CLIMATE CHANGE PROJECTIONS FOR THE SELECTED POLDERS OF THE COASTAL REGION OF BANGLADESH

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Southwest region of Bangladesh is the most disaster-prone area and vulnerable to climate change. Future climate scenario is generated from widely used Hadley Center Coupled Model (HadCM3). In order to find the projection of climate change impact, a statistical downscaling model (SDSM) is used. Climate simulation corresponding to the two extreme SRES A2 and B2 emission scenarios are carried out for future periods. Projections of climate change are established on the three coastal polders 3, 30 and 43/2f which are located in Satkhira, Khulna and Patuakhali, respectively. Climate projections are performed in three different time periods, viz. near (2020s, i.e. 2011–2040), transient (2050s, i.e. 2041–2070) and future (2080s, i.e. 2071–2099). The model shows significant rises in temperature towards the end of 21st century. In case of monthly precipitation, an overall precipitation increase is observed during the monsoon period in both Khulna and Satkhira which is about 15-20%. On the other hand, an exception is observed for Patuakhali where monsoon precipitation is decreased by 42% and pre-monsoon precipitation is slightly increased by 25%. Probability plot of one day monthly maximum precipitation (Rx1) shows increasing trend for all these polders. Similarly, A2 and B2 scenarios shows similar pattern of precipitation and temperature changes. However, magnitude of changes in B2 scenario is on the lower side.

Keywords: Bangladesh, Climate change, Coastal region, Statistical downscaling, SRES scenarios.

Introduction

The coastal region of the Ganges Delta in Bangladesh is vulnerable to different types of natural disasters. The country has life giving monsoons, while on the other hand catastrophic disasters like tropical cyclones, storm surges, floods, droughts and erosion. The present scenario is expected to be aggravated by various external drivers of change. The CGIAR Challenge Program on Water and Food (CPWF) has initiated the Ganges Basin Development Challenge (GBDC) to reduce poverty and improve food security in the fresh-brackish water coastal zones of the Ganges delta. The Ganges 4 (G4) project under GBDC is assessing the impacts of anticipated external drivers of change on water resources. G4 has identified climate change as one of the key external drivers that are likely to affect the crop pattern, human health, and fresh water resources of this region in the foreseeable future,. In addition, other diverse effect, salt water intrusion and inundation of coastal areas due to sea level rise are likely to be increased. Coastal polders of Bangladesh may experience severe water logging and monsoon flooding due to climate change effect. For this reason, climate change projection should be performed to predict the possible adverse impacts. At present coastal polders in Bangladesh are suffering water logging problem, for that case detailed analysis should be performed for mitigating future threats.

The objective of the present study is to perform projection of temperature and precipitation in three different time periods to assess the possible impacts in selected coastal polders (Polder 3, Polder 30, and Polder 43/2f). Climate projection was performed by statistical downscaling tool using data of HadCM3 GCM for A2 and B2 scenarios. Downscaling of climate is preferable than using coarse resolution GCM model data, since downscaled climate data can provide a more clear idea on the climate change in a locality. This study will provide idea on how the climate of coastal area is expected to change during the 21st century based on a range of future greenhouse gas emissions scenarios (A2, B2). The specific objectives are as follows:

- Projection of monthly mean temperature and precipitation intensity are performed in three different future time periods viz. near (2020s, i.e. 2011–2040), transient (2050s, i.e. 2041–2070) and future (2080s, i.e.2071–2099).
- Identification of precipitation pattern, trend of change in precipitation index (maximum 1 day precipitation).
- Observation of the change in extreme precipitation event.

Study Area

Climate projections were performed in southwest region of Bangladesh at selected coastal polders 3, 30 and 43/2f located in Satkhira, Khulna and Patuakhali respectively. The study area is showed in the Figure 2.

