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Agricultural Vulnerability Assessment using GIS: A Case Study of Pallar Basin of Chittoor District, Andhra Pradesh

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***Abstract:*— Drought is one of the short-term extreme events. There is no operational practice to forecast the drought. Drought indices play a significant role in drought mitigation. In the present study, Pallar basin which is present in Chittoor District of Andhra Pradesh, which are seriously prone to drought, has been established using meteorological and remote sensing based agricultural droughts indices. The meteorological droughts indices was Standard Precipitation index (SPI)and the satellite data based agricultural drought indices was Normalized Difference Vegetation Index (NDVI), Normalized Difference water Index (NDWI). The meteorological and remote sensing based agriculture drought indices has been determined and compared for the period of 2000, 2005 and 2010. The result shows from SPI Index the year 2005 is wet year and the year 2000 and 2010 are dry year. From NDVI index the year 2005 is having more vegetation area and the year 2010 is having less vegetation area. Hence, agricultural drought risk mapping can be used to guide decision making processes in drought monitoring, and to reduce the risk of drought on agricultural productivity.**

***Keywords:*-- Agricultural vulnerability, NDWI, NDVI, SPI, Mitigation.**

I. INTRODUCTION

Agriculture plays a crucial role in the life of economy, it is the backbone of our economic system. Agriculture not only provides food and raw materials but also employment opportunities to a very large proportion of population. InIndia, the main occupation of our working population is agriculture. About 70 per cent of our population is directly engaged in agriculture. Thus, agriculture is a source of livelihood. Agriculture is the premier source of our nation's income. According to National Income Committee and C.S.O., in 2001-02, it contributed around 32.4 per cent of national income. The main factor for agricultural vulnerability is drought. Drought always starts with the lack of precipitation, but may (or may not, depending on how long and severe it is) affect soil moisture, streams, groundwater, ecosystems and human beings. This leads to the identification of different types of drought (meteorological, agricultural, hydrological, socio-economic, ecological), which reflect the perspectives of different sectors on water shortages. Drought affects virtually all climatic regions and more than one half of the earth is susceptible to drought each year. Drought causes changes inthe external appearance of vegetation, which can clearly be identified (by their changed spectral response) using satellite sensors through the use of vegetation indices. NDVI is a powerful indicator to monitor the vegetation cover of wide areas, and to detect the frequent occurrence and persistence of droughts (1). It provides a measure of the amount and vigor of vegetation at the land surface. These indices are functions of rate of growth of the plants and are sensitive to the changes of moisture stressin vegetation (2). Wilhelmi, V.O (3) in his study of the assessment of vulnerability to agricultural drought in Nebraskahypothesized that the biophysical and social factors, that define agricultural drought vulnerability were climate, soil, land use and access to irrigation. The result of the study indicates that the most vulnerable areas to agricultural drought were non irrigated cropland and rangeland on sandy soil with a very high probability of seasonal crop deficiency. The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation. In general, higher values of NDVI indicate greater vigor and amounts of vegetation. Tucker first suggested NDVI in 1979 as an index ofvegetation health and density and it has been considered as the most important index for mapping of agricultural drought (4). In the year 2011, KaushalyaRamachandran had assessed the agricultural vulnerability to climate change using NDVI data products and the results were discussed spatio-temporally at district level for the country. Likewise, Sumanta Das (5) had assessed the severity of drought using long term mean values of maximum NDVI in Bankura District, West Bengal

In this paper, a conceptual approach for assessing agricultural vulnerability using geomatic technology is adopted and is presented by selecting Pallar basin of Chittoor District, Andhra Pradesh as the study area. The main objective of the present study is to make an attempt to understand the spatial aspects of agricultural vulnerability using remote sensing and GIS techniques. Agricultural vulnerability is determined based on Standardized Precipitation Index (SPI), Normalized Difference Vegetation Index (NDVI), and Normalized Difference Water Index (NDWI). Thus a contribution is made directly to enhance the efforts for the sustainability of agricultural sector. In order to understand the variation in weather and its impact on agriculture, a study of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) was undertaken using Landsat ETM+. Time series Landsat datasets were downloaded from their respective websites and is used for assessing agricultural vulnerablity in the study area. Standardized Precipitation Index (SPI) instead of actual rainfall data was used to corroborate extreme weather events with the resultant of NDVI and NDWI variations.

