IMPACT OF CLIMATE CHANGE ON RAINFALL INTENSITY IN BANGLADESH

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ABSTRACT

Being one of the most vulnerable countries of climate change induced disasters; Bangladesh is facing some basic and major changes in its climatic behavior and weather pattern. Now a day, erratic rainfall becomes very common in Bangladesh. The overall objective of this paper is to assess the present trend of high intensity rainfall and compare it with the predicted future trend and gather information on the effect of climate change on rainfall pattern and intensity. A trend analysis over Dhaka city during the last 67 years (1953-2009) shows a decreasing trend of about 0.0154 mm per year. But the trend of the last 30 years (1979-2009) is found to be increasing at a rate of 2.7 mm per year. Interestingly, ignoring the rainfall data of last ten years shows a decreasing trend of 1.06 mm per year. Records show that the more extreme events occurred over the last five years. The rainfall intensity of greater than 100mm is more frequent than rainfall intensity of greater than 125 mm. Although the rainfall intensity of greater than 150mm occurs infrequently but data from Bangladesh Meteorological Department (BMD) of last five years shows that the severity of this type of rainfalls increases. The mean daily predicted rainfall over the Dhaka city using PRECIS Regional Climate Model from 1951 to 2100 and observed by the station from 1953 to 2009. The trend of predicted rainfall is found increasing at a rate of 0.014mm per year whereas the observed rainfall also shows an increasing trend of 0.0103mm per year. The trend of predicted monsoon rainfall is about 0.1214mm per year and that of observed monsoon rainfall is 0.0033mm per year. It has been found that extreme rainfall events over the Dhaka city have increased over the last decade. Both regional climate model and observed data show increasing trends of rainfall. Hence, the climate change will impact the extreme rainfall events of the city.

Key Words: *Climate Change, Rainfall intensity, Extreme event, Global Climate Model, Regional Climate Model, PRECIS.*

1. INTRODUCTION

Bangladesh's unique geographic location, with the Indian Ocean to the south, the Himalayas to the North and the prevailing monsoons, has made it one of the wettest countries of the world. The mean annual rainfall is about 2320mm, but there are places with a mean annual rainfall of 6000mm or more (Hossain *et al*., 1987). A long duration of heavy rainfall associated with "norwester" thunder storms is very common in Bangladesh (Hossain *et al*., 1987, Rafiuddin *et al*., 2009). In September 2004, 341mm rainfall occurred in 8 hours in Dhaka which led to severe urban flooding (Ahmed, 2008). Serious drainage congestion took place in Dhaka city due to 333mm rainfall on 28th July, 2009 (Uddin, 2009). On that day around 290mm rainfall occurred in six hours. On 11 June, 2007 around 408 mm rainfall was measured in Chittagong that resulted in landslide killing at least 124 people (Uddin, 2009).

According to the fourth assessment report of IPCC the mean temperature of the earth has been increasing at a rate of 0.74 degree centigrade per century (IPCC, 2007). It is also found that climate change has profound impact on rainfall intensity and variability (Wasimi, 2009). Global Climate Models showed that global warming will increase the intensity of extreme precipitation events (Allan and Soden, 2008). Regional projections also revealed that climate changes would strengthen monsoon circulation, increase surface temperature, and increase the magnitude and frequency of extreme rainfall events. Regional climate models predict a large increase in annual precipitation although the more recent PRECIS run showed that the dry

season is becoming drier and water deficit is increasing due to population growth (Fung *et al*., 2006). Therefore, climate change will certainly bring changes to rainfall pattern.

Rainfall pattern will change due to global warming although the exact degree of change is not yet determined. This change will affect fresh water supplies that have already been stressed due to rising population and increased per capita consumption. This will cause more difficulty in estimating extreme rainfall events since there will no longer be a homogeneous series of values which can be extrapolated statistically. However, it is expected that higher extreme events will occur than before (Linarce, 1992).

2. METHODOLOGY

2.1 Study Area

The Greater Dhaka is situated at 23°40" N to 23°54" N latitude and 98°20" E to 90°31" E longitude having an area of 258.78 sq. km (figure 1(a)). The Greater Dhaka is bounded by the Balu River on the east, the Tongi khal on the north, the Turag-Buriganga Rivers on the west and the Dhaka-Chittagong Road cum embankment on the south, this area includes both flood protected western Dhaka and unprotected eastern Dhaka (Ahmed, 2008) as shown in Figure 1(b). There are more than 40 khals in Dhaka city to drain the runoff to the surrounding rivers.

