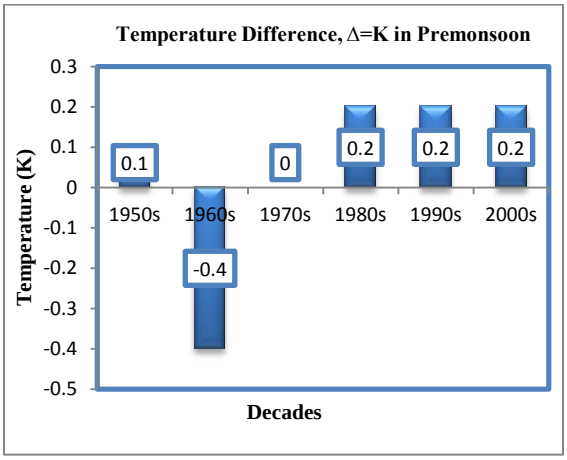

Figure 3: Deviation of pre-monsoon temperature from baseline (Source: [3, 20])

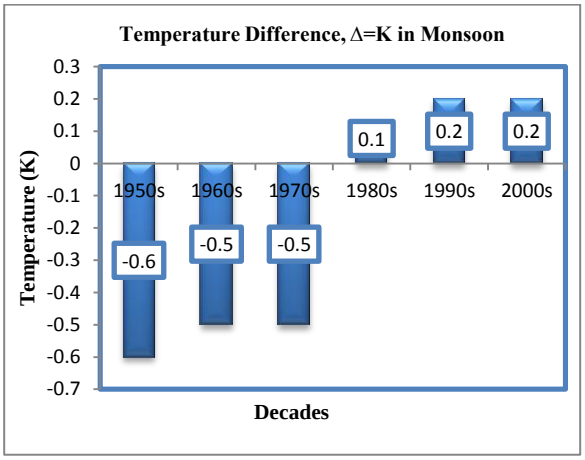

Figure 5: Deviation of monsoon temperature from baseline (Source: [3, 20])

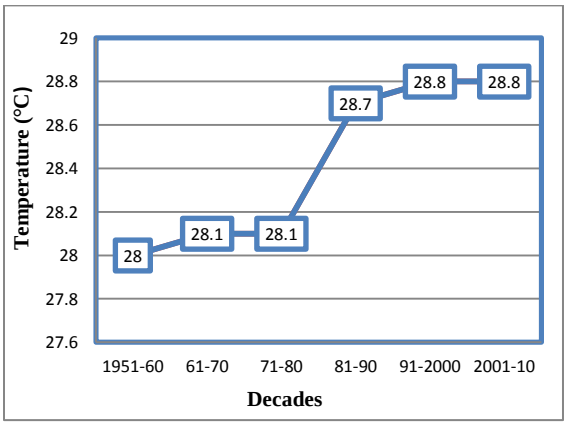

Figure 4: Decadal trend of monsoon temperature in Dhaka City (Source: [3, 20])

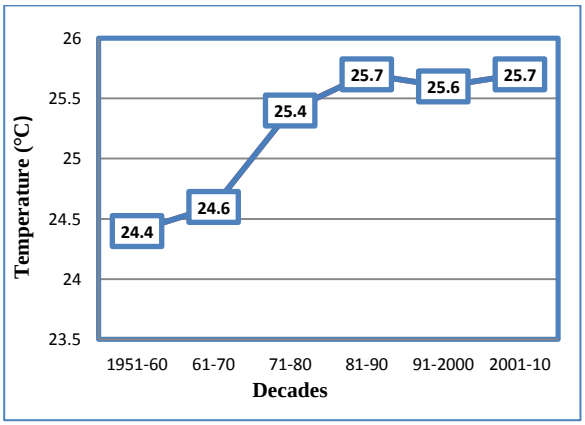

Figure 6: Decadal trend of post-monsoon temperature in Dhaka City (Source: [3, 20])

3.2.2. Monsoon season

The study showed that average temperature of monsoon season in Dhaka city was increased from 28^{0}C in 1950s to 28.1^{0}C in 1960s and over the next one decade monsoon temperature remained stable. However, from 1970s to 1980s monsoon temperature increased gradually from 28.1^{0}C in 1970s to 28.7^{0}C in 1980s. The study also revealed that in between 1991 to 2010 average monsoon temperature in Dhaka city was 0.2°C higher than the baseline temperature (28.6^{0}C). Moreover, during recent two decades the monsoon temperature increased 0.1^{0}C (Figure 4 & 5).

