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Assessment of drought using standard precipitation index in Prakasam district Andhra Pradesh, India

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Abstract
This paper discusses a method for calculating the severity of meteorological droughts based on historical precipitation data as the primary criterion Monthly precipitation data from 1970 to 2020 were used to obtain Standardized Precipitation Index (SPI) values for Prakasam district, Andhra Pradesh. SPI has the ability to analyse the drought at various time scales and for a variety of applications. SPI is calculated at various time scales (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 etc. months). Time scales of one, two, and three months are effective for agriculture, while time scales of six, nine, and twelve months are useful for hydrology. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The annual SPI for Prakasam district was calculated from 1970 to 2020 to show the frequency of occurrence of dry and wet conditions. Temporal SPI graphs show that the maximum SPI value (extreme drought) occurred in the year 2018 in that year, the SPI value was -2.6. Furthermore, in severe and extreme drought years, SPI values indicated only moderate dryness rather than extreme dryness, with SPI values never falling below -2.5.Severe and moderate drought occurred in 1984, 2002 and 2014. Drought patterns were evaluated, yielding many interesting results on the variability of drought occurrence in the region. The study's findings are relevant to climate change studies in order to understand historical patterns and build future scenarios of drought occurrences.

Keywords: Precipitation, meteorological drought, standard precipitation index, climate change

Introduction
Since the dawn of time, extreme meteorological events such as heat waves, cold waves, droughts, floods, etc. had affected human life, animal life, agriculture, and all other sectors collectively. Climate change is one of the causes for these extreme events as a consequence it adversely affects the social and economic conditions. The Sixth IPCC report summarizes warming even 1.5 degrees of global warming will still lead to large-scale drought, famine, heat stress, death of species, loss of entire ecosystems, and loss of habitable land, plunging more than 100 Million into economically low. Large variations in the frequency and intensity of excessive activities can result from enormously small fluctuations within the average of a distribution of precipitation, temperatures, or different weather variables. Among the extreme meteorological events, droughts had the least predictability and affecting greater humans than other dangers. Drought is unpredictable and also the most complex and least understood phenomenon among all the natural hazards (Hagman, 1984; Amrit *et al.*, 2018) [1 2]. Meteorological drought is the earliest and the maximum explicit event inside the manner of prevalence and progression of drought situations.

Drought is one of the extreme climatic event that is tricky in nature since it grows gradually and regularly sneaks up on one (Mukherjee, S *et al.*, 2018) [3]. Effect of drought under a global warming situation is bound to disturb later on (Dai. A 2011) [4]. Obviously dry spells have consistently happened, and the inconstancy in ocean surface temperature inconsistencies can cause worldwide droughts (Seager R, 2020) [5]. Droughts happen in practically all climatic zones, for example, high just as low precipitation regions and are for the most part identified with the decrease in the measure of precipitation got throughout a drawn out timeframe, like a season or a year (Mishra, A.K., and Singh, V.P. 2010) [6]. Drought is characterized as a cataclysmic event that happens when precipitation is altogether not as much as its ordinary time (Dikici, M.2020) [7]. Dry spells sway both surface and groundwater assets and can prompt decreased water supply, deteriorated water quality, crop failure, diminished reach usefulness, reduced force age, upset riparian natural surroundings, and suspended amusement exercises, just as influence a large group of monetary and social exercises (Riebsame *et al.*, 1991) [8].

The event of dry season makes the land unequipped for development consistently and the present circumstance renders brutal and cold ecological condition for person, domesticated animals populace and biomass potential and plant species (Dipanwita Dutta *et al.*, 2015) [9]. Dry spell occasions are viewed as made out of span, size (average water deficiency), and seriousness (Cumulative water insufficiency). (Dracup *et al.*, 1980) [10].

Drought index is an effective tool to monitor the current drought conditions. Globally there are several drought indices in the past dependent on precipitation as the single variable, consists of widely used deciles, Standardized Precipitation Index (SPI), and Effective Drought Index). There is additionally another notable index Palmer Drought Severity Index (PDSI), which considers temperature and precipitation. In this research study, the SPI tool has been decided to evaluate the drought condition because of its ease and simplicity, its capacity to address dry spell on different time scales, and on the grounds that it depends on likelihood. Agriculture, temperature, wind, and hydrological drought are the significant components. One of the significant difficulties of agrarian frameworks is the way to decrease the effects of dry seasons during crop growth. Dry spell impacts rural frameworks, financially just as naturally. According to a environment point of view, dry seasons can deny yields and soils of essential precipitation and also to increase the salt substance in soils and water system frameworks.

