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Review Article

SPATIAL AND TEMPORAL VARIATION OF DRY SPELLS

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Abstract: Rainfall is the major source of water. Rainfall pattern and moisture availability in root zone under rainfed condition is closely linked with the success or failure of crops. Distribution of rainfall is not uniform and occurrence of frequent dry spells is a common phenomenon observed. The spatial and temporal variability of rainfall and its uneven and inadequate distribution determines the failure of crops especially in drought prone areas. For this the rainfall analysis was carried out by different research workers for onset of effective monsoon, and dry and wet spell analysis for various places in dry land agriculture. Geospatial analysis techniques such as Remote Sensing and Geographic Information System were used for studying the spatial and temporal variation of dry spells and spatial variability of soil moisture. The knowledge on onset of effective monsoon (OEM), its withdrawal, period of occurrence and distribution of dry spells during the monsoon period is most important to the farmer for successful planning. Analysis of historical weather data and its soil moisture variability helps to develop and modify the management practice to increase and stabilize the agriculture production in the rainfed ecosystem.

Keywords: *Dry spells, Monsoon, Rainfall, Spatial and temporal variation*
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Introduction

Indian condition, the seasonal, spatial and temporal variation of rainfall negatively affects the crop production. The important features of rainfall affecting on agricultural production from rainfed areas are the date of onset of effective monsoon, the duration of dry spells, the time of occurrence of dry spells, the duration of wet spells and number of rainy days. Rainfall is not uniform and occurrence of frequent dry spells is a common phenomenon during the monsoon season. In rainfed agriculture, the adequate rainfall to meet the water requirements of crops and other consumptive and non-consumptive water needs is a basic requirement. The spatial and temporal variability of rainfall and its uneven and inadequate distribution determines the failure of crops especially in drought prone areas. Knowledge of the distribution of dry spells during the monsoon period is essential for successful planning of rainfed farming

Dry spell Analysis

Analysis of daily rainfall data for 5 stations in Akola district to determine mean date of OEM, earliest and latest probable date of OEM and Standard deviation. The mean date of OEM for Akola was June 23, for Akot was July 2, for Balapur was July, for Murtijapur was July4 and for Washim was June 21 and corresponding standard deviations (days) observed were 12, 17, 18, 20 and 18 respectively [1].

Analysis of daily rainfall data of 9 districts of Vidarbha region for a period of 20 to 22 years. The onset and termination of effective monsoon and dry spell analysis were done according to Ashok Raj's criteria. The critical value for each station was determined and critical dry spells were resolved for each station. The mean dates and durations for dry spells at different probability levels were plotted. The cumulative probability monographs were created for crop developmental stages of different crops. The study betrayed that in heavy rainfall zone, the highest probabilities of dry spells were noticed at Sironcha station. In moderate to moderately high rainfall zones maximum exceedance probabilities were found at Wardha [2].

Daily rainfall data of > 25 years was analyzed for justifying the failure of rainfed agriculture in semi-arid and arid areas of the country. Decisive dry-spell durations for the two crops were found in an innovative way by applying the methods used in the determination of frequency of irrigation. The results stated that rain-fed agriculture in the area is practically impossible without supplementary irrigation [3].

Morkov chain model was used to study sequence of dry and wet periods along with onset of monsoon and its withdrawal during 1976-2002 for Akola station in assured rainfall zone.

Onset and withdrawn of monsoon were worked out by forward and backward accumulation technique. He found that early and latest onset and withdrawal at Akola as 23rd and 30th and 33rd and 48th meteorological week (MW) respectively. Result indicated that onset and withdrawal of rainy season at Akola would be expected by 25th and 42nd MW respectively with 48 percent probability. The length of growing season extends upto 17 to 18 weeks at Akola [4].

A study on rainfall pattern characterization using 27 years rainfall data (1976-2002) at Nagpur representing central agro-climatic zone of Vidarbha. Using the rainfall data predicted onset of effective monsoon, length of growing season and dry and wet spell analysis. Study pertaining to onset and withdrawal of monsoon, length of growing season, and weekly sequences of dry and wet spells during the crop growth period and availability/deficit of moisture content during different growth stages would be of foremost important for crop planning [5].

The daily rainfall data for 20 years (1988 to 2007) was analyzed to find the dates of onset and end of effective monsoon [6]. The study concluded that, the average monthly rainfall for Beed was found to be varied from 4.39 mm to 190.41 mm. The average annual rainfall at Beed was recorded as 758.23 mm. The average number of rainy days was found to be 37.6 days. The mean date of OEM was observed to be June 29. The mean date of end of monsoon was found to be October 9. The mean dates of critical dry spells (CDS) were July 14, August 21, August 27 and September 24 with duration of 21, 23, 21 and 21 respectively as

1st, 2nd, 3rd and 4th CDS. The mean dates of wet spells were June 29 to July 13 for first, August 4 to August 20 for second and September 24 for third wet spell [7].