3.2.3 Post Monsoon Season

The study showed that average temperature of post monsoon season in Dhaka city was increased from 24.4^{0}C in 1950s to 25.7^{0}C in 1980s. However, from 1980s to 1990s post monsoon temperature declined by 0.1^{0}C which again increased 0.1^{0}C in 2000s (Figure 6). Baseline temperature was 25.6°C and in the decade of 2000s the average temperature of post monsoon season was 0.1°C greater than the baseline temperature (Figure 7).

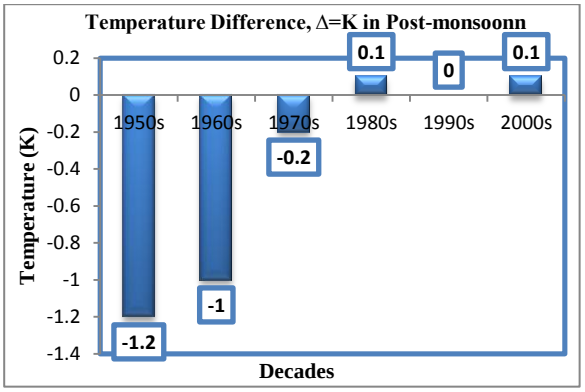

Figure 7: Deviation of post monsoon temperature from baseline (Source: [3, 20])

3.2.4. Winter season

The study showed that average temperature in winter season in Dhaka city was decreased from 19.3^{0}C in 1950s to 19.2^{0}C in 1960s. However, from 1960s to 1980s winter temperature increased by 0.9^{0}C which again fallen 0.3^{0}C in

1990s. Moreover, in recent decades winter temperature increased 0.6° from the baseline (Figure 8).

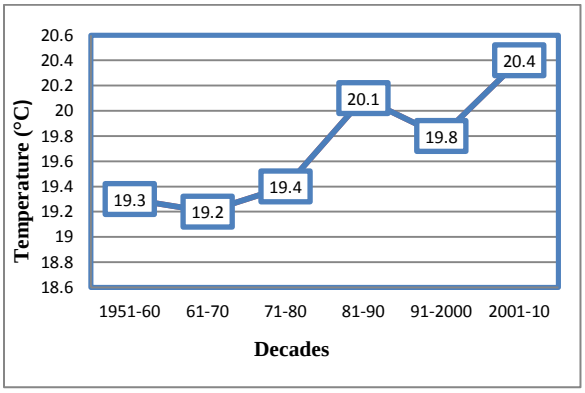

Figure 8: Decadal trend of winter temperature in Dhaka City (Source: [3, 20])

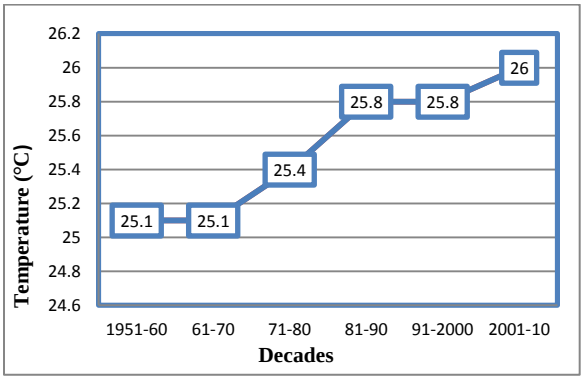

Figure 9: Decadal trend of average annual temperature in Dhaka City (Source: [3, 20])

3.3. Decadal trend of average annual temperature in Dhaka City

The study revealed that average annual temperature in Dhaka city was in increasing trend. From 1950s to 1960s average annual temperature was remained stable (25.1^0C) which is 0.6^0C lower than baseline temperature (25.7^0C). Then temperature increased sharply (25.4^0C in 1970s and 25.8^0C in 1980s). During 1980s to 1990s annual temperature remained stable but it was 0.1^0C higher than baseline temperature. Finally during 2000s annual temperature increased 0.2^0C which was 0.3^0C higher than baseline temperature (Figure 9).

