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Estimation of Drought Period in Karnataka: Its Impacts and Mitigation Strategies

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ABSTRACT: Drought is the most complex but least understood of all natural hazards. It is broadly defined as “severe water shortage”. Low rainfall and fall in agricultural production has mainly caused droughts. A droughts impact constitutes losses of life, human suffering and damage to economy and environment. Droughts have been a recurring feature of the Indian climate therefore study of Historical droughts may help in the delineation of major areas facing drought risk and thereby management plans can be formulated by the government authorities to cope with the disastrous effects of this hazard. In this study, Meteorological drought assessment was carried out using Rainfall data which is taken from India Meteorological department (IMD). Hydrological drought assessment is carried using Reservoir Storage data taken from Central Water Commission (CWC). The Meteorological drought and Hydrological drought risk maps were prepared by integrating the various classes of drought. Finally, the drought risk map shows that about 12 districts such as Bidar, Kolar, Kalaburagi, Bengaluru rural, Tumakuru, Mandya, Mysuru, Belagavi, Uttar Kannada, Dakshina Kannada, Bengaluru urban, Yadgir, were in Normal condition whose range lies between (-19 to +19%). 19 districts such as Chikkaballapura, Udipi, Ramanagara, Chamarajanagara, Hassan, Raichur, Vijayapura, Davanagere, Dharwad, Chitradurga, Chikkamagaluru, Gadag, Shivamogga, Koppala, Kodagu, Haveri, Bagalkot were in deficit condition whose range lies between (-20% to +20%).

KEYWORDS: Drought, Meteorological drought, Hydrological drought, Rainfall Related Index, Reservoir Storage Index

I. INTRODUCTION

Drought is considered by many to be the most complex but least understood of all natural hazards, affecting more people than any other hazard (G.Hagman 1984). However, there remains much confusion within the scientific and policy communities about its characteristics. It is precisely this confusion that explains, to some extent, the lack of progress in drought preparedness in most parts of the world. Drought is a slow-onset, creeping natural hazard that is a normal part of climate for virtually all regions of the world; it results in serious economic, social, and environmental impacts. Drought onset and end are often difficult to determine, as is its severity. The impacts of drought are largely non-structural and spread over a larger geographical area than are damages from other natural hazards. The non-structural characteristic of drought impacts has certainly hindered the development of accurate, reliable, and timely estimates of severity and, ultimately, the formulation of drought preparedness plans by most governments. The impacts of drought, like those of other hazards, can be reduced through mitigation and preparedness.

Droughts have no universal definition. As drought definitions are region specific, reflecting differences in climatic characteristics as well as incorporating different physical, biological and socio-economic variables, it is usually difficult to transfer definitions derived for one region to another. However some of the common definitions of drought can be noted as under:

- The Director of Common Wealth Bureau of Meteorology in 1965 suggested a broad definition of drought as “Severe water shortage”.
- Definition given by Palmer states that “Drought is an interval of time, generally of the order of months of years in duration, during which the actual moisture supply at a given place rather consistently falls short of the climatically expected or climatically appropriate moisture supply (Palmer, 1965)
- According to Mc Mohan and Diaz Arena (1982), “Drought is a period of abnormally dry weather sufficiently for the lack of precipitation to cause a serious hydrological imbalance and carries connotations of a moisture deficiency with respect to man’s usage of water.
- Another definition given by Flag is worth mentioning “Drought is a period of rainfall deficiency, extending over

months or year of such a nature that crops and pasturage for stock are seriously affected, if not completely burnt up and destroyed, water supplies are seriously depleted or dried up and sheep and cattle perish”.

- According to Hangman (1984), “Drought is considered by many to be the most complex but least understood of all natural hazards affecting more people than any other hazard.” (Wilhite, 2000)

Key Variables for Drought Monitoring

1. Meteorological data - Rainfall and other parameter like Temperature, Wind, and Relative Humidity
2. Hydrological data - Stream Flow, Ground Water Levels, Reservoir Storage Level.

II. LITERATURE REVIEW

Abhilash S and Vijaykumar [1] carried a study on Changing Characteristics of drought over Kerala : Inter Annual Variability and Trend. They Realized changes in the climate over Kerala received more attention during recent times under the back to back drought conditions prevailing over the state.the recent historic drought events over the Kerala is Examined and its impacts on different sector like agriculture and water resource are studied using Standardized Precipitation Index (SPI).these research paper found that South West rainfall over the Kerala is Decreasing over the South Kerala during recent decades, whereas the Post Monsoon rainfall is found to be increasing especially over South Kerala.

