Online Symposium UNESCO Chair Kobe 2024

Title: Climate Change Impact on Annual and Seasonal Rainfall Variability: A Case Study in Simunjan, Sarawak

By:

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Background of Study

- Climate change significantly impacts water resources, leading to both water shortages and altered water availability.
- Regions that rely on seasonal rainfall, such as the monsoon, may experience delayed or reduced rainfall, which directly impacts water availability for agriculture, drinking, and industrial use (Hirabayashi et al., 2013; Wilby & Keenan, 2012).
- The frequency and severity of droughts are increasing in many parts of the world due to climate change.
- Extended periods of low rainfall combined with higher temperatures result in decreased river flows, lower groundwater levels, and dried-up lakes and reservoirs.

Objective

- This study aims to study the effect of climate change under a specific IPCC scenario, on the annual and seasonal rainfall variability.
- This output of the study may contribute to the broader understanding of how climate change is affecting rural water service delivery in tropical regions and provide actionable insights for policymakers and local communities.

Methodology

- **Study area**: Simunjan (a town located in the Samarahan Division of Sarawak, situated approximately 120 kilometers northeast of Sarawak's capital, Kuching).
- **Total population**: 39,600, where 55.56% of Malays and 36.11% of Sea Dayak (also known as the Iban).
- **Sea Dayak**: One of the largest indigenous groups in Sarawak, are known for their rich cultural traditions, including their longhouse communities, where multiple families live together in a single, extended building.

Methodology

- **Water supply:** 25% from the water pipe (treated water), 75% from the rivers, gravity feeds as well storage tank, showing that the water supply from natural resources played an important role for the uses of daily activities.
- **Data:** The hourly historical and future rainfall data (under SSP5-8.5) of the study area was collected from NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6). The selection of SSP5-8.5 is mainly due to the intention of observing the impact on the rainfall variability caused by the worst-case scenario.

Methodology

- **Study Period:** The study periods were arbitrarily divided into four, which are 1990-2014 (historical period), 2026-2050 (future period 1), 2051-2075 (future period 2) and 2076-2100 (future period 3), each with an interval of 25 years.

No.	Description	Years	Number of Years
1	Historical Period	1990-2014	25
2	Future Period 1	2026-2050	25
3	Future Period 2	2051-2075	25
4	Future Period 3	2076-2100	25

Methodology

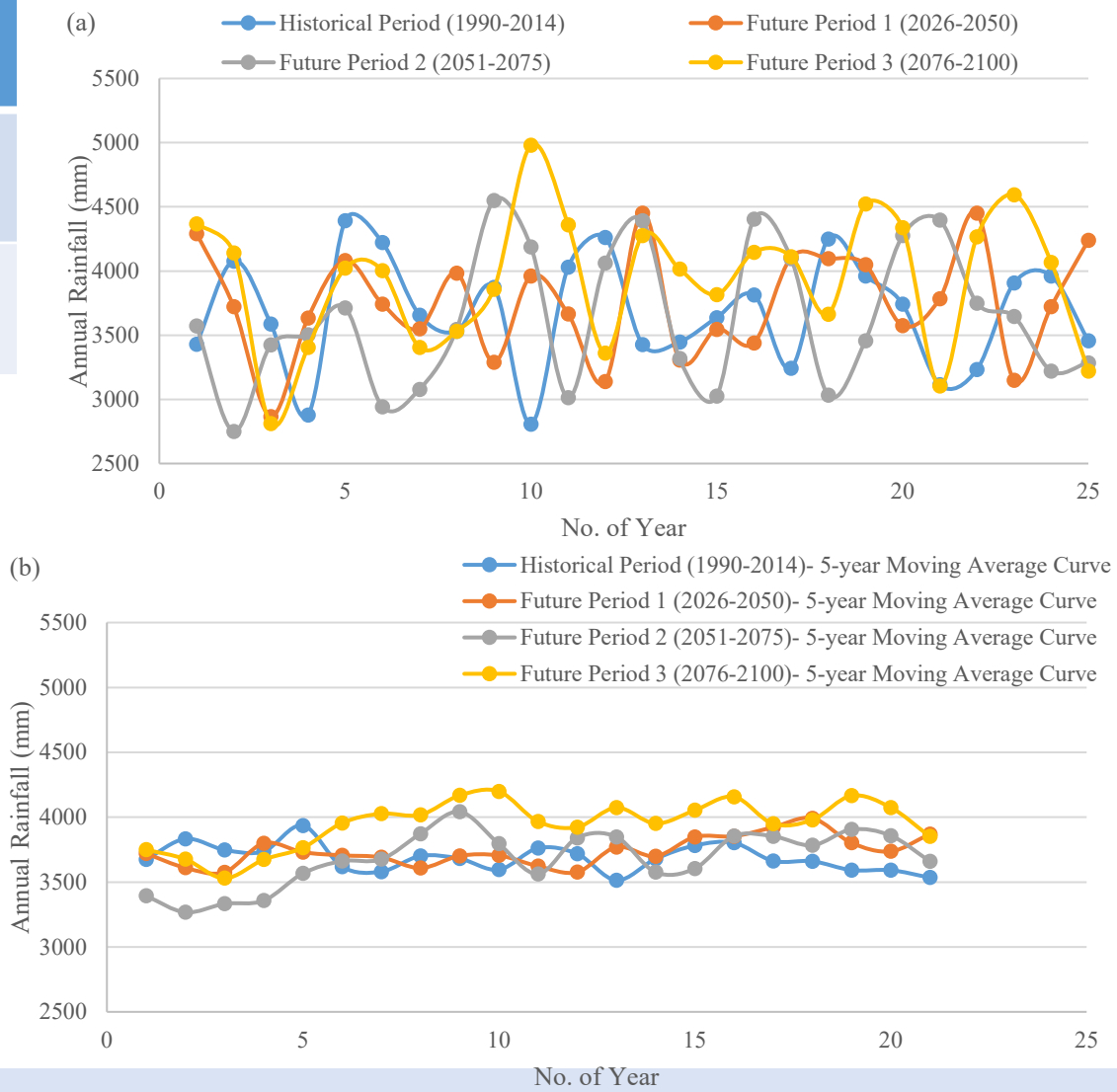
- **Monsoon Seasons:** The climate in Malaysia is predominantly shaped by the monsoon seasons, leading to fluctuations in both rainfall patterns and temperature.