Droughts can be categorized as meteorological, hydrological, agricultural and socioeconomic drought (Wilhite and Glantz 1985) [11]. Meteorological drought is related to the deficiency of rainfall compared to long-term average amounts on monthly, seasonal or annual time scales (Linsley and Kohler 1958) [12]. Hydrological drought is associated with the effects of periods of precipitation shortfalls on surface or subsurface water supply (Linsley *et al.*, 1975; Dracup *et al.*, 1980) [13, 14]. Agriculture drought occurs when there is insufficient rainfall for the soil moisture during crop growing season (National Commission on Agriculture, India) leading to less production (Rathore 2004) [15]. Socioeconomic drought is connected with the supply and demand of economic goods such as water, forage, food grains, fish and hydroelectric power (Marshall and Zhou 2004) [16].

A minimum of 30- year precipitation data is required to compute the SPI but a data of more than 60-year data is often analyzed (World Meteorological Organization (WMO) (2012) [17]. Standardized Precipitation Index User Guide. Geneva: World Meteorological Organization. Standardized Precipitation Index (SPI) expresses the actual rainfall as standardized departure from rainfall probability distribution function and, hence, this index has gained importance in recent years as a potential drought indicator permitting comparisons across space and time. Computation of SPI requires long term data on precipitation to determine the probability distribution function which is then transformed to normal distribution with mean of zero and standard deviation of one(On the use of Standardized Precipitation Index (SPI) for drought intensity assessment). Thus, the values of SPI are expressed in standard deviations with positive SPI values indicating greater than median precipitation and negative values indicating less than median precipitation (Edwards and McKee, 1997) [18].

Study area

Andhra Pradesh is the eight largest state in India covering an area of 62,970 sq.km. Based on geographical position, according to planning commission. There are 15 agro-climatic regions, in which Andhra Pradesh was partly in Southern plateau and hills region East coast plains and hills region. It is comprises of three regions that is Coastal Andhra, North coastal Andhra and Rayalaseema. Coastal Andhra region comprises six districts (East Godavari, West Godavari, Krishna, Guntur, Prakasam and Nellore), Uttar Andhra comprises of three districts Srikakulam, Vizianagaram and Visakhapatnam and Rayalaseema region having four districts Kurnool, Anantapur, Kadapa and Chittoor (www.ap.gov.in). The normal annual rainfall of the state is 966 mm. Season-wise normal rainfall is 556mm, 296mm, 15.7mm and 98.3 mm in monsoon (June–September), post-monsoon (October–December), winter (January–February) and summer (March–May) seasons, respectively(des.ap.gov.in) [19].

Prakasam district is flanked by Bay of Bengal in the east, Kurnool district in west, north partly by Guntur and mehaboobnagar district and south by partly Nellore and Kadapa districts. This district is situated in tropical regions between 14°57´´ to 16°17´´ northern latitude and 78°4´´3 to 80°25´´ in eastern longitude. The central portion of district contain large tracts of jungle diversified with rocky hills and stone plains which is peculiar feature of district. Soils in this district are red loamy, black cotton and sandy loamy are the predominant soils in the district forming 51%, 41% and 6% respectively over the total area of the district. Climate of the district is moderate in both cropping seasons from June to September and October to December. The agriculture activity in this district is deplorable owing to unreliable rainfall and much depends on tanks and canals for irrigation and irrigation potential of this district is Nagarjuna Sagar project and Krishna western delta are the major irrigation sources in the district. The present research focus on Annual rainfall variability and calculation of drought years in Prakasam district from 1970 -2020.

Methodology

SPI, which is solely based on precipitation data, can distinguish drought-prone areas. SPI reflects precipitation values as a standardised deviation from the rainfall probability function, and as a result, this index has gained attention recently as a potential drought indicator. SPI has the advantage of being simple to calculate and requiring modest form of data. (Agnew 2004) [20].

SPI has the ability to analyse the drought at various time scales and for a variety of applications. (wu *et al.*, 2001) [21] Drought was analyzed for 1, 3, 6 and 12-month time scales by researchers throughout the world (Carlos *et al.*, 2016; Kumar *et al.*, 2016; Malakiya *et al.*, 2016) [22, 23, 24] SPI is calculated at various time scales (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 etc. months) (Homdee *et al.*, 2016) [25]. Amongst all those time scales, 1, 3, 6, 9, 12, 24, and 48 show the most variation in reflecting agricultural and hydrological drought/impacts. (Karavitis *et al.*, 2011; Zargar *et al.*, 2011) [26, 27]. Time scales of one, two, and three months are effective for agriculture, while time scales of six, nine, and twelve months are useful for hydrology. (Bergman 2009) [28].

