Drought Monitoring and Assessment for Karur District in Tamil Nadu Using Remote Sensing and GIS Techniques

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Abstract:
Drought is a natural hazard due to adverse climatic changes which affects various sectors like environment, society and economy. It occurs not only because of the scarcity of rainfall but also due to the inefficient water resource management. Studies indicate that over 30\% of the entire land surface of earth is affected by drought. As a developing country, majority of Indian population depends directly or indirectly on agriculture. So the abnormal monsoon precipitation, causing loss of agricultural production, can highly influence the human life. In this paper, Karur district in Tamil Nadu which often has a very low annual rainfall is taken as the study area for drought monitoring. The technological evolution in remote sensing over the past few decades has opened a new era in the field of drought monitoring. Thus, use of remote sensing and GIS helps in developing early warnings about drought conditions which will be useful for planning the strategies for relief work. Drought analysis can be performed by calculating different drought indices like Standard Precipitation Index (SPI), Standardized Water Level Index (SWI) and Normalized Differences Vegetation Index (NDVI). Rainfall data from 2000-2009 is used to compute the Standardized Precipitation Index (SPI) in different time scales which is used in meteorological drought monitoring. Standardized Water Level Index (SWI) obtained from ground water level data is used for the hydrological drought analysis. Agricultural drought can be qualified using Normalized Differences Vegetation Index (NDVI) which is calculated from the satellite data.

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Introduction

Drought is a natural phenomenon which causes adverse social consequences like shortage of water, economic losses, etc. Frequent drought can damage the ecosystems and can lead to diseases and deaths of living beings due to the scarcity of fresh water. Unlike other natural hazards, drought does not have a proper definition. It is a creeping phenomenon (ref), hence it is difficult to determine when it get started and when it has ended. The first sector to be affected by drought is agriculture, since drought initially appears as a deficiency of water content in the soil. Drought occurring at different regions will be different due to the specific climatic characteristics of each region. Some of the factors affecting drought are wind characteristics, temporal distribution of rainfall, relative humidity, soil moisture and temperature.

Droughts are mainly classified into meteorological drought, hydrological drought and agricultural drought. Meteorological drought occurs due to the dominating dry weather condition of an area. Degree of dryness or precipitation deficiency threshold can be used to define meteorological drought. A long term meteorological drought can result in hydrological drought. It occurs due to the depletion of surface or subsurface water from rivers, lakes, reservoirs, streams and ground water level. It is not directly related to precipitation deficit. Inadequate soil moisture and rainfall which has adverse effects on various crop productions can cause Agricultural drought. . The soil with less water holding capacity will be more prone to this type of drought. Like hydrological drought, agricultural drought is not directly related to precipitation.

Drought indices

Many drought indices are used by meteorologists around the world. Analysis of drought can be performed by calculating different drought indices like Standard Precipitation Index (SPI), Standardized Water Level Index (SWI) and Normalized Differences Vegetation Index (NDVI).

(i) Standard Precipitation Index (SPI)

Standard Precipitation Index (SPI) developed by American scientists McKee, Doesken and Kleist in 1993 is a simple and statistically relevant index which gives an understanding of impacts of precipitation deficiency on reservoirs, ground water, soil moisture etc. It is a flexible and powerful probability index which is used to quantify the precipitation deficit. It is calculated for different time scale with precipitation as the only input parameter. SPI is given as the ratio of difference between the normalised seasonal precipitation and its long-term seasonal mean to the standard deviation.

\[ SPI = \frac{X_j - X_{im}}{\sigma} \]  

Where \( X_j \) the seasonal precipitation at the rain is gauge station and \( j \) th observation \( X_{im} \) the long-term seasonal mean and \( \sigma \) is its standard deviation.

(ii) Standard Water Level Index (SWI)

The standardized water level index is used for hydrological drought analysis. It was proposed to monitor the variation in ground water levels. Since the measurement of groundwater level is down from the surface, the positive value indicates drought and negative values indicate ‘no-drought’ or normal condition. The SWI is calculated by normalizing seasonal groundwater levels and by dividing with the standard deviation, the difference between the seasonal water level and its long-term seasonal mean.

\[ SWI = \frac{W_j - W_{im}}{\sigma} \]

Where \( W_j \) is the seasonal water level for the \( i \) th well and \( j \) th observation, \( W_{im} \) its seasonal mean, and \( \sigma \) is its standard deviation.

