Impact of Projected Extreme Climate Indices on Streamflow: A case study in Bago River Basin, Myanmar

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1. Introduction

Nowadays, global climate change has an effect on the hydrological regimes of numerous locations around the world, and this change is expected to continue in the future. Due to the effects of climate change, the river flow has changed in association with significant precipitation, variations in temperature, which have produced increasing concern in the Bago River Basin, Myanmar. Fig. 1 shows the location of the study area. The Soil and Water Assessment Tool (SWAT) model was used to investigate and predict the projected streamflow response over extreme climate change in this river basin. The objective of this study is to examine the impact of extreme climate changes on the streamflow in the Bago River Basin using the hydrological simulation.

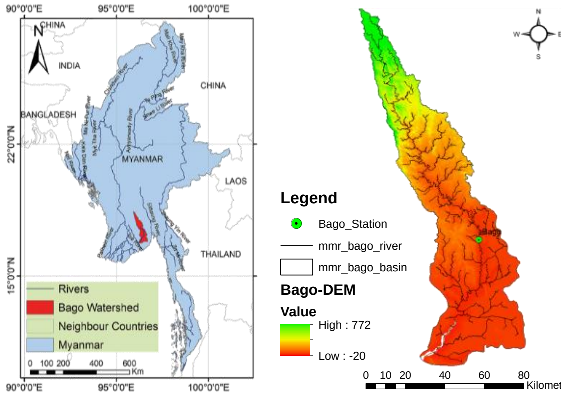
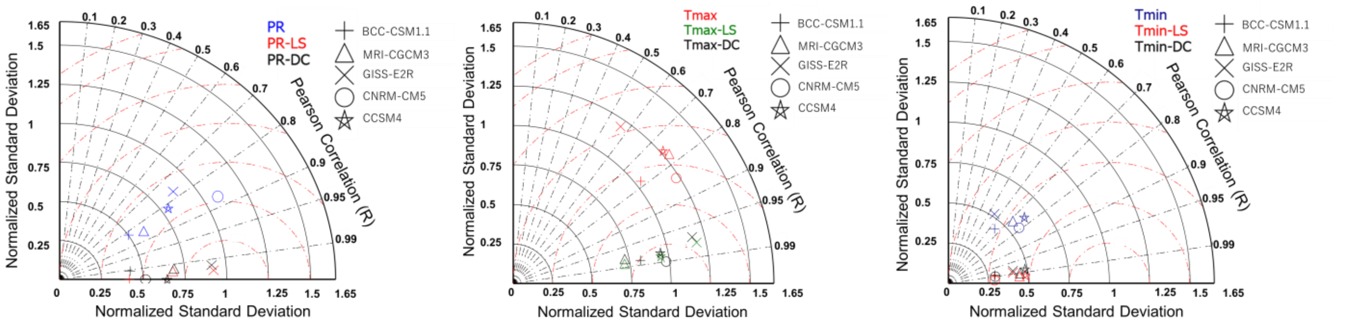


Figure 1. Location of the Bago River Basin, Myanmar.

2. Evaluation of climate models

Based on the climate change scenarios (Representative Concentration Pathways, RCP 4.5) from five different GCMs (BCC-CSM1.1, MRI-CGCM3, GISS-E2R, CNRM-CM5 and CCSM4) [1] for precipitation and temperature variables were used to estimate the extreme climate indices for the Bago River Basin. The outputs of climate models do not usually fit exactly the statistical properties of observations at gauging stations in the control period. Bias errors between GCMs and observations can be caused by an imperfect conceptualization, discretization and spatial averaging within grid cells. Therefore, the linear scaling method and delta-change approach bias-correction methods were applied to detect such errors. Fig. 2 shows the Taylor diagrams indicating the performance of precipitation (PR), maximum temperature (Tmax) and minimum temperature (Tmin) from five distinct GCMs using two bias correction methods, that is Linear Scaling (LS) and Delta Change (DC). The mean monthly maximum and minimum temperatures and precipitation exhibit significant correlation coefficients that are approaching unity after bias correction methods are applied.



(a) (b) (c)

Figure 2. Taylor diagram indicating the performance, (a) precipitation (PR); (b) maximum temperature (Tmax); and (c) minimum temperature (Tmin) of five GCMs using Linear scaling (LS) and Delta Change (DC) bias corrected data and original data.

3. Trend analysis in climate indices

The Joint Expert Team on Climate Change Detection and Indicators (ETCCDI) has defined a core set of extreme descriptive indicators to provide a consistent perspective on weather changes and climate extremes [2]. In this study, six climate indices (annual total precipitation (PRCPTOT), precipitation intensity (SDII), daily precipitation > 95th percentile (R95PTOT), daily precipitation > 99th percentile (R99PTOT), number of consecutive wet days (CWD), and number of consecutive dry days (CDD)) from precipitation variables and four climate indices (annual maximum values of daily minimum temperature (TNx), annual maximum values of daily maximum temperature (TXx), annual minimum values of daily minimum temperature (TNn), and annual minimum values of daily maximum temperature (TXn)) from temperature variables at Bago station are calculated using the ClimPAT software. Moreover, the Mann-Kendall and p-value tests [3] were utilized to perceive statistically significant decreasing or increasing trends in long-term temporal data in this analysis.

According to the analysis, the projected average annual temperature for each temperature indices indicates an increase for both periods (Fig. 3). There will be a significant increase in average annual maximum temperatures for both periods, from 32.5˚C to 35˚C, whereas the average annual minimum temperatures will also increase from 21˚C to 24.5˚C. Furthermore, the effects of each precipitation index had a significant impact on the variations in climate for future periods (Fig. 4). As a consequence of the increase in the average annual total precipitation amount, it is predicted that it will increase from 15% to 21% in both future periods throughout the basin. It indicates that, under RCP 4.5 scenario, both the amount of precipitation and maximum temperature values will increase in the upcoming decades.