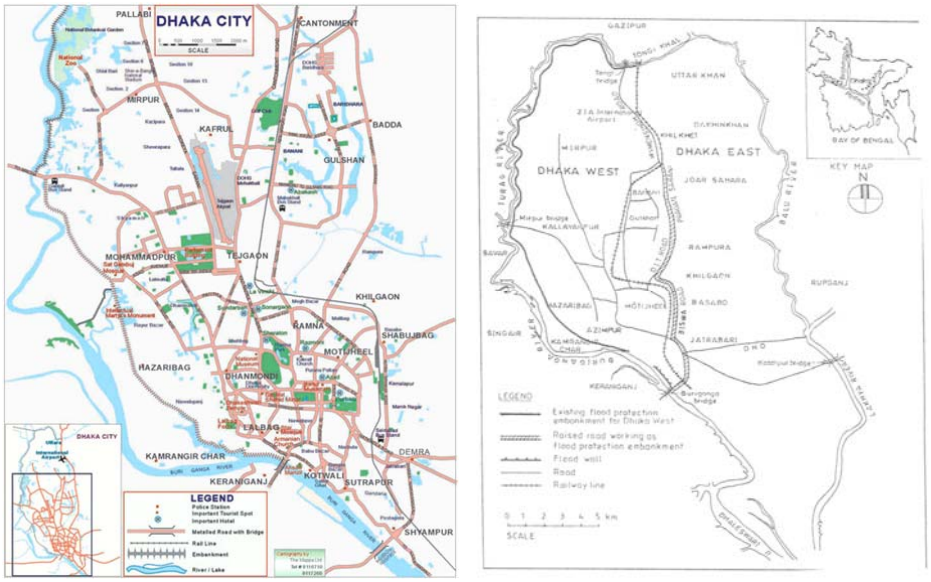


Figure-1: (a) Topography, road network, and (b) river network of Dhaka city

Dhaka, a city of tropical monsoon climate with four seasons: pre-monsoon (March to May), monsoon (June to September), post-monsoon (October to November) and dry season (December to February). Its annual rainfall is about 2000mm and approximately 80% of it occurs during the monsoon. Average monthly rainfall during monsoon period varies between 300mm to 450mm. Maximum daily rainfalls during this period recorded 13 September 2004 is 341 mm. Table 1 presents average monthly rainfall for the period of last 67 years (1953-2009), average number of rainy days per month and average number of days per month when rainfall is greater than 10 mm. It is evident that extreme rainfall events occurred during the monsoon (June-September).

Table 1: Rainfall condition in Dhaka

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. Rainfall (mm)	4.5	22.1	58.1	153.5	282.8	385.7	364.9	302.0	289.3	159.8	36.5	10.3
Days of Rain (Per Month)	1	2	4	8	12	17	20	17	14	8	2	1
Days of Rain > 10mm (Per month)	0	1	2	4	8	9	9	8	7	4	1	0

Annual average temperature of Dhaka in an average is maximum 34.5°C, minimum 11.5°C (Banglapeidia, 2006). Figure 2(a) and 2(b) shows the mean monthly distribution of maximum and minimum temperature over Dhaka city from 1953 to 2009, respectively.

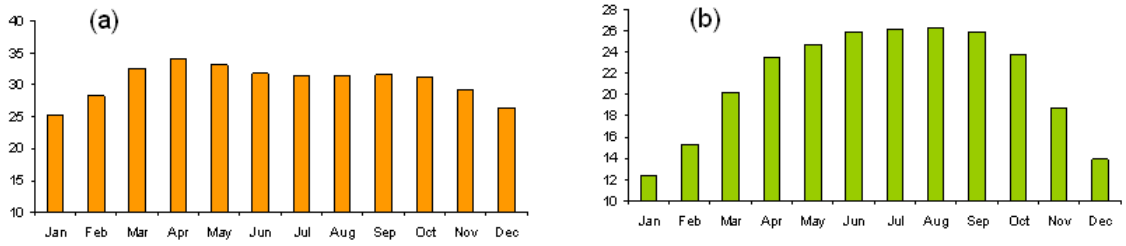


Figure-2: Monthly (a) maximum and (b) minimum temperature (^{0}C) of Dhaka city based on observation (1953-2009)

