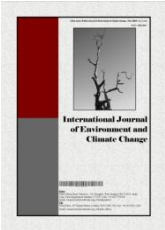

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Projected Changes in Climate Over Cauvery Delta Zone of Tamil Nadu in Southern India

M. Rajavel [a], M. Selva Kumar [a*], K. Bhuvaneswari [a], V. Vakeswaran [a], S. Mohan Kumar [a], N. K. Sathyamoorthy [a], N. Balakrishnan [a], R. Gowtham [a] and S. Priyanka [a]

[a] Tamil Nadu Agricultural University, Coimbatore - 641003, Tamil Nadu, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Climate change, as well as an increase in extreme weather, are posing a serious threat to socioeconomic and livelihood security. For this study, the Cauvery delta zone (CDZ) was chosen to examine current and anticipated climate variability and trend. The four largest districts of Tamil Nadu's Cauvery delta region are Thanjavur, Thiruvarur, Mayiladuthurai, and Nagapattinam. The Indian meteorological agency provided the baseline data sets (IMD). Using IPCC AR5 RCP4.5 and RCP8.5 scenarios, the maximum and minimum temperatures, as well as precipitation, were investigated. The maximum temperature could rise to 1.1^{o}C to 3.6^{o}C, while the minimum temperature could rise to 2.8 to 4.5^{o}C, according to the findings. It was also concluded that there will be 15-16% rise in the rainfall during end of the century.

Keywords: Cauvery delta zone; climate change; RCP; Tamil Nadu.

ABBREVATIONS

LPA : Long Period Average;
IMD : Indian Meteorological Department;
BL : Base Line;
IPCC : Intergovernmental Panel on Climate Change;
RCP : Representative Concentration Pathway.

**Corresponding author: E-mail: selvakumarmut2016@gmail.com;*

1. INTRODUCTION

Tamil Nadu's economic, industrial, and agricultural growth is fully dependent on the spatiotemporal distribution of several meteorological indices such as rainfall, temperature, and pressure. Rainfall and temperature are the two most essential factors that have a direct impact on a region's climate [1]. Variation in climatic occurrences, as well as an increase in extreme weather, pose a serious danger to socioeconomic and livelihood security [2].

The primary implications of the enormous increase in greenhouse gas concentrations owing to human activity, particularly industrialization, fossil fuel burning, and land use/land cover changes, invasive pests were taken into account for shifting temperature and global climate change [3,4,5]. According to reports, India's mean annual temperature has risen by 0.6 ^{o}C over the last century; monsoon rainfall has decreased in many parts of the country over the last three decades of the twentieth century, while some areas have seen an increase in the observed frequency of heavy rainfall events [6,7].

The temperature and rainfall trends, as well as their variability, were explored in a number of regional studies in India. The 30-year maximum and minimum temperature record (1981-2010) revealed a quicker warming trend [8,9,10] and increased extremities [11]. The expected maximum and minimum temperatures across Tamil Nadu were analyzed by Rajalakshmi [12] and they revealed a rising tendency with 1.7 to 3.7 °C and 1.9 to 4.3 °C, respectively. Geetha et al., investigated the future climate extreme indices of temperature and rainfall by PRECIS over Tamil Nadu [11]. The temperature indices for the future in Tamil Nadu revealed a strong rising trajectory. Future extreme rainfall indicators, on the other hand, showed an increase in extreme events (flash flood and storms).

The Cauvery delta zone (CDZ) was chosen for this study to analyze the current and projected climate variability and trend.

2. MATERIALS AND METHODS

2.1 Study Region

Thanjavur, Thiruvarur, Mayiladuthurai, and Nagapattinam are the four major districts of Tamil Nadu's Cauvery delta region. Due to the abundance of alluvial soil and the most fertile stretch in the Cauvery basin, it is regarded as the state's rice bowl. The region is considered Tamil Nadu's primary agro-climatic zone. The overall geographical position is 8281.72 square Kilometers, with an average elevation of around 110-200 meters above sea level [13]. The Cauvery Delta Zone (CDZ) districts of Thanjavur and Nagapattinam rely heavily on canal irrigation for farming and are subject to the whims of the monsoon [14].

