

Effect of climate change on precipitation and temperature on Malaprabha basin

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ABSTRACT: The aim of this study is to have a proper management strategy and effective utilization of the available water resources in the study area. The effects of changing hydrological variables such as precipitation and temperature are necessary since they have a significant role to play and has a huge direct impact on the ecology and environment. Ensembled average of five downscaled GCM models GFDL-ESM2M, HadGEM2-ES, IPSL-CM5A-LR, MIROC and NoerESM1-M for 2 emission scenarios RCP 4.5 and RCP 6.0 are used to simulate the future precipitation and temperature for the Malaprabha Basin for the time period 2056-2045.

Keywords - Climate Change, Precipitation, Temperature, Boxplot.

I. INTRODUCTION

Climate change have always affected the people and also the ecosystem globally. Climate change has significant impact on the meteorological extremes like drought, floods and storms which intern effects the agriculture and other activities. The adverse effect due to climate change is likely to be increased in future. (Al-Mukhtar et al. 2014). Malaprabha basin is facing the similar scenario due to the adverse effect of climate change. The average annual rainfall is showing the increase in trend due to the gradual increase in temperature which intern increases the evaporation which aids in the increase in annual precipitation. It is important to study the precipitation and temperature since it is the base of all the climate change. The proper knowledge of precipitation and temperature variation is important since the agricultural activities are directly dependent on these hydrological parameters. Here the study focuses on the evaluation and projection of precipitation and temperature from various downscaled GCM models.

II. DESCRIPTION OF STUDY AREA

Malaprabha river is one of the major tributaries of river Krishna. The basin lies in 15° 00' and 16° 12' north latitudes and 74° 14' and 76° 05' east longitudes. The river originates from the Chorla Ghats at an elevation of 792 m. The river flows for around 306 km before reaching the river Krishna at Kapila Sangam in Bijapur District at an elevation of 488 m. The total catchment area of the Malaprabha basin is 11,549 km². The dam is constructed across the river near Munavalli in Belgaum District and the reservoir is called as Renukasagar and is the major source of irrigation for around 3 million people in the nearby region. The soils found inside the basin are red loamy soil and medium dark soil. The average yearly precipitation is around 2262 mm. The temperature ranges in between 19.30 °C and 29.50 °C. The annual discharge of Khanapur gauge is 8989.45 m³/s.

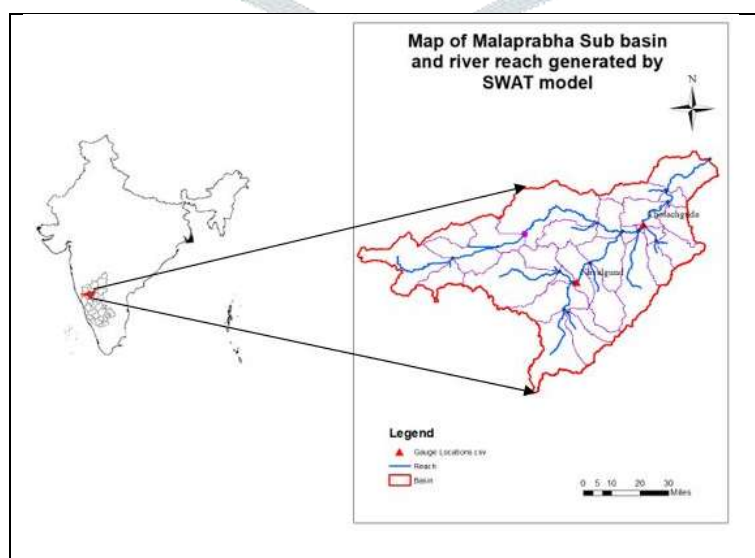


Fig. 1. Malaprabha subbasin in Karnataka, India

III.METHODOLOGY

3.1. GCM DATA USED

General Circulation Models (GCMs) currently available at 0.5° grid for maximum and minimum temperature and precipitation. The GCM model GFDL-ESM2M is used to generate the future discharge in the Malaprabha river using Soil and Water Assessment Tool (SWAT) developed in NOAA/Geophysical Fluid Dynamics Laboratory. The ensembled average of 5 GCM models are used to plot the variation in future temperature and precipitation. The list of GCM models used are mentioned in table 1. The future projected data used are from (2006-2085). The projection is done with reference to 2 representative concentration pathways *i.e.*, RCP 4.5 and 6.0 is used for projecting the future meteorological data based on the severity of the GHG emissions due to both anthropogenic and natural causes.