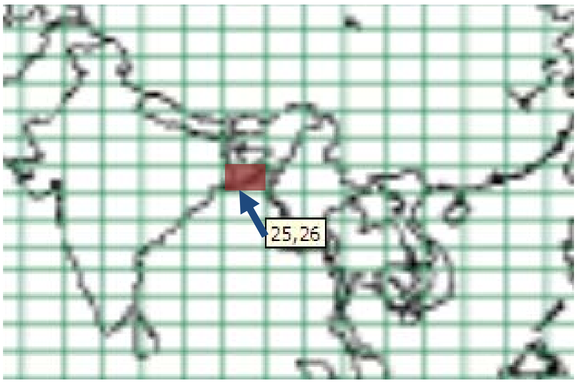

Figure 1: Domain of GCM predictor variable.
(Source: www.cccsn.ec.gc.ca/?page=pred-hadcm3)

A short description of present geographical and climate conditions of the selected area is given below:

- Satkhira District in Khulna Division has an area of 3858.33 sq km. The annual average maximum temperature reaches 35.5°C (95.9°F); and minimum temperature is 12.5°C (54.5°F). The annual rainfall is 1710 mm (67 in).
- Khulna District in Khulna division has an area of 4394.46 sq km. Annual average temperature is 35.5°C and the lowest 12.5°C; annual rainfall is 1710 mm.
- Patuakhali District in Barisal division has an area of 3204.58 sq km. This district comprise of some small chars or islands. Annual average temperature is 33.3°C and the lowest 12.1°C; annual rainfall is 2506 mm.

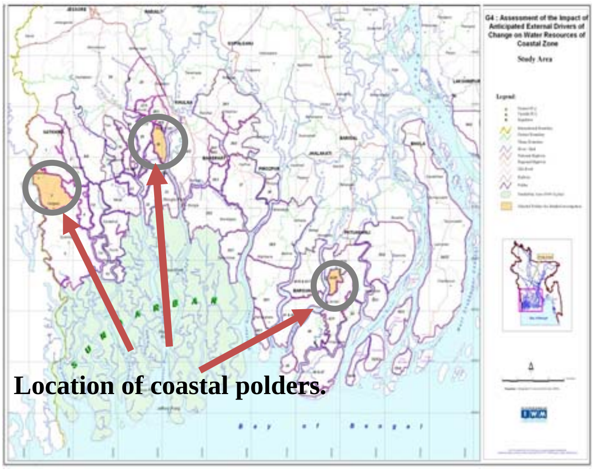

Figure 2: Study area.

Methodology

Downscaling of climate change data was conducted using SDSM. Figure 3 shows the main functions of SDSM. Before downscaling process, quality control was ensured. The empirical relationship between gridded predictors (such as mean sea level pressure) and single site predictands (such as station precipitation) was then evaluated. After finding suitable predictor variables, calibration process was performed. By using calibration parameter obtained from calibration process, climate scenarios were produced with ensembles of synthetic daily weather series derived from atmospheric predictor variables (Wilby et al., 2001).

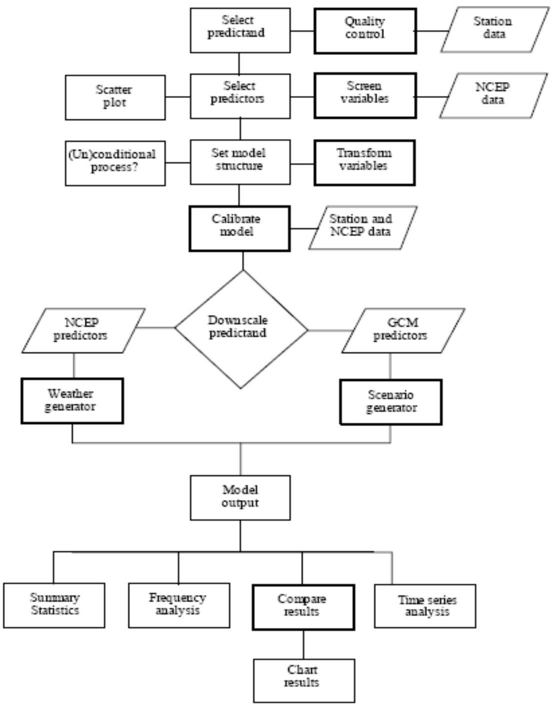

Figure 3: SDSM climate scenario generation process (Wilby et al., 2001).