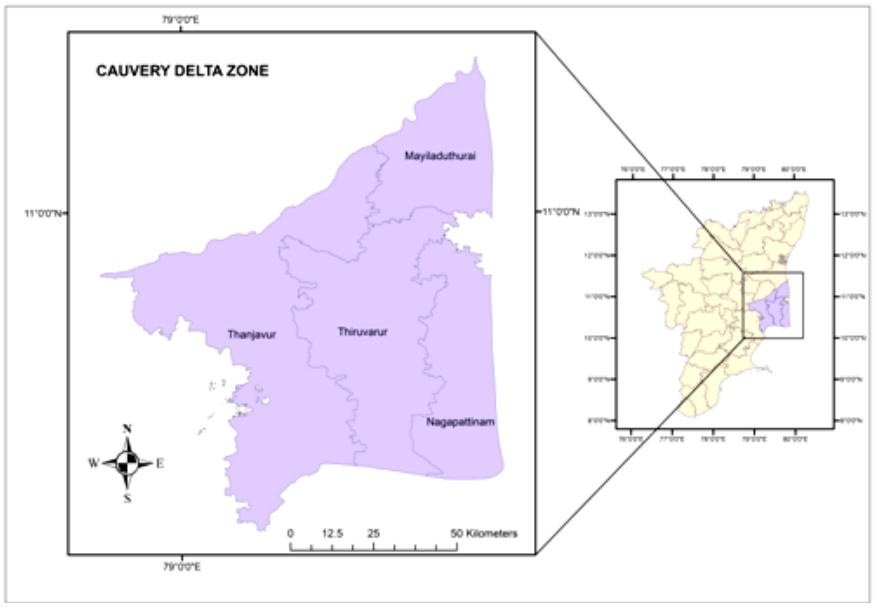

Fig. 1. Study area

2.2 Methodology

The historical data sets were taken from Indian meteorological department (IMD). The study used daily gridded rainfall data with a spatial resolution of 0.25 degree from 1951 to 2020, as well as daily temperature (maximum and minimum) with a spatial resolution of 1 degree from 1951 to 2020 [15,16,17]. The maximum and minimum temperature, as well as precipitation, has been examined using IPCC AR5 RCP4.5 and RCP8.5 scenarios for future variability research. The research was conducted using the ensemble mean of three regional climate models (RCM), namely REMO (from MPI), RCA4 (from SMHI), and CCAM (from CSIRO). The ensemble mean is chosen to minimize model-related uncertainty, and the ensemble mean climate is more similar to observed climate than any one model.

3. RESULTS AND DISCUSSION

3.1 Historical Analysis

Figs. 2 and 3 showed the long-term maximum and minimum temperature for Cauvery delta zone from 1951 to 2020. The average annual maximum temperature is 33.2^{o}C. The highest maximum temperature (35.12 ^{o}C) is recorded during the pre-monsoon season (summer), while the lowest maximum temperature (29.2 ^{o}C) is recorded during the winter season. The average minimum temperature for the zone is 24.47 ^{o}C. The Cauvery delta zone has a rising trend in both mean annual minimum temperature and means annual maximum temperature.

Rainfall is a chaotic hydrological occurrence that is unevenly dispersed in both location and time. As a result of the unevenness in monsoon reception, it is an important metric for thorough analysis [18,19]. Over a 70-year period, the average annual rainfall in the Cauvery delta zone was 1268.38 mm, with a range of 544.7 mm to 2098 mm (1951-2020). According to Fig. 3, the post-monsoon (October, November, and December) rainfall provides the most to the annual rainfall for the zone, accounting for around 64 percent. Pre-monsoon rainfall (March, April, and May) contributes 7.65 percent of annual rainfall, monsoon rainfall (June, July, August, and September) contributes 23.26 percent, and winter rainfall (January and February) contributes 4.8 percent. The north east monsoon has contributed the most rainy days to the Cauvery delta zone, with 32 days from the total of 62 rainy days.