Athira K [2] carried out the District Level drought Assessment over Tamilnadu.the present study was undertaken to assess the drought in Tamilnadu using Precipitation Index (PI) of historic climate period (1981 - 2018) with high spatial resolution (17Km).these research paper found that Tirunelveli, Tirupurr, Tiruchirapalli districts were prone to drought during South West Monsoon.

Keerthy R [3] carried out a study on Drought Vulnerability in Karnataka : Through Composite Climatic Index. Drought prone areas are usually developed from one or two components/parameters/indicators, like Rainfall Potential Evapo - Transpiration (PET) and Actual Evapo - Transpiration (AET). Standardized Precipitation Index (SPI). Crop Moisture Index (CMI) and Drought Severity Index (DSI) are used for identifying drought prone areas. From these data indicates that in (2001- 2015), three years (2005, 2007, & 2010) have no drought situation in the rest of 12 years 2003 was a Severe drought period & in the year 2001 & 2014 the drought was less Intense.

Subramanyam Gangaraju C [4] carried out a study on Assessment of drought in Andhra Pradesh using Different Meteorological Drought Indices. The monitoring of drought was done for all districts of Andhra Pradesh. In Andhra Pradesh, the districts fall under drought category that is Anapatur, Chittoor, Kadapa, Kurnool, Nellore and Prakasam. Summers in Andhra Pradesh are hot. On the hottest day, temperatures can reach 45 degree, with daytime temperatures averaging 40 degree. SPI was calculated using the following formula and classified scale as proposed by McKee et al. Z - Score index was used classifications for drought, as well as the behavior of SPI, PN, and DI in drought and normal years. The indices were used in this study to identify the occurrence of meteorological drought, its frequency and its spatio temporal extent and SPI indices was made to compare the results with PN, ZI, CZI and ZSI indices. The drought analyzed over 40 years of using SPI, PN and indices and drought years over the past data were presented, according to percent normal index, it was closely related to SPI, the extreme drought was found in the year 2002, 2018 over Anapatur and Chittoor districts. For deciles index, almost all the districts fall under drought conditions in the year 2002, 2009 and 2018. these three indices SPI, PN and DI were more or less identical and results showed with these three indices that drought years are nearly close in monitoring the drought.

III. METHODOLOGY

a. Rainfall Index (RI)

Rainfall is the most important indicator in the determination of drought. Rainfall deviation is calculated by the formula $RE_{dev} = \{(RF_i - RF_n) / RF_n\} * 100$

RF_i = current rainfall for a comparable period RF_n = normal rainfall (at least 30years average) Categories of rainfall deviations (IMD)



Deviation from Normal Rainfall (%)	Category of deficit
+19 to -19	Normal
-20 to -59	Deficient
-60 to -99	Large Deficient
-100	No rain

b. Reservoir Storage Index (RSI)

The availability of water in reservoirs can acts as an effective foil against drought. The reservoir storage status derived from percentage of storage deficit. Reservoir Storage Index can be calculated by the formula

$$RSI = \{MRSi - RSij\} * 100$$

MRSi

Where,

RSI = reservoir storage index for ith month & jth year

MRSi = mean reservoir storage for ith month (10yrs,cubic m)RSij = reservoir storage in ith month and jth year (cubic m)

Category of deficit based on % deficit in live storage vol of reservoir.

% deficit in live storage vol of reservoir w.r.t Average storage of last 10 years	Category of deficit
Less than 20%	Normal deficit
20 - 30%	Mild deficit
30- 40%	Moderate deficit
40 - 60 %	Severe deficit
>60%	Extreme deficit

IV. RESULTS

a. Final Results of Rainfall deviation during 2022 -23

Normal annual rainfall during 2023(mm)	Actual annual rainfall during 2023(mm)	% departure from normal	Category of deficit		
			Total districts	Normal condition	Deficient condition
1153mm	872mm	-24%	31	12	19