Calibration

The calibration of downscaling models was based on solving multiple regression equations, by given daily weather data (the predictand) and regional–scale atmospheric (predictor) variables. To initiate the calibration process it is prerequisite to define calibration time period. Calibration time period was determined in such a way that there exists least numbers of missing data. The observed data series (1961-2000) were divided into two periods, 1961-1980 and 1981-2000, since missing data exists in (1961-1974) time period for Patuakhali. In that case for Patuakhali the observed time period is (1975-2000) hence it splited into two periods, 1975-1987 and 1988-2000.

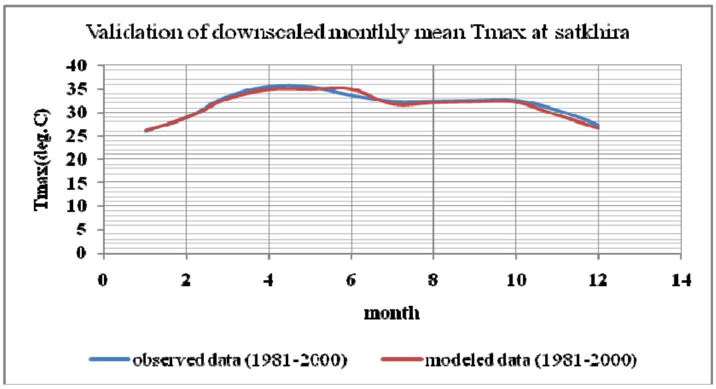

Figure 4: Comparison of observed and modeled mean Tmax during (1981-2000).

For validation of the climate model, first half of time period was used for calibration and second half was used for validation. There are three calibration parameters in SDSM, Variance inflation, bias correction and optimisation algorithm. These were adjusted to get the best statistical agreement between observed and simulated daily temperature and precipitation. Event threshold was best set to 0 mm/day, which indicates, rain day will occur when precipitation is greater than zero. The relative errors of long-term annual precipitation were used to calibrate bias correction and variance inflation.

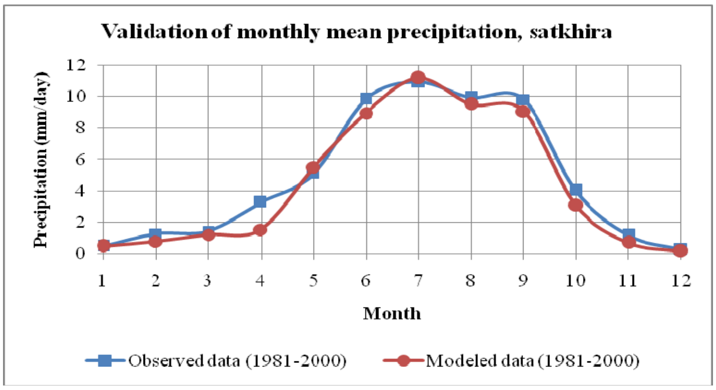

Figure 5: Comparison of observed and modeled rainfall during (1981-2000).

Results

The model generated scenarios (A2 and B2) for precipitation and temperature (maximum) were generated by SDSM is discussed in this section. Analysis of temperature and precipitation were performed with the help of time series data generated produced from SDSM.

Projection of temperature and precipitation

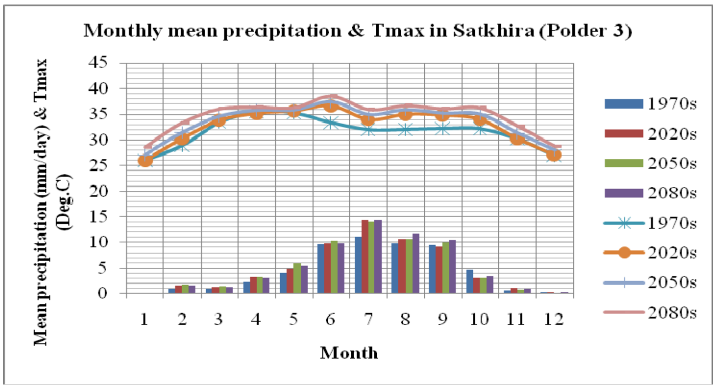

Figure 6: Annual cycles of mean precipitation (bars) and maximum air temperature (lines) using HadCM3 A2-scenario.

