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Climate and rainfall trend analysis in Ramanathapuram district, Tamil Nadu

[1]R Premavathi, [2]N Suganthi, [3]S Kanaga, [4]SP Kamali and [5]R Gangai Selvi

[1]Professor, Department of Agriculture Extension & Rural Sociology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

[2]Research Assistant, Department of Agriculture Extension & Rural Sociology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

[3]Assistant Professor, Department of Agriculture Economics, Rice Research Station, Tirur, Kerala, India

[4]Research Scholar, Department of Agriculture Extension & Rural Sociology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

[5]Professor, Department of Physical Sciences and Information Technology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

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Corresponding Author: N Suganthi

Abstract
Water resources and their planning and management can benefit greatly from rainfall predictions. The most important phenomenon is the fluctuating climate. It affects the world's water supplies and rainfall patterns. In order to plan and carry out regional projects like sustainable agriculture, rainfall data has become increasingly important. However, little less is known about the causes and spatiotemporal shift characteristics of extreme occurrences under climate change, particularly in Tamil Nadu's drought zones. Considering the secondary data from 1990-2022, this study examined the spatiotemporal change characteristics and trend analysis of extreme rainfall occurrences in Ramanathapuram district of Tamil Nadu. This study examines and compares the rainfall throughout four seasons and the level of instability in—Ramanathapuram district which lies in the Southern Zone of Tamil Nadu. The information was collected from seasonal crop reports, Department of Economics and Statistics in Chennai as well as from Tamil Nadu's policy and statistical reports. This research offers an in-depth evaluation of trend prevailing in the district. The results provide results on climate change and patterns in the area by highlighting clear differences in rainfall trends and instability. Thirteen years show positive SPI and the rest of the 18 years show negative SPI which shows drier years. Only two years shows normal precipitation conditions (0.08 in 2021 and 0.02 in 1996). When comparing the Ramanathapuram district to the other three districts, the temporal fluctuations show a decrease in rainfall.

Keywords: Temporal analysis, rainfall, contribution, time series, Mann-Kendall test

Introduction

Over the past century, the earth's climate has changed in terms of temperature and rainfall variations. Changes in precipitation patterns are the primary effect of climate change. A study of hydrologic design and management techniques is necessary because changes in rainfall brought on by global warming will affect the hydrological cycle, stream flow patterns, and demands (especially in agriculture) (John, 2018) [10].Researchers from all around the world have investigated climate change in an effort to understand the trajectory of different climatic indicators and define rainfall dynamics at the regional to local level (Singh, 2018, Talchabhadel, 2019, Tito *et al*., 2020, de Oliveira *et al*., 2021, Ferreira *et al*., 2021, Teixeira *et al*., 2021) [19, 22, 24, 5, 6, 23]. A natural occurrence known as drought is brought on by a region receiving less rainfall than is anticipated; if this condition persists for an extended length of time, there will eventually be insufficient water to support an array of human endeavours (Lalmuanzuala *et al*., 2023) [12].

Numerous attempts have previously been attempted in India to identify regional and national rainfall trends (Sen & Balling 2007, Goswami *et al*., 2006, Nikumbh *et al*., 2019, Varikoden *et al*., 2019, Bisht *et al*., 2018, Sanikhani *et al*., 2018, Paul *et al*., 2018, Srivastava *et al*., 2016) [18, 7, 14, 25, 3, 17, 15, 20]. Trend analysis study has been regarded as a valuable tool since it offers important insights about the likelihood of future changes (Islam *et al*., 2012, Guhathakurta & Rajeevan 2008, Srivastava *et al*., 2016, Swain *et al*., 2015) [9, 8, 20, 21].With proper management of water resources, policymakers may develop efficient hydrological policies to combat drought and lower the risk of flood by using trend analysis of historical rainfall data to understand local rainfall features at the regional level. In order to quantify changes of hydro-meteorological variables *viz*., temperature and rainfall, trend analysis can be employed (Cengiz *et al*., 2020, Ay & Kisi 2015) [4, 2]. As a result, the state is more susceptible to droughts of various severity and magnitude. The southern region is more vulnerable to drought conditions, particularly during the North East Monsoon Seasons (Ramaraj *et al*., 2015, Kokilavani *et al*., 2021) [16, 11]

Taking all into consideration, a study was carried out to evaluate the frequency and severity of drought as well as spatial and temporal changes in Ramanathapuram district of Tamil Nadu, with the objective of defining drought.