Table.1: List of GCMs

SI/No	Models	Institute
1	GFDL-ESM2M	NOAA/Geophysical Fluid Dynamics Laboratory
2	HadGEM2-ES	Met Office Hadley Center
3	IPSL-CM5A-LR	L'Institute Pierre-Simon Laplace.
4	MIROC	AORI, NIES and JAMSTEC
5	NoerESM1-M	Norwegian Climate Center

IV.RESULT AND DISCUSSION

4.1. Plots to show the future variation in hydrological parameters such as Maximum and Minimum temperature for RCP 4.5 and RCP 6.0 for the time period 2006-2085

In the Figure 2, the variation in the future maximum temperature is plotted for the year 2006-2085. It is seen that there is an average increase of 0.0022°C in the maximum temperature in the Malaprabha under RCP 4.5 every year. The increase in average annual maximum temperature is 31.157°C and varies from 31.19°C to 31.35°C . There is a temperature difference of about 0.16°C for the time span of 79 years *i.e.*, from 2006-2085.

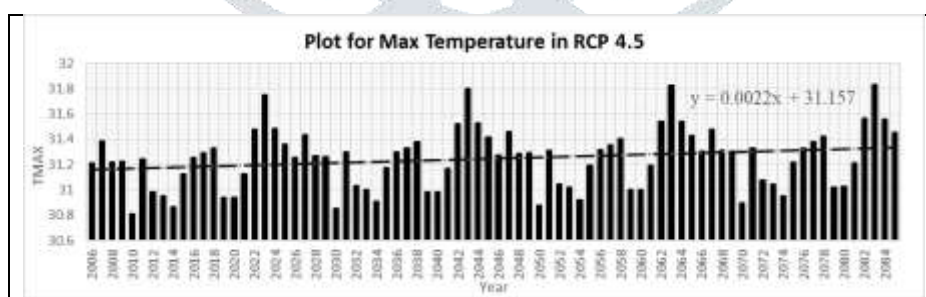


Figure 2: Plot for Max temperature in RCP 4.5

In the Figure 3, the variation in the future maximum temperature is plotted for the year 2006-2085. It is seen that there is an average increase of 0.0025°C in the maximum temperature in the Malaprabha under RCP 6.0 every year. The increase in average annual maximum temperature is 31.149°C and varies from 31.19°C to 31.35°C . So, we can infer that the change in temperature is seem to be little more in comparison with RCP 4.5. There is a temperature difference of about 0.2°C for the time span of 79 years *i.e.*, from 2006-2085.

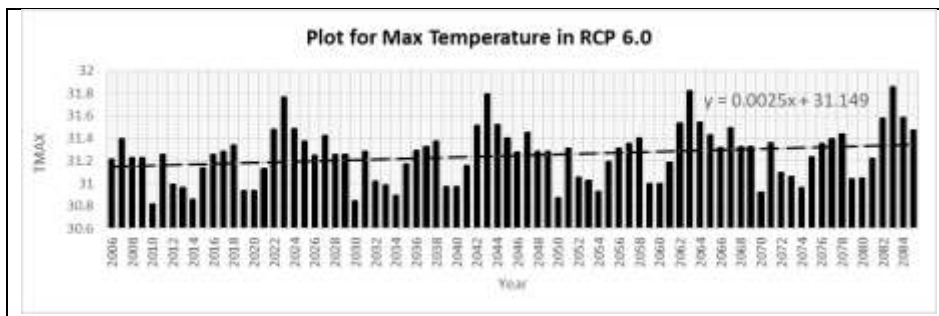


Figure 3: Plot for Max temperature in RCP 6.0

In the Figure 4, the variation in the future minimum temperature is plotted for the year 2006-2085. It is seen that there is an average increase of 0.0008 °C in the minimum temperature in the Malaprabha under RCP 4.5 every year. The increase in average annual minimum temperature is 21.571°C and varies from 21.59°C to 21.65°C. There is a temperature difference of about 0.06°C for the time span of 79 years i.e., from 2006-2085.

