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Projecting Droughts in the Purview of Climate Change under RCP 4.5 for the Coastal Districts of South India

Dhanya Praveen[1*], A. Ramachandran[1], R. Jaganathan[2], E. Krishnaveni[1] and K. Palanivelu[1]

[1]Centre for Climate Change and Adaptation Research, Anna University, Chennai - 600025, Tamil Nadu, India; dhanyapraveen.cc@gmail.com, andimuthu.ramachandran@gmail.com, krishnaveniprabu@gmail.com, kpvelu@gmail.com
[2]Tamil Nadu Agricultural University, Coimbatore - 641003, Tamil Nadu, India; jangan@tnau.ac.in

Abstract

Background: Global warming and the resultant changes in climate may add the risk for human survival. To understand and simulate the temporal and spatial pattern of the impacts in the form of the drought, this local study over Kancheepuram district was carried out. **Methods:** Dynamical downscaling using RegCM4.4 model under the IPCC's latest RCP 4.5 emission trajectory was used to project future drought scenario for the end of 21st century compared to the reference period 1971-2000. Simulated rainfall data was used to derive Standardized Precipitation index for drought assessments. **Results:** The projected increment in the mean day time and night time temperature was 2.3oC to 2.5oC respectively. With this the drought situations are also expected to increase towards the end of 21st century .The frequency of moderately dry (SPI values in the range of 1 to -1.49) drought situations are projected to be more in future. As per the projections, there is going to be 3 to 23% increase in the number of drought days in blocks covering the south east parts of the district such as Tiruporur, Tirukalikundram and Lathur. **Application:** Mainstreaming of appropriate drought proofing adaptations into developmental planning is the need of the time to enhance its resilience as far the key sectors like agriculture and water management.

Keywords: Adaptations, Climate Change, Drought, Regcm4.4, RCP 4.5, Standardized Precipitation Index

1. Introduction

Drought is surfacing as one of the leading environmental tribulations facing the present world. Periodic droughts facade serious limitations to nation's efforts towards water and agricultural self-efficiency[1]. Analyzing the historical and future probable occurrence of drought provides an understanding of the range of climate possibilities for a country, resulting in more informed management decision-making. Climate variability and change is characterized by apparent precipitation variability at both temporal and spatial scales. In this regard, Regional Climate Models (RCMs) facilitates simulations of prospective climate under a range of emission pathways with higher spatial and temporal resolution[2]. As per the reports of Inter-Governmental Panel on Climate Change (IPCC), global surface temperature may raise in the range of 1.8˚C to 4˚C under various representations concentration pathways[3]. The most recent improvements in the climate simulation models aid a better perceptive on the future climate change based on probable emission scenarios which may exist in the future[4].Various scientific reports reveals the usage of high resolution future climatic scenarios in different parts of the world for impacts and vulnerability studies[5-8]. Modifications in the local climate, its direction and magnitude will be the driving force for changes in the drought conditions. Drought occurs due to the deficiency of precipitation over an extended time period when a region faces a shortage in its water supply, both surface and underground water[8]. There may be changes with respect to the time, duration, intensity of occurrence and extent of the area affected[9]. The impacts of

* *Author for correspondence*

future climate change on creating drought situations have strong trepidation as it is a slow moving natural hazard. Meteorological drought is a condition when there is a significant decrease in precipitation from the long term average. It is extremely crucial to appraise the occurrence of droughts in an area in order to formulate site specific coping strategies. This study is an endeavour to project future possible drought over Kancheepuram district using standardised precipitation indices employing the long term time series of projected rainfall data for the end of 21st century. As the basic factor for drought is deficiency of water, which depends on rainfall, it is aimed to analyses long-term rainfall data and to assess the drought severity.

2. Materials and method

2.1 Study Area

Kancheepuram is a coastal district lies in the northeast part of the state of Tamil Nadu of Indian sub-continent. It shares boundaries with Bay of Bengal shown in Figure 1. Its proximity to the Chennai metropolitan city makes it the second most populous district of Tamil Nadu. This district can be categorised under the tropical semi-arid to dry sub humid climate. The coastal areas of this study region fall under the latter and interiors falls under the former category. This region receives rain under the influence of both southwest and northeast monsoons. A large share of the rainfall is obtained during the northeast monsoon, due to cyclonic depressions formed in Bay of Bengal, chiefly during October-November and December months. The rain showers are highly erratic. Any collapse in monsoon showers leads to distress conditions. The chief livelihood option of the rural populations is Agriculture .The crops paddy, groundnut, sugarcane and millets are cultivated here. This district was known for its lakes.