Materials and Methods

Study area

Tamil Nadu is divided into eight agroclimatic zones, with the North Eastern and South Zones holding the top two positions with 24% and 20% of the total area, respectively, according to a report by the Indian Meteorological Department (IMD). Next behind are the Western Zone (12%), North West Zone (14%), Southern Zone (12%), and Cauvery Delta Zone (15%). Thus, the current study was carried out in Tamil Nadu's Southern Zone. The study area is situated between latitudes 8° 9' and 10° 50' North and longitudes 77° 10' and 79° 25' East. The region stretches from the coastal areas in the east to the high mountain regions in the west. Fig. 1 shows the map of the research area. The elevation diverges from the average sea level of 100 meters

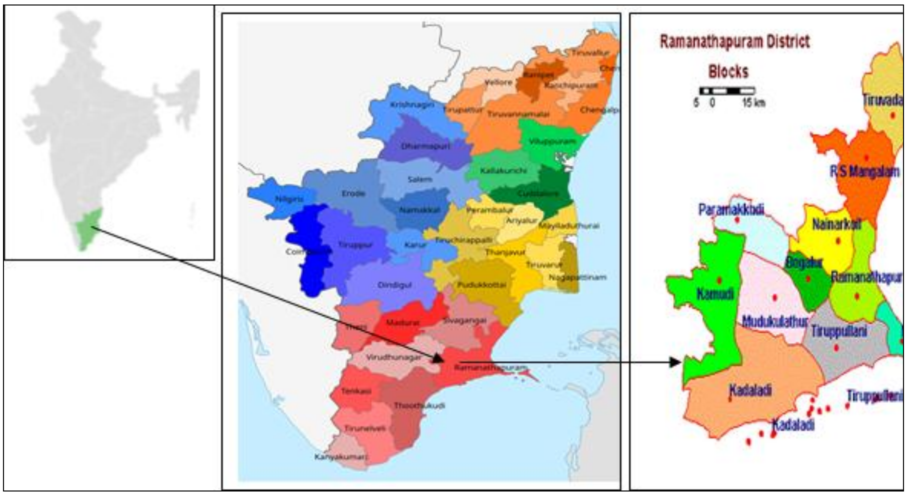

Fig 1: Map depicting the study area

Data Collection

With a focus on the South West Monsoon (June-September), North East Monsoon (October-December), Winter Season (January-February), and Hot Weather Season (March-May), this study thoroughly examines rainfall and temperature in Tamil Nadu's Southern Zone. The study offers a thorough temporal examination of trends and patterns related to the four seasons, spanning the years from 1990-2022. The study uses data from all four seasons in Ramanathapuram, district—to account for the impact of seasonal fluctuations. The study aims to provide a comprehensive understanding of Ramanathapuram district and the consequences of drought and climate change in the area by examining these four unique seasons. When comparing the Ramanathapuram district to the other three districts, the temporal fluctuations reveal a decrease in rainfall.

The Directorate of Economics and Statistics, Government of Tamil Nadu, provided the secondary sources from which the data used in this study was gathered. The seasonal crop report, which provided a comprehensive data on rainfall distribution for Ramanathapuram district of Tamil Nadu for the four seasons—South West Monsoon (SWM), North East Monsoon (NEM), Winter Season, and Hot-Weather Season—is the primary source of data used in this study. This comprehensive dataset serves as the foundation for the analysis of rainfall trends in the region.

Mann-Kendall (MK) test

As one of the most widely used global techniques for trend detection in hydrology, climatology, and meteorology, the non-parametric Mann-Kendall test was used in this work to identify the trend in rainfall. A time series' trend analysis includes both the trend's statistical significance and magnitude. This statistical technique is employed to investigate the temporal trends and spatial variation of hydroclimatic series(John,2018) [10].

$$\sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sgn(xj - xk)$$

where this MK test is applied to two time series, xk which is ranked from k=1, 2, …, n−1, and xj which is ranked from j=k+1, 2, …, n. Every data point xk is used as a reference and compared to other data points. sgn(θ)={1, θ>0, 0, θ =0, −1, θ}

$$Var\ s = \frac{n((n-1)(2n+5)) - \sum_{i=0}^{n} t(t-1)(2t+5)}{18}$$

where the notation t indicates the extent of every specific tie, and t represents the sum of all ties. Z statistics is computed using below equation, where the sample size n should be more than 10

The variance of MK statistic (S) is calculated using below equation.

$$Z = \{ \frac{s+1}{\sqrt{var(s)}}\ if\ S > 0\}, 0\ if\ s = 0, \frac{s+1}{\sqrt{var(s)}}, ifS < 0$$

where positive and negative Z numbers denote the increasing and decreasing trends, respectively.