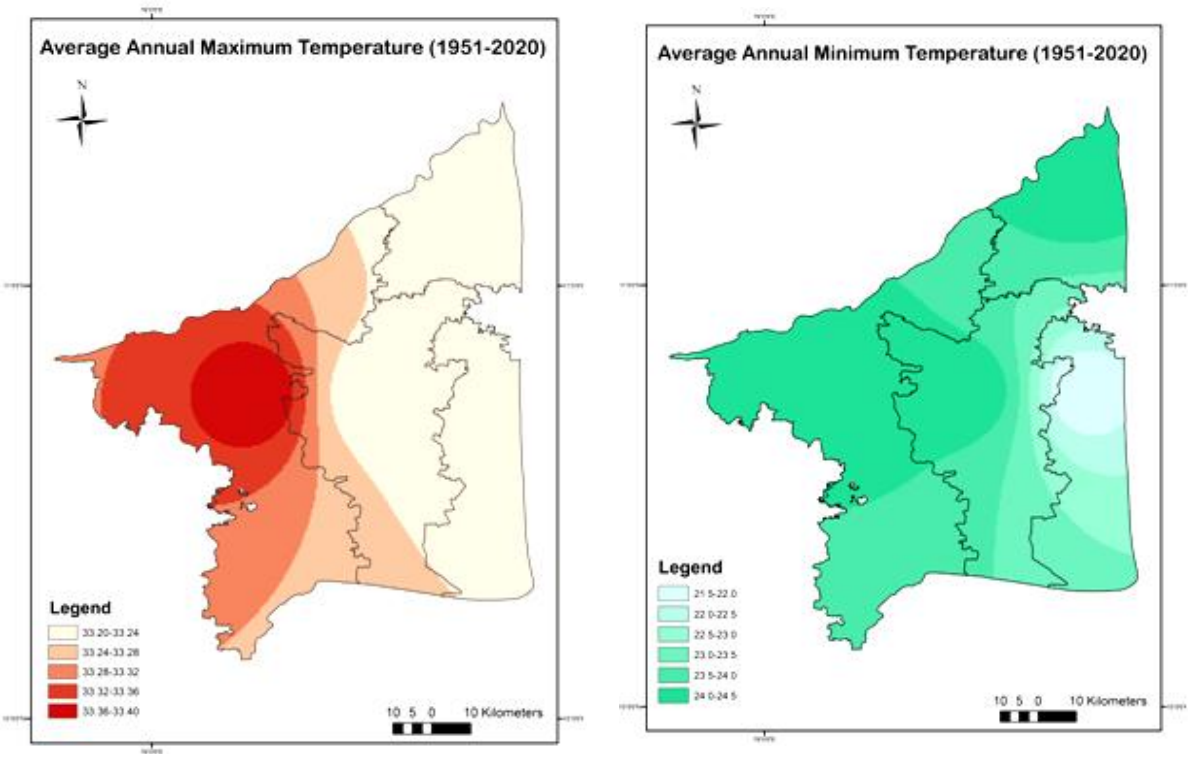

Fig. 2 and Fig. 3. Average annual maximum and minimum temperatures (1951 to 2020)

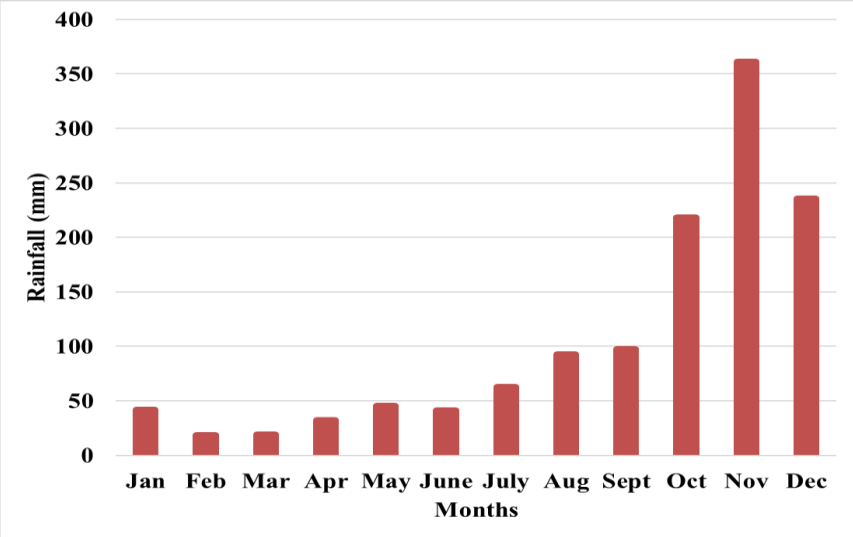

Fig. 4. Monthly rainfall distributions for Cauvery delta zone (1951-2020)