Description	Duration
Northeast Monsoon Season (NEM)	November – March
Inter-Monsoon Season 1 (IM1)	April
Southwest Monsoon Season (SWM)	May – September
Inter-Monsoon Season 2 (IM2)	October

Results and Discussion: Annual Rainfall Assessment

Annual Rainfall	Historical Period	Future Period 1	Future Period 2	Future Period 3
Maximum	4393 mm (1994)	4452 mm (2047)	4551 mm (2059)	4980 mm (2085)
Minimum	2807 mm (1999)	2867 mm (2028)	2751 mm (2052)	2811 mm (2078)

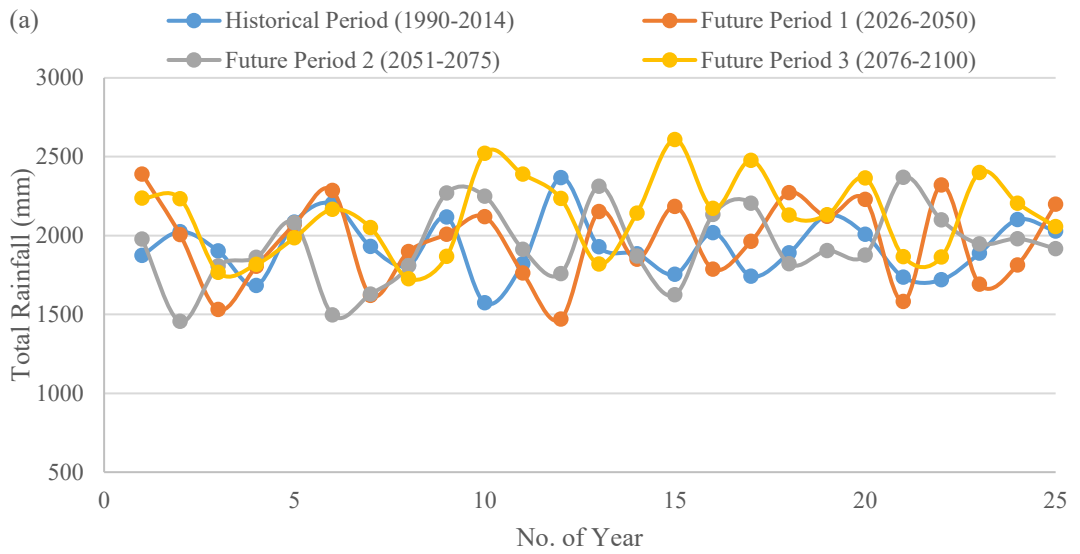
- It is worth highlighting that for the future period 2, there is a year with a projected annual rainfall **lesser than 2807 mm**. Hence, this may affect the water supply at Simunjan, especially in the rural area for that particular year.