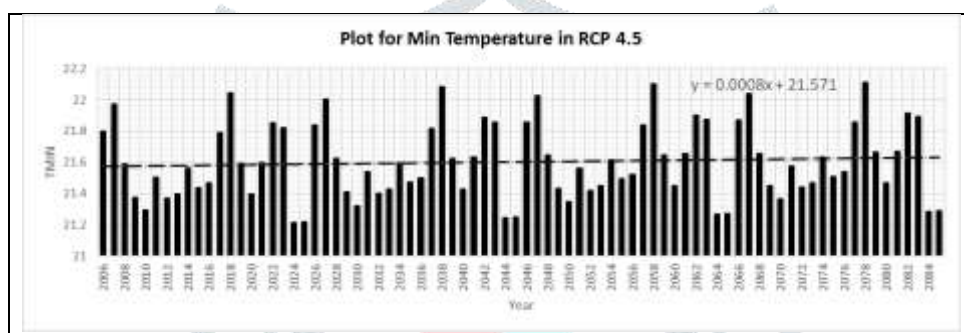


Figure 4: Plot for Min temperature in RCP 4.5

In the Figure 5, the variation in the future minimum temperature is plotted for the year 2006-2085. It is seen that there is an average increase of 0.001 °C in the minimum temperature in the Malaprabha under RCP 6.0 every year. The increase in average annual minimum temperature is 21.565°C and varies from 21.55°C to 21.63°C. There is a temperature difference of about 0.079°C for the time span of 79 years i.e., from 2006-2085. So, we can infer that the change in temperature is little more in comparison with RCP 4.5.

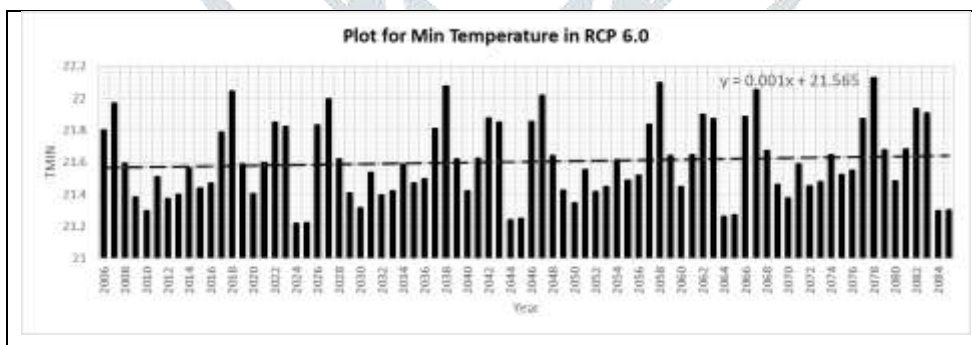


Figure 5: Plot for Min temperature in RCP 6.0

4.2. Plots to show the future variation in average annual precipitation for RCP 4.5 and RCP 6.0 for the time period 2006-2085.

In the Figure 6, simulated precipitation plot is plotted for the year 2006-2085. It is seen that there is a gradual increase in the average annual precipitation of 15.803 mm/day in Malaprabha sub basin. The increase in average annual precipitation is 5722.4 mm/day and varies in between 5900-7000 mm/day for RCP 4.5. In this context, we can confirm that with the increase in the Representative Concentration Pathway (RCP) there is a gradual increase in average annual precipitation.

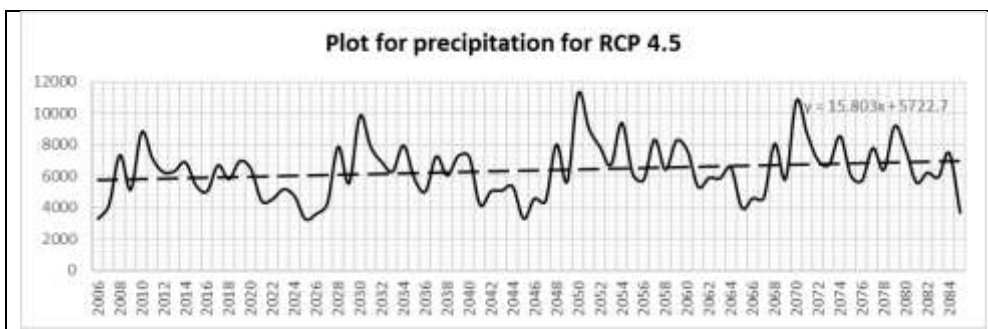


Figure 6: Plot to show the future variation in precipitation for RCP 4.5

In the Figure 7, simulated precipitation plot is plotted for the year 2006-2085. It is seen that there is a gradual increase in the average annual precipitation of 13.467 mm/day in Malaprabha sub basin. The increase in average annual precipitation is 6411 mm/day and varies in between 6200-7800 mm/day for RCP 6.0. In this context, we can confirm that with the increase in the Representative Concentration Pathway (RCP) there is a gradual increase in average annual precipitation.