Standardized precipitation index (SPI)

Standardized precipitation index (SPI): The SPI was designed by transforming the probability of observed into an index (McKee *et al*., 1993) [13] to quantify the precipitation deficit for multiple time scales. SPI = (Xik-Xi) / Ai; Where, Ai = Standardized deviation for the year; Xik = Precipitation for the year and kth observation; Xi = mean precipitation. For calculating SPI, 33 years or more of continuous monthly precipitation data is needed. Positive SPI values indicate greater than median precipitation and Negative SPI values indicate less than median precipitation. Based on the SPI values, conditions are classified as Extremely wet (SPI > 2.0), Very wet (1.50 to 1.99), Moderately wet (1.00 to 1.49), Mildly wet (0 to 0.99), Mild drought (0 to -0.99), Moderate drought (-1 to -1.49), Severe drought (-1.50 to -1.99) and Extreme drought (Less than -2.00).

Results and Discussion

Basic characteristics of monthly, seasonal and annual rainfall data

For the period 1990-2022, statistical rainfall characteristics of Ramanathapuram district were evaluated and given in Table 1 and Fig 2, The average annual precipitation of Ramanathapuram district was 844.85 mm. The highest mean precipitation was in October 210.64 mm and the lowest in February (18.93 mm).

Table 1: Statistical summary of monthly, rainfall of Ramanathapuram district (1990-2022)

Months	Minimum	Maximum	Mean	Std. Deviation	CV, %	% Contribution to Rainfall
January	0.1	235.8	30.14	44.96	149.17	3.57
February	0.0	177.1	18.93	34.28	181.09	2.24
March	0.0	376.6	23.58	66.21	280.79	2.79
April	0.0	261.3	48.96	54.70	111.72	5.80
May	0.0	180.6	49.21	45.79	93.05	5.82
June	0.0	64.8	19.72	17.947	91.01	2.33
July	0.1	77.9	20.83	16.62	79.79	2.47
August	6.0	108	35.72	24.76	69.32	4.23
September	14.0	180.2	56.81	39.91	70.25	6.72
October	51.1	398.7	210.64	90.23	42.84	24.93
November	53.6	398.6	220.50	97.40	44.17	26.10
December	14.0	290	109.76	85.66	78.04	12.99
Total	428.3	1313.9	844.85	222.23	26.30	100

