Impact of climate change on summer and monsoon precipitation in the north-east region of Bangladesh

Abstract

Climate change is highly likely to influence the hydrological cycle in the north-east part of Bangladesh. The people lives in this region will also be impacted. The people and decision makers need quality information about the future changes. The problem is that a lot of uncertainty surrounds the climate in the north-east region of Bangladesh, in particular the summer rainfall, which occurs before the large scale monsoon. We know that this rainfall is important to society, but we do not know how well it is resolved in climate models. In turn, we do not know how useful the climate models might be in decision-making processes. Therefore, in the proposed study, the impact on summer and monsoon precipitation in the north-east region of Bangladesh due to climate change will be assessed. Firstly, we will assess the quality of the Coupled Model Inter-comparison Project 5 (CMIP5) models on simulating the precipitation climate in the north-east region of Bangladesh. Thereafter, the future scenarios of precipitation will be generated using the results from the best CMIP5 models downscaled to scales relevant for the study area. Downscaling of the climate variables will be performed by using the statistical method described in Basher, M.A.et al. (2010). A suitable hydrological model will be developed to determine the climate change impact on precipitation using downscaled climate variables.

1. Background

1.1. Study area:

"Bangladesh is ranked as one of the most climate-vulnerable countries in the world. It is at extreme risk of floods, tropical cyclones, sea level rise and drought, all of which could drive millions of people to migrate" (CDKN, 2014). Bangladesh is already experiencing climate induced hazards like storm surge, flood, drought etc. The north-east region of Bangladesh is experiencing extremely decreasing trend of annual precipitation during last decades (Begum, S. and Alam, M.S., 2013).

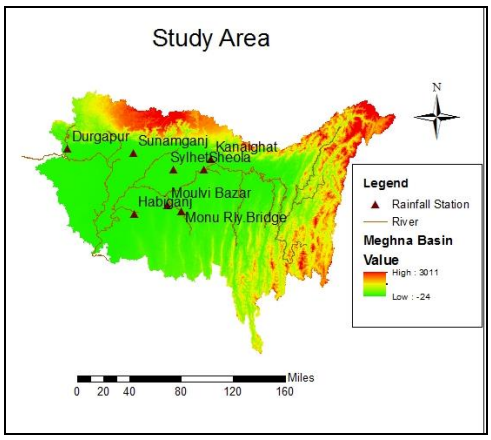

Figure 1: Study area

Whereas, the extreme precipitation is likely to increase due to climate change. The changes in extreme precipitation may not be directly related to changes in mean precipitation. In the north-east region of Bangladesh, the extreme precipitation is likely

to increase during pre-monsoon while there were no significant change of annual volume of rainfall at 2050s (Nawreen, S. et al., 2013).

The north-east part of Bangladesh is located at 24°53′ latitude and 91°52′E longitudes and characterized by number of special topographical features like hills, hillocks, haors and high flood Land. The rivers in this region are originated from adjacent hilly area of India. As a result, the rainfall pattern of adjacent hilly part of India has great influence on flooding in this region (Nawreen, S. et al., 2013). The hydrological and climatic condition is characterized by extreme flash flood during summer, prolong riverine flood during monsoon and drought during dry period. This region is very important for socio-economic development as well as ecological balance of the country.

1.2. Research Approach:

In this research, the impact of future climate change and its consequences in the community level will be studied according to 'post-normal science' approach (Funtowicz, S., and Ravetz, J., 1993). In this approach, an interdisciplinary collaboration between natural scientist and different social groups of the society takes place for better understanding of local climate variability and adaption strategy through interviews with the extended peer community. In this connection, a workshop was taken place at Dhaka in which guests from the research community, NGOs and Government institutions based in Dhaka were participated. In that workshop, it was agreed that all parts of north-eastern region of Bangladesh are fallen in almost same meteorological mapped weather systems. The communities share common experiences like flash floods due to summer rainfall and prolong riverine flood due to monsoon heavy rainfall. Just after Dhaka workshop, another workshop was hold in Sylhet in which representatives from different stakeholders were participated.

Also, 9 pilot interviews were carried out with local people in the Sylhet region. On the basis of these answers and the response at the workshops, the TRACKS researchers met and discussed all the different climate topics that had arisen. Through considerable discussion, the researchers decided that the climate research in TRACKS should initially concentrate on the early summer rainfall. This was particularly important issue.

Due to this contact with experts and local stakeholders, this PhD project will concentrate on the early summer rainfall with special emphasis on past trends and future projections. The contact with the stakeholder community will be maintained throughout the project through good communication and collaboration with the other work packages in TRACKS.