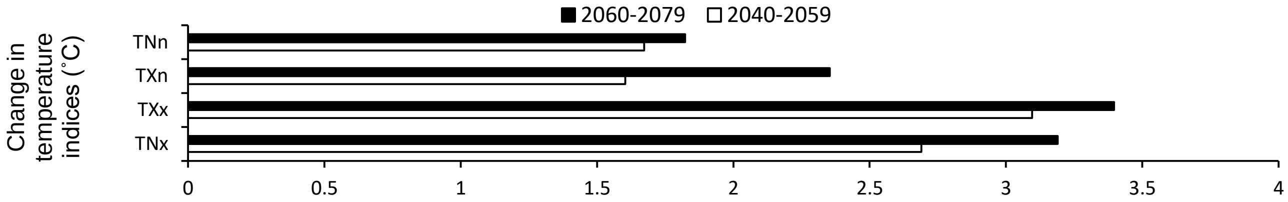


Figure 3. Changes in each temperature indices (˚C) under RCP 4.5 scenario during the 2040-2059 and 2060-2079 periods.

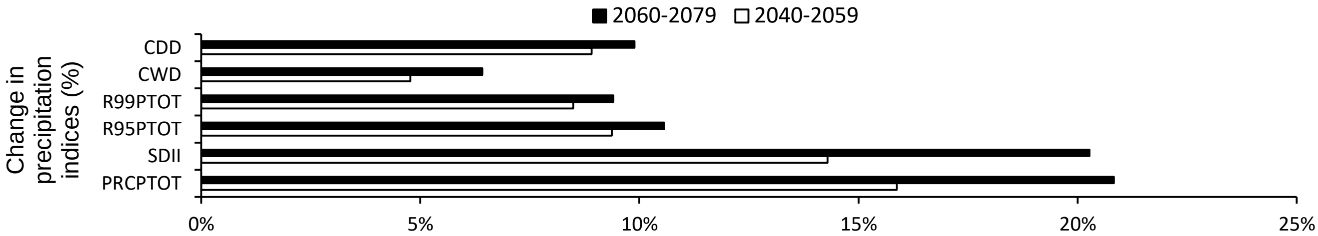


Figure 4. Changes in each precipitation indices (%) under RCP 4.5 scenario during the 2040-2059 and 2060-2079 periods.

4. Extreme climate indices impact on streamflow

The variations of the future streamflow in the Bago River Basin, are projected using the SWAT model with 10 extreme climate indices for the periods of 2040-2059 and 2060-2079, under RCP 4.5 scenario. During the calibration and validation periods, the SWAT model performed successfully in simulating the observed streamflow at Bago station. The potential changes in the future streamflow for the projection periods are presented in Fig. 5. Based on the effect of increased precipitation and temperature indices, the impact on average annual streamflow is projected to increase in future periods. As a result of an extremely elevated annual total precipitation index, the average annual streamflow is expected to be highest in the 2040-2059 and 2060-2079 periods.

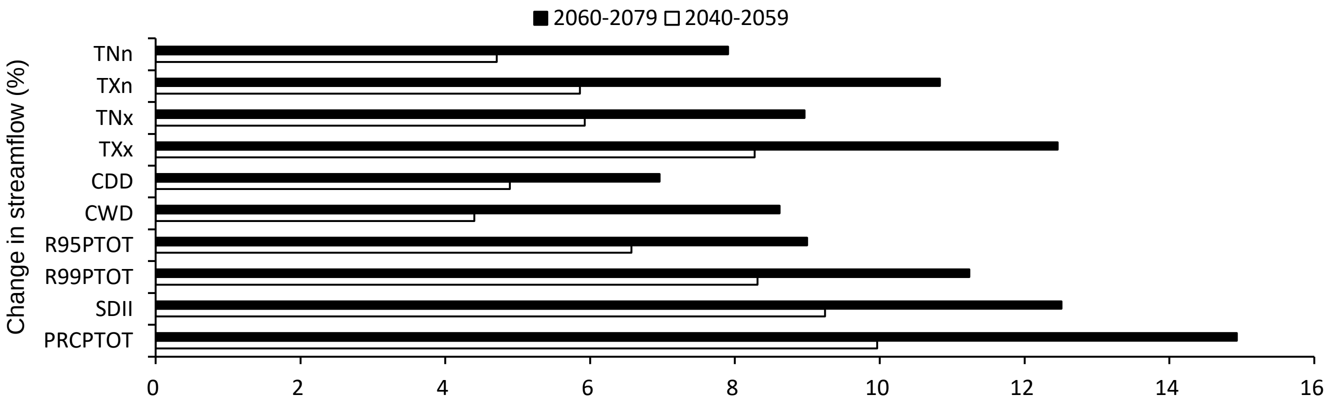


Figure 5. Changes in average annual streamflow (%) using each climate indices under RCP 4.5 scenario during the 2040-2059 and 2060-2079 periods.

5. Conclusion

1) This analysis was to evaluate the effects of extreme climate indices based on temperature and precipitation variables for future periods. As a consequence of climate change, the projected climate indices for both variables will be substantially increased in upcoming periods.
2) According to the results, the Bago River Basin will experience an increase in streamflow in the coming periods due to the influence of extreme climate indices. This would require proper planning and the implementation of efficient adaptive water management strategies for the climate change on the future water resources of the basin.

References

[1] IPCC. Third Assessment Report, Working Group-I Report. Cambridge University Press, Cambridge, UK, 2001.
[2] http://etccdi.pacificclimate.org/list_27_indices.shtml
[3] M. G. Kendall, Rand Correlation Methods, Charles Grifffin, London: 4th edition, 1975.