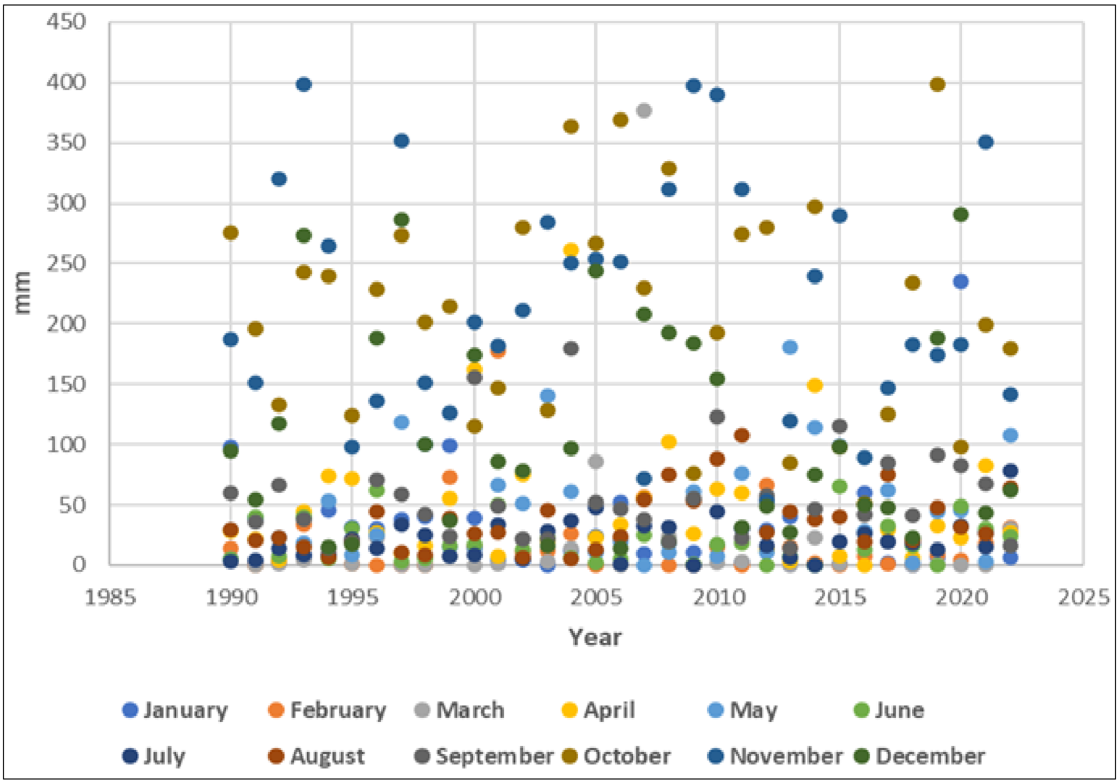

Fig 2: Rainfall distribution over 33 (1990-2022) years across months

From Fig.2. it noticed that during the month October (398.7mm) and November (398.6 mm) i.e., North East Monsson there is high distribution of rainfall and low distribution of rainfall in the month of February (winter season), March and April i.e., hot weather season. In the year 2019 high distribution of rainfall was observed and in 1997 and 1998 low rain fall was observed.

Table 2: Statistical Analysis of Rainfall data along with Mann-Kendall Trend, Sen's Slope estimator and P-Value

Series	Kendall's tau	p-value
January	-0.116	0.345
February	0.073	0.555
March	0.056	0.652
April	-0.038	0.757
May	0.068	0.577
June	-0.006	0.963
July	0.163	0.183
August	0.286	0.019
September	0.083	0.495
October	-0.068	0.577
November	-0.049	0.687
December	-0.076	0.535

The Mann-Kendall trend, its statistical significance, for rainfall data spanning the years 1990 to 2022. Table 2 demonstrates the trend in total yearly rainfall over 33 years. There is decreasing trend in the month of January, June October, December. The month of August is significant at 0.05 level of significance. The months showed the trends with a significance level of 0.05, which means there is a 95% probability of not making a mistake in trend hypothesis.

Table 3: Standardized precipitation Index

Year	Total Annual rainfall (mm)	SPI
1990	830.20	-0.07
1991	563.50	-1.27
1992	714.50	-0.59
1993	1125.10	1.26
1994	742.30	-0.46
1995	445.10	-1.80
1996	850.30	0.02
1997	1186.00	1.54
1998	688.90	-0.70
1999	717.00	-0.58
2000	932.50	0.39
2001	831.20	-0.06
2002	777.90	-0.30
2003	723.20	-0.55
2004	1313.90	2.11
2005	1024.10	0.81
2006	839.60	-0.02
2007	1158.70	1.41
2008	1136.00	1.31
2009	866.40	0.10
2010	1115.00	1.22
2011	940.50	0.43
2012	656.50	-0.85
2013	645.70	-1.35
2014	985.50	0.63
2015	835.00	-0.04
2016	428.30	-1.87
2017	583.40	-0.90
2018	546.20	-1.34
2019	1007.50	0.73
2020	1075.60	1.04
2021	862.90	0.08
2022	770.50	-0.33

From Table 3 negative SPI values (e.g., -1.26 in 1991) indicate drier-than-average years. Positive SPI values (e.g., 1.26 in 1993) indicate wetter-than-average years. Values near zero indicate normal precipitation conditions. Only two years shows normal precipitation conditions (0.08 in 2021 and 0.02 in 1996). Thirteen years show positive SPI and the rest of the 18 years show negative SPI which shows drier years. Moderate drought observed in 2013, 2016 and 2018 and mild drought observed in most of the years. Moderatly wet in 1991 and 2020.Extremly wet can be noticed in 2004.