For any location, SPI index can be calculated based on the longterm precipitation record for a desired length of time. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee, 1997) [16] as the SPI index a value is normalized, wet and dry climates can be shown as same way. positive SPI index value represents greater than median

precipitation negative values represents less than median precipitation.

SPI algorithms analyse the input data to optimally estimate two key coefficients which govern the transformation, and the observed precipitation data are transformed to Gaussian (normal) equivalents. The transformed precipitation data are then used to compute the dimensionless SPI value, defined as the standardized anomaly of the precipitation:

SPI = (P-P*) / σ p.

Where P = precipitation. p* = mean precipitation. σ p = standard deviation of precipitation

McKee and others (1993) used the classification system shown in the SPI value table below (Table 1) to define drought intensities resulting from the SPI. They also defined the criteria for a drought event for any of the timescales. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's "magnitude". In table no.1 shows the SPI values from extremely wet condition to extremely dry conditions to delineate the dry and wet spells.

Table 1: SPI Values based on McKee classification

SPI Values	Condition
2.0+	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

Results and Discussion

Descriptive statistics

A yearly rainfall departure analysis was performed on rainfall data to identify drought years and the magnitude of annual rainfall deficits. If the total quantity of annual rainfall falls below 25% of the normal rainfall value, the year is considered as a drought year. The annual rainfall (fig no.1) and deviation in Prakasam district is shown in fig no.2. Analyse shows that in years 1970, 1971, 1984, 2002, 2014, 2016, 2017 drought occurred Prakasamam district. it is also evident that the region also experienced severe drought in 2018 when the deficit rainfall about greater than -50% in addition to it trend analysis showed that decrease in precipitation over the past 50 years with linear regression Y= -0.1555x+4.0429 R^2=0.00094 (fig no.2)

