*International Journal of Environment and Climate Change*

***Volume 14, Issue 7, Page 548-556, 2024; Article no.IJECC.118703***
***ISSN: 2581-8627***
*(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)*

# Agroclimatic Drought Analysis in Mahasamund District of Chhattisgarh, India

**J.L. Chaudhary [a*], Bhumika Chandrakar [a] and Rajendra Lakpale [a]**

[a] *Department of Agricultural Meteorology, IGKV Raipur, (Chhattisgarh)- 492 012, India.*

***Authors' contributions***

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

***Article Information***

DOI: https://doi.org/10.9734/ijecc/2024/v14i74292

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers,peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/118703

***Original Research Article***

***Received: 04/05/2024***
***Accepted: 06/07/2024***
***Published: 13/07/2024***

## ABSTRACT

Drought is an insidious natural hazard that results from a departure of precipitation from expected or normal and when extended over a season or longer period of time, is insufficient to meet the demands of human, plant and animal activities. Drought can have a serious impact on health, agriculture, economy, energy and the environment. Drought is a prolonged dry period in the natural climate that can occur any where in the world. It is a slow-onset disaster characterized by the lack of precipitation, resulting in a water shortage. The study was conducted to analyze agroclimatic drought in Mahasamund district of Chhattisgarh. Mahasamund district is chosen for the study on agroclimatic drought analysis and also to examine the farmer's adaptability under AICRPAM-National Innovations on Climate Resilient Agriculture (NICRA) project. Two time periods have been taken into account viz., annual and SWM season. Long term rainfall data has been analyzed through Weathercock software and pattern has been drawn through Trend software. Rainfall data

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

***Cite as:*** *Chaudhary, J.L., Bhumika Chandrakar, and Rajendra Lakpale. 2024. "Agroclimatic Drought Analysis in Mahasamund District of Chhattisgarh, India". International Journal of Environment and Climate Change 14 (7):548-56. https://doi.org/10.9734/ijecc/2024/v14i74292.*

for Mahasamund, Bagbahara, Basna, Saraipali, Pithora blocks of Mahasamund district were collected from the Department of Agrometeorology, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur.Study is as a part of CRIDA, (Hyderabad) sponsored NICRA project which has been implemented in Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) w.e.f. 2011.The result showed significant increasing trend for high rainfall events in summer and winter season particularly for Mahasamund block. Long term data analysis indicates that only Saraipali blocksufferedfrom agricultural drought while other blocks do not indicate any rabi drought. Drought proofing management and climate resilent technologies like increasingwater use efficiency through micro-irrigation, reorientation of cropping pattern, use of suitable drought tolerant crop cultivars, water harvesting structures, deep summer ploughing followed by surface tilling during rest of year should be propagated among farming community.

*Keywords: Drought; rainfall; trend analysis; weathercock; kharifdrought; rabi drought.*

## 1. INTRODUCTION

“Drought is a significant consequence of climate variability, and its impact is always adverse towards the geographical condition ofany location” [1]. “It also causes water deficits and crop damage” [2]. “Various climatic parameters, viz., evapotranspiration, precipitation, and temperature are the prime in categorization of the drought situation and it differs with respect to climatic regimes around the world” [3]. “The prolonged drought may hinder social, economic, agricultural and other societal art effects” [4,5]. “The severity of the drought is difficult to determine as it develops gradually and has an extended duration. Conventionally, drought events are categorised into three major classes: (i) Meteorological Drought (MD), (ii) Hydrological Drought (HD), and (iii) Agricultural Drought (AD)”. [6,7,8,9,10] “Meteorological drought suggests a rainfall deficit where the precipitation is reduced by more than 25% from normal in any given area” [11]. “Hydrological drought is linked with the deficit of water on the surface and subsurface area of the region due to a shortage of precipitation” [12]. “Agricultural drought is depend as existing when the soil moisture in the root zone is at or below, the permanent wilting percentage. The condition continues until rain falls in excess of the daily evapotranspiration” [13].