2.2 Trend Analysis of Observed Dry Periods

Rclimdex software was used to analyze the trend of consecutive dry days observed in this area during the base line period 1970-2000. It estimates the largest number of consecutive days in the time series, where precipitation is $RR_{ij} < 1mm$.

2.3 Climate Projections

Regional Climate Models, Version 4 (RegCM4.0) of Abdus Salam International Centre for Theoretical Physics (ICTP), Italy to simulate the future climate under IPCC AR5 s latest Representative Concentration Pathway (RCP) 4.5 for the study region. The GCM boundaries utilized to drive the RCMs were HadGEM2-ES. The simulation output for the period 2070-2098 (end century) period were utilized to project and assess the changes in drought situations under RCP 4.5 pertaining to the study region. The weather variable rainfall was used to perform SPI.

2.4 Standardized Precipitation Index

In this study, Standardized Precipitation Index (SPI)

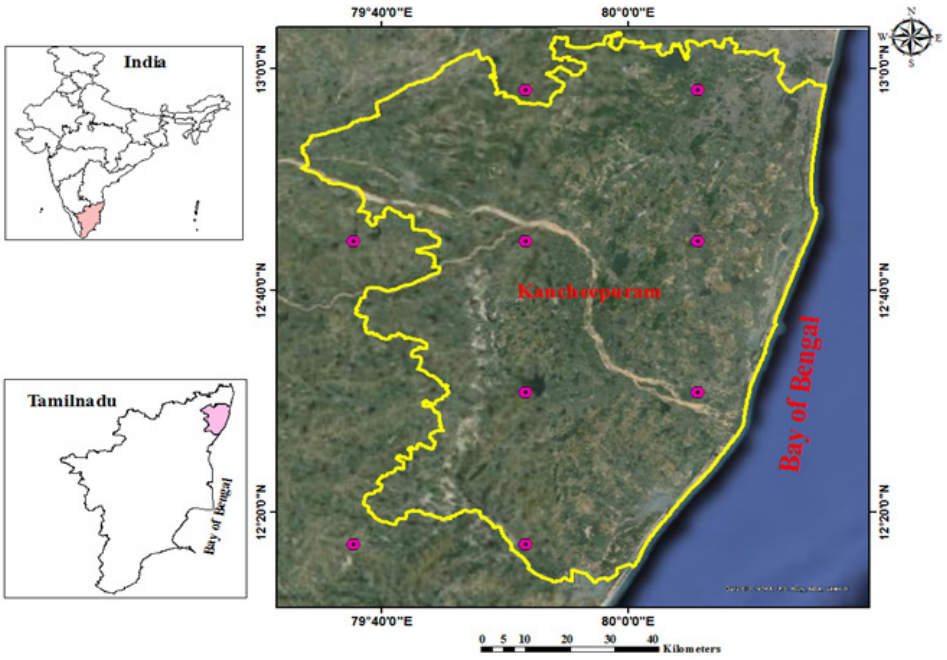

Figure 1. Reg CM grid points in Kancheepuram district.

developed[9] is used. SPI is calculated by considering the rainfall anomaly with respect to the mean value for a given time scale, divided by its standard deviation. The precipitation is not a normal distribution, at least for time-scales less than one year. This distribution is normalized using a probability distribution so that values of SPI are actually seen as standard deviations from the median. Normalized distribution allows for estimating both dry and wet periods in a given time scale. The variable is adjusted so that the SPI is a Gaussian distribution with zero mean and unit variance. Therefore adjusted index allows comparing values related to different regions and timescales. The index calculation is based on the following expressions shown in Table 1.

Table 1. Catogarization of SPI values

SPI values	Classes
>2	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-0.99 to 0.99	near normal
-1 to –1.49	moderately dry
-1.5 to-1.99	Severely dry
< -2	Extremely dry

3. Results and Discussion

3.1 The Trend of Observed Dry Period

The Figure 1 shows the results of trends in Consecutive Dry Day (CDD) period prevailed in Kancheepuram District. The output shows a positive trends as the number of CDD is increasing, which indicates a drying trend is observed in the study area.