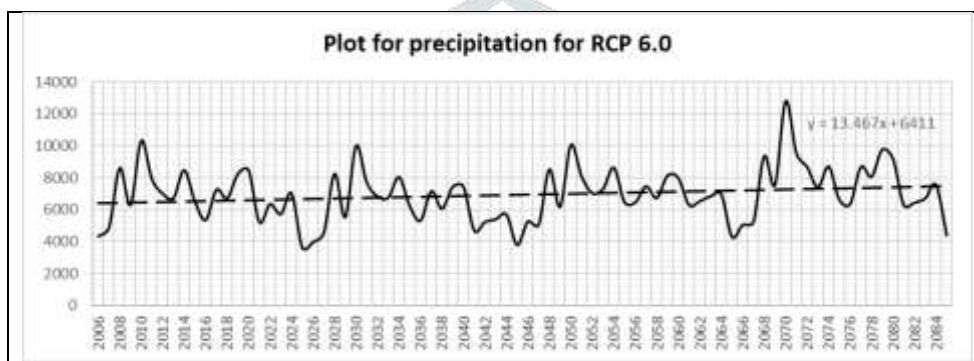


Figure 7: Plot to show the future variation in precipitation for RCP 4.5

4.3. Boxplot to show the monthly variation in the Maximum and Minimum temperature for RCP 4.5, 6.0 for 2026-2045

Box plot of Minimum temperature for RCP 4.5 is plotted for four time slices as shown in Figure 8. From the plots it is seen that the month of May records the highest minimum temperature for all the four time slices and ranges in between 23.9°C to 25.9°C and the mean temperature is 24.5°C. The month of January records the lowest minimum temperature for all the time slices and ranges in between 16.7°C to 19°C and the mean temperature is 17.9°C for RCP 4.5

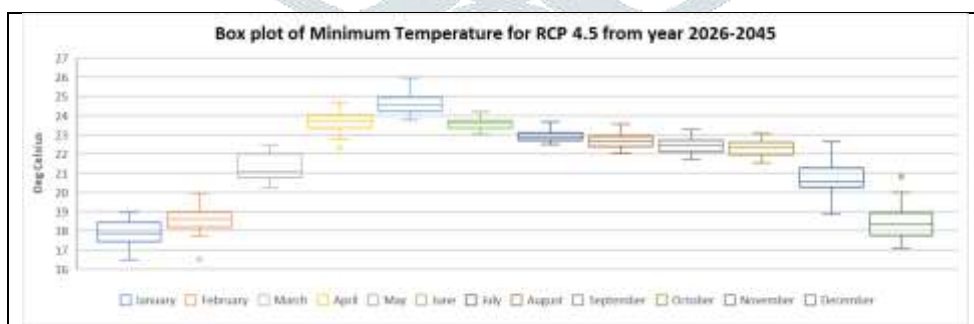


Figure 8: Box plot of Minimum Temperature for RCP 4.5 from year 2026-2045

Box plot of Minimum temperature for RCP 6.0 plotted for four time slices as shown in Figure 9. From the plots it is seen that the month of May records the highest minimum temperature for all the four time slices and ranges in between 24°C to 26°C and the mean temperature is 24.8°C. The month of January records the lowest minimum temperature for all the time slices and ranges in between 16.2°C to 19°C and the mean temperature is 18°C for RCP 6.0