“The meteorological drought is characterized by its duration, distribution, severity and intensity. Drought hazard mapping and its trend analysis has become indispensable due to the aggravated impact of drought in the era of climate change” [14]. “The conventional drought monitoring includes analysis of the rain gauge network based observations; which is reliable with long-term records. However, this method has several limitations such as spatial contiguity, data unavailability for remote areas, high-cost maintenance and near real-time data inaccessibility to the common users, etc. Alternatively, the spatially contiguous precipitation data allows a better assessment of the drought events. In India, the precipitation data facilitated by the Indian Meteorological Department (IMD) data at 0.25 degree resolution is commonly used in various studies. These events have a particularly broad impact affecting a wide range of industries including agriculture, public works, transportation, and water resources. Therefore, long-term changes in extremes are required to be analyzed to understand and prevent future climate- related damage to social infrastructure” [15]. “Drought is a natural disaster that causes much damage to the communities. Recently, water demand has been increasing sharply due to the population growth and the development process. By approaching the amount of water demand to the natural supplies, any decrease in the water supply may lead to a considerable negative socio-economic consequence. In this condition, the sense of drought prevails over the physical drought” [16].

“Rainfall pattern and the quantity decide the cropping system, choice of any particular crop and agronomic practices. Analysis of rainfall would enhance the management of water resources applications as well as the effective utilization of water resources” [17]. Rainfall plays a crucial role in transporting water from the atmosphere to the Earth's surface, connecting weather patterns, climate and the hydrological cycle [18]. “Crop planning and management has their application to ensure the yield of the crop. Dry spell coincidence with sensitive phenological stages of crop is very likely to affect the crop development. Hence, it is very important to analyze the sequence of dry and wet weeks for

crop planning purpose" [19]. "Agricultural drought is considered a situation in which soil, rainfall and plant-water requirements are not enough to mature a healthy crop. Much of agricultural productivity is related to the amount of rainfall that one experiences in vivo. More than 50% of India's productive farmland is rain-fed, which has far-reaching consequences in regards to food production, energy generation, animal feed and human settlement. As technology has changed, so have the stages of drought risk response" [20].

Chhattisgarh situated in Eastern India, is located between 17º 46' N and 24º 05' N latitudes and 84º 15' E and 84º 24' E longitudes (Fig. 1). Mahasamund district (NICRA-AICRPAM domain district) is spread out in an area of 4790 Sq. Kms in the Central-East of Chhattisgarh State. The district lies between 20°47' to 21°31'30'' latitude and 82°00' to 83°15'45'' longitude, surrounded by districts of Raigarh and Raipur of Chhattisgarh State and Nawapara and Bargarh districts of Odisha. The climate of NICRA-AICRPAM district Mahasamund which was moist sub-humid in the beginning of 20$^{th}$ century has changed to semi-arid type by the end of the 20$^{th}$ century. Added to the agony, Mahasamund district comes under trans-Mahanadi area where the soils are very light (sandy loam) and hence the impact of climate change is easily discernible. In view of this decreasing rainfall pattern, Mahasamund district is chosen for the study on climate resilience on agriculture and also to examine the farmer's adaptability under AICRPAM-National Innovations on Climate Resilient Agriculture (NICRA).

