Spatio-temporal impacts of climate change over Cagayan River Basin, Philippines

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Introduction

Severe droughts and frequent heavy precipitation events are likely to increase because of climate change and a higher degree of fluctuation in precipitation and temperature (IPCC, 2007; Carter et al., 2007). The most critical impacts are affecting water resources, which directly affect agricultural systems and food security. And the Cagayan River Basin (CRB) in the Philippines (**Figure 1**) is the largest, covering a total land area of 27,493.49 km2, currently facing critical issues of rapid climate variability and frequent occurrences of hydroclimatic extremes events like flood, drought, etc. These are the most significant constraints that somehow prevent further development in CRB, and the situation may worsen in the upcoming period due to the rapid climate variability and changes over CRB.

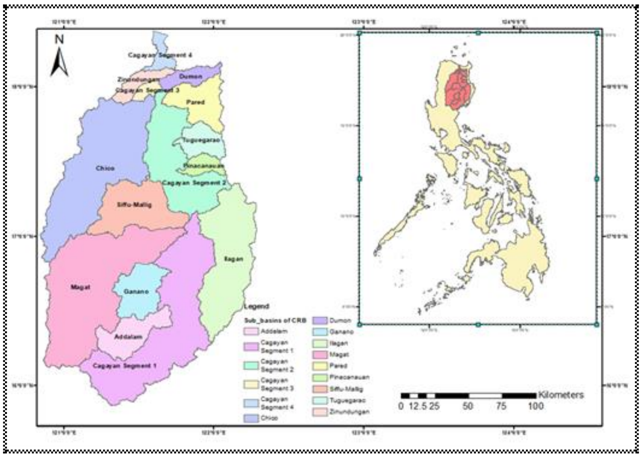

Figure 1: Location map of study area.

Therefore, there is a strong need for an integrated approach to study climate change, by combining aspects of climate projections and prediction of future potential impacts to understand the spatio-temporal changes. Hence, this research has been conceptualized to explore the spatial and temporal changes in climate variability and extreme climate indices using long-term historical and future climate data to identify the present and future potential climate change risk over Cagayan River Basin in the Philippines.

Methodology

The Spatio-temporal modeling by Sen's slope estimation using Mann Kendall's (MK) test was used to analyze the magnitude of change and variability in climate variables and extreme climate indices, using the meteorological variables obtained from high-resolution CMIP6 simulation data produced by MRI-AGCM3.2S over historical (1951-2014) and future (2015-2099) period (Mizuta et al., 2019). This study estimated the relative changes for extreme climate indices like CDD, CWD, R95p, TX90p, and TN90p (**Table 1**) to determine the magnitude of change and level of climate risk over each sub-basin and time, considering the most relevant for agriculture and water resource protection point of view.

Table 1: Indices for characterizing temperature and rainfall extremes (Source: ETCCDI)

Precipitation Indices			Temperature Indices		
Indices	**Definition**	**Unit**	**Indices**	**Definition**	**Unit**
PRCPTOT	Total Annual Precipitation	mm/yr	**TX**	Mean daily max. temperature	^{0}C
CDD	***Consecutive Dry Days:*** Number of Spell of five consecutive days with rainfall <1mm per year	days	**TN**	Mean daily min. temperature	^{0}C
CWD	***Consecutive Wet Days:*** Number of Spell of five consecutive wet per year with rainfall <1mm	days	**TX90p**	***Amount of hot days:*** Percentage of days when TX>90^{th} percentile	%
R95p	***Very wet days rainfall*:** Annual total rainfall when daily rainfall exceeds the 95^{th} percentile of wet days	Mm/yr	**TN90p**	***Amount of warm nights:*** Percentage of days when TN>90^{th} percentile	%

Results

The estimated relative changes of climate variables, and extreme climate indices over space and time were illustrated in Figure 2 and Figure 3.

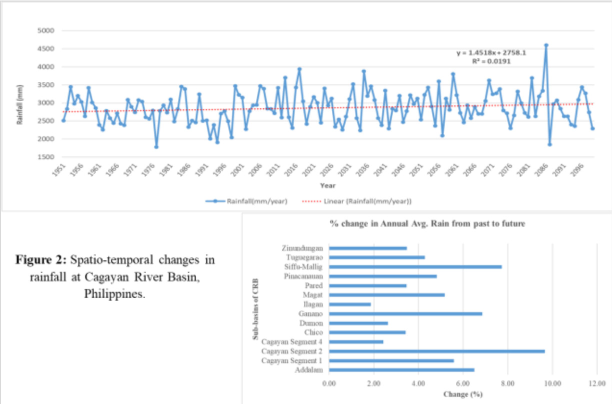

Figure 2: Spatio-temporal changes in rainfall at Cagayan River Basin, Philippines.

In the future, the intra-annual rainfall trend has been increasing with a higher fluctuation rate in minimum and maximum annual rainfall. This will result in droughts in the sub-basins of Chico, Magat, and Cagayan Segment1 where precipitation has been observed to decrease in the future, whereas floods are expected in the sub-basins of Siffu-Mallig, Ganano, and Addalam where precipitation has shown an increasing trend in future (Figure 2). Findings also revealed that the Addalam sub-basin would experience an increase in average annual rainfall and percentage of consecutive dry days (CDD) in the future, which indicates an increased risk of intense dry spells and heavy precipitation events resulting in severe drought and flood events (Figure 3).

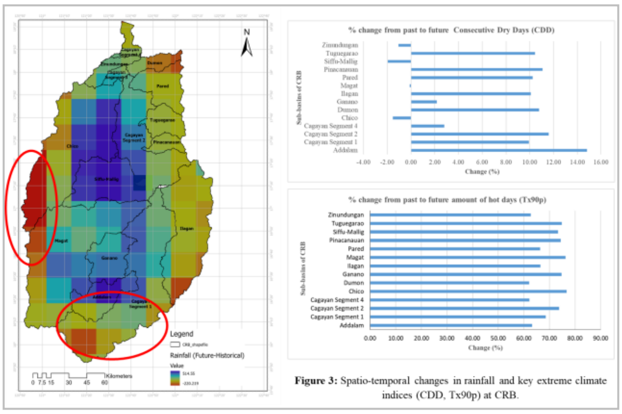

Figure 3: Spatio-temporal changes in rainfall and key extreme climate indices (CDD, Tx90p) at CRB.

Hence, these results would be an easy-to-use resource to tackle the higher-risk zone and able to provide guidance to the disaster risk reduction authority for taking an appropriate decision for executing the feasible adaptation strategies.

Conclusion

A consistent increase in temperature and precipitation is likely to bring prolonged dry spells leading to droughts and wet spells leading to intensive floods at the Cagayan River Basin. However, the climate change risk will not be uniform; some sub-basins will experience higher vulnerability than the other sub-basins, significantly accelerating the different changes of hydroclimatic extremes. Therefore, spatiotemporal modeling is crucial to determine the changes over space and time across river basins and is useful for the effective implementation of adaptation strategies.

Acknowledgment

This research is funded by "Asia-Pacific Network for Global Change Research" (APN) under project reference number CRRP2020-09MYKantoush (Funder ID: https://doi.org/10.13039/100005536).

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