The annual rainfall distribution analysis for the Cauvery delta zone and its districts has been studied. Rainfall is classed according to how far it differs from the long-term average rainfall (LPA) as defined by the India Meteorological Department (IMD).

Fig. 5 shows that the delta zone had 18 excess rainfall years,17 normal rainfall years, 11 above normal years, 8 below normal rainfall years and 16 deficit rainfall years on average from 1951 to 2020. It can be seen that the decade 2001-2010 in the zone experienced 5 years of deficit rainfall than the other decades. The Cauvery delta zone has a rising trend with low confidence in mean annual rainfall.

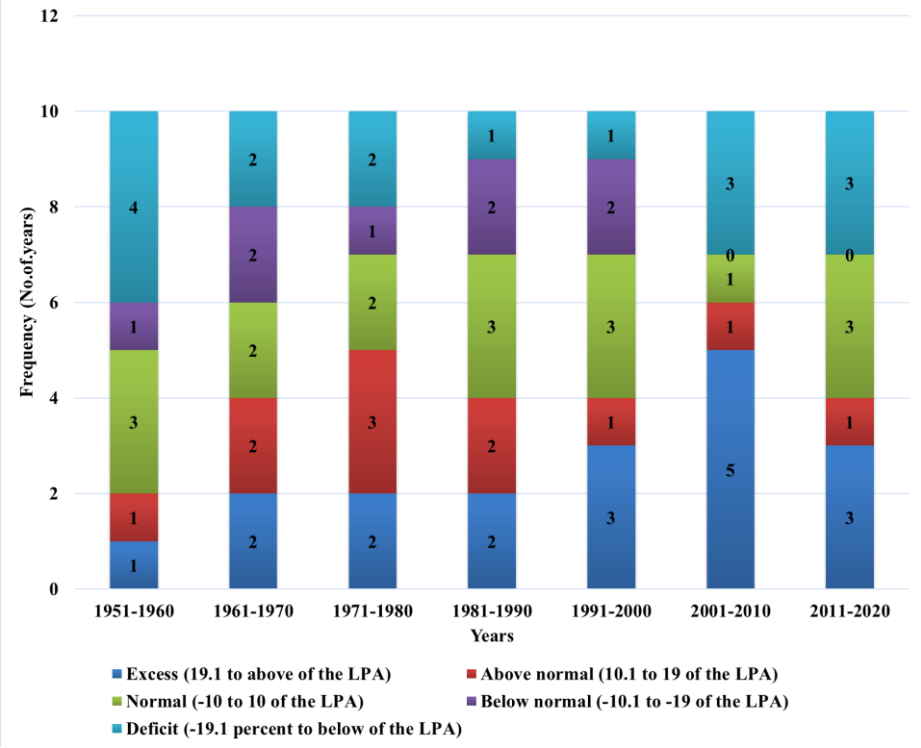

Fig. 5. Frequency of deficient, normal and excess years of annual rainfall of cauvery delta zone

3.2 Future Projections

Climate projections for the Cauvery delta zone for the near-term (2021-2050), mid-century (2050-2070), and end-of-century (2071-2100) with respect to the base line period (1951-2020) revealed that the annual mean maximum temperature could rise by up to 1.1°C to 3.6°C by the end of the century under RCP4.5 and RCP8.5 scenarios. The expected change in these data by the end of the century is 1.8°C for RCP4.5 and 3.6°C for RCP8.5, respectively. Seasonal changes are more obvious, with the rise being greatest during the pre-monsoon season of March-May (Fig. 6).