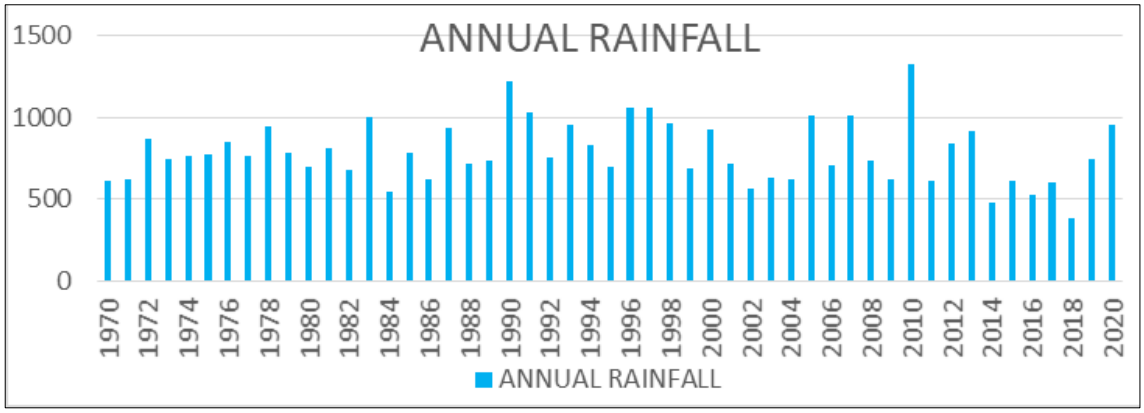

Fig 1: Total annual rainfall from 1970 -2020 of Prakasam district

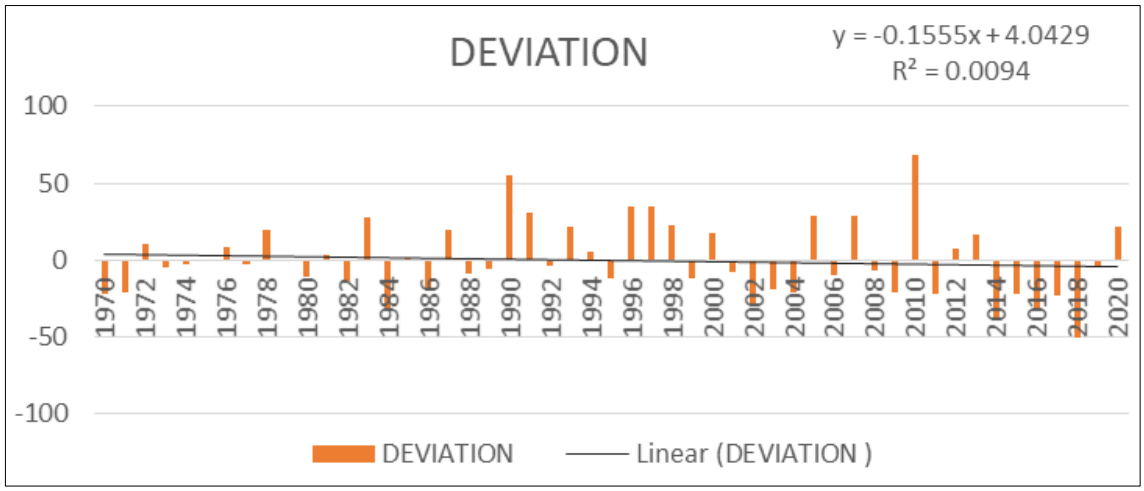

Fig 2: Rainfall deviation from 1970 -2020 of Prakasam district

Drought assessment

The annual SPI for Prakasam district was calculated from 1970 to 2020 to show the frequency of occurrence of dry and wet conditions. SPI-based's drought classification (McKee *et al.*, 1993) was used in this study. The SPI value is a measure of the severity of a wet or dry event. A drought event occurs when the SPI value is -1.0 or less and the event lasts for at least one month when the index becomes positive (Bordi *et al.*

2001). SPI was calculated at 1-month, 3-month, 6-month, 9-month, and 12-month timescales. On smaller scales, such as the SPI-1 and SPI-3 series, drought intensities are highly variable, becoming less than 1.0 and greater than 1.0 on several occasions. SPI-6, SPI-9, and SPI-12 drought intensity, on the other hand, decreases over longer timescales. This variation is due to a seasonal component found in the rainfall data since SPI is relative to the rainfall characteristics of that area.

3, 6, 9, 12 month SPI Analysis

The 3-month (fig no.3) SPI specifies both short- and medium-term moisture conditions and provides an estimate of seasonal precipitation. A 3-month SPI is more useful than many other hydrological indices in emphasising existing moisture levels in major agricultural regions. Figure 5 depicts the 3-month SPI in Prakasam district from 1970 to 2020.the lowest SPI on 3-month timescale below – 2 was which occurred in these years 1971, 1972, 1975,1991,2001,2005 and 2018.

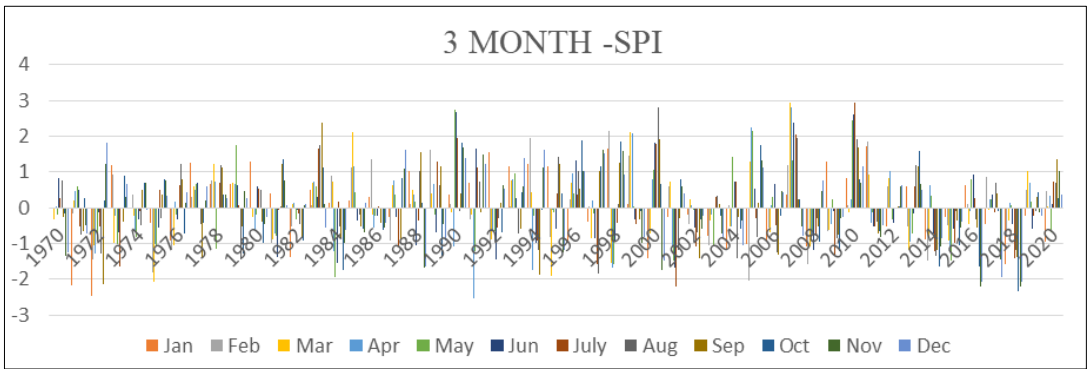

Fig 3: 3 month SPI Values of Prakasam district

The 6-month (fig no.4) SPI specifies seasonal to medium-term precipitation trends and is very potent at depicting precipitation over different seasons. From 1970 to 2020, the Prakasam district has a 6-month SPI. Figure X depicts this. The lowest 6-month SPI on a 6-month timescale below – 2 was which occurred in the year 1972, 2001, 2017 and 2018.

