

Urbanization and Microclimatic Change of Dhaka City

**Sohag Chandra Roy
Md. Asaduzzaman
Israt Jahan**

Introduction

The global climate is changing and it is likely to change further over coming decades due to increasing concentrations of 'greenhouse gases' in the earth's atmosphere caused largely by human activities. This will result in greater variations in weather pattern, a greater frequency of extreme weather events, such as floods, droughts and tropical storms, and gradual rises in average temperatures and sea levels. Bangladesh is extremely vulnerable to climate change impacts because of its geographical location, high population density, high levels of poverty, and the reliance of many livelihoods on climate-sensitive sectors, particularly rural agriculture and fisheries. Climate change, therefore, threatens both previous achievements and future efforts to reduce poverty in Bangladesh due to problems related to water and food security and damage to essential infrastructure during more frequent disaster events.

Introduction

According to the 1991 census, urban population growth rate in Bangladesh was 5.4 percent with 6.8 percent of area expansion per annum (1981-1991). At that time, urban population was about 22 million, i.e. 20.1 percent of total population of the country (BBS, 1997). By the year 2001, it increased to 28 million (nearly 23.4 percent of national population), which indicates that urban population growth rate, in the last 10 years (1991-2001), was about 3.2 percent per annum (BBS, 2001). United Nation's Human Settlements Programme projected that Bangladesh might have 4.5, 3.6 and 2.8 percent urban population growth rate in the year of 2000, 2015 and 2025 respectively (UN, 1999).

Rapid urbanization of Dhaka City without considering the geological aspects has brought significant changes in the geo-environment of the Dhaka City. Land filling, water logging, pollution, and changes in the hydro-geological system, localized land subsidence and building collapse are the hazards associated with these change in the geo-environment. In the process of urbanization, Dhaka city has increased its population, different structure, transport services, industrialization etc. In the addition, removal of vegetation, construction of buildings, roads, pavement and other human transformations of the natural environment, together with direct heat generation from human activity, are known to cause the temperatures of urban areas to rise above those of surrounding rural areas.

According to the Bangladesh Meteorological Department in 2003, the maximum and minimum temperature of Dhaka City was 30 °C and 22 °C respectively but in 2004 it becomes 31°C and 22°C respectively. In 1995, the total annual rainfall was 1752 millimeters, which becomes 2351 millimeters in 2004. In 1993, annual average relative humidity was 77 percent, which in turn becomes 72 percent in 2004. In 1961-92, the annual average sunshine was 7.5 hours per day but in 1992-2004 it reduces to 6.2 hours per day (Ahmed, 2006). As a result of rapid and unplanned urbanization and population growth, the microclimatic factors are changing unevenly, which cause environmental degradation of the city. It also contributes to increase emission of hazardous gases like CFC, CO etc. Urbanization contributes to climate change because rich urbanites produce more greenhouse gases than poor rural people.

For changing pattern of the weather condition, it poses the risk of natural disaster like flood, temperature rising, rainfall fluctuation etc. The climatic condition of the Dhaka city can be improved by planned and organized urbanization processes, which are essential to protect the city from unexpected natural hazard.

Analysis

The nature and characteristics of urbanization has remained similar to the pattern during the British period despite the growth in the urban population (CUS, 1976). There was no significant industrialization in this part during the first half of Pakistani rule. The most phenomenal urban population growth in Bangladesh occurred during the 1961-74 inter-census period. Over 6 million people were living in urban areas constituting roughly 8.0 percent of the total population (BBS, 1987). Thus the percentage of increase of the urban population during these 13 years was striking. That accelerated growth is to a great extent the result of the very recent influx from rural villages. The growth rate of the urban population was 5.4 percent during the 1981-1991 (BBS, 1997). The total urban population increased to 28.6 million by 2001 (BBS, 2003).

Trend Analysis of Urbanization in Dhaka City

Dhaka City has emerged as a fast growing mega city in recent times. It began with a manageable population of 2.2 million in 1975, which reached 12.3 million in 2000. The growth rate of the population during 1974-2000 was 6.9 percent (UN, 1998). There is no city in the world, which has experienced such a high growth rate in population during this period. The United Nations (1999) describes the rapid population growth of this city as 'exceptional'. The growth rate of Dhaka City's population will also continue to remain high. During 2000-2015 it is expected to grow at a 3.6 percent annual growth rate and reach a total population of 21.1 million in 2015. This will put it in 4th position on the list of the world's mega cities (UN, 1999). Furthermore, the population density in Dhaka City was 4813.09 per sq.km. in 1951 which become 8496.73 per sq. km. in 2005. It indicates that, the population density in Dhaka city is increasing. But, in 1981-1991, it decreased and after that it continued to increase.