2.2 Historical Extreme Rainfall Events

Due to sudden heavy rainfall, Dhaka city is normally affected by storm water flooding when the regulator and sluice gates were closed to prevent river flooding during the monsoon season. On The recorded highest daily rainfall of 341 mm compared to a mean monthly rainfall of 264 mm in September was observed on 14 September 2004. On that day, approximately 40% area of Dhaka West was inundated (Rahman at el., 2005). Another high event of rainfall (333 mm/day) was occurred on the 28 July 2009. Streets of the city were flooded and traffic system was collapsed on that day as shown in Figure 3. Table 2 presents date of historic rainfall events on Dhaka city and amount of rainfall on that day. It was found that with a rainfall more than 10mm for a day can cause surface drains in many areas clogged, contributing to water logging, and thereby creating traffic jam. Poor drainage systems, mismanagement in pipeline renovation work and unplanned infrastructure development works for water logging every year during the monsoon. The situation of urban flooding becomes worsen due to the inadequate conveyance capacity of the sewer because of accumulation of solids in the sewers.

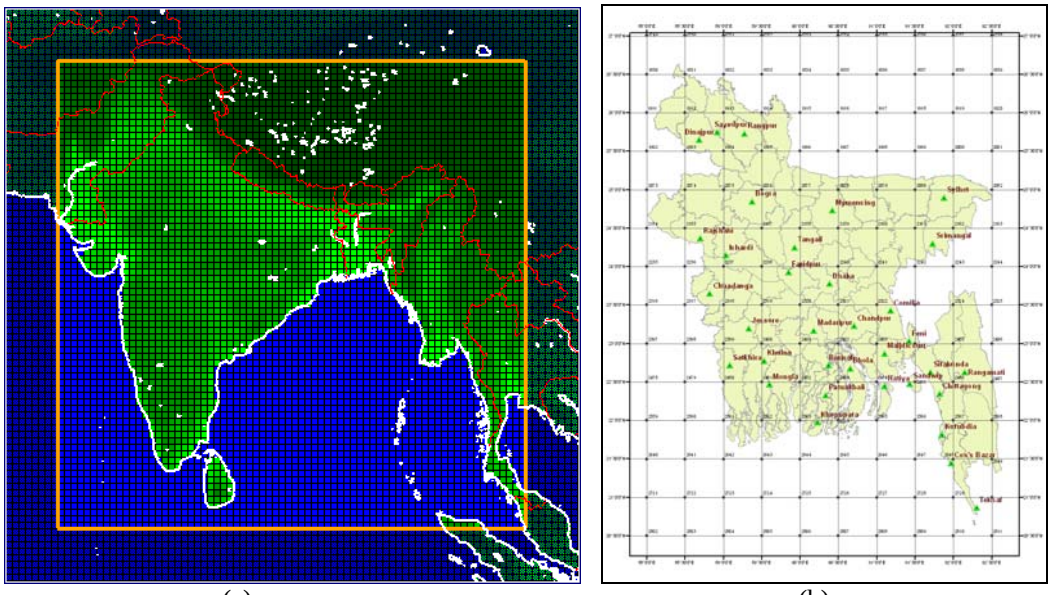
Table 2: List of the historic highest rainfall events of Dhaka city.

Rank	Date	Rainfall (mm/day)	Rank	Date	Rainfall (mm/day)
1	14-Sep-04	341	6	25-May-72	231
2	28-Jul-09	333	7	19-Jun-63	189
3	14-Jul-56	326	8	21-Jun-61	185
4	16-Sep-66	257	9	12-Sep-06	185
5	22-Jul-71	251	10	12-May-65	177

Figure 3: Street conditions of Dhaka city (a) when it gets a record rainfall (333 mm/day) on the 28 July 2009; the second highest one-day rainfall in the past 60 years period.(b) with a single day rainfall (100mm/day) on 15 June 2007.[Source: http://www.thedailystar.net/story.php?nid=3883]

2.2 Regional Climate Model (RCM) Prediction

A Regional Climate Model, PRECIS (Providing Regional Climates for Impact Studies), has been simulated in IWFM (Institute of Water and Flood Management) simulation laboratory from which the primary climate prediction data were collected (PRECIS, 2010). PRECIS is developed by the Hadley Centre, UK which is physically based model to help generate high-resolution climate change information for Bangladesh. Figure 4(a) shows the simulation domain that includes Bangladesh and south Asia and 4(b) shows grid points of the domain over Bangladesh. The domain has 88×88 grid points with a 50 km horizontal resolution. The SRES A1B scenario of IPCC was used to derive the lateral boundary conditions of the simulation using three dimensional ocean-atmospheric coupled model (HadCM3Q) to generate prognostic variables over the simulated domains. This information was used to generate diagnostic variables such as rainfall using PRECIS model all over the domain. The regional climate model dynamically downscaled the data of the Global Climate Model (GCM) with a resolution of 50km from 250km from 1951 to 2100 over the study area.