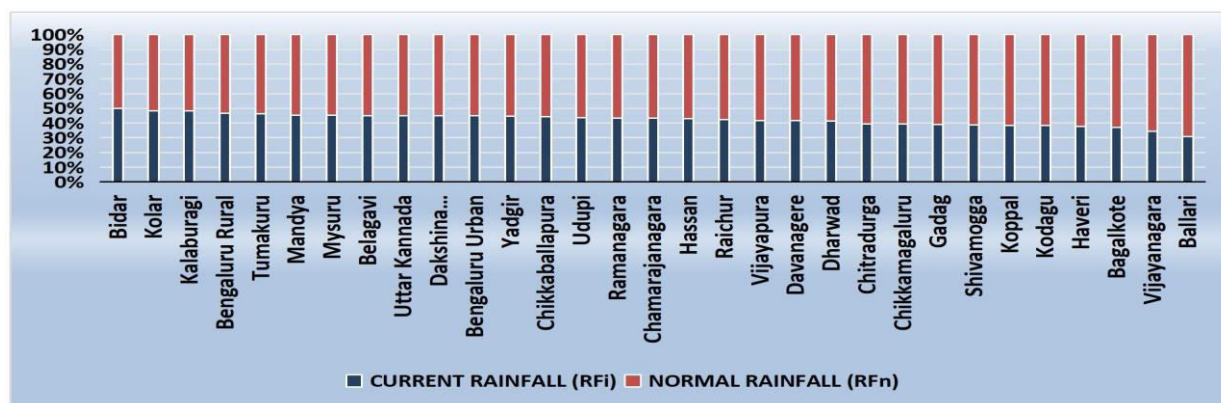


Fig 1. Percentage departure of Annual rainfall from Normal for Karnataka during 2022 -23



b. Final Result of Reservoir Storage Capacity during 2023 -24

In K.R.S reservoir, it is observed that reservoir levels in all recent 5 years is Normal and higher compared to the year 2024. the reservoir storage level of 124.8 feet was reached during 2022, and there is a drop of 86.54 feet in year 2024, up to month of March. and when we analysis Week - Wise reservoirs storage capacity of K.R.S during 2024, it is observed that about 65 -70% deficit in Live storage volume of reservoir with respect to average storage levels, and also less by 13 feet compared to previous year level.

In Kabini reservoir, it is observed that reservoir levels in all recent 5 years is Normal and higher compared to the year 2024. the reservoir storage level of 64.84 feet was reached during 2022, and there is a drop of 46.95 feet in year 2024, up to month of March. and when we analysis Week - Wise reservoirs storage capacity of Kabini during 2024, it is observed that about 20 -30% deficit in Live storage volume of reservoir with respect to average storage levels, and also less by 8 feet compared to previous year level.

In Harangi reservoir, it is observed that reservoir levels in all recent 5 years is Normal and higher compared to the year 2024. the reservoir storage level of 129 feet was reached during 2022, and there is a drop of 97.95 feet in year 2024, up to month of March. and when we analysis Week - Wise reservoirs storage capacity of Harangi during 2024, it is observed that about 15 -20% deficit in Live storage volume of reservoir with respect to average storage levels, and also less by 21 feet compared to previous year level.

In Hemavathy reservoir, it is observed that reservoir levels in all recent 5 years is Normal and higher compared to the year 2024. the reservoir storage level of 117 feet was reached during 2022, and there is a drop of 77.73 feet in year 2024, up to month of March. and when we analysis Week - Wise reservoirs storage capacity of Hemavathy during 2024, it is observed that about 18 -20% deficit in Live storage volume of reservoir with respect to average storage levels, and also less by 11 feet compared to previous year level.

Reservoirs	Category of deficit w.r.t Average Reservoir Storage Level during 2024.
K.R.S	Extreme deficit
Kabini	Mild deficit
Harangi	Mild deficit
Hemavathy	Mild deficit

V. CONCLUSION

1. A deficiency in rainfall causes depletion of Soil moisture, fall in surface and ground water levels which effects economic, environment and social resources.
2. Rainfall indices and Reservoir Storage indices help us in identifying drought prone areas in Karnataka State.
3. Rainfall is the most important indicator in the determination of drought, from rainfall indices we observed that about
 - 12 districts such as Bidar, Kolar, Kalaburagi, Bengaluru rural, Tumakuru, Mandya, Mysuru, Belagavi, Uttar Kannada, Dakshina Kannada, Bengaluru urban, Yadgir were in Normal Condition whose range lies between (-19% to +19 %).
 - 19 districts such as Chikkaballapura, Udupi, Ramanagara, Chamarajanagara, Hassan, Raichur, Vijayapura, Davanagere, Dharwad, Chitradurga, Chikkamagaluru, Gadag, Shivamogga, Koppala, Kodagu, Haveri, Bagalkotte were in Deficit Condition whose range lies between (-20% to -50%).
4. From Reservoir Storage indices it is observed that Cauvery basin reservoirs such as Harangi, Hemavathi, KRS, and Kabini which are used for irrigation purpose are subjected to Severe drought condition.

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