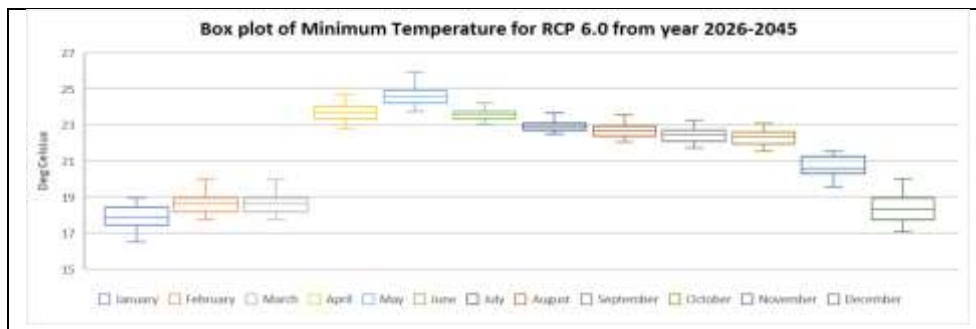


Figure 9: Box plot of Minimum Temperature for RCP 6.0 from year 2026-2045

Box plot of Maximum temperature for RCP 4.5 plotted for four time slices as shown in Figure 10. From the plots it is seen that the month of April records the highest maximum temperature for all the four time slices and ranges in between 35.3⁰C to 33.3⁰C and the mean maximum temperature is 34.2⁰C. The month of August records the lowest maximum temperature for all the four time slices and ranges in between 27.1⁰C to 29⁰C and the mean temperature is 28⁰C for RCP 2.6. Here the trend shows the decrease in maximum temperature in the monsoon season i.e., from June to October and the increase in maximum temperature in the pre-monsoon season i.e., from Feb to May.

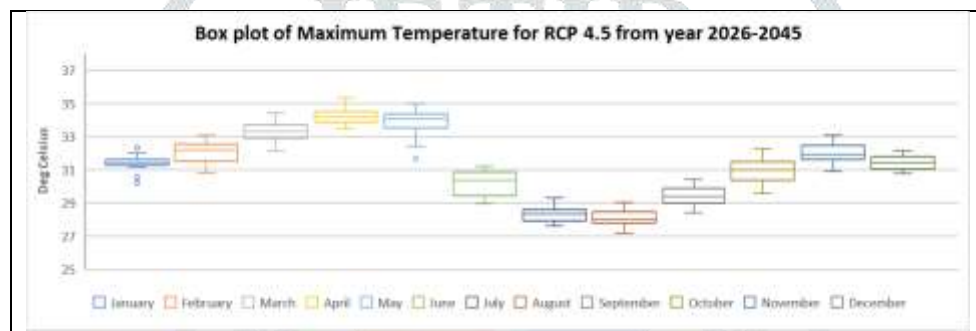


Figure 10: Box plot of Maximum Temperature for RCP 4.5 from year 2026-2045

Box plot of Maximum temperature for RCP 6.0 plotted for four time slices as shown in Figure 11. From the plots it is seen that the month of April records the highest maximum temperature for all the four time slices and ranges in between 33.5⁰C to 35.5⁰C and the mean maximum temperature is 34.6⁰C. The month of August records the lowest maximum temperature for all the four time slices and ranges in between 26.9⁰C to 29⁰C and the mean temperature is 28⁰C for RCP 6.0 Here the trend shows the decrease in maximum temperature in the monsoon season i.e., from June to October and the increase in maximum temperature in the pre-monsoon season i.e., from February to May.

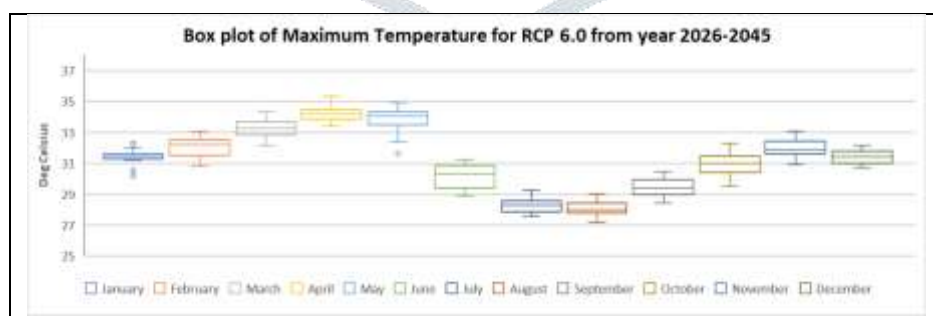


Figure 11: Box plot of Maximum Temperature for RCP 6.0 from year 2026-2045

4.4. Boxplot to show the monthly variation in the average annual precipitation for RCP 4.5, 6.0 for 2026-2045

Box plot of simulated precipitation for RCP 4.5 is plotted for four time slices as shown in Figure 12. From the plots it is seen that the month of July records the highest rainfall intensities and ranges in between 800-3900 mm/day and the mean maximum intensity is 1600 mm/day. It simulates no rainfall in between the month December to March. The rainfall gradually increases from the month of May to July with the highest intensity and gradually reduces from the month of August to November.