(a) (b)

Figure 4: (a) Domains of the PRECIS experiments over Bangladesh, (b) Grids over the simulation domain

3. RESULTS

Annual maximum daily rainfalls over Dhaka city during the last 67 years (1953-2009) are shown in Figure 5(a). A decreasing trend of about 0.0154 mm per year is found. However, over the last 30 years (1979-2009), the trend is found to be increasing at a rate of 2.7 mm/year [Figure 1(b)]. But if the data of last ten years are ignored, then a decreasing trend of 1.06 mm per year is observed. Records show that the more extreme events occurred over the last five years.

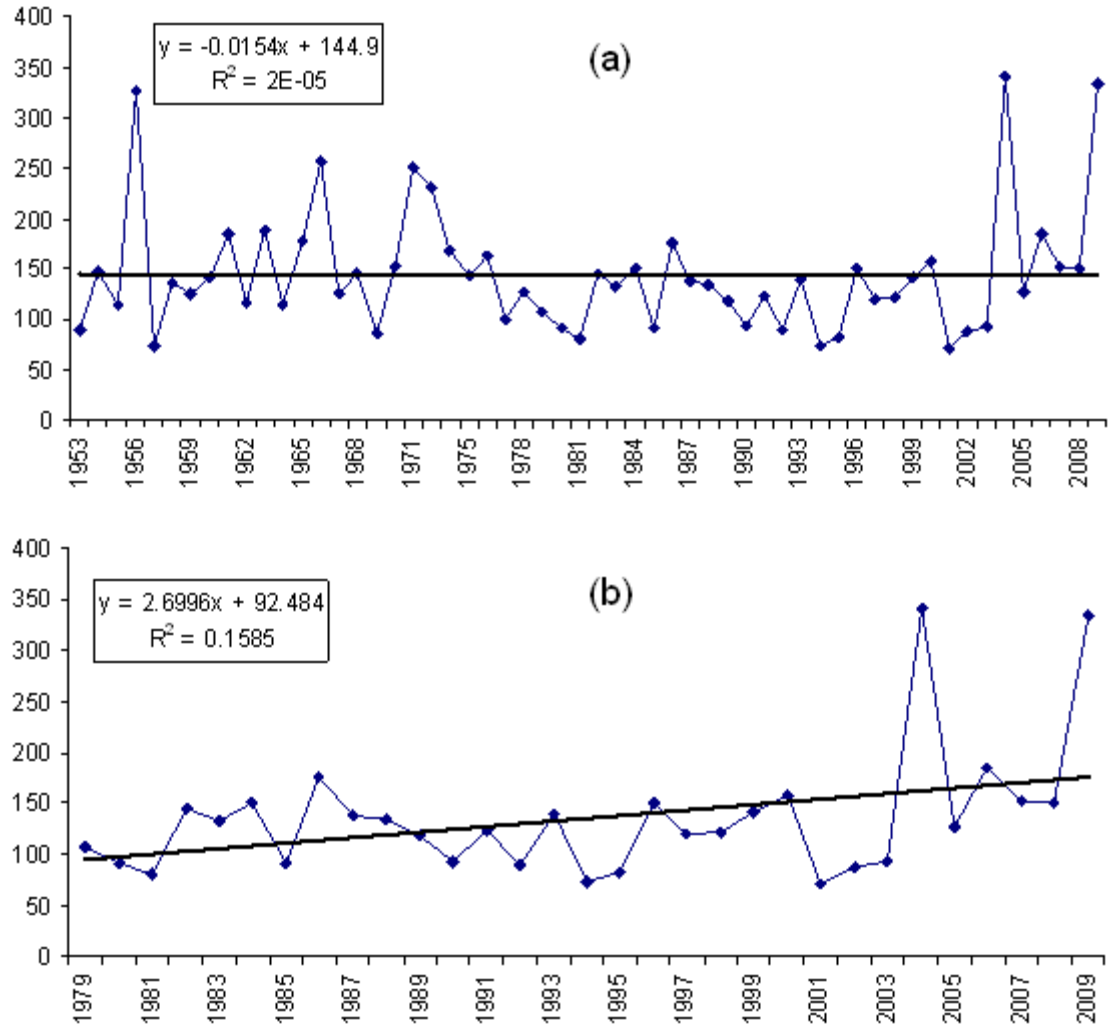


Figure 5: Annual maximum daily rainfall (a) over the last 67 years (1953-2009) and (b) over last 30 years (1979-2009).