Increase of highest temperatures is observed during July, August, September and October (JASO). Maximum increase of temperature is observed 13.97% in Khulna, 13.83% in Patuakhali and 13.46% in Satkhira in 2080s during July, August, September and October using A2 scenario. Therefore on an average 13.5% temperature will increase in the study area. As A2 scenario shows higher emission than B2 scenario, rise in temperature obtained from B2 shows lower magnitude than A2. B2 scenario shows an average of 8.7% increase of temperature in 2080s.

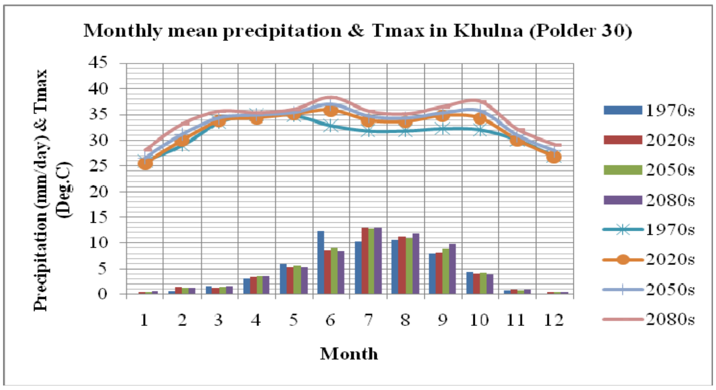

Figure 7: Annual cycles of mean precipitation (bars) and maximum air temperature (lines) using HadCM3 A2-scenario.

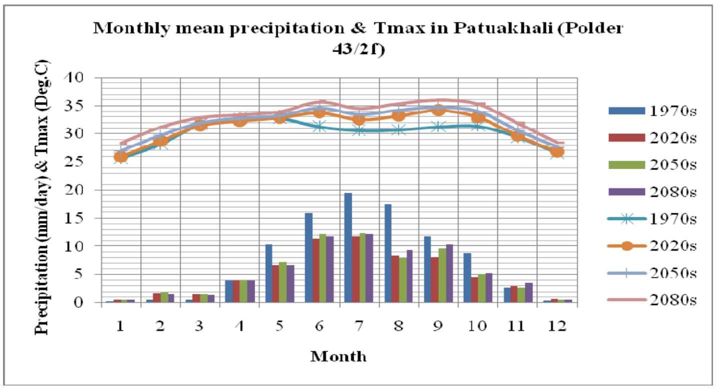

Figure 8: Annual cycles of mean precipitation (bars) and maximum air temperature (lines) using HadCM3 A2-scenario.

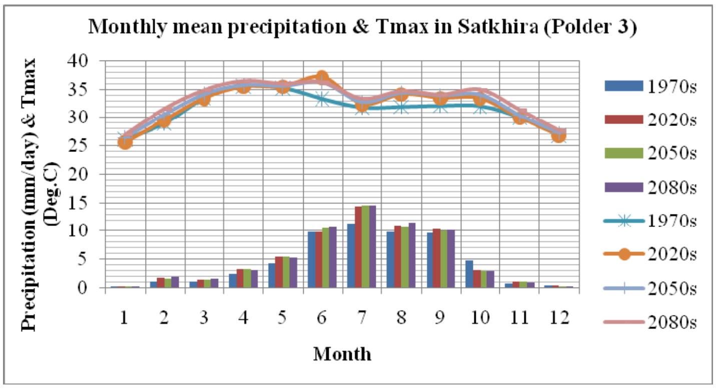

Figure 9: Annual cycles of mean precipitation (bars) and maximum air temperature (lines) using HadCM3 B2-scenario.