Appraisal and analysis the monthly rainfall data of thirty years (1975-2004) was done at Udumalpet station located in Parambikulam Aliyar sub-basin (Tamilnadu) on annual, seasonal, and monthly basis for planning a suitable water conservation management system. In the study period, four years were found to be wet, four years were found to be dry and the remaining twenty two years were found to be normal years. The analysis found that the annual and seasonal rainfall data did not clearly indicate the problem of drought in the region; whereas the monthly rainfall data showed a serious concern to deal with drought especially during the winter and summer months. It also showed that the winter months were subjected to severe drought conditions. Out of 30 years of study, January and February were identified to be the dry months which normally promotes for the good harvest of the *kharif* sown long duration crops [8].

A trial on wet and dry spell analysis using 26 years (1984 to 2010) of weekly rainfall data to find out the initial and conditional probability of their occurrence using Markov chain approach. The probability of occurrence of wet spell of 10, 20, 30, 40 and 50 mm rainfall was 73-100, 65-85, 46-81,31-73 and 31-65 % respectively during 26 to 35 Standard Meteorological Weeks (SMW), whereas the same was 0-23, 0-15, 0-12, 0-8 and 0-8 % respectively during 39-52 SMW and it was 11- 42, 4-23, 0-19, 0-12 and 0-12 % respectively during 1-22 SMW for the corresponding wet limits. The rainfall distribution for different crop seasons were also determined to adjust various crop phenophases and their planning based on moisture availability [9].

The weekly rainfall data of 30 years (1976-2005) for Belval and Bhusawal stations was analyzed. The behaviour of rainfall, occurrence of dry spell and critical dry spell was worked out by using initial and conditional probability method. The initial probabilities of rainfall > 20 mm varied between 60-70 per cent at Belval while at Bhusawal it was 75-80 per cent. The conditional probability (W/W) for both the stations varied between 80-90 percent. The initial probabilities of rainfall > 30 mm differing between 50-60 per cent at both the stations and the conditional probability (W/W) varied between 60-70 percent at Belval, while at Bhusawal it was in the range of 70-80 percent. The conditional probability (W/D) varied in between 40-50 percent at Belval and Bhusawal. The dry spells were found 62 at Belval, and 44 at Bhusawal and the critical dry spells were 12 and 9 for Belval and Bhusawal respectively [10].

Thirty-three years of weather data to evaluate the potential of sufficient rainfall occurrences and precipitation surplus and deficits in the central highland of Ethiopia for a selected district was done by researchers [11]. For estimating the probability of occurrences Weilbul frequency formula was applied during both belg (shorter) and kiremt (main) seasons and some of the models [12, 13] were used to set the threshold limits. The results showed that the chance of occurrences of the sufficient amount of rainfall during the decades of main rainy season is promisingly stable while belg is observed to suffer from fewer occurrences of the sufficient amount even at the lower probability levels (25% chance of occurrences).

The rainfall data from 1971-2010 to look at the Mandal-wise distribution pattern of rainfall and occurrence of dry spells during different growth stages of rice in Medak district. Dry spells of < 20 mm rainfall were worked out using Weathercock v 1.0 software. Results recorded that eastern part of district had dry spell probability of 60-70% during seedling phase (24-26 standard meteorological weeks SMW). The probability of dry spell during active vegetative phase (27-30 SMW) falls to about 50% in all mandals. Most of mandals (with few exceptions) received rainfall of 20 mm or more from 31-32 SMW coinciding with vegetative lag phase. During reproductive phase (33-38 SMW), except 11 mandals, the probability for a dry spell was less than 50% in the remaining mandals. Dry spells were likely to occur during the ripening phase (39-43 SMW) with probability exceeding 60% [14].

Analysis of the daily and weekly rainfall data of 20 years (1990-2009) to decide the minimum duration of critical dry spell in Buldhana district. Average seasonal rainfall during *kharif* season in different talukas of Buldhana district ranges from 650 to 837.5 mm. Effective monsoon (OEM) normally starts from 20th June to 3rd July (25-27 MW) in Buldhana district. It may start earliest by 4th June to 18th June and latest by 30th June to 31st July. On an average, there are 2 to 3 CDS(s) occurs in Buldhana district. First CDS of 13 to 18 days duration occurs immediately after OEM during 12-30 June (24-26 MW), whereas the second CDS of 13 to 24 days occurs during 20th July to 4th August (29-31 MW). Third CDS of duration 17 to 23 days occurs during 16th August to 10th September (33-37 MW). The duration of critical dry spell was found to be 16 for sorghum crop and 12 days for soybean and green gram crop [15].

