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## Reconnaissance drought index based evaluation of meteorological drought characteristics in Bundelkhand

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### Abstract

Among all the different types of extreme events drought is considered to be the most hazardous in terms economic losses and number of people being affected by its impacts, mainly due to the various complexities involved. Since it is rather difficult to predict and forecast droughts with a reasonable degree of certainty, the drought management aspects are also very complex and needs to be fine-tuned with the spatial and temporal variation of drought characteristics. It is therefore mandatory to evaluate the drought characteristics effectively for development of operative action oriented drought management plans. Generally there are many techniques available for the measurement of drought characteristics; however the drought indices can be effectively used to identify the characteristics of various types of droughts including the meteorological, hydrological and agricultural droughts. The Reconnaissance Drought Index (RDI) have been applied to evaluate the characteristics of the meteorological drought in Bundelkhand region located in central India. RDI has been used by many researchers for identifying the drought characteristics as it is more suited to arid and semi-arid areas. The RDI uses precipitation as well as potential evapotranspiration (PET) and can also be used to analyse the climate change impacts on the drought scenario of a region. The Penman-Monteith method has been used to estimate the PET. The spatio-temporal variation of drought in Bundelkhand has been investigated and it is found that every drought events has its own characteristics in terms of its areal extent, its progression, withdrawal and severity.

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## 1. Introduction

Drought is a complex and least understood phenomenon which generally occurs due to the below normal availability of water for a considerable period which can extend to regions, countries or continents [1]. Even though drought is a recurring phenomenon and affects all geographical areas, but its impacts are more severe in arid and semi-arid regions where there already exists high natural variability in the rainfall pattern. The main characteristics include severity, intensity, areal extent, progression and withdrawal of droughts. The understanding of the temporal and spatial evolution of drought events are important for planning drought response and mitigation [2],[3]. Drought severity, duration and its spatial extent are some of the important characteristics. Meteorological drought severity is generally assessed by the negative deviation of precipitation from its normal.

The development of any efficient drought monitoring system among others is generally based on drought indices and drought triggers which are its essential elements [4]. Drought indices are indicators used to characterize drought to assist decision makers for taking measures for mitigating its effects. Generally the Standardised Precipitation Index is being used worldwide due to its low data requirement and its ability to analyse the various aspects of drought based on varying time-scales. However, in arid and semi-arid regions, high temperature along with deficit precipitation is a key factor responsible for the development and progression of droughts. In this regard, the Reconnaissance Drought Index (RDI) has been used in several arid and semi-arid regions worldwide. This drought index is based both on cumulative precipitation (P) and potential evapotranspiration (PET). It is quite an useful drought indicator owing to its low data requirements and high sensitivity and resilience [5],[6],[7],[8],[9],[10]. Since RDI incorporates precipitation and potential evapotranspiration which are directly affected by climate change, it is considered to be a more suitable index for studying drought severity under climate change.

## 2. Study Area

The Bundelkhand region located in Central India is bounded by Vindhyan Plateau in south, Ken River in east rivers Betwa and Pahuj in west, and Yamuna river in north, and falls in both Uttar Pradesh (U.P.) and Madhya Pradesh (M.P.). The Bundelkhand region comprises of six districts in M.P. viz., Sagar, Damoh, Chhattarpur, Tikamgarh, Panna and Datia and seven districts in U.P. viz., Jhansi, Lalitpur, Jalaun, Hamirpur, Banda, Mahoba and Chitrakoot. The topography comprises of gently-sloping uplands, distinguished by barren hilly terrain. The region lies between 23° 08' N to 26° 30' N latitude and 78° 11' E to 81° 30' E longitude with a total area of 71,619 sq. km. Most of the agriculture is rain-fed and the main occupation of the local population is agriculture [11]. The average annual rainfall varies between 514 mm and 1260 mm and about 90% of it occurs during the south-west monsoon. The rainfall pattern is erratic and uncertain with very high variability. The complete drainage system forms a part of Ganga basin and area generally slopes from south to north. The map showing the study area is given in Fig 1.

## 3. Data availability

The analysis for evaluating the drought characteristics have been carried out for all the 13 districts of Bundelkhand. The data used include, daily rainfall data at each development block of every district, the climatic data including maximum and minimum temperature, wind speed, solar radiation and relative humidity at each of the district headquarters. The daily rainfall and climatic data have been obtained from India Meteorological Department (IMD), Pune; whereas the block level rainfall data have been obtained from Water Resources Department, Govt. of M.P. and from the office of Superintendent of Land Records of the respective districts. The processing and analysis of the data have been performed before initiating the detailed analysis for evaluation of drought characteristics. The daily rainfall values have been aggregated into monthly values and used for the estimation of SPI at various time scales of 3, 6 and 12 months. The climatic data including the rainfall have been used in the estimation of potential evapotranspiration by the Penman-Monteith method. The GIS based analysis has been performed using ILWIS 3.0.

## 4. Methodology

The FAO Penman-Monteith method used to estimate reference evapotranspiration ( $ET_o$ ) is given as:

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