Spatio-temporal variability and trends of extreme rainfall and temperature events over Cagayan River Basin, Philippines

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1. ABSTRACT

Extreme climate events, such as heavy rainfall, drought, flood, and heat waves, have become the most common natural disasters over the Cagayan River Basin. Addressing the consequences and the occurrence of these disasters has always a major challenge, due to increasing population and the impacts posed by extreme climate events. In order to help meet these challenges, this study has been undertaken considering the aim of evaluating of spatio-temporal variation of extreme climate events based on comprehensive assessment of extreme rainfall and temperature indices using long-term high-spatial-resolution climate data for worst-case (RCP8.5) climate change scenarios of MRI-AGCM3.2S data.

These findings would be a straightforward resource for addressing the high-risk zone and guiding disaster risk reduction authorities in making appropriate decisions for implementing adaptation strategies.

Keywords: Extreme Climate Events, Flood Risk, Drought Risk, Climate Change Adaptation, Spatio-temporal Changes.

2. INTRODUCTION

- Frequent heavy precipitation events and severe droughts are likely to increase due to the adverse effect of climate change and a greater degree of fluctuation in precipitation and temperature (IPCC, 2007; Carter et al., 2007).
- Cagayan River Basin (CRB) in the Philippines (**Fig. 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 such as flood, drought, etc.
- Significant constraints that somehow prevent further development in CRB.
- Therefore, to be prepared and counter these changes, there is a strong need for an integrated approach to study climate change, with combing aspects of climate projections and prediction of future potential impacts in order to understand Spatio-temporal changes, for relevant national and regional long-term development strategies toward achieving sustainable development goals (SDG); especially on water and climate change (Goal 6 and 13), and to consider implication for sustainable cities and communities (Goal 11).

Objective

To study 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.

3. STUDY AREA AND DATA USED

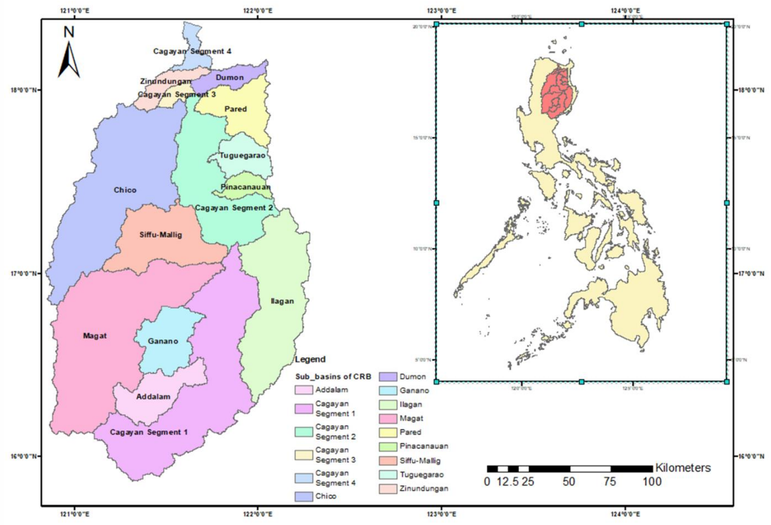


Fig. 1: Study Area Map of Cagayan River Basin in Philippines

4. METHODOLOGY AND DATA USED

- Spatio-temporal modelling approach by Sen's slope estimation using Mann Kendall's test was applied to analyze the variability and magnitude of change in climate variables and extreme climate indices.
- Used high-resolution CMIP6 simulation data produced by MRI-AGCM3.2S over historical (1951-2014) and future (2015-2099) period (Mizuta et al., 2019).