Researchers analyzed daily rainfall data of 20 years (1991-2010) for Durg, Dhamdha and Patan blocks of Durg district in Chhattisgarh for the purpose of agriculture planning. Study revealed that on an average 138, 139 and 137 days were observed as dry days (rainless days) in Durg, Dhamdha and Patan blocks, respectively during complete monsoon season. During the entire productive phase including flowering stage, 22-23 dry days occurred at the three study blocks out of 28 days of this phase that fell during 37 to 40 standard meteorological weeks. Probability analysis of relentless dry days based on gamma distribution revealed that during flowering stage (37-38 MW), an expected dry spell of 7 days at Dung, of 5 days at Dhamdha, and of 4 days may be experienced at 25% probability of exceedance that was considered for rice crop planning, indicating less proneness of drought condition at Patan in comparison to Durg and Dhamdha blocks. At reproductive phase, 3 to 4 days dry spell might occur at all the study blocks. Markov Chain modelling of dry spells indicated that during nursery and reproductive stages of rice crop, the initial and conditional probabilities of dry weeks were as high as 71-90 % indicating severe shortage of rainfall and supplemental irrigation was a must for realizing good yields at all the blocks [16].

Analysis of daily rainfall data of 15 years (1998-2013) to compare the large-scale duration characteristics of rainfall over semi-arid region. The analysis has been carried out for ten locations, *viz*., Dahiwadi, Islampur, Kadegaon, Karad, Koregaon, Miraj, Palus, Tasgaon, Vaduj and Vita in the Yerala river basin. The range of both dry and wet spell perod is from 4 to 33 days in the Yerala river. During this investigation, the rain spells were categorized into low, medium, high, very high and extreme rain spells. These spells were examined only for the monsoon season (June-October) because all the above categories of rain spells occur only in this season and it helps to co-ordinate various activities like water release schedule, supplementary irrigation effect on crop growth etc. The highest dry spell was 33 days at Palus in 2002 and minimum 17 days at Kadegaon in 2003 [17].

They did the analysis on trends of the drought in Ichkeul lake basin, Northern Tunisia, examined from the daily rainfall data of five stations (Fritissa, Ghèzala Dam, Wadi Joumine Antra, Sidi Abdelbasset and Sidi Salem). The alternating wet-dry spell model and a precipitation threshold value are used to determine the rainfall/dry event. The Mann–Kendall test and the Sen's estimation method were used to analyze the probable trends and the magnitude of variables analyzed, respectively. The results recorded that an increasing trend of maximum monthly dry spells. Changes in the start and end of rainy season have occurred over the past years was found non-significant. These analyses provide information which is beneficial for science and society and make it possible to reduce unpredicted damage due to long dry spells and to have productive and efficient planning for different stakeholders [18].

Spatial and temporal variation of dry spells

Forty years of rainfall data (1958-1997) was analyzed for spatio-temporal variation of dry spells occurred in the Greek. The longest dry spells are identified in central (Cyclades) and the south-east Aegean Sea whereas dry spells with the minimum length are shown over the north-west of the Greek area that reflects the significance of the latitude and the topography. Negative Binomial Distribution and Markov Chains of second order have been used to fit the duration of the dry spells of different lengths. Frequency of occurrence of dry spells in both seasonal and annual distribution showed that dry spells in Greece depict a seasonal character, while medium and long sequences are associated with the duration and hazards of drought [19]. He and his co-workers conducted study on climatological water balance using 30 years climatic data at taluka level in Amravati division, to characterize area for optimizing agriculture productivity under changing rainfall pattern due to climate change impact.

Annual rainfall pattern during 1975-2005 shows a dominant semi-arid climate feature in Buldana and Akola districts, semi-arid to sub-humid nature in Washim and Amravati districts and humid to per-humid climate in Yeotmal district. Spatial and temporal variability of soil moisture deficit in Amravati division was studied and based on soil moisture deficit fluctuations; principle component analysis resolved the area in Amravati division into four climatologically homogeneous regions which can be used for deciding soil management strategies and suitable cropping systems for optimizing agriculture production under changing climate scenario [20].