Changes in average annual minimum temperature are expected to be considerably more significant. By the end of the century, the average minimum temperature in the zone is expected to range from 2.8 to 4.5°C, depending on the RCP4.5 and 8.5 scenarios.

Average rainfall in the Cauvery delta zone is expected to increase marginally by 5.3 percent by mid-century and increase by about 15.78 percent by end-century, while it is expected to decrease fractionally by 0.7 percent by mid-century and rise by 16.79 percent by end-century under the RCP8.5 scenario. Rainfall is expected to decrease in the summer (pre-monsoon season), whereas it is expected to increase in the other seasons by the Mid Century (MC) and End Century (EC), as compared to the baseline (BL). Annual rainfall projected under RCP4.5 and RCP8.5 are shown in the Fig. 8 and Fig. 9.

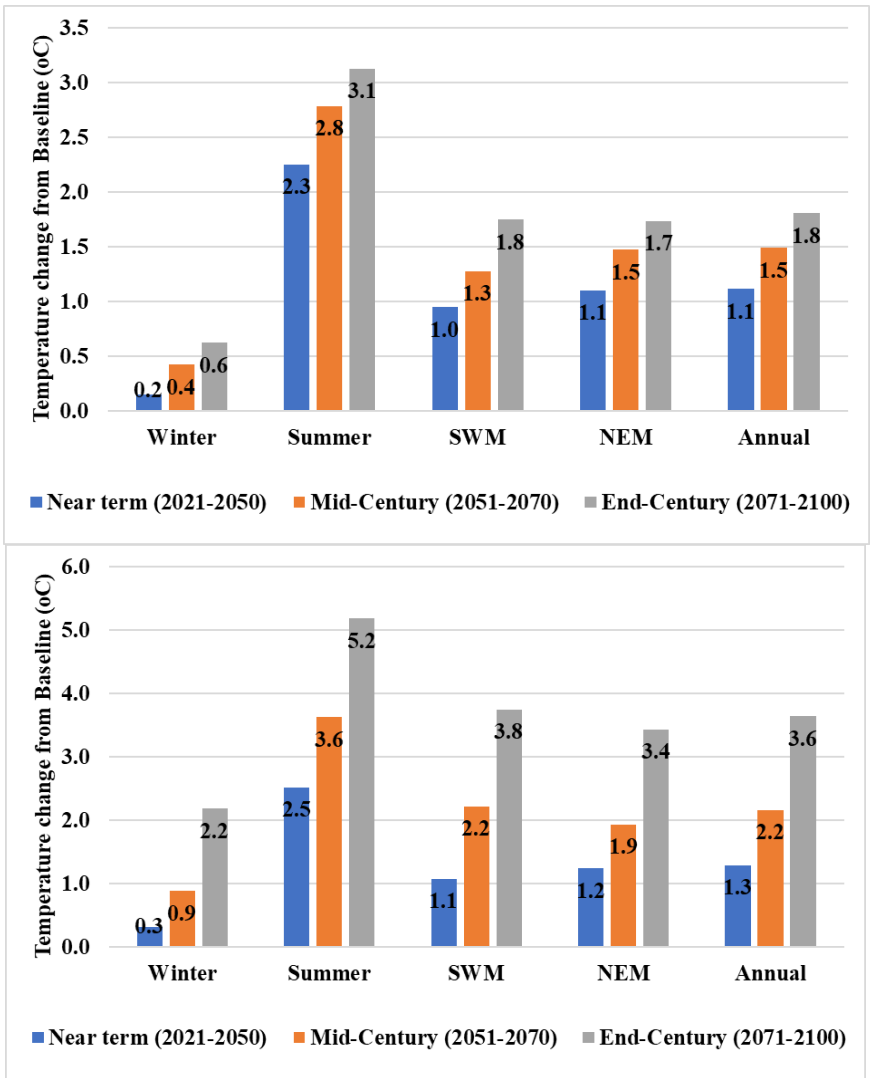

Fig. 6. Projected changes with respect to baseline (BL) in seasonal and annual maximum temperature under RCP4.5 (top) and RCP8.5 (bottom)