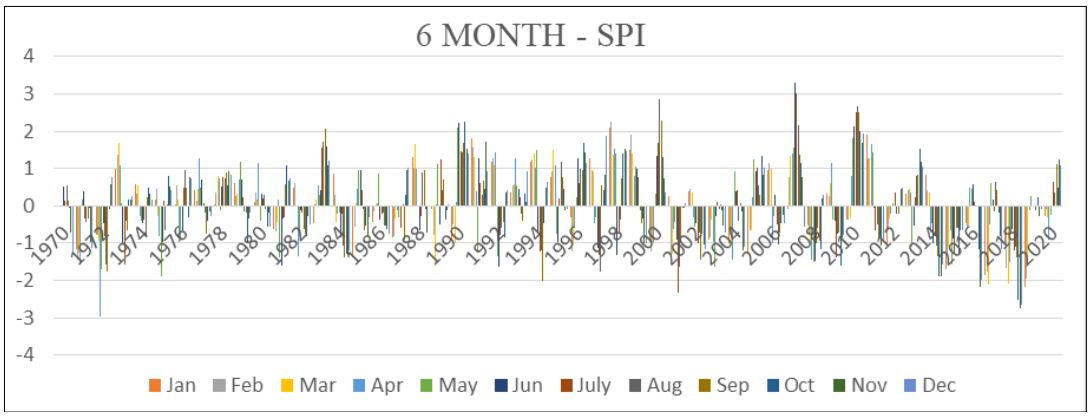

Fig 4: 6 month SPI Values of Prakasam district

The 9-month (fig no.5) SPI gives an insight into inter-seasonal precipitation patterns over a medium time scale. Droughts typically develop over the course of a season or more. An SPI value of -1.5 or less for a 9-month time scale indicates that dryness has a significant impact on agriculture as well as other sectors. Figure represents the 9-month SPI for the Prakasam district from 1970 to 2020. The lowest SPI on a 9-month timescale was below – 2 was which recorded in these years 2017, 2018 and 2019.

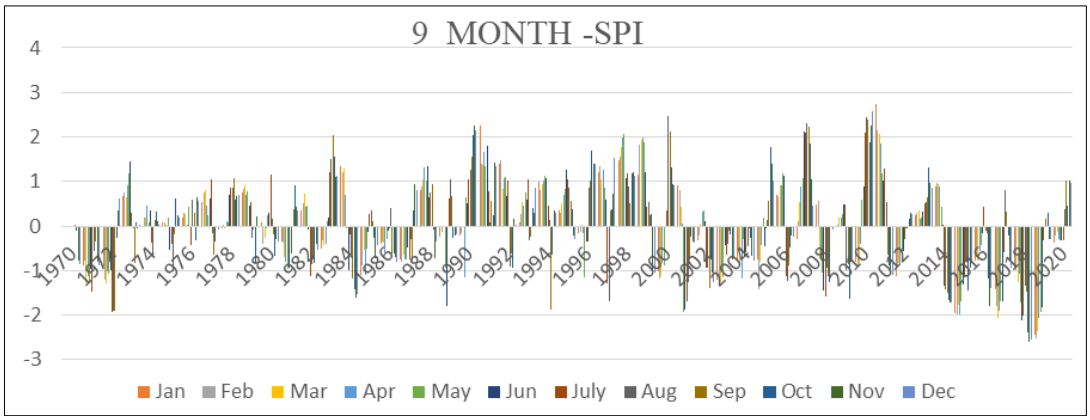

Fig 5: 9 month SPI Values of Prakasam district

At long timescales, 12-month SPI (fig no.6) values are generally linked to stream flows, reservoir levels, and even groundwater levels. Figure depicts the 12-month SPI in Prakasam district from 1970 to 2020. The lowest 12-month SPI on a 12-month timescale was below the value – 2 was recorded in these years 2001,2015,2018,2019