Again, the rainfall intensity of greater than 100 mm is more frequent than rainfall intensity of greater than 125 mm. Although the rainfall intensity of greater than 150 mm occurs infrequently but the BMD data of last five years shows that the severity of this type of rainfalls increases (Figure 6).

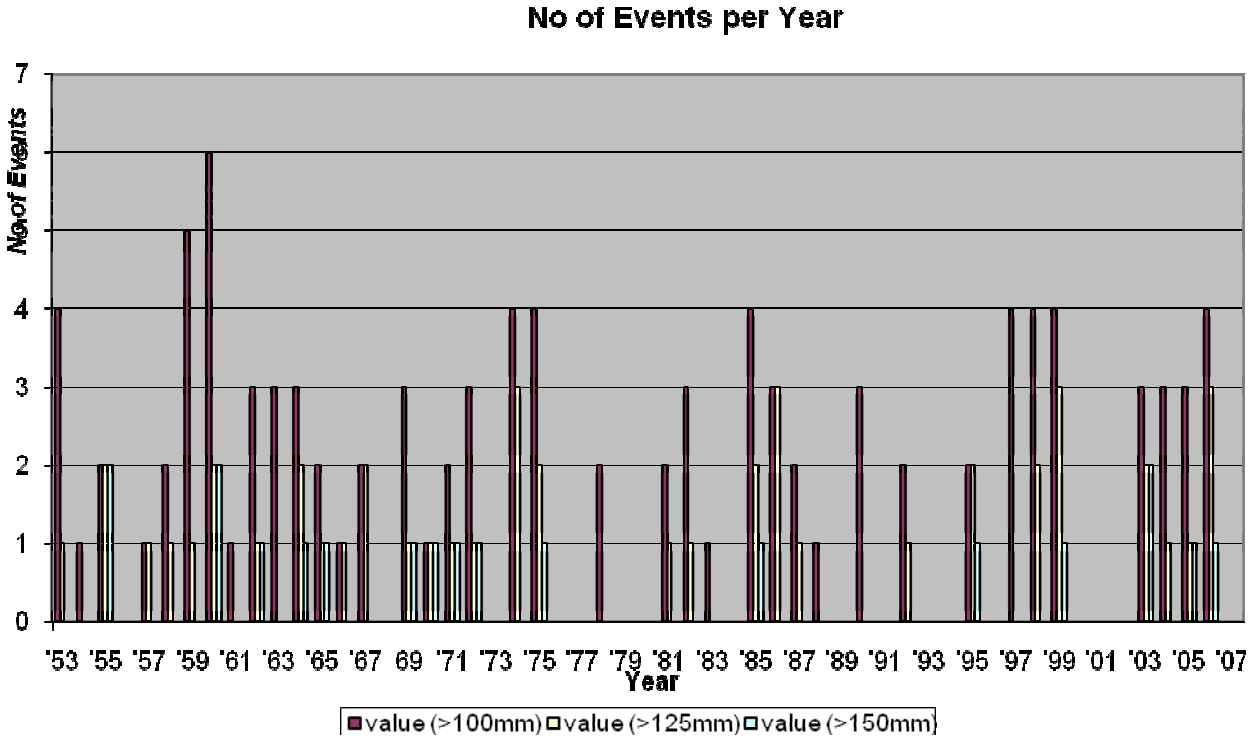


Figure 6: Comparison of number of events per year for annual maximum daily rainfall of 100mm,

In Figure 7(a) shows the mean daily predicted rainfall over the Dhaka city using PRECIS from 1951 to 2100 and observed by the station from 1953-2009. The trend of predicted rainfall is found to increase at a rate of 0.014mm per year whereas the observed rainfall also shows an increasing trend of 0.0103mm per year. Figure 7(b) shows the observed and predicted monsoon (June-September) rainfall over Dhaka city. The trend of predicted monsoon rainfall is about 0.1214 mm per year and that of observed monsoon rainfall is 0.0033 mm per year.