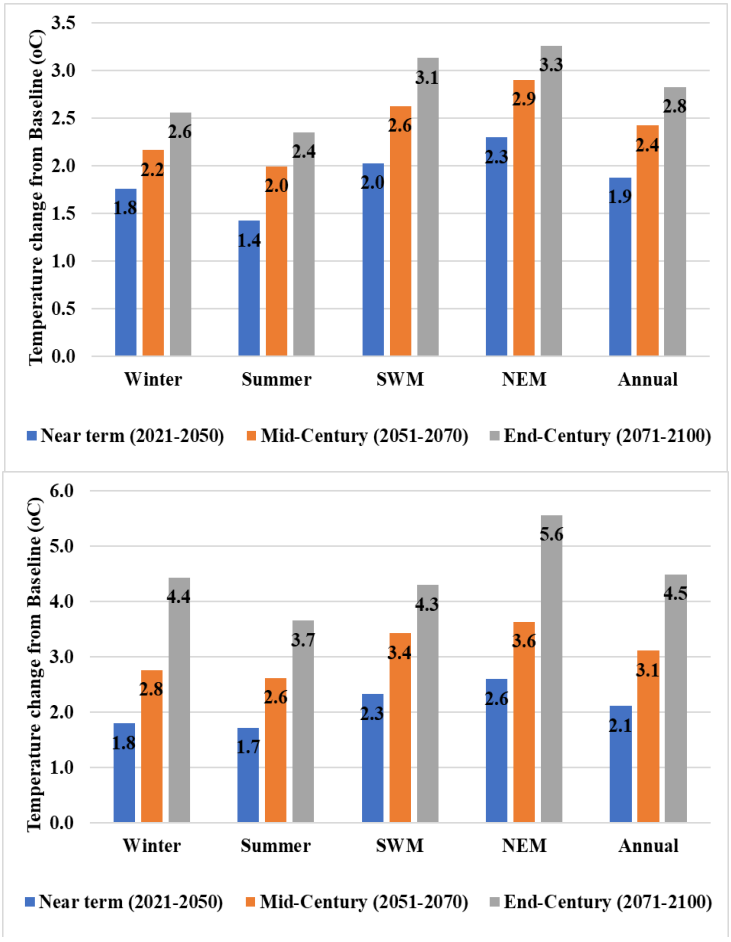

Fig. 7. Projected changes with respect to baseline (BL) in seasonal and annual minimum temperature under RCP4.5 (top) and RCP8.5 (bottom)

