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Drought Assessment under Climate Change by Using NDVI and SPI for Marathwada

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ABSTRACT

Drought is considered to be the most vulnerable natural hazards which affectlarge amount of people. The impacts of drought are nonstructural and spread over a large geographical area damaging the life of human beings.Marathwada the most vulnerable region to frequent droughts located in central Indiawas selected as the study area. The spatial and temporal data of region required for the drought analysis was collected from meteorological stations and satellite data Resourcesat-1 Awifs was procured from NRSC, Hyderabad. GISwas used to analyze the spatial and temporal variation of drought across the study area to determine the droughtaffected area accurately so as to provide effective drought proofing. Meteorological drought analysis was performed by Standardised Precipitation Index (SPI) to determine drought severity classes.Using NDVI analysis, Marathwada region is classified into severe, moderate, mild drought classes. Frequencies of various droughtclasses were determined by using SPI. Drought classification based on SPI indicated that majority of the region suffered from extreme to severe drought conditions for 2 to 3 times during study period. Based on the drought risk area map was prepared for Marathwada region.

Key words: *Meteorological Drought, Standardized Precipitation Index, Agricultural Drought, NDVI, GIS*

INTRODUCTION

Drought is caused by sudden and significant deficiency in precipitation, resulting in acute water scarcity, remarkable shortage of soil moisture and reduced crop yield. While meteorological droughts occur mainly due to deficient precipitation, agricultural droughts develop due to the impact of meteorological and hydrological droughts. Severity, duration and spatial extent of agricultural droughts vary from place to place and time to time depending on various other factors such as late arrival and/or early retreat of the monsoon, duration of dry spell, lack of irrigation water, etc.The natural process of drought occurrence is presented in Fig.1 Marathwada region of Maharashtra is frequently suffering from drought situation due to variation in amount of rainfall and its uneven and ill distribution.

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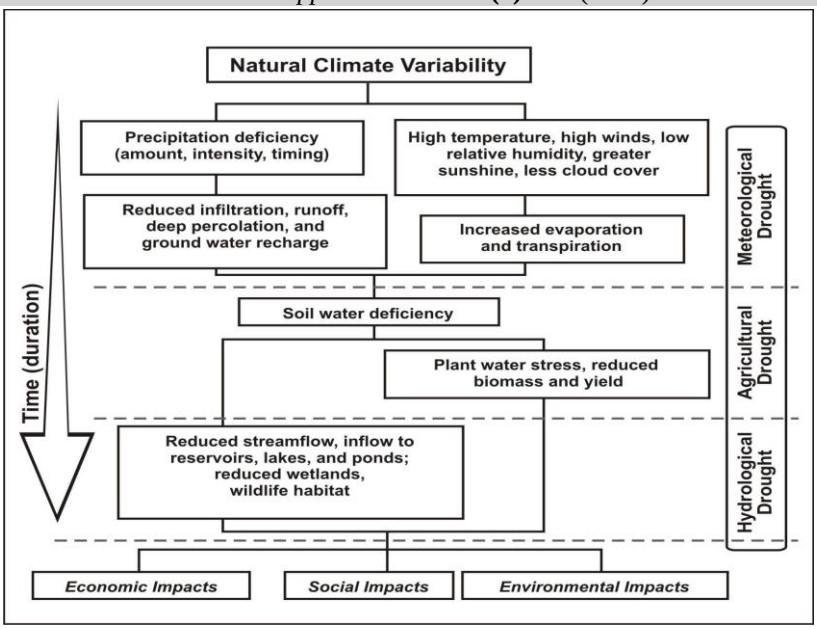

Fig. 1: Natural process of Drought

1. **Research Objectives:**
   - ❖ To investigate meteorological drought based on ground based observations
   - ❖ To estimate agricultural drought based on remote sensing indices
2. **Study area, location and Climate:**
   Marathwada is located in Maharashtra state (Fig.2). Marathwada consisted of eight districts *viz.*, Aurangabad, Jalna, Parbhani, Hingoli, Nanded, Latur, Beed and Osmanabad. The total geographical area is around 64525 km^2.Climate of the region is Semi-arid type. The average annual rainfall ranges between 600-900 mm.