In the coming years, climate resilent agricultural technologies already developed will be refined. Mahasamund district located in eastern part of the state about 55 km from University [headquarter] is selected as the study area for demonstration of technologies under climate resilience. The KVK situated at Mahasamund has been part of these NICRA-AICRPAM activities. Being mainly a mono-cropped region, rice is the main cereal crop of the district during *kharif* season. Nearly 88.61 percent are allocated under paddy crop in *Kharif* season. The total area under different crops in *kharif* and *Rabi* season is observed as 83.91 percent and 7.57 percent respectively. Remaining 8.51 percent of the total cropped area is allocated during summer season in the district.(Anonymous,2023, Dept. of Agricultural and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Govt. of India, Directorate of economics and Statistics) [21]. The remaining area is allocated under other crops like urd, groundnut, wheat and gram etc in different season. Urd is second most important crop of the region during *kharif* season which occupies 3.64 percent area of the gross cropped area.(Anonymous,2023, Dept. of Agricultural and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Govt. of India, Directorate of Economics and Statistics) [21]. However, several other cereal crops are being grown in *kharif* as well as during *rabi* season in this district, although the area under cultivation is very less. Drought is generally associated with arid or semi-arid regions, yet drought can also occur in the areas that normally enjoy adequate rainfall. The drought's societal and economic impact significantly reduces food supplies and adversely impacts the habitat conditions, leading to irreversible damage. It causes societal anxiety and depression among the inhabitants. In Mahasamund district with agrarian economy, drought impacts on agricultural productivity are visible and therefore this study has been carried out.

**Table 1. Land utilization pattern of Chhattisgarh and NICRA domain district in Chhattisgarh (area in hectares)**

| S.No | Particulars | CG state | Mahasamund district |
|---|---|---|---|
| 01 | Total Geographical Area | 13790000 | 496300 (3.60 %) |
| 02 | Area Under Forest | 5977000 | 11020(1.74) |
| 03 | Land Under Non-Agriculture use | 1004000 | 47510(4.73) |
| 04 | Permanent Pasture and Grazing | 855000 | 30250(3.54) |
| 05 | Cultivable Waste Land | 344000 | 8210 (2.37%) |
| 06 | Fallow land (old fallow+current fallow) | 523000 | 13060 (2.50%) |
| 07 | Net Cropped Area (ha) | 4710000 | 263700 (5.60%) |
| 08 | Gross Cropped Area (ha) | 6183000 | 314370 (5.08%) |
| 09 | Cropping intensity (%) | 131.27 | 119.2 |

*Source: Department of Agriculture and Statistics, Mahasamund, 2023*
*Note: Figure in parenthesis indicates percentages of total geographical area of the state*