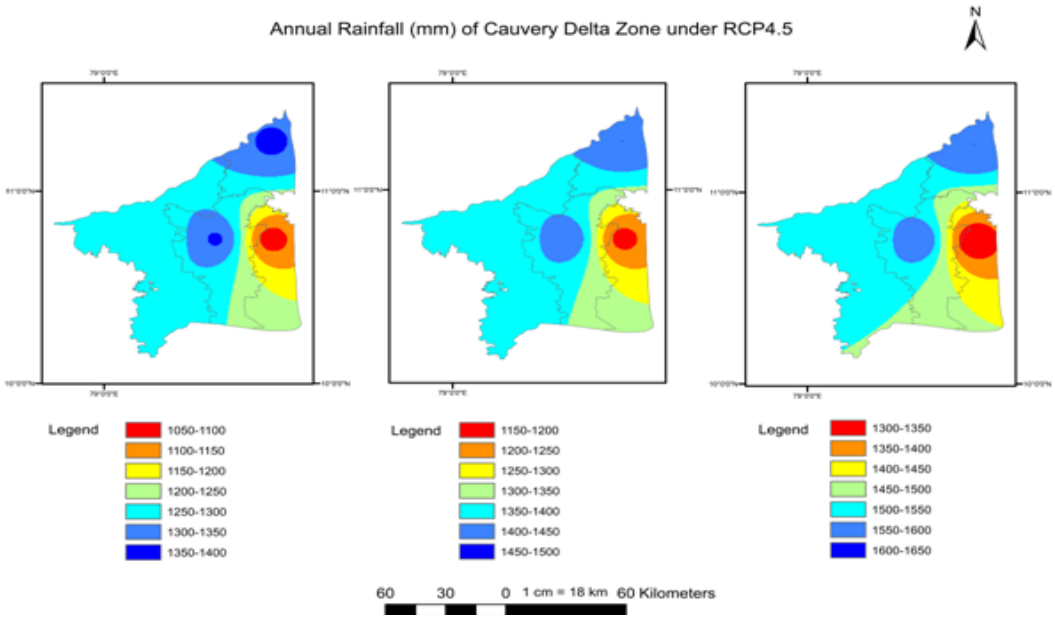

Fig. 8. Projected changes in annual rainfall under RCP4.5 scenario during the near-term, mid-century and end-century. (Rainfall is denoted in millimetre)

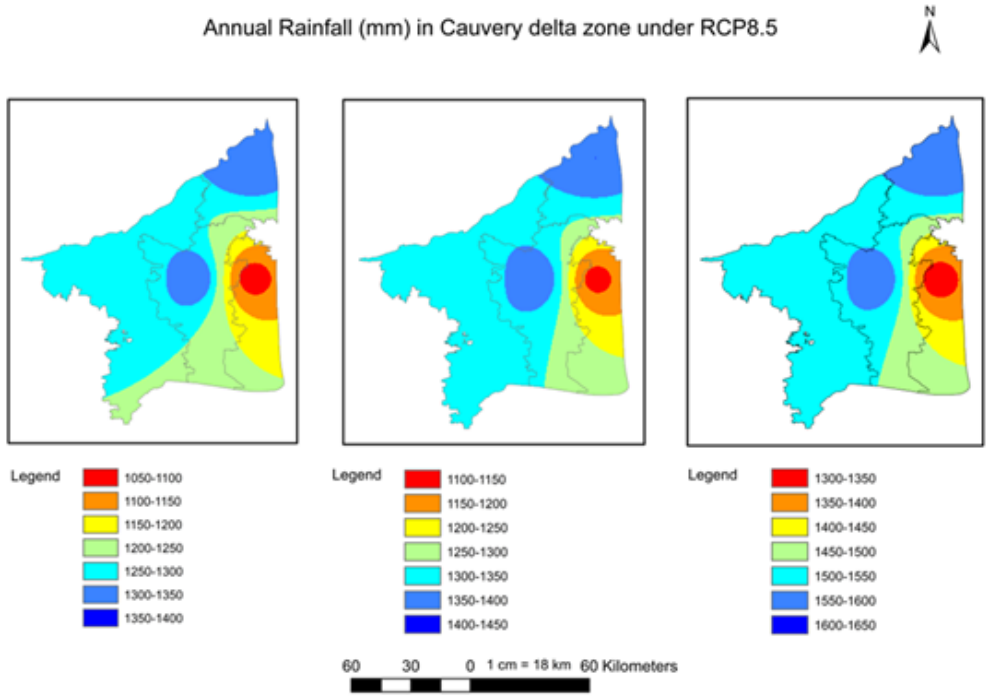

Fig. 9. Projected changes in annual rainfall under RCP8.5 scenario during the near-term, mid-century and end-century. (Rainfall is denoted in millimetre)

4. CONCLUSION

The average annual maximum and minimum temperature were 33.2^{o}C and 24.47^{o}C. The average annual rainfall in the Cauvery delta zone was 1268.38 mm with highest rainfall being recorded during the month of November. Climate projections for the Cauvery delta zone for the near-term (2021-2050), mid-century (2050-2070), and end-of-century (2071-2100) with respect to the base line period (1951-2020) revealed that the annual mean maximum temperature could rise by up to 3.1 to 5.2^{o}C during the Summer season under RCP4.5 and RCP 8.5 scenarios respectively. While, RCP4.5 and RCP8.5 scenarios revealed that the annual mean minimum temperature could rise by up to 3.3 to 5.6^{o}C during the North east monsoon. By the end of 21st century, heavy precipitation events are projected to increase under both RCP4.5 and RCP8.5 scenarios [20]. As a result, in future studies, agricultural adaptation options for managing high precipitation risk should be addressed alongside water conservation measures.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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