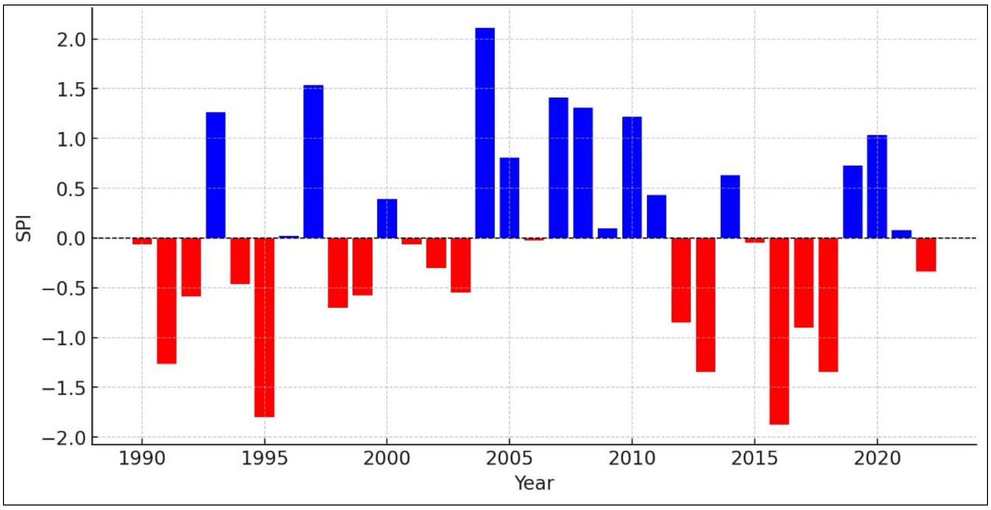

Fig 3: Standardized precipitation Index

From Fig.3 the Standardized Precipitation Index (SPI) over the years can be visualized. Blue bars indicate wetter-than-average years. Red bars indicate drier-than-average years. The dashed line at zero represents the normal precipitation level.

Conclusion

In the present study, the dynamics of seasonal rainfall time series data of 33 years (1990-2022) for Ramanathapuram district of Tamil Nadu, India, were analysed using spatio-temporal patterns of rainfall. The number of rain days has decreased during the winter, while increased during the October and November in Ramanathapuram district of Tamil Nadu as per the trend analysis method. The monsoon season has exhibited a declining trend in moderate intensity. The presence of these trends depicts the impact of climate change and climatic variability on rainfall and number of rain days. The findings have assessed the descriptive and systematic features of rainfall patterns for seasonal rainfall in Ramanathapuram district of Tamil Nadu. Such analysis along with the spatio-temporal figures would be useful for planning well-organized use of water resources and also for district-level water management in a sustainable manner considering the impact of climate change on changing rainfall pattern and number of rain days in a particular season in Ramanathapuram district of Tamil Nadu. The agricultural or other socio-economic activities can also be managed by taking into account the changing rainfall pattern.