They analyzed the spatial and temporal variation of rainfall in Nagaland state of India. The analysis of rainfall determined that there exists a wide variation in the rainfall amounts with variation from 859 mm to 212 mm. Annual rainfall pattern indicates that northern part receives greater rainfall as compared to eastern and western side of the state. Similarly, for July and monsoon season northern side receives higher rainfall. However, eastern, and western part of the state receives higher rainfall than Northern part during December [21].

Efficient and effective of drought in Jodhpur district with the aid of geospatial techniques was studied and it was found to be successful [22]. Drought assessment indices such as Standardized Precipitation Index, Normalized Difference Vegetation Index and Vegetation Condition Index were used. Standardized Precipitation Index was used to monitor meteorological drought. Normalized Difference Vegetation Index and Vegetation Condition Index were used to determine vegetative drought in the drought-prone areas. Geospatial analysis techniques such as Remote Sensing and Geographic Information System have been used to discover drought conditions in the study area by determining these indices by using meteorological data and other relevant information. To perform data processing and analysis of the collected data ArcGIS software was used. Geographical visualization of the results of analysis helps to identity the unusual patterns of drought occurrences.

A study on spatio-temporal variability of rainfall impacts on the growth of vegetation during the monsoon season in the Sahel. This study evaluates this effect for the Ferlo basin in central northern Senegal. Relationships between rainfall, soil moisture (SM), and vegetation were assessed using remote sensing data (TRMM3B42 and RFE 2.0 for rainfall, ESA-CCI.SM for soil moisture and MODIS Leaf Area Index (LAI). The key objective was to analyze the response of vegetation growth to water availability during the rainy season using statistical criteria at the scale of homogeneous vegetation-soil zones. The study covers the period from June to September for the years 2000 to 2010. The surface SM was well correlated with both rainfall products. Ferruginous soils showed suitable correlation of intra-seasonal variations and stronger sensitivity of the vegetation to rainfall than lithosols. LAI respond, on average, 2 to 3 weeks after a rainfall anomaly. Besides, dry spells (negative anomalies) of 7 days' period (three days for SM anomaly) significantly affect the vegetative growth (maximum LAI during the season). A strong and significant link was also determined between total precipitation and the number of dry spells. These datasets proved to be sufficiently reliable to assess the impacts of rainfall variability on vegetation dynamics [23].

This study stated that the occurrence of 7-days dryspell during monsoon season is maximum (6-7 times during the season) over the regions of south-western Andhra Pradesh and Central Maharashtra. Fourteen days dryspell during monsoon season (Jun to Sep), north-western India *i.e.*, western Rajasthan is prone to highest frequency (more than 4 times during the season) in the country. The trend analysis using Mann Kendal method for dry spells of 7-days and 14-days duration during *kharif* season recorded significant increase in dry spell of 7-days duration in some regions of Central Maharashtra, while significant decrease in the same is observed over major parts of West Bengal. However, no significant increase/ decrease was found in the dry spell of 14-days duration during *kharif* season, except few pockets in south-western Maharashtra [24].

Both dry and wet spells have been analyzed in the Wadi Cheliff basin (Algeria) by means of annual precipitation noticed at 150 rain gauges during 1970-2018. Specially, the characteristics of dry and wet spells (frequency, duration, severity, and intensity) have been examined by means of the run theory applied to the 12-month standardized precipitation index (SPI) values. Besides this, in order to identify possible tendencies in the SPI values, a trend analysis has been carried out by means of two non-parametric tests (Theil-Sen and Mann-Kendall test). Ultimately similar values of frequency, severity, duration, and intensity between the dry and the wet spells, although wet events recorded higher values in the extreme. Moreover, the results of the trend analysis showed a different behavior between the northern side of the basin, characterized by a negative trend in the 12-month SPI values, and the southern side, in which positive trends were observed [25].

Conclusion

The knowledge of normal dates of onset of effective monsoon (OEM), its withdrawal, period of occurrence and distribution of dry spells during the monsoon period is essential to the farmer for successful planning of rainfed farming. It is also important to know the chances of occurrence of dry spells for planning of the sowing dates, cropping pattern, protective irrigation, and intercultural operations. Such information will also be useful in designing of rain water harvesting structures for harvesting of excess rainwater at suitable locations and use it as protective irrigation during dry spell period.

Application of research: Analysis of rainfall distribution pattern and resulting dry spells is very much essential for crop planning of the region to utilize maximum potential of dry land agriculture.