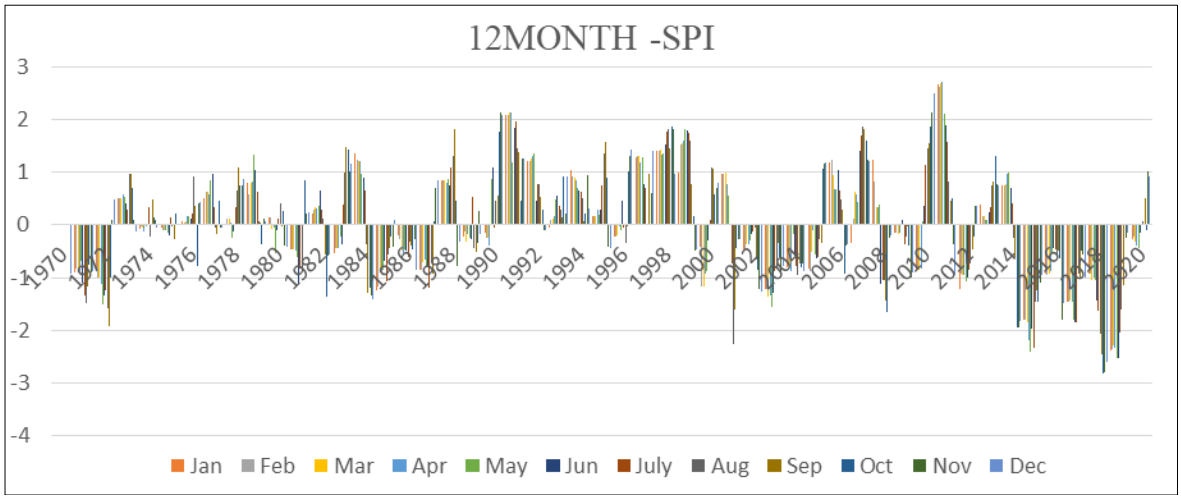

Fig 6: 12 month SPI Values of Prakasam district

In India based on monsoon, cropping season is classified in to two main season kharif and rabi there is need to identify the drought condition in these seasons. The major crops grown in this season are Paddy, Redgram, Cotton, Black gram, Green gram, Chilli. June represents the start of the Agriculture field operations, in prakasam most of the farmers start the sowing of seed during end of July to early august moreover in end of October to fortnight of November second season starts Therefore, keeping in view the crop phenology and crop calendar, rainfall during June, July, August and September play a vital role in crop production.

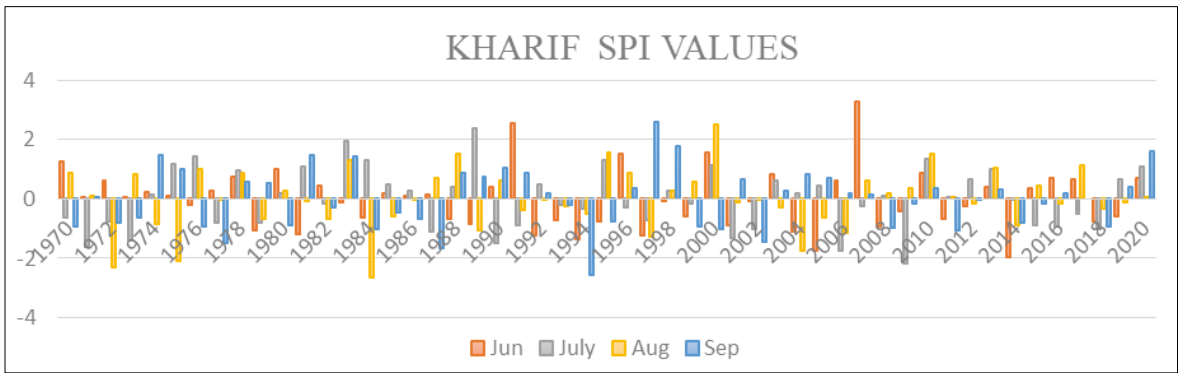

Fig 7: Kharif (Jun – Sep) SPI Values of Prakasam district

Results show for Kharif season (fig no. 7_ show that moderate drought occurred in the years 1973,1977,1979, 1992,1994,1997,2002 and 2011; severe drought occurred in the years 1971, 1987, 2001 and 2006; whereas extreme drought occurred in 1972,1975, 1984,1994and 2009. For Rabi season, (fig no.8) moderate drought occurred in the years 1970, 1979, 1982 and 1992; severe drought occurred in the years 1970, 1989 and 2009; whereas extreme drought occurred in the years 1971, 1988, 2016 and 2018. Thus, the most critical drought year in the area was 2018 with greater than 50% deviation from the normal rainfall.

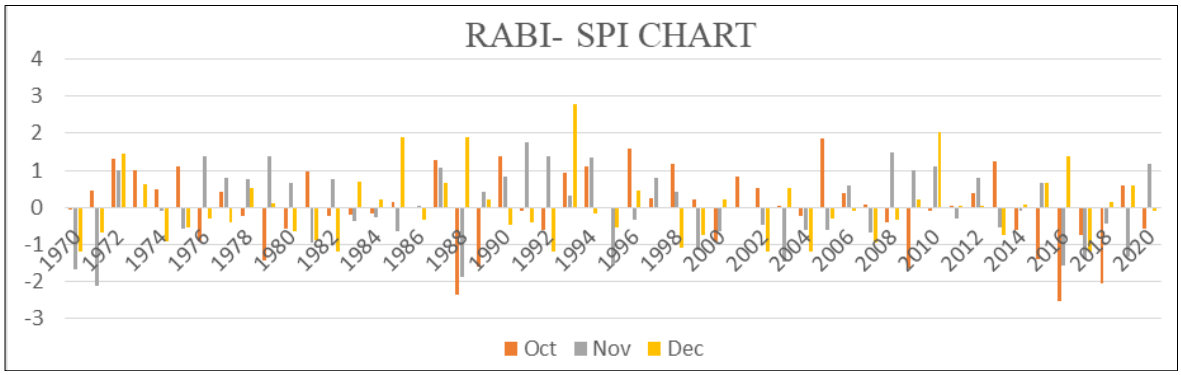

Fig 8: Rabi (Oct – Dec) SPI Values of Prakasam district.