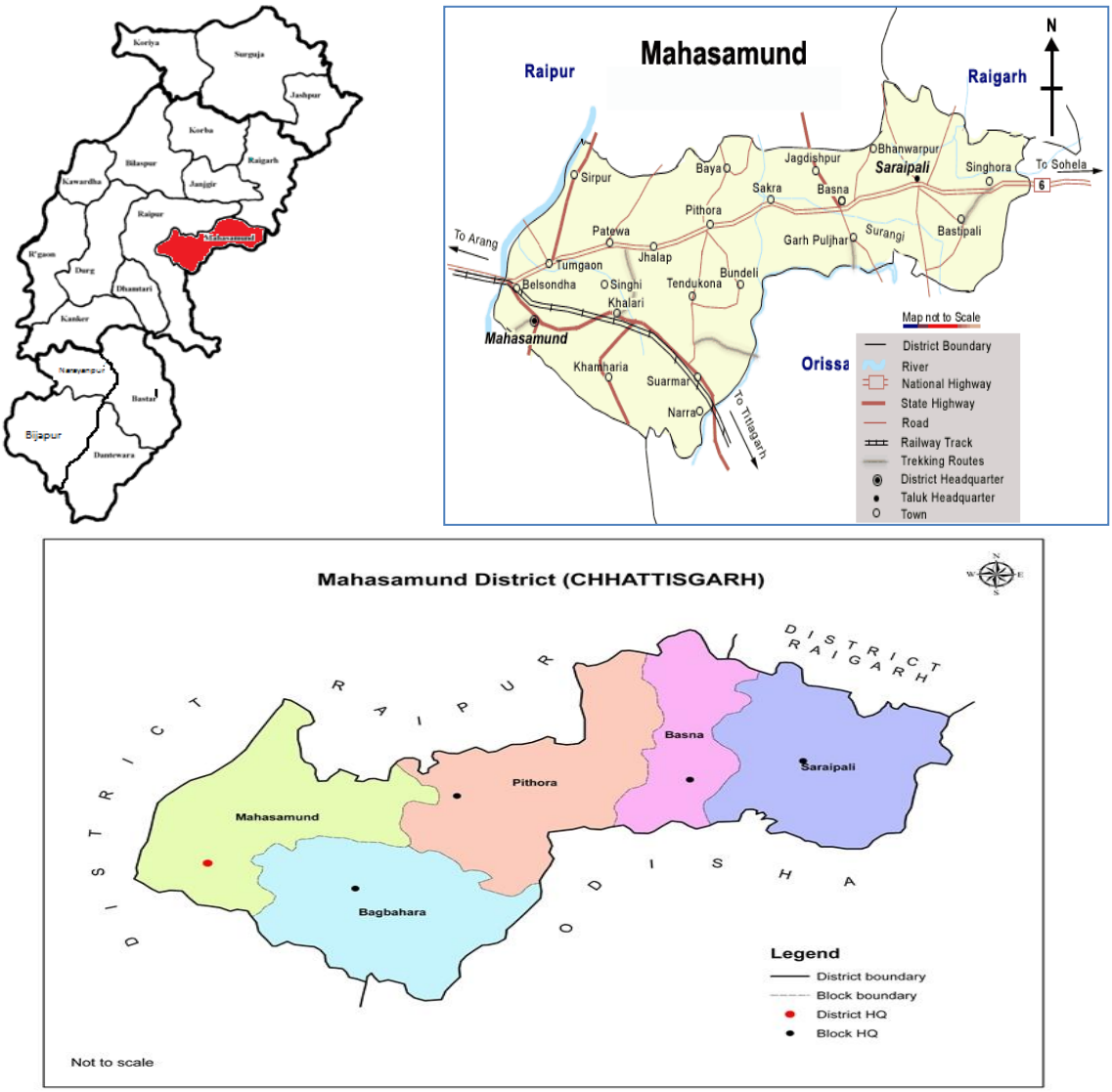


**Fig. 1. Location map of Mahasamund district and block wise boundaries**

The total geographical area of the state is 1,37,90000 hectares. Out of the total geographical area, Mahasamund district has 496300 hectare area constituting 3.60 percent. The cropping intensity of the district is 119.2 percent as compared to 131.27 percent in the state. (Anonymous, 2023, Dept. of Agricultural and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Govt. of India, Directorate of Economics and Statistics) The land utilization pattern of the NICRA domain district as compared to CG state is presented in Table 1.

## 2. METHODOLOGY

Here two time periodshave been taken into account viz., annual and South Western Monsoon season. Long term data has been considered and analyzed to give a clear picture through Trend software. Rainfall data for Mahasamund, Bagbahara, Basna, Saraipali, Pithora were collected from the Department of Agrometeorology, Indira Gandhi Krishi Viswavidyalaya, Raipur. The length of rainfall data period available for Bagbahara (1984-2022), Basna (1990-2022), Mahasamund (1973-2022), Saraipali (1981-2021), Pithora (2001-2022) were used for study. Rainfall data was converted into seasonal viz. winter (Jan–Feb), summer (March–May), southwest monsoon (June –Sep) and annual format using weathercock software. Rainy days are counted with 24-hours rainfall recorded with minimum quantity of 2.5 mm as per standards norms.

According to National Commission on Agriculture, 1976 Agricultural drought is calculated as:

***Kharif* drought**: At least four consecutive weeks receiving less than half of the normal rainfall (> 5 mm).

***Rabi* drought**: Six such consecutive weeks.

Input is taken as Weekly rainfall data and Output is coming out in weathercock software as explained in Weathercock software manual by Rao et al. [22]. Agriculture drought weeks during *kharif* and *rabi* season each year are calculated.

## 3. RESULTS AND DISCUSSION

### a. Trend Analysis of Rainfall and Rainy Days in Different Blocks of Mahasamund District

Rainfall is not found to be decreasing significantly. Generally perception of farmers is like that rainfall has decreased but for both the annual and SWM basis, rainfall has not decreased. However, pattern of rainy days which determine length of crop growing season is found to be increasing for Pithora block (Table 2).