3.2 Drought Projections over Kancheepuram

Reg CM model has projected a profound increase in day time and night time temperature of **2.3** and **2.5° C,** with this drought are going to be increased in many parts of these districts**.** Analogous projections for India were also reported[10]. The result of rate of increase in night time temperature is higher than that of maximum temperature is in agreement with[11-13] who employed projections for the entire Tamil Nadu. SPI-12 was employed to analyze the occurrence and severity of drought events over this district in the past. The SPI values calculated using simulated future rainfall series and the arithmetic means of the reference period 1970-2000. The projected SPI analysis revealed a value of –2.13 for the year 2076 and 2077 indicating the extremely severe drought period during the period 2070-2098. The years 2081-82 (–1.92), 2084-85 (–1.67), 2092-93 (–1.48) were projected as severe dry years. However as per the SPI classifications majority of the years can be categorised under the moderately dry classes are shown in Figures 2, 3 and 4.

As far as drought situations are concerned, the frequency of moderately dry drought periods is projected to be more during end century. Extremely severe drought (compared with average values) may be experienced only

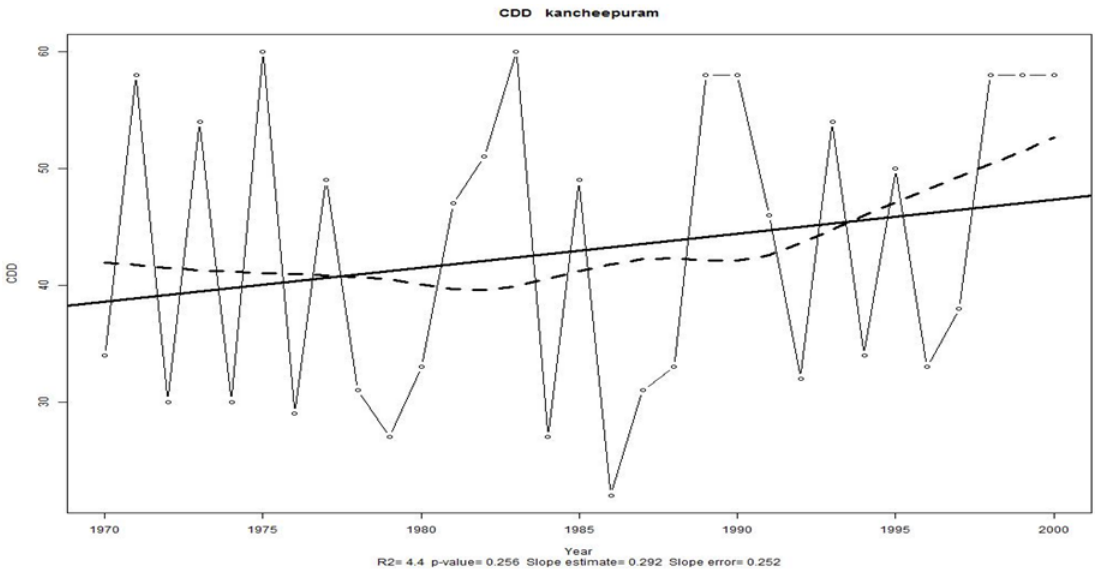

Figure 2. Trends of observed number of CDD for the period 1970-2000 over Kancheepuram district.