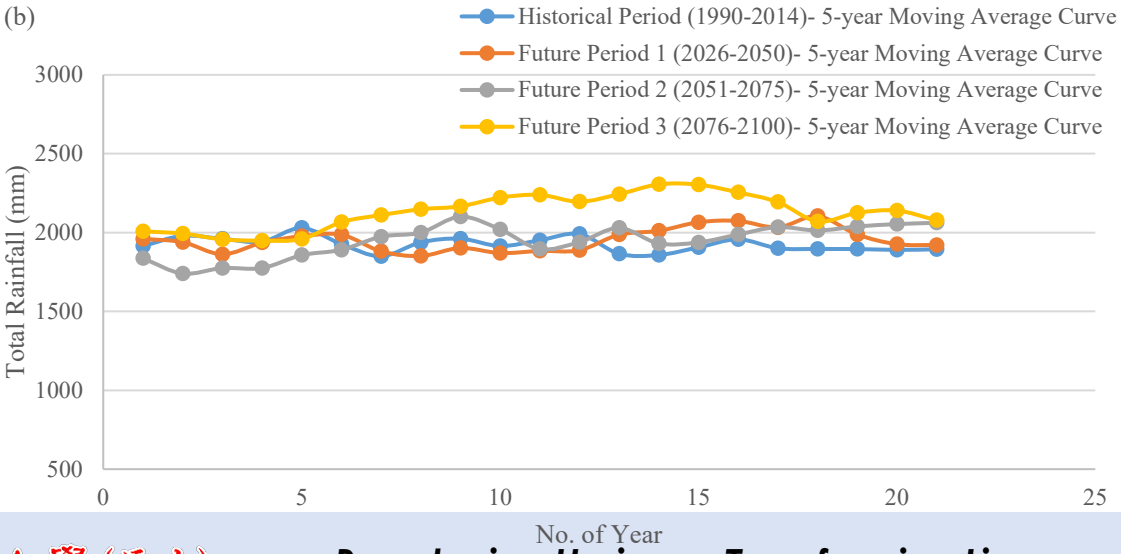


Seasonal Rainfall Assessment (Northeast Monsoon Season)

Annual Rainfall	Historical Period	Future Period 1	Future Period 2	Future Period 3
Maximum	2366 mm (2001)	2389 mm (2026)	2368 mm (2071)	2608 mm (2090)
Minimum	1573 mm (1999)	1470 mm (2037)	1455 mm (2052)	1726 mm (2083)

- It is observed that there are a total number of 4 years that have a projected total rainfall of **less than 1573 mm**, which are the year 2028 (with projected total rainfall of 1530 mm), 2037 (with projected total rainfall of 1470 mm), 2052 (with projected total rainfall of 1455 mm) and 2056 (with projected total rainfall of 1496 mm). Hence, during the NEM of the aforementioned year, there may be a possibility of encountering a water shortage issue.