In this study we had taken a yield attributes of major crops growing in prakasam district in comparison with the SPI values from 1995 – 2020. from the fig no.9 it shows the severe drought year 2016 and extreme drought year 2018 observed -2.8 SPI, -1.81 at the same period yields of red gram are 133 kg/hectare and Bengal gram is 833 kg /hectare and chillies 3737kg/ hectare in 2018 was observed and in 2016 yields of Red gram are 442 kg/hectare and Bengal gram is 1490 kg /hectare and chillies 3016 kg/ hectare. But the average yields of redgram is 462.1 kg/ha, Bengal garam 1530 kg/ha and chilli 2820.8 kg/ha respectively. So we can conclude it that dry periods affected the growth and development of plant and yielded comparatively less yields than average year yields which are not prone to drought. And however there may be many factors included in declining the yield.

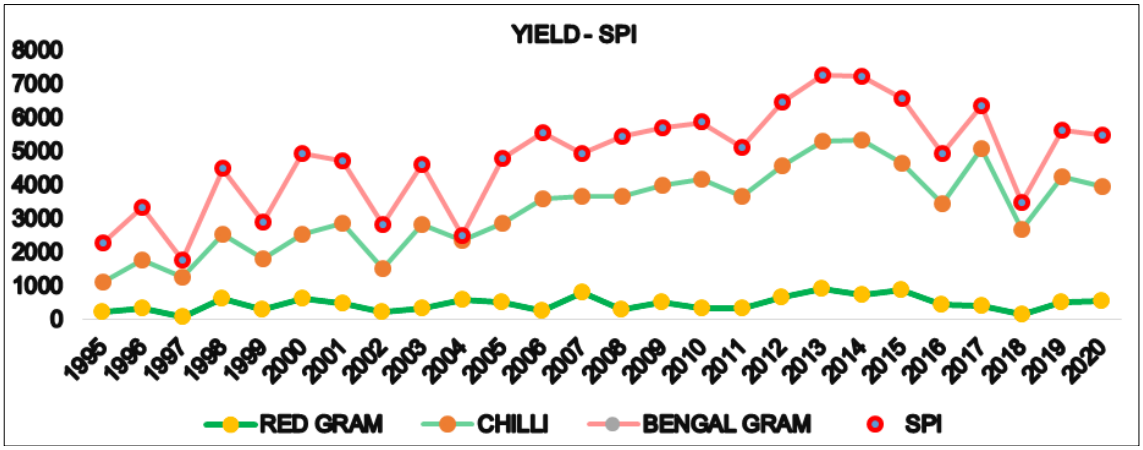

Fig 9: Graph showing yield values of Red gram, Chilli, Bengal gram with SPI values

Conclusion

The purpose of this study was to use the Standardized Precipitation Index criterion to assess droughts observed in the prakasam district. Drought patterns were evaluated, yielding many interesting results on the variability of drought occurrence in the region. For the given rainfall data, a decreasing trend was observed in the area, indicating that the area under consideration is under drought prone. Temporal SPI graphs show that the maximum SPI value (extreme drought) occurred in the year 2018 in that year, the SPI value was -2.61.Furthermore, in severe and extreme drought years, SPI values indicated only moderate dryness rather than extreme dryness, with SPI values never falling below -2.5.Severe and moderate drought occurred in 1984, 2002 and 2014. It was found that SPI is a valuable tool for assessing drought characteristics like frequency and severity. With respect to agriculture the widespread adoption of improved farming techniques, advances in breeding programmes that yield more resilient crops, and biotechnology adoption in local communities will assist farmers in making better use of water on their farms to meet demand and nourish a growing world and moreover drought can be overcome by adopting climate resilient dry farming crops (drought tolerant crops), micro irrigation, capturing and storing water, growing cover crops, conservation tillage practices The study's findings are relevant to climate change studies in order to understand historical patterns and build future scenarios of drought occurrences.