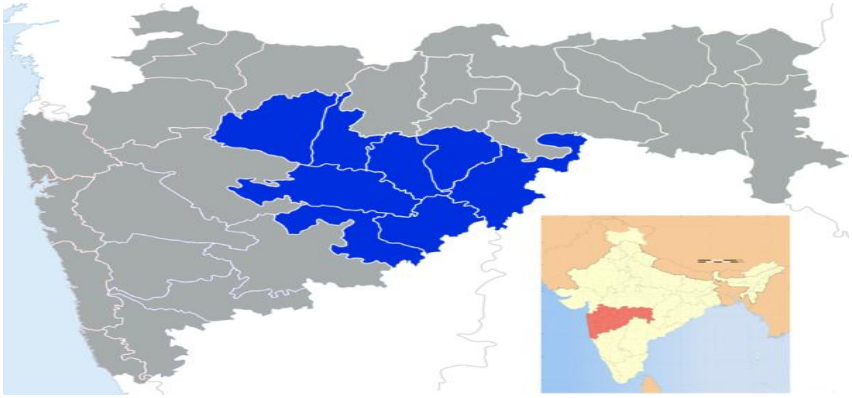

Fig. 2: Location of Study area

DATA AND METHODOLOGY

1. **Data**: The present study considered both ground station data as well as remotely sensedsatellite data.

I. Daily data of precipitation of 36 years (1981–2016) for the meteorological stations across Marathwada were procured from IMD, Pune.

II. Satellite data was procured from NRSC, Hyderabad consisted of Resourcesat-1 (Awifs) data having 56 m spatial resolution from 2011-2016.

2. **Methodology:**
   Meteorological drought originates due to deficiency in precipitation, and since vegetative drought develops from meteorological drought, SPI was

used for investigating meteorological drought.

- **Meteorological drought Index:**
  - ✓ **Standardized Precipitation Index**

The Standardized Precipitation Index (SPI) was developed by McKee *et.al* [2] which is based only on precipitation. The SPI assigns a single numeric value to the precipitation, which can be compared across regions and time scales with markedly different climates. SPI is reported to be the most widely used index to quantify drought using meteorological data among number of indices.

The SPI calculation is based on the following expression:

$$SPI = \frac{(xi - x)}{\rho}$$

where, x is the mean annual rainfall, x_i the annual rainfall at any year and ρ the standard deviation. The SPI values are ranging from -2 to 2 indicating extreme drought to extreme wet condition respectively.

- **Remote Sensing based drought Indices:**

Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is based on the concept that vigor of vegetation is an indication of water availability or lack thereof and is a measure of the "greenness," or vigor of vegetation. It is based on the known radiometric properties of plants, using visible (red) and near-infrared (NIR) radiation. NDVI is defined as:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

where NIR and RED are the reflectance in the near infrared and red bands. NDVI values range from−1 to +1, with values near zero indicating no green vegetation and values near +1 indicating the highest possible density of vegetation.

Vegetation Condition Index (VCI)

VCI is a widely used algorithm for estimating vegetation condition based on NDVI minimum and maximum value. The VCI is expressed in percentage (%) and gives an idea where the observed value is situated between the extreme values (minimum and maximum) in the previous years. The VCI was calculated using following equation:

$$VCI_j = \frac{(NDVIj - NDVImin)}{(NDVImax - NDVImin)} * 100 \quad \ldots (13)$$

where NDVIj, $NDVI_{min}$, $NDVI_{max}$are the NDVI of respective month, minimum and maximum values of NDVI, respectively.

RESULTS AND DISCUSSION

A comprehensive analysis of the spatial and temporal extension of droughts can help to develop drought-monitoring signals based on relevant drought indices. Rainfall is one of the important climatic variables that largely determine the occurrence of drought and also influences the growth and development of vegetation which is reflected in NDVI.Drought classification based on meteorological drought index SPI indicated that majority of the stations suffered from extreme to severe drought conditions for 2 to 3 times within 36 years of study period(Fig.3). The mild drought and wet drought were more frequent among all the locations of Marathwada. Agricultural drought assessment was carried out by using remote sensing based various drought indices such as NDVI and VCI in order to evaluate overall vegetation condition in study area. During March to August of 2015 as well as February to May of 2016 major area of Marathwada including Aurangabad, Jalna, Beed, Latur, Osmanabad, Parbhani, Hingoli and Nanded was covered under moderate to severe drought. Monthly average values of VCI during the period 2011 to 2016 indicated that on an average in the month of early June to mid-July there was poor vegetation condition in Marathwada region(Fig.4).