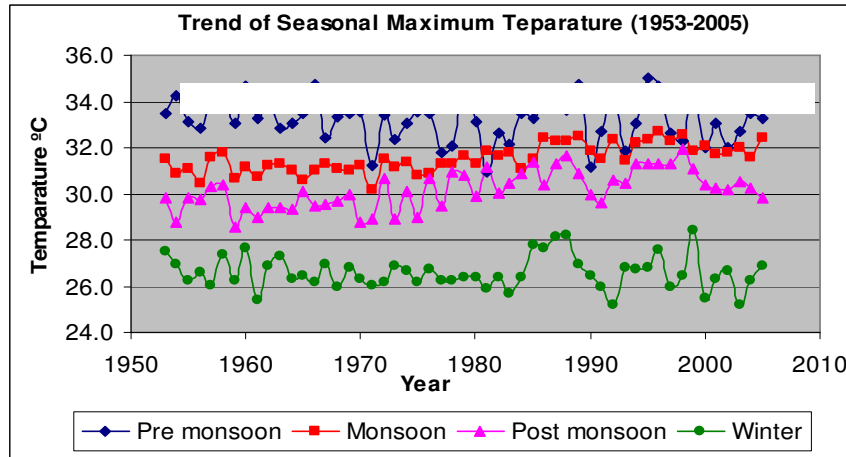
Microclimatic Variable Analysis

As a mega city, Dhaka is now growing up its area, population, and infrastructure etc. deliberately or haphazardly, which directly or indirectly affect the microclimatic condition of this city. In this section the following different microclimatic variables are analyzed:

- Temperature
- Rainfall
- Relative Humidity
- Bright Sunshine

Temperature: Urbanization in general and desertification could have contributed only a small fraction of the overall global warming, although urbanization may have been an important influence in some regions. In 1953-1963, the average annual maximum temperature was 30.4 °C, which becomes 30.6 °C in 1997-2005. But in 1986-1996, the average annual temperature was 31 °C. It is the evidence of temperature increase but slowly. Nevertheless, the highest maximum temperature of Dhaka City was in pre monsoon season in 1990-2000 and the lowest maximum temperature was in winter season in 1990-2000. In 1953-1963, the average minimum temperature was 20.82 °C, which becomes 21.76 °C in 1997-2005. It proves that, the minimum temperature is increasing. Moreover, the highest minimum temperature of Dhaka City was in monsoon season (1995) and the lowest minimum

temperature was in winter season (1955). In pre monsoon and post monsoon season, the minimum temperature exists between 20 °C -24 °C.

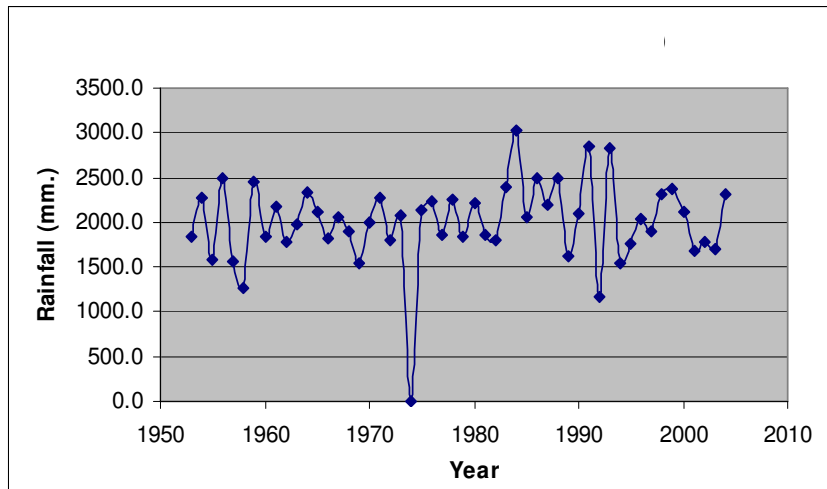


Source: BMD, 2008.