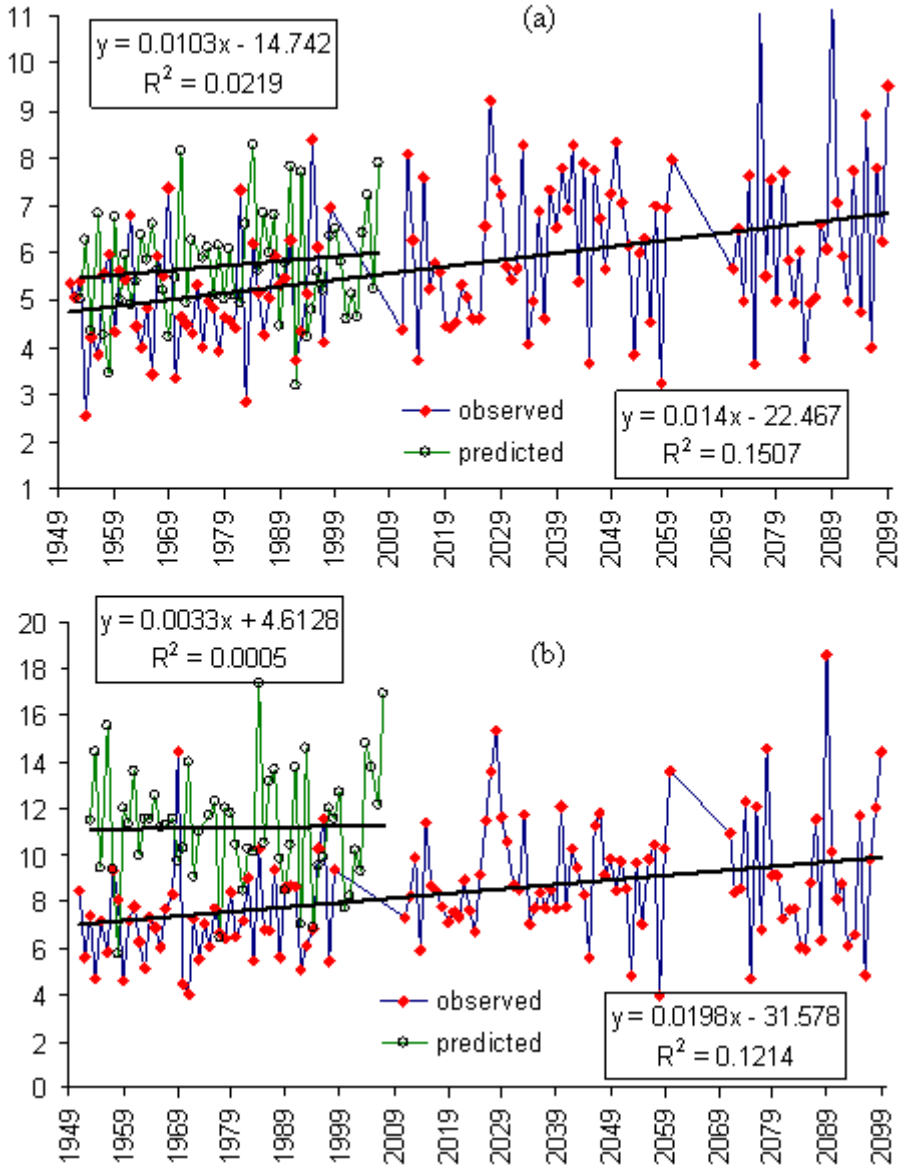


Figure 7: Daily RCM predicted rainfall over Dhaka city from 1951 to 2100 using A1B scenario for (a) whole year and (b) monsoon (June-September).

4. CONCLUSIONS

Climate change has induced erratic extreme rainfalls in many parts of the world. This rate is increasing abruptly. Long term unmitigated climate change will "likely" exceed the capacity of people and the natural world to adapt (IPCC, 2007). Extreme rainfall events over the Dhaka city have increased remarkably over the last decade. Both regional climate model and observed data present the evidence of increasing trends of rainfall. Climate change has played a vital role in changing the climatic behavior of Bangladesh, consequently increasing the extreme rainfall events of the Dhaka city.

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