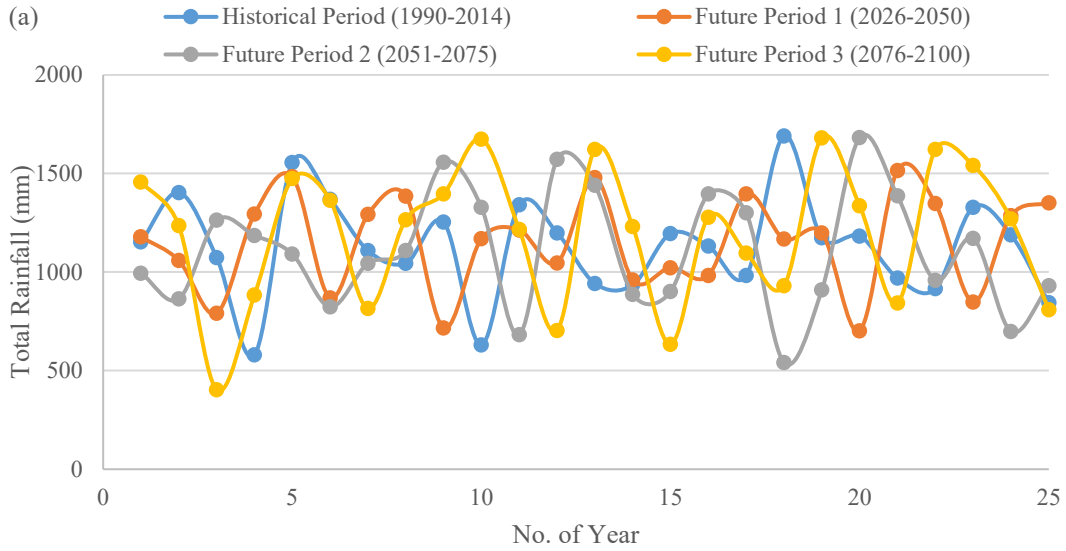


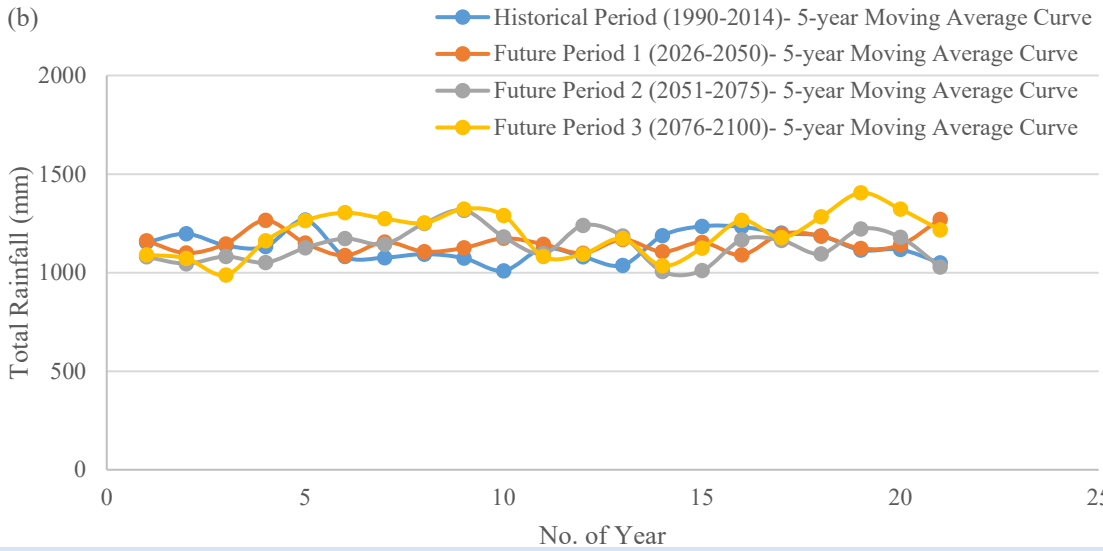


Seasonal Rainfall Assessment (Southwest Monsoon Season)

Annual Rainfall	Historical Period	Future Period 1	Future Period 2	Future Period 3
Maximum	1690 mm (2007)	1515 mm (2046)	1682 mm (2070)	1680 mm (2094)
Minimum	1152 mm (1990)	1178 mm (2026)	540 mm (2068)	403 mm (2078)

- It is observed that there are several years in future periods 2 and 3, showing a projected total rainfall of **less than 1152 mm**.
- In future period 2, the years are 2051, 2052, 2055, 2056, 2057, 2058, 2061, 2064, 2065, 2068, 2069, 2072, 2074 and 2075. The range of projected difference is **between 3% and 53%.**
- In future period 3, the years are 2078, 2079, 2082, 2087, 2090, 2092, 2093, 2096 and 2100. Among the years, the **year 2078** exhibits a projected value of **65%** less than the historical minimum total rainfall.