3.4. Change of temperature in Dhaka city and its relationship with different factors

The study revealed that average annual temperature, and average seasonal temperatures were in an increasing trend during last couple of decades. Annual average temperature and seasonal temperature started to exceed the baseline temperature from the 1980s although base line temperature was not constant. But from 1980s temperature exceeded than the average value. In the most cases sharp rise was seen from either 1980s or 1970s. Since this period the trend of increase has become a common issue. These increases may have relationships with issues like; global climate change, rapid population increase, infrastructural development, decrease of urban open spaces and vegetation coverage, increase in the rate of anthropogenic heat generation. Actually these issues are inter-related. Population growth can trigger infrastructural development and increase the rate of anthropogenic heat. Yamane *et al.*, [3] identified that global temperature increase rate is 0.9°C but in Dhaka city it is 1.9°C, almost double. Population change and its aftermath may have positive relationship with the increase of temperature. The present study revealed that during last 59 years population in Dhaka city has increased 13,894,000 and decadal increase rate was 23,54,915. From 1951 to 1981 decadal population increase was below the average rate. In the 1980s sharp population increase started. Similar trend was also observed in case of temperature increase. Actually this increase of population may have triggered the infrastructural development in Dhaka city. It diminished green spaces and structured areas increased dramatically. It may have relationship with the development of microclimatic condition and heat island in Dhaka city.

4 Conclusions

Climate change is now a reality and on the verge of a tipping point. The consequences of climate change are dreadful and they are already taking place. Floods and cyclones are getting more frequent, storms and tidal surges are getting tougher and land droughts are getting longer.

Table 1: Trend of population change and annual temperature change in Dhaka city (Source: [20, 21])

Year	Population	Increase (population)	Decade	Average Annual Temperature (^{0}C)	Increase (^{0}C)
1951	3,36,000	--	1951-1960	25.1	-
1961	5,57,000	221,000	1961-1970	25.1	0
1974	17,74,000	12,17,000	1971-1980	25.4	0.3
1981	34,40,000	16,66,000	1981-1990	25.8	0.4
1991	68,44,000	34,04,000	1991-2000	25.8	0
2001	107,10,000	38,66,000	2001-2010	26.0	0.2
2010	142,30,000	35,20,000	2011-2020	-	-

The melting of the ice caps in Greenland and the Arctic is picking up pace and hence, sea levels are rising. The terrestrial and aquatic ecosystems are shrinking and habitats of plants and animals are threatened, and sustainable crop production is under stress. It is agreed by scientists around the world and Intergovernmental Panel on Climate Change that Bangladesh is one of the most victimized countries of the world due to the climate change. Northern part of Bangladesh is gradually going to be desert with continued drought. At the same time southern part of Bangladesh

affected by frequent cyclone, tidal surge and soil and water salinity. Six seasons of Bangladesh now reduced to three seasons; summer, rainy and winter. But those three does not continue to function with as usual rules; during summer it is so hot, during winter it is unbearable cold. Cold is regularly breaking old record and making new records. It is expected that sooner people will see snowfall in Bangladesh. Therefore, it is high time to take urgent action to address climate change. Adaptation and mitigation are two options for Bangladesh. Of which, the first one is country specific, or even local specific, but mitigation demands communal efforts of global communities. Development of adaptation policies for different sectors will help Bangladesh to face the crucial natural and anthropogenic hazards. Proper mitigation plan and formulating adaptation policies are emerging need to minimize the impacts of climate change.

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