Research Category: Soil and Water Conservation

Abbreviations: OEM-Onset of Effective Monsoon, MW-Meteorological Week
CDS-Critical Dry Spells, SMW-Standard Meteorological Weeks
LAI-Leaf Area Index, SM-Soil Moisture, RFE-RainFall Estimate
TRMM-Tropical Rainfall Measuring Mission, ESA-European Space Agency
CCI-Climate Change Initiative, MODIS-Moderate Resolution Imaging Spectroradiometer

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References

[1] Pawade M.N. (1982) *Ph D. thesis Faculty of Post Graduate School, Indian Agricultural Research Institute (IARI), New Delhi*.
[2] Kolhe N.R. (1988) *MTech. Thesis, PGI Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, 444104, India*, 45-55.
[3] Belachew A.B. and Horlacher (2002) *Dry spell Analysis for studying the sustainability of Rain-fed Agriculture: Applied to the Arbaminch Area in Ethiopia, Hydrology Days.*

[4] Satpute G.U. (2006) *Proceeding of 40th Annual convention and symposium of ISAE. Jan. 19-24, held at TNAU, Coimbatore*, 4.2-4.3.
[5] Satpute G.U., Singh R.V. and Wanjari S.S. (2008) *13th Vasantrao Naik Memorial National Agriculture seminor on "Livelihood security through Rainwater Management", January 22-23, held at College of Agriculture, Nagpur*, 5.
[6] Ashok Raj P.C. (1979) *IARI Bulletin No.II, WTC, IARI, New Delhi*.
[7] Abuj M.D., Magar A.P., Bombale V.T., Popale P.G. and Birajdar S.A. (2010) *Rainfall and dry spell anaylasis for beed district, Engineering. & Technology in India*, 2, 37-42.
[8] Kandasamy P. and Chellamuthu M. (2012) *International Journal of Applied Sciences and Engineering Research*, 1(2).
[9] Kingra P.K., Gill, K.K and Singh S. (2013) *Journal of Agricultural Physics*, 13(2), 193-202.
[10] Nikam S.P. and Dhanphule S.S. (2013) *International Journal of Agricultural Engineering*, 6(1), 231-235.
[11] Yemenu F. (2013) *Journal of Biology, Agriculture and healthcare*, 3(11).
[12] FAO (Food and Agriculture Organization). (1978) *Report on the agro-ecological Zones Project Vol.1 Methodology and Results of Africa. Rome*
[13] Reddy S.J., (1990) *Agro climatology Series Eth 86/o21-WMO/UNDP NMSA, Addis Ababa, Ethiopia*, 60.
[14] Rao A.V.M., Jaypal M., Rao V.U.M., Rao V.N. and Raju N.S. (2013) *Journal of Agrometeorology, 15 (Special Issue-II),* 73-79.
[15] Khardiwar M.S., Ade G.S., Chinchorkar S.S., Ram B., Kumar S., Sayyad F.G., Takare I.S. and Yaduvanshi B.K. (2013) *Spring*, 2(3), 17-25.
[16] Pali A.K and Thakur H. (2015) *Indian Journal of Soil Conservation*, 43(3), 277-283.
[17] Kamalkishor R.T. and Abijit M.Z. (2015) *Wet and dry spell characteristics of semi-arid region, western Maharashtra, India. E-proceedings of the 36th IAHR World Congress.*
[18] Mathlouthi M. and Lebdi F. (2021) *Comprehensive study of the wet and dry spells and their extremes in the Mediterranean climate basin Northern Tunisia, SN Applied Sciences*, 3, 850.
[19] Anagnostopoulou C., Maheras P., Karacostas T. and Vafiadis M. (2003) *Theoretical and Applied Climatology,* 74(1), 77-91.
[20] Satpute G.U., Surse S.R. and Bhuyar R.C. (2010) *Soil moisture zoning in amaravati division for cropping strategies under changing rainfall pattern, State level seminar on soil resource management for sustainable soil health and food security, January* 2-3, 111.
[21] Kusre B.C. and Singh Kh.S. (2012) *International Journal of Geomatics and Geosciences*, 2(3).
[22] Shuchi M., Jat M.K. and Pradhan P. (2014) *An Approach to analyse Drought occurrences using Geospatial Techniques, 15th Esri India User Conference*.
[23] Soukeye C., Eymard L., Ottle C., Jacques A.N., Gaye A.T. and Pinsard F. (2016) *Journal of remote sensing*, 66.
[24] Vijaya Kumar P. Sandeep V.M. Bal S.K. Subba Rao A.V.M. and Pramod V.P. (2019) *Spatial and temporal variability of dry spells over India. ICAR–Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad-500 059, Telangana, India*, 44.
[25] Achite M., Krakauer N.Y., Wałega A. and Caloiero (2021) *Atmosphere*, 12, 798.