2. Objective

The evaluation of climate change impact on summer and monsoon precipitation in the north-east region of Bangladesh has been set as the main object of this research. It is noted here that the research direction may be changed according to recommendations of the extended peer communities in future workshop. To accomplish the main objective, the natural science research will have the following goals:

- To analyze the trend of observed rainfall in north-east region of Bangladesh.
- To evaluate the performance of the RCMs model under newly developed representative concentration pathways (RCPs) for the study area;
- To downscale of the climate variables from RCMs for generating climate change scenario for 2100s;
- To set up and validate a hydrological model to determine the risk of flooding using downscaled climate variables as well as changes in land management practices and vegetation.

In response to the overall TRACKS objectives of developing “quality knowledge with and for society”, this research will also aim:

- To communicate the results responsibly to the TRACKS extended peer community and other relevant stakeholders.
- To use feedback from the extended peer community to revise our research plan as the project progresses.

3. Research questions

The proposed study will be guided by the following questions:

- What are the pattern and trend of precipitation in the study area?
- How well the RCMs perform in depicting the summer and monsoon precipitation for the study area?
- How the summer and monsoon precipitation will be impacted as a result of climate change?

4. Data

Hydro-meteorological as well as climate data is essential for climate change impact analysis. In this study, hydro-meteorological data (daily rainfall, daily average temperature, daily minimum & maximum temperature and discharge) will be collected from Bangladesh Water Development Board (BWDB) as well as Bangladesh Meteorological Department (BMD).The climate data will be collected from Coupled Model Inter-comparison Project 5 (CMIP5) under newly developed representative concentration pathways (RCPs)

5. Methodology

The main task of this research is to assess impact on summer and monsoon precipitation due to climate change in the north-east region of Bangladesh. The future scenarios of precipitation series will be generated using the results from Coupled Model Inter-comparison Project 5 (CMIP5) under newly developed Representative Concentration Pathways (RCPs) downscaled to scales relevant for the study area. Hydrological model will be simulated using the future scenarios of precipitation series to determine the risk of flooding due to climate change. Thus the methodology of the research will be consisting of following steps:

- Trend analysis of Observed rainfall
- Evaluation of RCMs
- Downscaling of climate data
- set up and validation of hydrological model

5.1 Trend analysis of Observed rainfall:

Mann–Kendall trend test (Mann, 1945; Kendall, 1975) and the Sen's slope method (Sen, 1968) will be used for trend analysis of observed rainfall. The Sen's slope method will be applied for estimating the magnitude of trend whereas the Mann–kendall trend test will be applied for detecting the significance of trend. To classify the significance of positive and negative trend, the confidence levels of 90%, 95% and 99% will be taken as thresholds. Homogeneity test, consistency check and auto correlations test will be performed before applying trend test. The homogeneity of the rainfall records will be analyzed by standard normal homogeneity test.

5.2 Evaluation of RCMs:

The Projected climate variables from the climate model may not reflect the climate systems of the study area. So, before using RCMs output it is very important to check their performance whether the model can be used to generate climate change scenarios for future for the particular location. In this study, the Taylor Diagrams (Taylor, K. E., 2001) will be used to assess the performance of CMIP5 model representing summer and monsoon rainfall in the north-east region of Bangladesh. The model performance can be assessed conveniently using Taylor Diagrams with help of three related parameters: standard deviation, correlation with observed data, and centered root mean square (RMS) distance (Kumar, C.R. et al. 2012). As RCMs are inherited some bias from GCMs, It is very much essential to correct the model bias for impact analysis. In this study, the model bias will be corrected using quantile-quantile mapping technique. The quantile mapping technique will be applied on a monthly data set because Maurer et al. (2010) showed that the monthly level data showed almost same result as daily data.

5.3 Downscaling of climate data:

Though the spatial resolution of the RCMs are finer than that of the GCMs, the output of the RCMs model cannot be used directly for impact analysis because the coordinate of RCMs and local observation may not synchronize to each other. So, it is essential to transfer the RCMs projection to the local observations. In this study, statistical downscaling technique will be applied for transferring RCMS projection to local observations and for generating future climate change scenarios. In literature, there different downscaling methods are available. In the proposed study, downscaling of the climate variables will be performed by using the statistical method described in Basher, M.A. et al. (2010). In this statistical method, downscaling of rainfall time series consists of two steps. The first step is to apply wet-day frequency perturbation technique which signifies the changes in the number of wet-days and the second step is to apply wet-day intensity perturbation technique which signifies the changes in the magnitude of the rainfall intensity in a wet-day including the extremes. Since inter annual variability of temperature and evapotranspiration are low, simple delta change approach will be applied for these two variables.