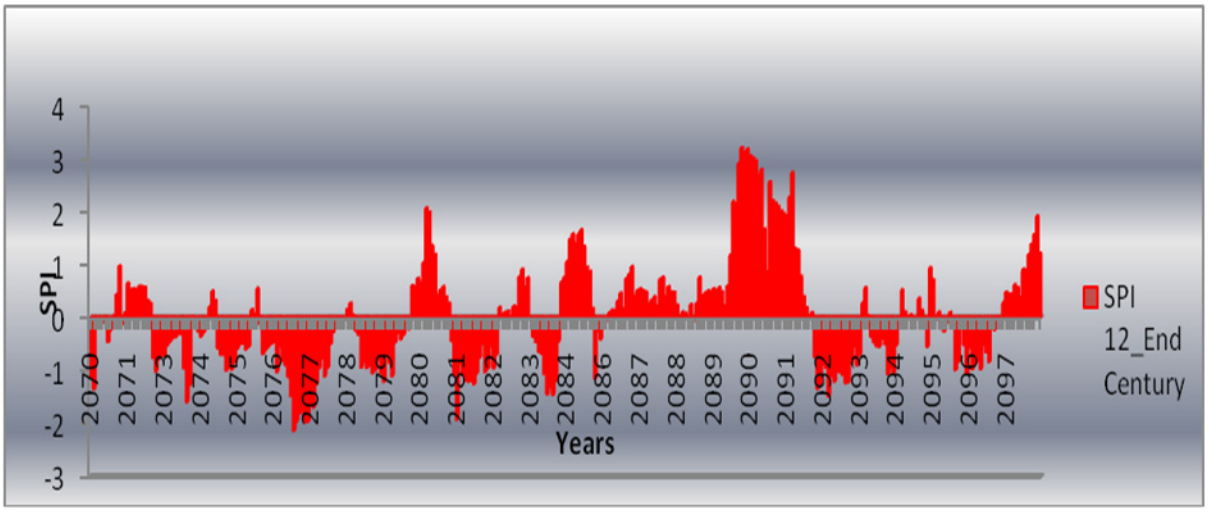

Figure 3. Projected SPI under RCP 4.5 for the period 2070-298 over Kancheepuram district.

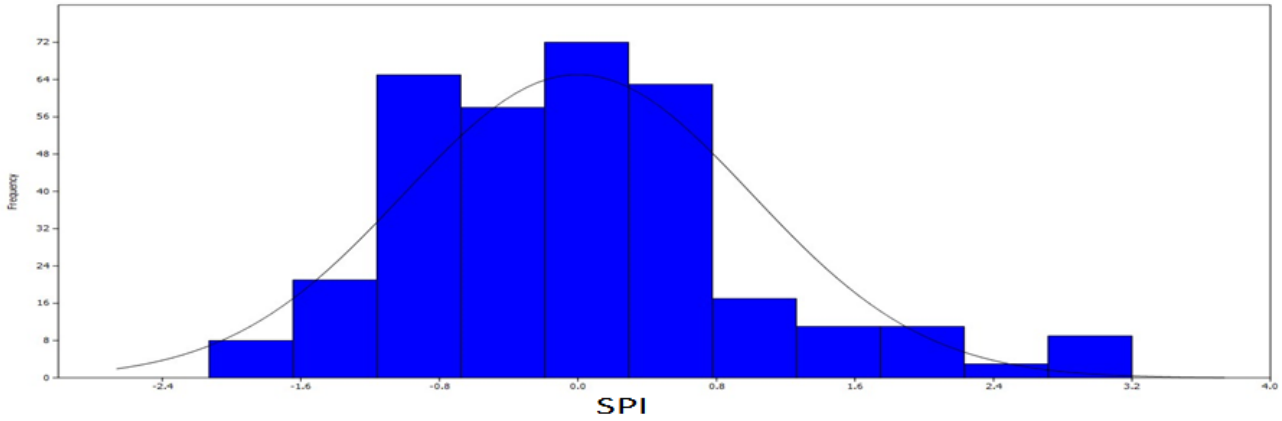

Figure 4. Frequency of simulated SPI under RCP 4.5 for the period 2070-2098 over Kancheepuram district.

in 2076. However, during the 2081-2084 and 2092 to 2094 period, particularly severe drought conditions are likely to be occurred in the region.

Based on above analysis, we can conclude that SPI can be used as an effective tool to project meteorological drought. As proven through CDD analysis this study area has proven to have had drying due to climate change.

To quantitatively examine the spatial distribution of projected drought, mapping has been done shown in Figure 5. It shows the SPI-12 under RCP 4.5 Pathway. According to the figure, the percentage numbers of drought days are going to be more in blocks covering the south east parts such as Tiruporur, Tirukalikundram and Lathur. It is projected that during the end century period, there may be an increase of 3 to 23 percentages in the number of the drought days. In particular, it was projected that the risks of droughts will increase more at the end of the 21st century because of increased atmospheric warming and rise evapotranspiration increases at the end of the 21st century.

