Regional Shifts in Precipitation Patterns and Indices in Northeast India

Akshara N G[1], Arunkumar R, S. K. Panda[1*], Toru Terao[2], Aditya Sharma[3], Unashish Mondal[1] and Devesh Sharma[1]

[1]Department of Atmospheric Science, School of Earth Sciences, Central University of Rajasthan, Bandar Sindri, Kishangarh, Ajmer, Rajasthan, India
[2] Faculty of Education, Kagawa University, Takamatsu, Japan.
[3]School of Public Policy, Indian Institute of Technology, Delhi, India

(*Corresponding E-mail: subrat.atmos@curaj.ac.in)

Abstract: This study delves into the recent decline in rainfall observed in Northeast India (NEI). It investigates the factors driving this decrease, emphasizing the influence of climatic phenomena such as the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD), along with the broader impacts of climate change on regional precipitation patterns. The study aims to analyze temporal variations in Precipitation Indices (PI) over NEI, employing the ETCCDI precipitation indices like consecutive dry days (CDD), consecutive wet days (CWD), and total precipitation (PRCPTOT). PI are calculated using the ClimPACT2 software, facilitating the analysis of temporal variations. Furthermore, temporal trends experienced by the indices throughout the study period are comprehended through the application of the Mann-Kendall test. Findings indicate a significant increase in CDD alongside significant decreases in CWD and PRCPTOT, underscoring shifting precipitation dynamics in NEI.

Keywords: ***Indian ocean dipole, El Niño southern oscillation, Precipitation indices, ClimPACT2.***

Introduction

Rainfall over India is a critical component of its climate system, influencing agricultural productivity, water resources, and the livelihoods of millions of people. India experiences diverse rainfall patterns, influenced by both regional and global climatic factors. The Southwest Monsoon, which typically occurs from June to September, accounts for a significant portion of India's annual precipitation. Conversely, the Northeast Monsoon, occurring from October to December, primarily affects southeastern India, contributing to the rainfall in the region.

In recent years, India has witnessed notable variations in rainfall patterns. These variations manifest as deviations from long-term averages, leading to fluctuations in precipitation intensity, frequency, and spatial distribution. Factors such as sea surface temperature anomalies, atmospheric circulation patterns, and land-use changes contribute to these fluctuations.

To assess the impact of rainfall variability on climate status, various PI, such as those derived from the Expert Team on Climate Change Detection and Indices (ETCCDI) and the Regional Climate Indices (RClimDex), are utilized (Gu et al., 2024). These indices provide valuable insights into changes in the frequency, intensity, and duration of extreme precipitation events, as well as overall precipitation patterns (Gajić-Čapka et al., 2015).

Precipitation Indices

The Expert Team on Climate Change Detection and Indices (ETCCDI), established by the World Meteorological Organization (WMO), develops standardized climate indices to assess trends and variability in climate extremes such as temperature and precipitation. These PI help evaluate the effects of climate change on rainfall patterns (Funk et al. 2019). Among them, CDD represents the longest dry spell (days with <1 mm rain), CWD the longest wet spell (days with ≥1 mm rain), and PRCPTOT the total precipitation on wet days over a given period.

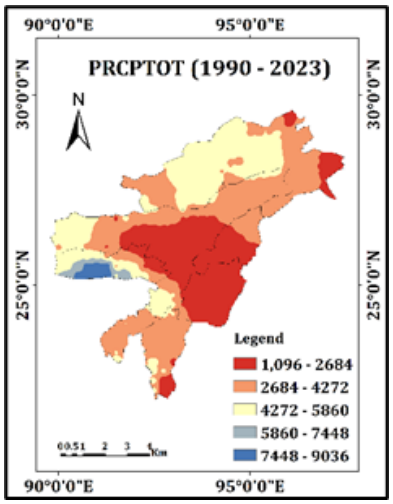

Figure 1, Spatial distribution of total precipitation (PRCPTOT) over Northeast India for the period of 1990 to 2023.

Methodology

The study uses the Daily data of 0.25° x 0.25° resolution for the period of 1990 to 2023, 33 years. The

methodology adopted for calculating the PI is to use the RClimDex software.

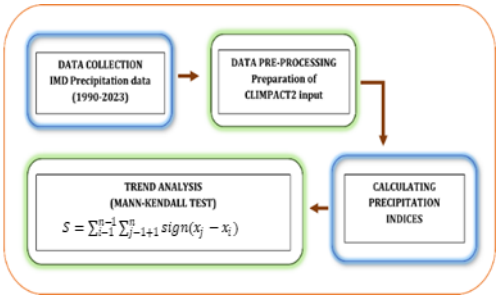

Figure 2, The flowchart of methodology.