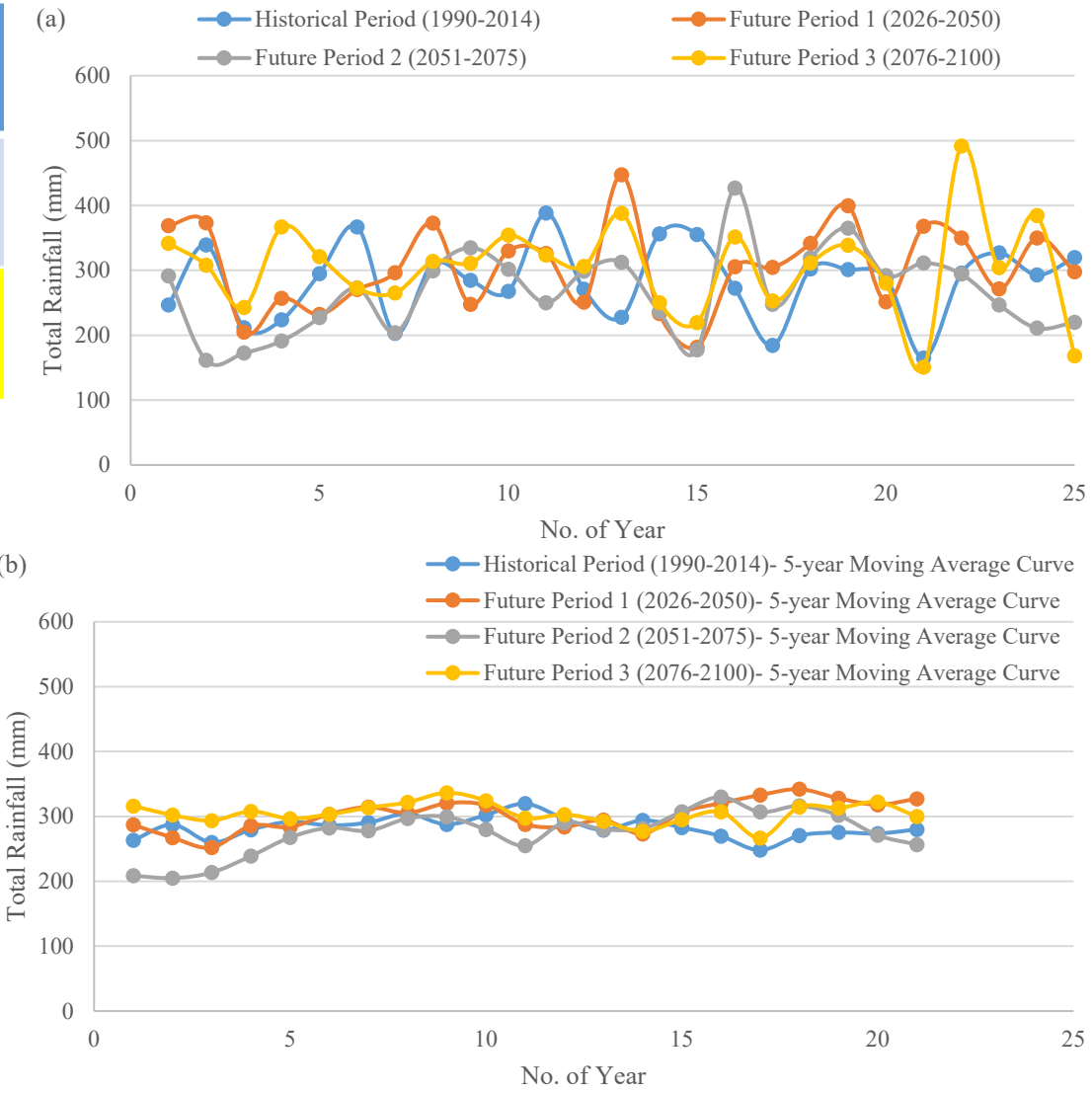




Seasonal Rainfall Assessment (Inter-Monsoon Season 1)

Annual Rainfall	Historical Period	Future Period 1	Future Period 2	Future Period 3
Maximum	388 mm (2000)	447 mm (2038)	426 mm (2066)	491 mm (2097)
Minimum	164 mm (2010)	181 mm (2040)	161 mm (2052)	150 mm (2096)