**Table 2. Trend analysis for rainfall and rainy days of blocks in Mahasamund district**

| Blocks and Time -Period | Rainfall | | Rainy day | |
|---|---|---|---|---|
| | Annual | SWM | Annual | SWM |
| Bagbahara (1984-2022) | 3.651 (NS) | 2.973 (NS) | -0.042 (NS) | -0.057 (NS) |
| Basna (1990-2022) | 9.60 (NS) | 6.399 (NS) | 0.008 (NS) | -0.125 (NS) |
| Mahasamund (1973-2022) | 0.401 (NS) | -0.335 (NS) | 0.127 (NS) | 0.122 (NS) |
| Saraipali (1981-2021) | 0.383 (NS) | -1.614 (NS) | -0.029 (NS) | 0.007(NS) |
| Pithora (2001-2022) | 9.37 (NS) | -11.77 (NS) | -0.389 (NS) | **0.458 (0.05)** |

*0.05 -Significant at 5% level NS-Non-significant*

**Table 3. Long-term analysis of Agricultural drought (*kharif* season) in different blocks of Mahasamund district**

| Station | Mahasa Mund | Saraipali | | Bagbahara | | Basna | | Pithora | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Drought Week | Year | Drought Week | Year | Drought Week | Year | Drought Week | Year | Drought Week |
| 1991 | 25 – 28 | 1991 | 25 - 28 | 1994 | 38 - 41 | 1992 | 37 - 40 | 1992 | 37 - 40 |
| 1992 | 37 – 42 | 1998 | 38 - 41 | 1995 | 36 - 42 | 1994 | 38 - 42 | 1994 | 38 - 42 |
| 1994 | 38 - 42 | 2000 | 39 - 42 | 2000 | 39 - 42 | 1999 | 26 - 30 | 1995 | 36 - 41 |
| 1995 | 36 - 41 | 2008 | 39 - 42 | 2001 | 35 - 38 | 2000 | 39 - 42 | 2000 | 29 - 32 |
| 1996 | 37 - 42 | 2015 | 39 - 42 | 2002 | 26 - 30 | 2004 | 35 - 38 | | 39 - 42 |
| 1998 | 38 - 41 | 2018 | 39 - 42 | 2004 | 35 - 38 | 2006 | 24 - 27 | 2004 | 35 - 38 |
| 2000 | 34 - 37 | | | 2006 | 37 - 42 | 2008 | 39 - 42 | 2008 | 39 - 42 |
| | 39 - 42 | | | 2008 | 39 - 42 | 2011 | 38 - 42 | 2011 | 39 - 42 |
| 2002 | 26 - 30 | | | 2010 | 22 - 25 | 2015 | 39 - 42 | 2015 | 39 - 42 |
| | 38 - 41 | | | 2011 | 39 - 42 | 2018 | 39 - 42 | 2018 | 39 - 42 |
| 2004 | 35 - 38 | | | 2015 | 39 - 42 | | | | |
| 2006 | 39 - 42 | | | 2018 | 39 - 42 | | | | |
| 2008 | 39 - 42 | | | | | | | | |
| 2009 | 35 - 38 | | | | | | | | |
| 2011 | 39 - 42 | | | | | | | | |
| 2015 | 39 - 42 | | | | | | | | |
| 2018 | 39 - 42 | | | | | | | | |
| 2021 | 25 - 28 | | | | | | | | |

**Table 4. Agricultural drought (Rabi season) in different blocks of Mahasamund district**

| **Station** | **Mahasamund** | **Saraipali** | | **Bagbahara** | | **Basna** | | **Pithora** | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Drought Week* | Year | Drought Week | Year | Drought Week | Year | Drought Week | Year | Drought Week |
| No drought | | 1996 | 40 - 45 | No drought | | No drought | | No drought | |
| | | 2000 | 40 - 45 | | | | | | |
| | | 2008 | 40 - 45 | | | | | | |
| | | 2011 | 40 - 45 | | | | | | |
| | | 2015 | 40 - 45 | | | | | | |
| | | 2018 | 40 - 45 | | | | | | |