References

1. Ahmad I, Zhang F, Tayyab M, Anjum MN, Zaman M, Liu J, *et al*. Spatiotemporal analysis of precipitation variability in annual, seasonal and extreme values over upper Indus River basin. Atmos Res. 2018;213:346-360. https://doi.org/10.1016/j.atmosres.2018.06.019.
2. Ay M, Kisi O. Investigation of trend analysis of monthly total precipitation by an innovative method. Theor Appl Climatol. 2015;120(3-4):617-629. https://doi.org/10.1007/s00704-014-1198-8.
3. Bisht DS, Chatterjee C, Raghuwanshi NS, Sridhar V. Spatio-temporal trends of rainfall across Indian river basins. Theor Appl Climatol. 2018; 132(1-2):419-436.
4. Cengiz TM, Tabari H, Onyutha C, Kisi O. Combined use of graphical and statistical approaches for analyzing historical precipitation changes in the Black Sea region of Turkey. Water. 2020; 12(3):705.
5. de Oliveira-Júnior JF, Correia Filho WLF, de Barros Santiago D. Rainfall in Brazilian Northeast via in situ data and CHELSA product: mapping, trends, and socio-environmental implications. Environ Monit Assess. 2021;193:263. https://doi.org/10.1007/s10661-021-09043-9.
6. Ferreira FLV, Rodrigues LN, da Silva DD. Influence of changes in land use and land cover and rainfall on the streamflow regime of a watershed located in the transitioning region of the Brazilian Biomes Atlantic Forest and Cerrado. Environ Monit Assess. 2021;193:16. https://doi.org/10.1007/s10661-020-08782-5.
7. Goswami BN, Venugopal V, Sengupta D, Madhusoodanan MS, Xavier K. Increasing trend of extreme rain events over India in a warming environment. Science. 2006;314(5804):1442-1445.
8. Guhathakurta P, Rajeevan M. Trends in the rainfall pattern over India. Int J Climatol. 2008; 28:1453-1469.
9. Islam T, Rico-Ramirez MA, Han D, Srivastava PK, Ishak AM. Performance evaluation of the TRMM precipitation estimation using ground-based radars from the GPM validation network. J Atmos Sol-Terr Phys. 2012;77:194-208.
10. John A. Rainfall Trend analysis by Mann Kendall Test for Vamanapuram River Basin, Kerala. Int J Civil Eng Technol. 2018;9(13):1549-1556.
11. Kokilavani S, Ramanathan S, Dheebakaran G, Sathyamoorthy N, Maragatham N, Gowtham R. Drought intensity and frequency analysis using SPI for Tamil Nadu, India. Curr Sci. 2021;121(6):781-788.
12. Lalmuanzuala B, Sathyamoorthy NK, Kokilavani S, Jagadeeswaran R, Balaji Kannan. Drought analysis in southern region of Tamil Nadu using meteorological and remote sensing indices. Mausam. 2023;74(4):973-988.
13. McKee TB, Doesken NJ, Kleist J. Drought monitoring with multiple time scales. Preprints, 9th Conference on

Applied Climatology, 15-20 January, Dallas, TX; c1993. p. 233-236.
14. Nikumbh AC, Chakraborty A, Bhat GS. Recent spatial aggregation tendency of rainfall extremes over India. Sci Rep. 2019;9(1):10321.
15. Paul S, Ghosh S, Oglesby R, Pathak A, Chandrasekharan A, Ramsankaran R. Weakening of Indian summer monsoon rainfall due to changes in land use land cover. Sci Rep. 2018;6:32177.
16. Ramaraj A, Kokilavani S, Manikandan N, Arthirani B, Rajalakshmi D. Rainfall stability and drought valuation (using SPI) over southern zone of Tamil Nadu. Curr World Environ. 2015;10(3):928.
17. Sanikhani H, Kisi O, Mirabbasi R, Meshram SG. Trend analysis of rainfall pattern over the Central India during 1901-2010. Arabian J Geosci. 2018;11(15):437.
18. Sen Roy S, Balling RC. Diurnal variations in summer season precipitation in India. Int J Climatol. 2007;27(7):969-976.
19. Singh P. Rainfall and financial forecasting using fuzzy time series and neural networks based model. Int J Mach Learn Cybern. 2018a;9(3):491-506.
20. Srivastava P, Singh R, Tripathi S, Raghubanshi AS. An urgent need for sustainable thinking in agriculture-An Indian scenario. Ecol Indic. 2016;67:611-622.
21. Swain S, Verma M, Verma MK. Statistical trend analysis of monthly rainfall for Raipur District, Chhattisgarh. Int J Adv Eng Res Stud. 2015;IV(II):87-89.
22. Talchabhadel R, Karki R. Correction to: Assessing climate boundary shifting under climate change scenarios across Nepal. Environ Monit Assess. 2019;191:707. https://doi.org/10.1007/s10661-019-7907-0.
23. Teixeira D, Veloso B, Ferreira MF, FLV. Spectro-temporal analysis of the Paraopeba River water after the tailings dam burst of the Córrego do Feijão mine, in Brumadinho, Brazil. Environ Monit Assess. 2021;193:435. https://doi.org/10.1007/s10661-021-09218-4.
24. Tito TM, Delgado RC, de Carvalho DC. Assessment of evapotranspiration estimates based on surface and satellite data and its relationship with El Nino-Southern Oscillation in the Rio de Janeiro State. Environ Monit Assess. 2020;192:449. https://doi.org/10.1007/s10661-020-08421-z.
25. Varikoden H, Revadekar JV, Kuttippurath J, Babu CA. Contrasting trends in southwest monsoon rainfall over the Western Ghats region of India. Clim Dyn. 2019;52(7-8):4557-4566.