Fig. 2: Trend of Maximum Temperature of Dhaka City

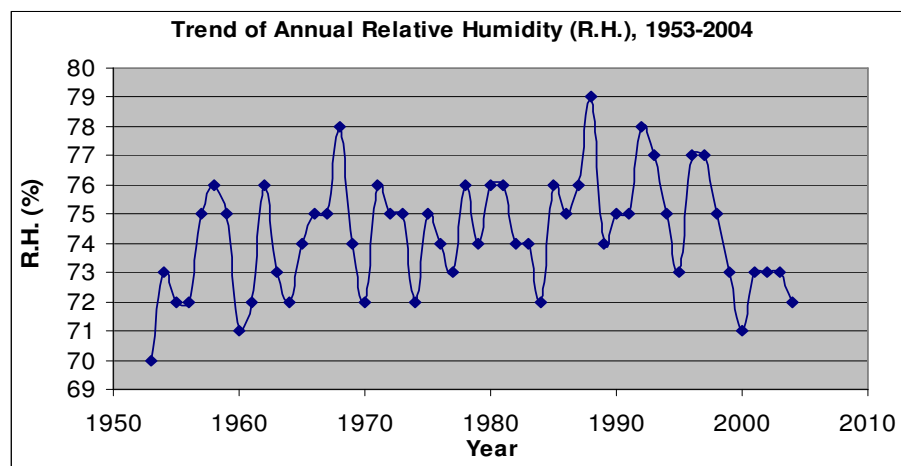
Rainfall: Rainfall is the imperative variable for microclimatic change measurement. In Dhaka City the average annual rainfall is 2002 mm. In 1953-1963, the average annual rainfall was 1927.3 mm, which becomes 2023mm. in 1997-2004. The average annual rainfall varies from season to season. In this section we are discussing about different annual and seasonal variation of rainfall. In Dhaka City the highest amount of rainfall is taken place in monsoon season while in winter season there is very little amount of precipitation. Normally in monsoon season the total rainfall trend line is increasing, which is the evidence of increase growth of rainfall. During the last 52 years the precipitation increase 381 mm. In pre monsoon season the total rainfall pattern is fluctuating in Dhaka City. In 1953, the total rainfall was 364 mm. which was 877 mm. in 1988. In this season floods has occurred over the country. In 1998, the total rainfall had increased but not such level of 1988. After that, the amount of rainfall is decreasing. However, in post monsoon season the amount of rainfall of Dhaka City is decreased. In this season the rainfall amount exist between ranges of 100mm. to 400 mm. In 1954 the post monsoon rainfall was 14 mm. which become 45 mm. in the year of 2004. Like post-monsoon, the rainfall is decreasing in winter. But in 1957 it suddenly raised to 150 mm. and in 1992 it was 157mm. Beyond these facts the precipitation pattern remain normal in the winter season in Dhaka City.

Relative Humidity (RH): For detail relative humidity analysis here we are presenting the different seasonal relative humidity trend of Dhaka City. The pre monsoon season the highest relative humidity was 78.33 percent in 1993. This figure presenting that the relative humidity at different year is varying. These variations are occurred for the pollution level of Dhaka City which ultimate result of unplanned urbanization and development. In pre monsoon season the relative humidity are decreasing over the year in Dhaka City. In the monsoon season relative humidity remain same as pre monsoon season at Dhaka City. But here we should mention that, in monsoon season the relative humidity is fluctuating in different year over the Dhaka City. In 1980-1990, the relative humidity had upward but after that it started to decrease.



Source: BMD, 2008.