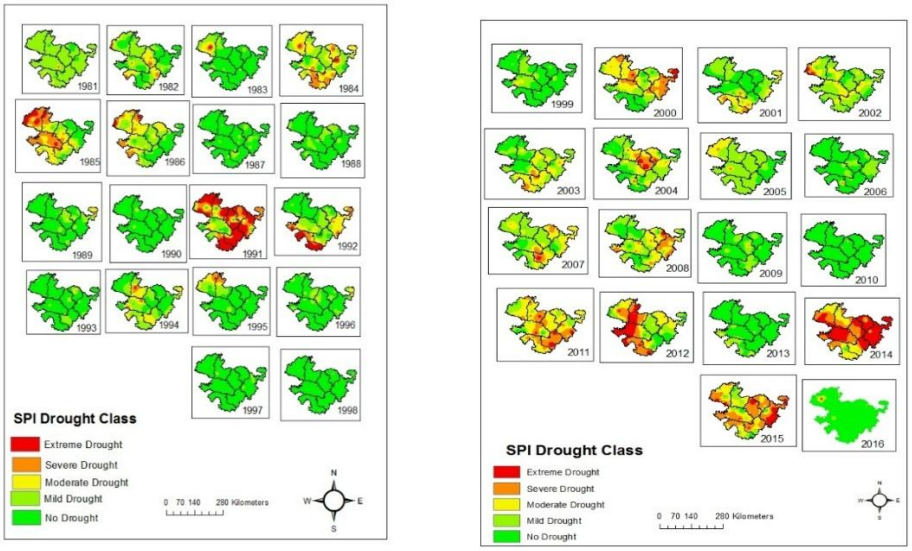

Fig. 3: Drought classification based on SPI during 1981-2016

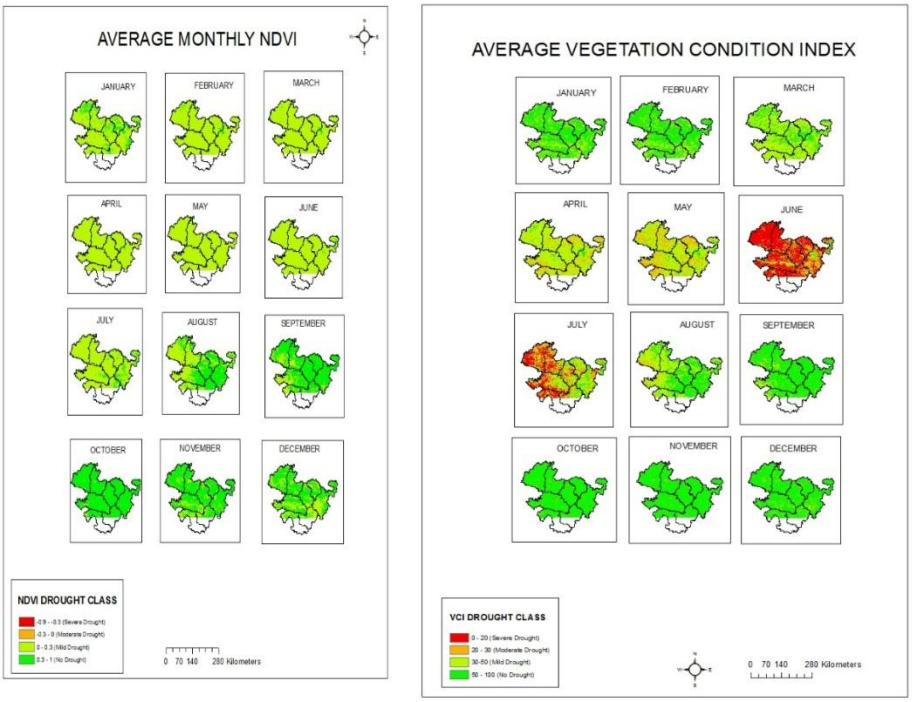

Fig. 4: Drought classification based on average monthly NDVI and VCI during 2011-2016

CONCLUSIONS

1. Drought classification based on SPI indicated that majority of the stations suffered from extreme to severe drought conditions in 2 to 3 times during study period. The mild drought and wet drought were observed more frequently among all the locations of Marathwada.. SPI was found to be more suitable because it gave better understanding of drought conditions as well as wet condition for different timescales.
2. The spatiotemporal analysis of NDVI shows overall vegetation condition of Marathwada which can be used for crop planning in the region. Remote sensing based drought indices such as NDVI and VCI can be used for classification of agricultural drought in the area since they give better synoptic view for

understanding drought affected area in the study region.

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