** standard meteorological weeks*

**Table 5. Trends of high rainfall events in different blocks of NICRA-AICRPAM district**

| Sl. | Districts | Winter | Summer | SWM | NEM | Annual |
|---|---|---|---|---|---|---|
| **1** | **Bagbahara** | NS – Inc | **S – Inc *** | NS – Inc | NS - Inc | NS – Inc |
| **2** | **Basna** | NS – Inc | NS – Inc | NS – Inc | NS – Inc | NS – Inc |
| **3** | **Mahasamund** | **S - Inc *** | **S - Inc *** | NS – Inc | NS – Inc | NS – Inc |
| **4** | **Pithora** | NS – Inc | NS – Inc | NS – Inc | NS – Inc | NS – Inc |
| **5** | **Saraipali** | NS - Inc | NS – Inc | NS - Inc | NS –Dec | NS – Inc |

### b. Studies on Agricultural Drought in Mahasamund district of Chhattisgarh State for Strategic Crop Planning in Rice Based Cropping System

Blocklevel analysis of agricultural drought has been done. Basically there are two seasons viz. *kharif* and *rabi*. *Kharif* season agricultural drought has been shown in Table 3. Drought during *kharif* season indicates that all blocks can experience intermittent dry spells of 4 weeks. Maximum agricultural droughts during *Kharif* season are being experienced in Mahasamund block followed by Bagbahara block. However, the least *kharif* agricultural droughts are being experienced in Saraipali.

Rabi season drought analysis has been shown in Table 4. Long term data analysis indicates that only Saraipali block suffers from agricultural drought while other blocks do not indicate any *rabi* drought.

**Studies on high rainfall events trend in different blocks of Mahasamund district:** High rainfall events have been studied for different seasons in different blocks. Results have been shown in Table 5. There have been mostly non-significant trends but there has been significant increasing trend in summer and winter season particularly for Mahasamund block.

## 4. CONCLUSION

This work has been carried out so that scenario of regional agroclimatic drought at block level can be understood. The study area records a fluctuating trend of South West Monsoon rainfall, which is the main source of water supply for rainfed agriculture and agricultural activities in the region. There has been significant increasing trend in summer and winter season rainfall particularly for Mahasamund block. Long term data analysis indicates that only Saraipali block suffers from rabi agricultural drought while other blocks do not indicate any rabi drought. However, the least kharif agricultural droughts are being experienced in Saraipali and maximum agricultural droughts during Kharif season are being experienced in Mahasamund block followed by Bagbahara block. For managing the situation in these drought prone blocks, farmers need to be advised to go for less water requirement crops or varieties. There are also possible options in *kharif* season i.e. suitable alternative crops like groundnut, arhar, millets etc. Other strategies for rainwater conservation measures and suitable climate resilent measures need to be adopted for sustainable agriculture.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Shah R, Bharadiya N, Manekar V, Drought index computation using standardised precipitation index (SPI) method for Surat District, Gujarat; Aquat. Procedia. 2015; (4):1243–1249.
2. Sharma A, Spatial data mining for drought monitoring: An approach using temporal NDVI and rainfall relationship; International Institute for Geo-Information Science and Earth Observation Enschede, The

Netherlands & Indian Institute of Remote Sensing, Dehradun; 2006.