Fig. 3: Trend of Annual Rainfall of Dhaka City

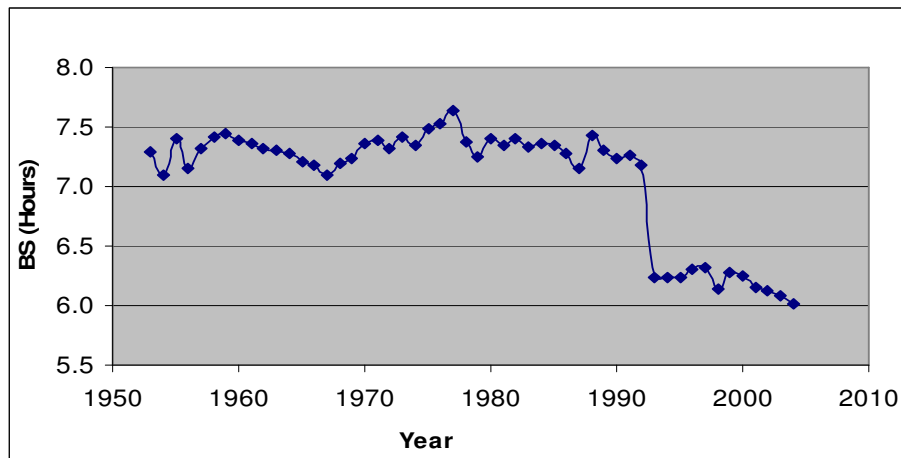


Source: BMD, 2008.

Fig. 4: Trend of Annual Relative Humidity of Dhaka City

In post monsoon season the relative humidity of Dhaka City is existing normal condition. The trend of post monsoon relative humidity of Dhaka City is presenting in following. In this we can see that, in 1953 the relative humidity was 69.67 percent which become 71.67 percent in 2004. From this data we can easily understand that the relative humidity is increased 2 percent over the 51 years. In winter season relative humidity remains over 70 percent averagely. In earlier of 1953, the average relative humidity was below 70 percent but in 1960 it becomes above 70 percent. After that it remains increasing up to 2000. But suddenly it started to decrease after 2000. In 2004, the relative humidity was 72 percent. So that we can say that, over the 51 years the relative humidity increases 2 percent. From the above figure 1.4 we can easily understand that, in 1953 the annual average relative humidity was 70 percent which becomes 72 percent after 2004. Here it indicates that, over the 51 years the relative humidity increases 2 percent. But in different year it is fluctuating in Dhaka city.

Bright Sunshine: Bright Sunshine is another variable from which we can easily understand the actual microclimatic condition of Dhaka City. In 1953-1963, the average bright sunshine was 7.3 hours which becomes 6.2 hours in 1997-2004. It indicates that, the bright sunshine is decreasing. We can easily understand that, the bright sunshine existed in a satisfactory level up to 1992. After that, it is decreased. In 2004, the average annual bright sunshine of Dhaka City is 6 percent which was 7.3 in 1953. From this statistics we can easily say that, the bright sunshine level of Dhaka city is decreasing.



Source: BMD, 2008.

Fig. 5: Trend of Annual Bright Sunshine of Dhaka City

Spatio-Temporal Analysis of Dhaka City

Urban built-up areas of Dhaka City are expanding almost in all directions around some urban centers. The major urban centers are Dhaka City Corporation (DCC), Narayanganj, Gazipur, Savar and Tongi municipalities. All of these urban centers are expanding rapidly with the pressure of increased population. Industrialization is playing a vital role in defining the built-up pattern of the region (Basak, 2006). Since 1971 the pressure on Dhaka has been enormous. The city registered a steady growth in the number of residents. It was calculated that between 1983 and 1991 some 14,000 acres of land were converted to urban use within Dhaka Statistical Metropolitan Area (Nabi and Hashem, 2007). Along with it the water bodies and low lands are being filled up gradually to meet the ever-increasing demand of land for housing and other purposes. In addition, there is large floating population the pressure of which has resulted in the growth of slums in all vacant pockets in between the built-up areas (Basak, 2006). It can also be seen that while urban built-up areas are increasing, water and agricultural areas are decreasing. This indicates that new urban built-up areas are developing on filled up water bodies or on agricultural land in most of the cases.

Table 1: Spatio-temporal trend of Dhaka City

Land cover	1989	1999	2003
Water	40.14	28.42	19.65
Vegetation-1 ¹	16.76	12.66	24.33
Vegetation-2 ²	29.57	26.00	28.24
Earth Fill or Sand	0.83	0.50	0.91
Built-up Area	2.01	3.60	4.28
Bare Soil	10.69	28.82	22.60

Source: Basak, 2006.