References

1. Hagman G. Prevention Better than Cure: Report on Human and Natural Disasters in the Third World, Stockholm: Swedish Red Cross 1984.
2. Amrit K, Pandey RP, Mishra SK. Characteristics of meteorological droughts in north western India. Nat Hazards 2018;94:561-582 https://doi.org/10.1007/s11069-018-3402-0
3. Mukherjee S, Mishra A, Trenberth KE. Climate Change and Drought: a Perspective on Drought Indices. Curr Clim Change Rep 2018;4:145-163.
4. Dai A. Drought under global warming: a review. Wiley Interdiscip Rev Clim Chang 2011;2:45-65.
5. Seager R, Kushnir Y, Ting M, Cane M, Naik N, Miller J. Would advance knowledge of 1930s SSTs have allowed prediction of the dust bowl drought? J Clim 2008, 2018;21:3261-81.
6. Mishra AK, Singh VP. A review of drought concepts. J Hydrol 2010;391(1-2):202-216.
7. Dikici M. Drought analysis with different indices for the Asi Basin (Turkey). Sci Rep 2020;10:20739.
8. Riebsame WE, Changnon SA Jr, Karl TR. Drought and Natural Resources Management in the United States: Impacts and Implications of the 1987-89 Drought, Boulder, CO: Westview Press 1991.
9. Dipanwita Dutta, Arnab Kundu, Patel NR, Saha SK, Siddiqui AR. Assessment of agricultural drought in Rajasthan (India) using remote sensing derived Vegetation Condition Index (VCI) and Standardized Precipitation Index (SPI),The Egyptian Journal of Remote Sensing and Space Science 2016;18(1):53-63.
10. Dracup JA, Lee KS, Paulson EG. On the definition of droughts. Water Resour. Res 1980;16(2):297-302.
11. Wilhite DA, Glantz MH. Understanding: The drought phenomenon: The role of definations. Water Int 1985;10(3):111-120.
12. Linsley RK, Kohler MA. Hydrology for engineers. (No.627 L5). McGraw-Hill, New York 1958, 627L5.
13. Linsley RK Jr, Kohler MA, Paulhus JL. Hydrology for engineers, 2nd ed. McGraw-Hill, Kogukusha, Tokyo 1975.
14. Dracup JA, Lee KS, Paulson EG. On the definition of droughts. Water Resour. Res 1980;16(2):297-302.
15. Rathore MS. State level analysis of drought polices and impacts in Rajasthan, India. Int Water Manage. Inst 2004, 93.

16. Marshall G, Zhou X. Drought detection in semi-arid regions using remote sensing of vegetation indices and drought indices. Geoscience and Remote Sensing Symposium. IGARSS'04. Proceedings. 2004 IEEE International, Anchorage, Alaska 2004, 903-905.
17. World Meteorological Organization (WMO). Standardized Precipitation Index User Guide. Geneva: World Meteorological Organization (WMO) 2012.
18. Edwards DC, McKee TB. Characteristics of 20th Century Drought in the United States at Multiple Times Scales. Atmospheric Science Paper 1997;634:1-30.
19. Agricultural Statistics at a Glance. Directorate of Economics and Statistics. Ministry of Agriculture and Cooperation. Government of India. New Delhi 2007. https://des.ap.gov.in/
20. Agnew CT. Using the SPI to identify drought. Drought Network News 1994-2001, 2004.
21. Wu H, Hayes MJ, Weiss A, Hu Q. An evaluation of the standardized precipitation index, the China-Z-index and the statistical Z-score, International Journal of Climatology 2001;21:745-758.
22. Carlos BC, Brenda C, Gonzalo P, Hugo J. Drought assessment in Zacatecas, Mexico. Water 2016;(8):416.
23. Kumar A. Characterizing meteorological drought using standardized precipitation index for Dehradun, Uttarakhand. Indian Journal of Soil Conservation 2016;44(2):157-162.
24. Malakiya LA, Suryanarayana T. Assessment of drought using standardized precipitation index (SPI) and reconnaissance drought index (RDI): a case study of Amreli district. International Journal of Science and Research 2016;5(8):1995-2002.
25. Homdee T, Pongput K, Kanae S. A Comparative performance analysis of three standardized climatic drought indices in the Chi River basin, Thailand. Agric. Nat. Res 2016;50(3):211-219.
26. Karavitis CA, Alexandris S, Tsesmelis DE, Athanasopolos G. Appilication of standard precipitation index (SPI) in Greece. Water 2011;3(3):787-805. Doi: 10.3390/w3030787
27. Zargar A, Sadiq R, Naser B, Khan FI. A review of drought indices. Environ. Rev 2011:19(NA):333-349.
28. Bergman CJ. A survey of drought impacts and mitigation planning in Kentucky. Masters Theses & Specialist Projects. Paper 95. A Thesis Presented to The Faculty of the Department of Geography and Geology, Western Kentucky University, Bowling Green, Kentucky. Bordi, I., Frigio, S., Pa 2009.