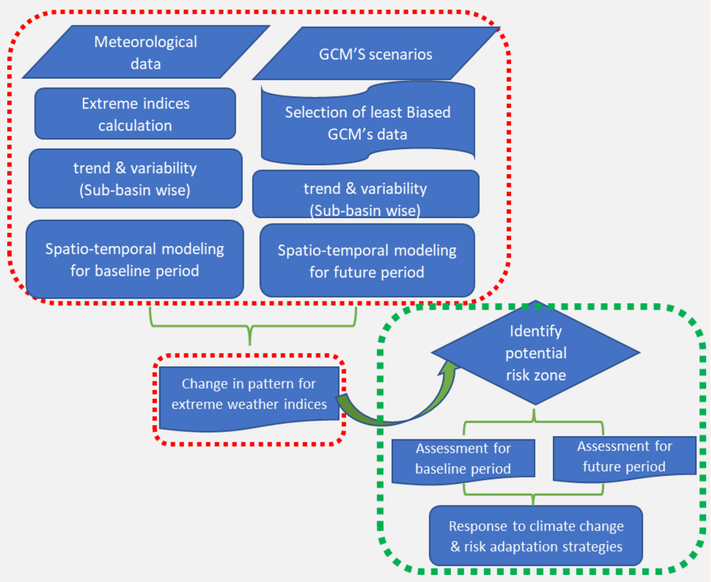


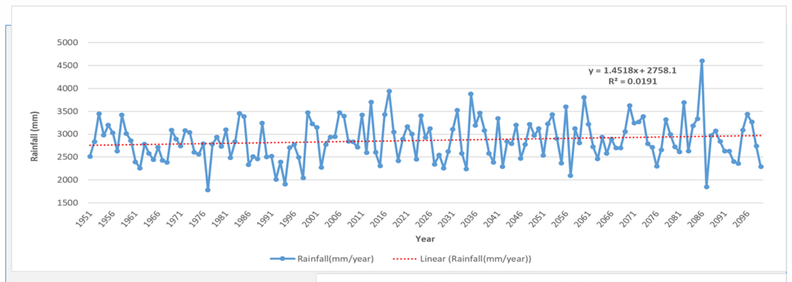
Fig.2. Overall Methodology Framework for climate change assessment and prediction of potential risk from extreme climate

- This study estimated the extreme climate indices such as CDD, CWD, R95p, TX90p, and TN90p, considering the most important and relevant for agriculture and water resource protection point of view to identify the level of climate change risk (**Table 1**).

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>90th percentile	%
R95p	Very wet days rainfall: Annual total rainfall when daily rainfall exceeds the 95th percentile of wet days	Mm/yr	TN90p	Amount of warm nights: Percentage of days when TN>90th percentile	%

5. RESULTS AND DISCUSSION



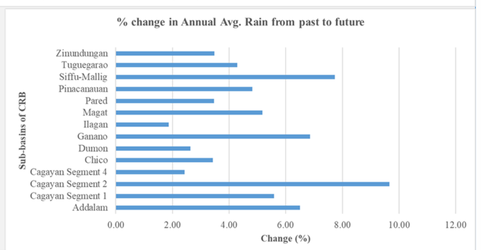


Figure 2: Spatio-temporal changes in rainfall at Cagayan River Basin, Philippines.

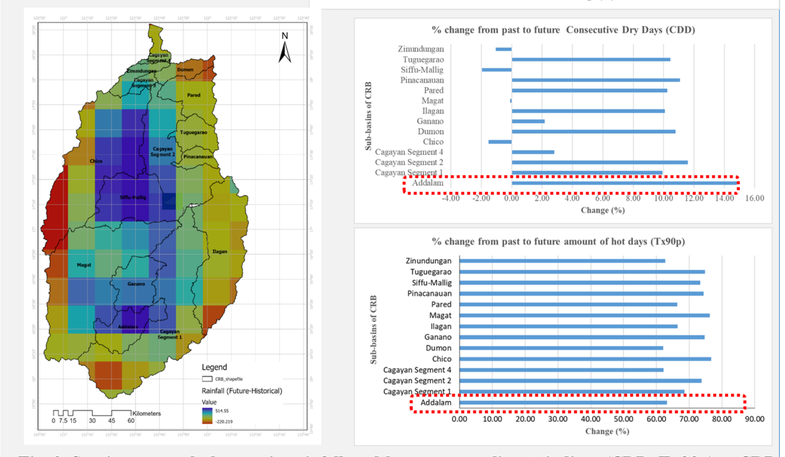


Fig. 3. Spatio-temporal changes in rainfall and key extreme climate indices (CDD, Tx90p) at CRB.

- Temporally, the intra-annual rainfall has shown an increasing trend over the future period, with a higher fluctuation rate in minimum and maximum annual rainfall (**Figure. 2**).
- Spatially, it has shown that the sub-basins, namely Chico, Magat, Cagayan Segment1 will experience a drought-like situation in the future, compared to the present rainfall scenario over these sub-basins (**Fig.3**) Whereas the sub-basin like Addalam will experience more floods in the future.
- All sub-basins shows increasing trend in the amount of hot days in future. This indicates the probability of increasing warming over CRB in the future.

6. CONCLUSIONS

- Quantitative knowledge about the impacts of climate change on the hydrological regime is essential in order to achieve meaningful insights to address various adverse consequences related to water such as water scarcity, flooding, drought, etc.
- Understanding of knowledge regarding the identification of specific risks and their possibility will be more important for managing climate-related risks (Weaver et al. 2017)

7. REFERENCES

1. Carter, T. R., et al. 2007. General guidelines on the use of scenario data for climate impact and adaptation assessment. Geneva: Intergovernmental Panel on Climate Change, Task Group on Data and Scenario Support for Impact and Climate Assessment.
2. Expert Team on Climate Change Detection and Indices (ETCCDI), available at https://www.wcrp-climate.org/etccdi
3. IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change
4. Mizuta, Ryo; Yoshimura, Hiromasa; Ose, Tomoaki; Hosaka, Masahiro; Yukimoto, Seiji (2019). MRI MRI-AGCM3-2-S model output prepared for CMIP6 HighResMIP-Version1. Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.1625
5. Weaver CP, Moss RH, Ebi KL, Gleick PH, Stern PC, Tebaldi C et al (2017) Reframing climate change assessments around risk: recommendations for the US National Climate Assessment. Environ Res Lett 12(8):080201

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