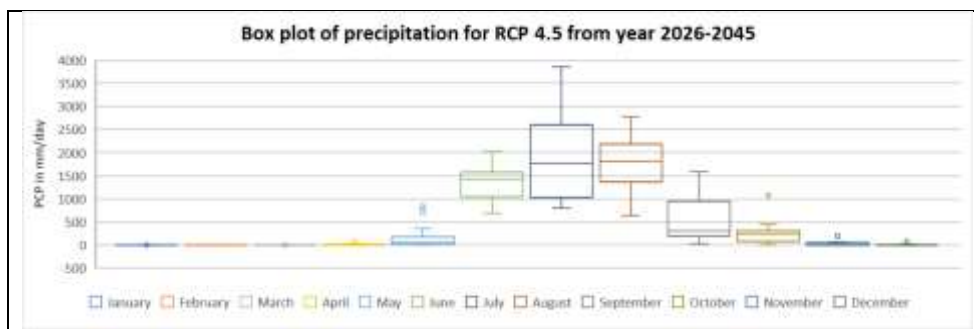


Figure 12: Box plot of precipitation for RCP 4.5 from year 2026-2045

Box plot of simulated precipitation for RCP 6.0 is plotted for four time as shown in Figure 13. From the plots it is seen that the month of July records the highest rainfall intensities and ranges in between 900-3500 mm/day and the mean maximum intensity is 2000 mm/day. It simulates no rainfall in between the month December to March. The rainfall gradually increases from the month of May to July with the highest intensity and gradually reduces from the month of August to November.

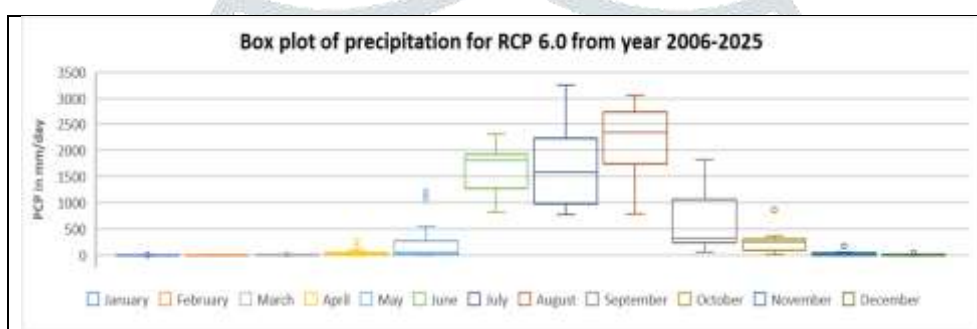


Figure 13: Box plot of precipitation for RCP 6.0 from year 2026-2045

V. CONCLUSION

Due to the complex nature of the hydrological variables it is difficult to assess the future change in the climate due to natural and human factors. The effects of climate change always have an adverse effect in local and global scale. The study reveals that there is a gradual increase in the maximum and minimum temperature for the time period 2006-2085 with an increase of 31.19⁰ C to 31.35⁰ C for RCP 4.5, 31.19⁰ C to 31.39⁰ C for RCP 6.0 for maximum temperature and 21.59⁰ C to 21.62⁰ C for RCP 4.5, 21.55⁰ C to 21.75⁰ C for RCP 6.0 for minimum temperature which may have led to the increase in average annual evaporation for the time period 2006-2085. Which intern have resulted in the increase of average annual precipitation rate of 5900-7000 mm/day for RCP 4.5, 6200-7800 mm/day for RCP 6.0. The boxplot is plotted to show the monthly variation in the Minimum and Maximum temperature where month of May records the highest Minimum Temperature for time period 2026-2045 and ranges in between 23.9⁰ C to 25.9⁰ C and 24⁰ C to 26⁰ C for RCP 4.5, 6.0 and month of April records the highest Maximum Temperature for time period 2026-2045 and ranges in between 33.3⁰ C to 35.3⁰ C and 33.5⁰ C to 35.5⁰ C for RCP 4.5, 6.0. This information could be used in studying the climate driven alterations on the hydrological parameters which could be used in strategic management of the watershed.

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