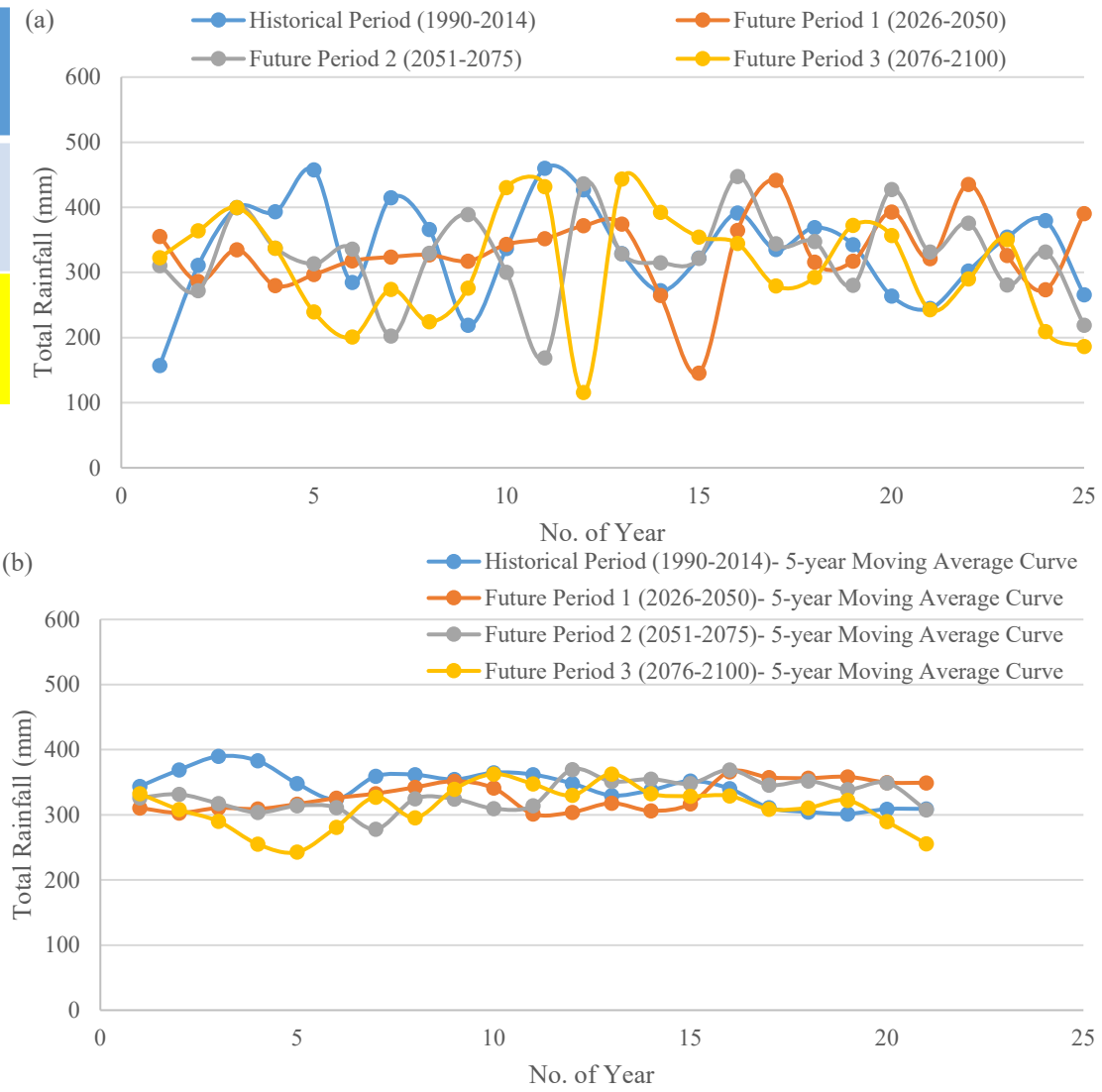
- It is noticed that there are a total number of 2 years which have a projected total rainfall of **less than 164 mm**, which are the **year 2052** (with projected total rainfall of 161 mm) and **2096** (with projected total rainfall of 150 mm).
- Hence, during IM1 of the aforementioned year, extra awareness should be created so that the water supply in the communities will not be affected.



Seasonal Rainfall Assessment (Inter-Monsoon Season 2)

Annual Rainfall	Historical Period	Future Period 1	Future Period 2	Future Period 3
Maximum	459 mm (2000)	441 mm (2042)	447 mm (2066)	443 mm (2088)
Minimum	157 mm (1990)	355 mm (2026)	168 mm (2061)	115 mm (2087)

- It is noticed that there is a year that has a projected total rainfall of **less than 157 mm**, which is the year 2087 (with a projected total rainfall of 115 mm).
- Hence, during IM2 of the aforementioned year, close monitoring should be conducted to ensure the water supply is sufficient for the communities in the study area.



Conclusions

- The increased variability in both annual and seasonal rainfall poses serious challenges for the communities in Simunjan, for example, the Sea Dayak, who rely on consistent rainfall for their water needs.
- The projected decrease in rainfall during dry seasons threatens to exacerbate water shortages and strain existing water supply systems.
- In terms of annual rainfall, the findings show that in the **year 2052**, there may be a high risk of facing a water crisis in the study area.
- Meanwhile, from the perspective of the seasonal rainfall, **during the NEM**, the study area may face water shortage issues as it shows a total of **65% deduction** in the total rainfall in the **year 2078**.
- It is imperative to develop adaptive strategies accordingly to enhance the resilience of the water resources system in Simunjan in the future.
- This includes investing in water storage infrastructure, improving water management practices, and exploring alternative water sources to ensure reliable access to clean water throughout the year.

Thank you

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