3. Haied N, Foufou A, Chaab S, Azlaoui M, Khadri S, Benzahia K and Benzahia I, Drought assessment and monitoring using meteorological indices in a semi-arid region; Energy Procedia. 2017;119: 518–529.
4. Golian S, Mazdiyasni O and Aghakouchak A, Trends in meteorological and agricultural droughts in Iran,Theor. Appl. Climatol. 2015;119(3–4):679–688.
5. Edwards B, Gray M, Hunter B, The social and economic impacts of drought, J. Soc. Issues. 2019;54(1):22 –31.
6. Feng K, Zhang Su X, Javed G and Zhang Z, Development of a new integrated hydrological drought index (SRGI) and its application in the Heihe River Basin, Theor. Appl. Climatol. 2020; 141: 1–17.
7. Chowhan, Vikas DM, Chandargi SB, Goudappa SK, Kammar BG, Koppalakar Lokesh GB. Exploring climate patterns in Karnataka, India: A comprehensive examination of rainfall and temperature variability over time and space. Journal of Scientific Research and Reports. 2024;30(4):187-96.

   Available:https://doi.org/10.9734/jsrr/2024/v30i41904.
8. Fayiga OA, Saha UK. Effect of climate change on soil productivity in developing countries. Asian Journal of Environment & Ecology. 2017;4(1):1-22.

   Available:https://doi.org/10.9734/AJEE/2017/35485
9. Rötter RP, Appiah M, Fichtler E, Kersebaum KC, Trnka M, Hoffmann MP. Linking modelling and experimentation to better capture crop impacts of agroclimatic extremes—A review. Field Crops Research. 2018 May 15;221:142-56.
10. Wu B, Ma Z, Yan N. Agricultural drought mitigating indices derived from the changes in drought characteristics. Remote Sensing of Environment. 2020 Jul 1;244:111813.
11. Murad H, Agricultural and meteorological drought assessment using remote sensing and GIS in north-west region of Bangladesh; 2010.
12. Wu J, Chen X, Yao H, Gao L, Chen Y and Liu M, Nonlinear relationship of hydrological drought responding to meteorological drought and impact of a large reservoir, J. Hydrol. 2017;551:495–507.
13. Rickard DS, The occurrence of agricultural drought at Ashburton, New Zealand, New Zealand J, Agric. Res.1960;3(3): 431–441.
14. Pandey V, Srivastava PK, Singh SK,Petropoulos G, Pand Mall RK, Drought Identification and trend analysis using long-term CHIRPS satellite precipitation product in Bundelkhand, India, Sustainability. 2021;(13)1042.
15. Kaur B, Kaur N, Kataria SK, Singh S, Assessing the variability in temperature and rainfall extremes using RClimdex in Jalandhar district of Punjab, Journal of Agrometeorology. 2022; 437-439.
16. Hooshyaripor F, Sardari J, Dehghani M and Noori R, A new concept of drought feeling against the meteorological drought, Scientific Reports.2022;12:1671.
17. Wale VD, Sthool VA andUpadhye SK, Trend analysis of rainfall and rainy days using Mann Kendall method and sen's slope estimator in Tasgaon Tahsil of Sangli District of Maharashtra (India), Journal of Pharmacognosy and Phytochemistry. 2020;9(4):99-102.
18. Singh R, Chandravanshi A,Gurjar S, Saxena B and Sahu KK, Trend analysis of rainfall patterns in Rajnandgaon District, Chhattisgarh, India, International Journal of Environment and Climate Change. 2023;3553-3561.
19. Munde PS, Upadhye SK,Wale VD, Jadhav JD, Sthool,VA and Bhagat AA, Weekly Rainfall and rainy days trend analysis for crop planning in baramati tehsil of Pune District, International Journal of Current Microbiology and Applied Sciences. 2021; 10(02):589-598.
20. Purohit S, Rout S, Mishra U and Prusty A, Indian agricultural drought and its significant impacts -a scenario. Chapter contributed in Book on Modern Technology of Agriculture, First Edition: 2022; ISBN: 978-93-91872-27-4.
21. Anonymous, Dept. of Agricultural and Farmers Welfare, Ministry of Agriculture and Farmers Welfare Govt. of India, Directorate of economics and Statistics; 2023.

22. Rao VUM, Rao AVMS, Rao GGSN, Satyanarayana T, Manikandan N, Venkateswarlu B and Ramamohan I, Weathercock software, Central Research Institute for Dryland Agriculture, Hyderabad; 2011.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/118703*