Major Findings

Like any other mega city in the world the microclimatic condition of Dhaka City is also changing. In microclimatic change, urbanization plays an important role. The major findings of microclimatic variable analysis are as follows:

- There has been seen a significant change in temperature pattern of Dhaka City. In 1953, the annual average maximum temperature was 30.7 °C, but in 2005 the temperature increase to 30.8 °C. That is after 51 years, the maximum temperature is increased by 0.1 °C. On the other hand, the minimum annual average temperature was 20.87 °C in 1953, which become 22.42 °C in 2005. That means the minimum annual average temperature rise 2.45 °C within the last 51 years.
- There also have been seen changes in seasonal maximum and minimum temperature pattern in Dhaka City. In pre monsoon season maximum annual average temperature is decreased by 0.2 °C while minimum annual average temperature increased by 0.48 °C within the last 51 years. In monsoon season the maximum annual average temperature is increased by 0.9 °C and minimum annual average temperature is increased by 0.89 °C during the last 51 years in Dhaka City.
- In post monsoon season, there is no significant change in the maximum annual average temperature during the period of 51 years in Dhaka City. But the minimum annual average temperature has been increased by 2.05 °C during the last 51 years in Dhaka City.
- In winter season, the maximum annual average temperature have been decreased by 0.6 °C while minimum annual temperature have been increased by 3.15 °C during the period of 51 years in Dhaka City.
- In precipitation pattern there has also been changing record in Dhaka City. During the last 51 years, the amount of annual total rainfall has been increased by 485 mm. in Dhaka City. Where in monsoon season, the annual total rainfall has been increased by 381 mm. during the last 51 years in Dhaka City.
- In pre monsoon season, the total rainfall is decreased by 35 mm. during the same period in Dhaka City. But yearly fluctuation is occurred during the pre monsoon season. On the other hand, in post monsoon season, the rainfall increased by 139 mm. during the same in Dhaka City. Similarly in winter season, the total annual rainfall amount has been increased by 31 mm. during the last 51 years in Dhaka City.

¹ Vegetation-1: Mainly rural settlement, urban fringe and high class residential area & park

² Vegetation-2: Agricultural Land

- The annual relative humidity has been increased by 2 percent during the last 51 years in Dhaka City. Similarly, the seasonal relative humidity has also been changed. In pre monsoon, monsoon, post monsoon and winter season, the relative humidity has been increased 2 percent during the last 51 years.
- The bright sunshine pattern usually shows how much we pollute or disturb our nature or environment. During the last 51 years, average annual bright sunshine was decreased by 1.3 hours per day. Nevertheless, in different seasons, this amount varied in Dhaka City. In pre monsoon, the average annual bright sunshine amount decreasing by 1.33 hours per day while 1.07 hours per day in monsoon season during the last 51 years.
- In the post monsoon, the average annual bright sunshine amount has been decreased by 0.6 hours during the last 51 years in Dhaka City. The deviation was highest during the period of winter season (2.13 hours per day) in Dhaka City.
- From the very beginning of the industrialization, unplanned and haphazard urbanization have been occurred in Dhaka City. As a result, the Dhaka City becomes the more population concentrated city in Bangladesh. To meet the pressure of increasing population, Dhaka City has developed its surroundings in a way of spontaneous development. Because of these spontaneous developments, Dhaka City had loosed its environmental beauty and it goes to a dangerous environmental condition. We can comment that the built area is increasing in here and there by side and centre point of the Dhaka City. As a result, Dhaka City have been losing its beauty of nature and ultimately vegetation decreasing and temperature increasing. From this point of view, urbanization or rapid population growth is ultimately responsible for this microclimatic change.

Recommendations

The microclimatic condition of Dhaka City is most vulnerable for the pressure of urbanization. The global impact of greenhouse gases and pollution is also implied on us. For that sack our cities became more vulnerable in economic, service taking and giving and so many other ways. So it is the time to make people aware about the impacts of climate changes and different management activities to minimize the vulnerability of the people and the nations. Nevertheless in the context of microclimatic effect on Dhaka City, following recommendations have been proposed:

- Capacity building and promoting partnerships
- Coordinated institutional responses to climate change
- Different projects initiatives
- Increased budget for climate change activities
- Climate change science and technology integration

Conclusion

Climate change is the most talked issue in our global environment in present days. Noticing this issue, world environmental scientist is getting anxious day-by-day. To get ride from the impacts of climate change several policies, projects and agreements have been taken globally, regionally and locally. We should keep in mind always the climatic issue when we intrude any type of development.

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