Based on above analysis, we can conclude that SPI can be used as an effective tool to project meteorological drought. As proven through CDD analysis this study area has proven to have had dryingdue to climate change. A research report published[14,15] reveals the fact that groundnut crop over one lakh (100,000) hectares had been destroyed the in the districts of Chengalpet areas due to the drought of 1980. The incidence of droughts and its revisiting time in Tamil Nadu is moderately severe and once in three years[16]. The probable warming in future stand as a key challenging issue that warrants appraisals on the present coping mechanisms as an immediate

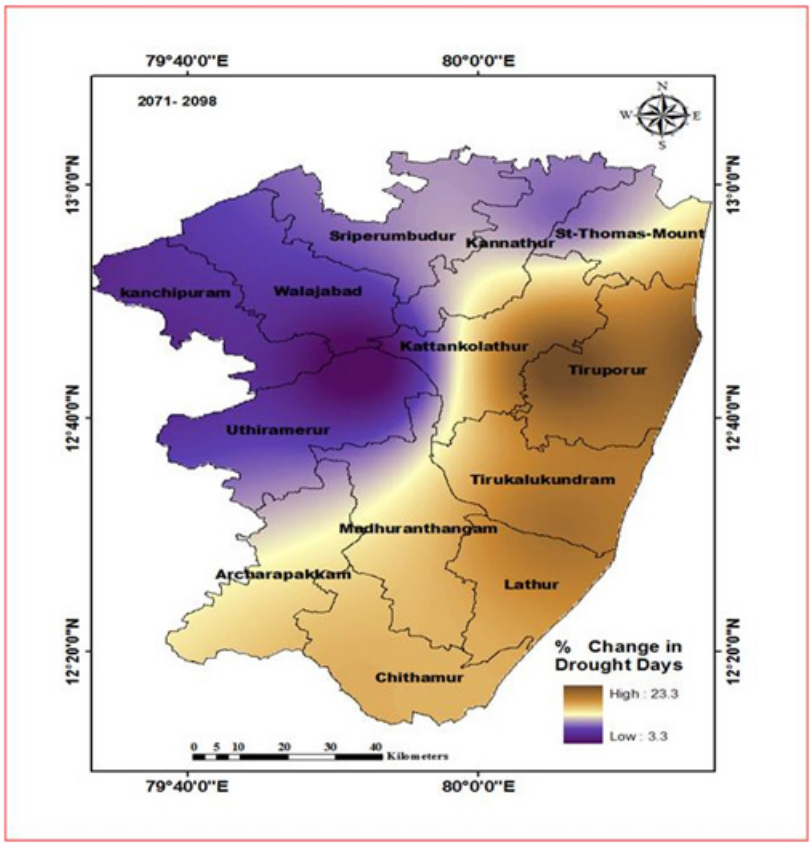

Figure 5. Projected percentage change in droughts days in Kancheepuram under RCP 4.5.

responses for drought hit areas[16]. There may be far reaching consequences of drought range from deficiency in water supply, crop failures, famine, livelihood insecurities and human abandonment of geographical areas[17]. It is extensively accepted that droughts may exacerbate serious detrimental implications in the purview of climate change on coastal ecosystems and pose developmental challenges for dependent communities and sectors[18,19]. In recent years, particularly in the last one decade, the death tolls due to adverse heat wave, cold wave, sudden heavy rains, frequent drought and fresh floods have made the vulnerable impact upon economic and social warfronts of our country[20]. Lessons can be learnt from the recent floods of Chennai 2015, including the present study area Kancheepuram and could be taken as evidence of intensity of devastating extreme climate events.

4. Conclusion

This study was an effort to project drought in the end century period using SPI under RCP 4.5 trajectory. This study provided a promising conclusion that moderate droughts will be more in the end of 21st century. With this understanding, a combination of the anticipated increase in warming and erratic rainfall, may accelerate the duration, and frequency of extreme events especially drought and dry spells in future. It may pass on swarming long and short term setbacks to the various sectors. Suitable measures need to be incorporated for adapting to these to this situation and negate the future impacts to a great extent. Mainstreaming of appropriate drought proofing adaptations into local developmental planning is the need of the time to enhance its resilience as far the key sectors like agriculture, water etc are concerned.

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