5.4 Set up and validation of Hydrological model:

A suitable hydrological model will be set up and validate accordingly to determine the climate change impact on summer and monsoon precipitation using downscaled climate variables as well as changes in land management practices and vegetation. A variety of software packages are available for developing hydrological model ranging for very simple to very complex depending on catchment characteristics. The SWAT, the HEC-HMS, the MIKE SHE are the most widely used distributed rainfall-runoff model. In this research, the hydrological model will be developed using any of the model listed above which is suitable for the study area.

6. Expected Outcomes

6.1 *Trends of observed rainfall:*

The trend of extreme indicators (showed in Table 1) of observed rainfall for the period of 1984 to 2014 will be available for almost 8 stations in north-east region of Bangladesh.

Table 1: List of extreme rainfall indicators and analysis period.

Sl No	Category	Period
1	One Day Maximum(RX1)	For each month of Pre-Monsoon season(MAM)
2	Five Day Maximum(RX5)	For each month of Monsoon season(JJA)
3	Monthly Average Rainfall	For each month of Pre-Monsoon and Monsoon season
4	Number of Rainy Day	For each month of Pre-Monsoon and Monsoon season
5	Seasonal Average Rainfall	For Pre-Monsoon and Monsoon season

6.2 *Performance of RCMs:*

Each and every RCMs is not suitable for all location. So, the performance analysis is very much essential prior to climate change impact analysis otherwise it may provide misleading information. After doing evaluation of RCMs, the suitable model will be in hand for generating the climate change scenarios for the study area.

6.3 Climate change scenario for the study area:

The climate change scenarios are essential for policy making and undertaking proper adaptation strategy. After this research, the climate change scenarios for the study area will be available which will be helpful for reducing climate induced vulnerability by adapting proper adaptation strategy.

6.4 *Hydrological model:*

A suitable hydrological model for the study area will be available which will be helpful for determining the climate change impact on summer and monsoon precipitation using downscaled climate variables as well as changes in land management practices and vegetation.

6.5 *Impact of climate change on summer and monsoon precipitation:*

The adaptation strategy may be different for different seasons of the year. Therefore, after this research, the climate change impact on summer and monsoon precipitation will be addressed which will be helpful for introducing season specific adaptation strategy.

7. Publications

7.1 Trends of extreme rainfall events for the north-east region of Bangladesh:

This paper will present rainfall trends for northeast Bangladesh. The paper will focus on local changes, which could be relevant for local climate adaptation. We will apply well-known climate indices in order to compare with previous studies with a lower observation station density. We also plan to apply indices that have been defined by the TRACKS stakeholder community. This will be a powerful indicator for the usefulness of present climate research in an adaptation setting.

7.2 Identifying the suitable Regional Circulation Models(RCMs) for the north-east region of Bangladesh:

This paper will analyze the quality of the RCM with regard to rainfall in north-east region of Bangladesh with special emphasis on early summer rainfall. The quality of the model will be examined in terms of three related parameters such as standard deviation, correlation with observed data, and centered root mean square (RMS) distance. These three parameters of available RCMs for the study area will be summarized in a single

diagram which will be useful to summarize how well the model simulates the rainfall for the study area.

7.3 Impact of climate change on summer and monsoon precipitation in north-east region of Bangladesh:

This paper will investigate the how the summer and monsoon precipitation in north-east region of Bangladesh will be impacted due to climate change. In particular, we will analyze the change of extreme indicators of precipitation under climate change condition with respect to present day condition. This study will provide information to policy maker for setting up appropriate policies and adaptation strategies.

8. **Work Schedule:** The Monthly activity plan has been shown in details in Table 2 and the Objective wise schedule has been shown Table 3.

Table 2: Schedule of the work

Activity	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17	Jan-18	Feb-18	Mar-18
PhD Proposal Writing																																				
Data collection and processing																																				
Courses at BUET	Course 1 and 2						Course 3																													
Stay in Norway																																				
*Paper -1																																				
**Paper - 2																																				
***Paper -3																																				
PhD Thesis																																				
PhD Defense																																				

*Trends of extreme rainfall events for the north-east region of Bangladesh
**Identifying the suitable Regional Circulation Models(RCMs) for the north-east region of Bangladesh
***Impact of climate change on summer and monsoon precipitation in north-east region of Bangladesh

Table 3: Schedule of the Objectives

Obs RF Trend																																				
Evaluation of RCMs																																				
Downscaling																																				
Dev. Hydro. model																																				

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