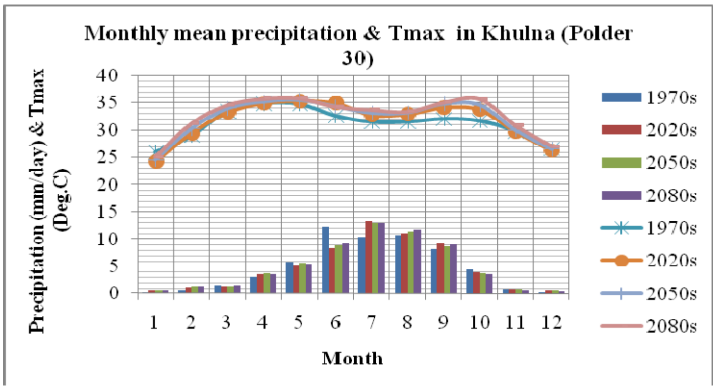

Figure 10: Annual cycles of mean precipitation (bars) and maximum air temperature (lines) using HadCM3 B2-scenario.

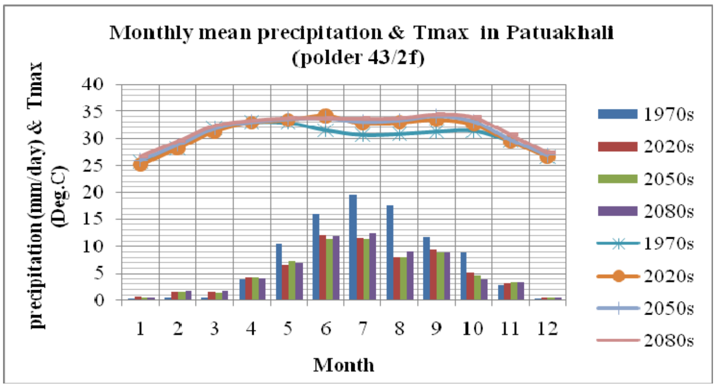

Figure 11: Annual cycles of mean precipitation (bars) and maximum air temperature (lines) using HadCM3 B2-scenario.

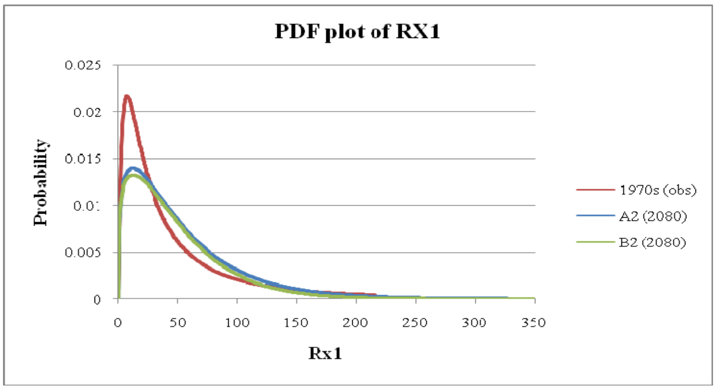

Figure 12: Probability distribution function plot of Rx1 (Maximum 1-day precipitation) in Khulna (polder 30).

Considering A2 scenario, significant increase of precipitation is observed in July, August and September. About 19.27% increase of precipitation is observed in Khulna and 19.03% in Satkhira during July, August and September. In Patuakhali, precipitation will decreased by 32.14% during July, August and September. However, B2 scenario provides smaller magnitude of rainfall changes than A2 scenario. Probability distribution function plot of maximum 1-day rainfall in future shows increasing trends both for A2 and B2 scenarios whereas, probability curve for B2 scenario lies on lower side than A2 scenario.

Conclusion

In this study, monthly mean maximum temperature and precipitation were projected in three different future time periods viz. near (2020s, i.e. 2011–2040), transient (2050s, i.e. 2041–2070) and future (2080s, i.e.2071–2099). The analysis shows uniform increase in temperature for all future time periods. Increase of monsoon rainfall is evident in the analysis at Satkhira and Khulna except Patuakhali. Probability distribution function plot of maximum 1 day precipitation shows chance of increasing heavy precipitation in future. It implies that the polders in these areas are likely to experience prolonged water logging due to climate change.

Acknowledgements

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