(iii) Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) is a numerical indicator that can be used in remote sensing to analyze whether the observed target contains vegetation or not. It uses visible and near-infrared bands of the electromagnetic spectrum. The NDVI is calculated as follows.
\[ NDVI = \frac{NIR - VIS}{NIR + VIS} \]

where NIR and VIS represents the spectral reflectance measurements acquired in the near-infrared regions and visible(red) regions, respectively. The result of this calculation always gives a number that ranges from -1 to +1. Value close to +1 indicates highest density of vegetation and close to zero means no vegetation. The NDVI values can be used to identify the growing conditions for the vegetation in a particular region for a given time of the year. Health of vegetation is characterized by NDVI, i.e healthy vegetation reflects large portion of NIR and absorbs most of the VIS light that falls on it whereas unhealthy vegetation reflects less NIR and more VIS light. Comparison of NDVI data obtained over different periods of time reveals the productivity of a region whether the productivity of the area is typical, or the plant growth is significantly more or less productive. The reduced plant growth can be due to the lack of precipitation which is labelled as ‘in drought’. The other reasons for lower NDVI than normal value can be cold temperatures and clouds.

**Study Area**

The area chosen for study is Karur district of Tamil Nadu, India. The region is centrally located district in Tamil Nadu which covers approximately 2,895.57sq.km accounting for 2.2 per cent of the geographical area of the state. Karur district, with its administrative headquarters at Karur town is about 371km south west of Chennai, the capital of Tamil Nadu. The district has 2 Revenue Divisions, 6 Taluks, 2 Municipalities, 11 Town Panchayats and 157 Village Panchayats and 203 Revenue Villages. The study area is bounded in the north by Namakkal district, in the South by Dindigul district, in the east by Tiruchirappalli district and in the west by Erode district.

Karur district lies between 11° 00’-12° 00’ North latitude and 77° 28’-77° 50’ East longitudes. The major rivers flowing through the area is Cauvery river and Amarvathi river. They are normally found to be dry during summer season. The temperature obtained in early May to early June is about 37 °C and in January the average temperature is around 24 °C. Karur has an average annual rainfall of about 615mm. The region gets its seasonal rainfall mostly from the north-east monsoon winds, during late September to mid November.
Fig 2: (a) Drainage Pattern of Karur district, (b) Transportation in Karur District, (c) Landuse Land cover of Karur District
Methodology

This section describes the methodology used in this work. IRS P6 Awifs satellite image and IRS 1D LISS III images of the year 2000 and 2009 were used for the analysis of drought in Karur district. NDVI was calculated for each of the two images. Fig:3 shows the Schematic representation of the methodology. The satellite images of Karur district of the year 2000 and 2009 is shown in Fig 4.

![Schematic representation of the methodology]

Fig 3: – Schematic representation of the methodology
Results and Discussions

The study also performed comparison of NDVI Images of IRS 1D LISS III and IRS P6 AWiFs data. The measurement of the amount of vegetation of the study area was performed by analysing these NDVI images. NDVI values were classified into five classes Very Low, Low, Moderate, High, and Very High. Fig: 5 and Fig: 6 shows the NDVI image of 2000 and 2009. The mean annual rainfall in the study area from 2000-2009 is analyzed as shown in the Fig:7.
Fig 6: NDVI of Karur District in 2009

Fig 7: Rainfall data from 2000-2009
Conclusion

Drought is one among the most devastating and creeping natural hazard which occurs due to the shortage of rainfall causing severe damage to vegetation, human life, wild life and local economies. GIS and remote sensing techniques play a major role in drought analysis. The study computed Normalized Difference Vegetation Index (NDVI) of the Karur district during the year 2000 and 2009. The results show that there is a decrease in NDVI values during the year 2009, which correlates to the reduced rainfall quantity of the year. Thus Normalized Difference Vegetation Index (NDVI) can be used as the major indicator to evaluate drought. The analysis showed that drought has been more frequent in the year 2009 and also it lasted longer than the year 2000. Mean annual rainfall data map and land use/land cover map was also generated for the study area which helped in the analysis. Assessment of hydrological drought and meteorological drought can be done by calculating Standardized Precipitation Index (SPI) and Standard Water Level Index (SWI).

References