Trend analysis

In this study, the long-term trend was analyzed. Figure 3 depicts the trend for CDD and CWD over NEI, showing an increasing trend for CDD and a decreasing trend for CWD. There was a noticeable hike in dry spells during the year 2013. As per the monsoon report of IMD, ENSO neutral conditions prevailed during the 2013 monsoon season, with minimal impact on rainfall distribution. Although a weak negative Indian IOD initially developed, it became neutral and had little impact on rainfall. Favorable MJO activity and active westward-propagating monsoon lows led to above-normal rainfall over central India and the west coast, while NEI shows below-normal rainfall.

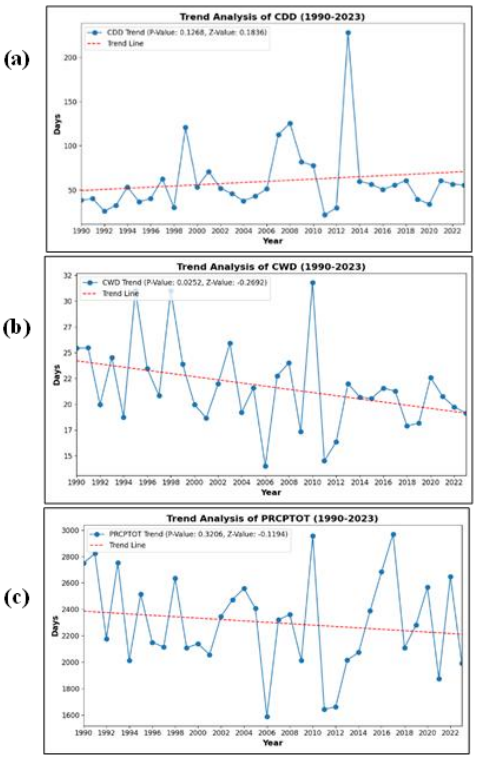

Figure 3, Climatology of trends analysis (a) consecutive dry days, (b) consecutive wet days, and (c) Trend analysis of Annual Total Wet Day Precipitation over Northeast India during the period of (1990 to 2023).

During the 1995, 1998, and 2010 monsoons, NEI had normal to above-average rainfall. In 2006, reduced CWD led to below-normal rainfall in winter, pre-monsoon, and post-monsoon seasons, while monsoon rainfall remained normal, lowering the annual total. Trends in CDD and CWD indicate a shift toward drier conditions, with extended dry spells in 2013. PRCPTOT shows an overall decreasing trend (Table 1). In 2017, rainfall increased, consistent with the IMD report: India received 1127 mm (95% of LPA), NEI 1409 mm (98% of LPA), with the East Khasi Hills recording the highest annual rainfall at 7679.8 mm; annual and seasonal rainfall was below normal except in pre- and post-monsoon periods.

Table 1, Mann–Kendall trend and Sen's slope for rainfall indices in NEI (1990–2023).

INDICES	THE STANDARDIZED TEST STATISTIC (z)	SENS'S ESTIMATOR OF THE SLOPE (Q)	P-VALUE	TREND	REMARK
CDD	0.1836	0.5136	0.1268	INCREASE	SIGNIFICANT*
CWD	-0.2692	-0.1441	0.0252	DECREASE	SIGNIFICANT**
PRCPTOT	-0.1194	-5.6060	0.3206	DECREASE	INSIGNIFICANT

Conclusion

This study analyzed rainfall trends in Northeast India (1990–2023) using six indices and the Mann-Kendall test. Results show more consecutive dry days, fewer wet days, and declining total precipitation, indicating a shift toward drier conditions influenced by topography, monsoon patterns, and climate variability.

Acknowledgement

The authors thank the India Meteorological Department, WMO team, and ClimPACT2 software; supported by JSPS Core-to-Core Program (JPJSCCB230002) with facilities from the Central University of Rajasthan and Kagawa University.

References

Gu, Z., Li, Y., Qin, M., Ji, K., Yi, Q., Li, P., and Feng, D. (2024). Spatiotemporal variation characteristics of extreme precipitation in Henan Province based on RClimDex model. Atmosphere, 15(11), 1399. https://doi.org/10.3390/atmos15111399

Funk, C., Harrison, L., Alexander, L., Peterson, P., Behrangi, A., and Husak, G. (2019). Exploring trends in wet-season precipitation and drought indices in wet, humid and dry regions. Environmental Research Letters, 14 (11), 115002. https://doi.org/10.1088/1748-9326/ab4a6c

Gajić-Čapka, M., Cindrić, K., and Pasarić, Z. (2015). Trends in precipitation indices in Croatia, 1961–2010. Theoretical and Applied Climatology, 121 (1), 167–177. https://doi.org/10.1007/s00704-014-1217-9