II. STUDY AREA:

The major part of study area is covered by Chandragirimandals, Pulicherla – hinnagottigallumandals on NorthWest,Pakala- Puthalapattu on South West, Ramachandrapuram on South East and Tirupati (Urban & Rural) on North East in Chittoor district of Andhra Pradesh. It is located 13°26’ to 13° 45’ N and 79° 6’ to 79° 22’ E and covering an area of 545.79 Sq.Km it is shown in **Figure 1**. It is included in the Survey of India Topographical sheets of 57 o/1 , 57 o/2and 57o/3 on a scale of 1:50,000. The average monthly temperature varies between maximum 33.7º C and minimum is 23.4º C. The Monsoon period is June to December and June to September (SW monsoon) , October to December (NE monsoon). The region is semi-arid

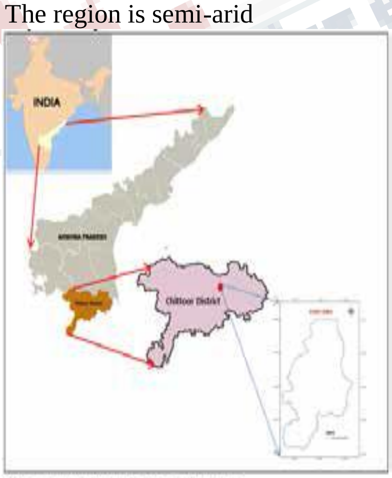

Fig 1: Location of the study area

3. DATASET: The dataset used in the present study and their basic characteristic relevant to the aim of the study isbriefly described as follows:

***3.1. RAINFALL DATA*:** Monthly rainfall datasets were acquired from the IMD Department pune for the period of 2000-2010. The Indian Meteorological Department (IMD) and statically department setup a rainfall monitoring station for the district.Thus, there are three meteorological stations (Chandragiri, puthalapattur and pulicharla) within the study area and are selected for the present study

***3.2. SATELLITE DATA*:** The satellite data has been downloaded from united states of geological society. LANDSAT ETM+ data for the year 2000 December, 2005 December and 2010 December of path/row 142/51 with spatial resolution of 30 m.

The methods used in the present study to assess the agricultural vulnerability of Pallar basin isgivenbelow.

4. METHODS:

4.1. *STANDARDIZED PRECIPITATION INDEX (SPI)*: The SPI formulated by Tom Mckee, Nolan Doesken andJohn Kleist of the Colorado Climate Center in 1993 was used in the present study for the estimation of SPI value for the three meteorological stations viz. chandragiri, puthalapattu, and Pulicharla. The purpose of calculating SPI is to assign a single numeric value to precipitation, which can be compared across regions with markedly different climates. Technically, SPI is the number of standard deviations that the observed value would deviate from the long-term mean, for a normally distributed random variable. Mathematically, SPI is based on the cumulative probability of a given rainfall event occurring at a station (6).

In order to analyse the impact of rainfall deficiency and the development of drought in this study area, SPI has been used to quantify the precipitation deficit in the three different periods i.e. 1990, 2000 and 2011. The SPI is calculated using the following equation,

$$\mathbf{SPI = (Xij - Xim) / \sigma}$$

Where, Xij is the monthly precipitation at the i^{th} rain-gauge station and j^{th} observation, Xim is its long-term precipitation mean and σ is its standard deviation. SPI has been computed separately for each of the 3 rain-gauge stations falling within the study area. The SPI values and classification with respective drought indices is sho**Table 1**: **SPI values and its indication on drought.**

SPI values	Class
>2	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	extremely dry

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The SPI index has been calculated for the study area and the values are shown in **Table 2.**Which shows that the year 2000 is near normal , year 2005 shows extremely wet and year 2010 showsNear normal drought.

Table 2: SPI values of the study area

2000	7196.2	-0.10062
2001	7727.7	
2002	5549.4	
2003	6954.8	
2004	7207.9	
2005	10793.7	2.22508
2006	5466.6	
2007	8717.8	
2008	7264.0	
2009	5383.6	
2010	8608.6	0.81246

4.2. NORMALISED DIFFERENCE VEGETATION INDEX (NDVI): The Normalised Difference VegetationIndex (NDVI) gives a measure of the vegetative cover and is sensitive to the chlorophyll content of plants. Dense vegetation shows high value in the NDVI imagery, and the areas with little or no vegetation shows negative value and is also clearly identified. The water surface is also delineated from NDVI images. Vegetationdiffers from other land surfaces because it tends to absorb strongly the red wavelengths of sunlight and reflect in the near-infrared wavelengths.

The NDVI images are generated using the imageries of LANDSAT ETM+ acquired in 2000 December , 2005 December and 2010 December. The LANDSAT ETM+ measures the intensity of the reflection from the Earth's surface in both these wavelength ranges. The Normalised Difference Vegetation Index (NDVI) is a measure of the difference in reflectance between these wavelength ranges. NDVI takes values between -1 and 1, with values 0.5 indicating dense vegetation and values lessThe NDVI is given by the following equation: than 0 indicating no vegetation.

NDVI= (NIR-RED/NIR+RED)

Where RED and NIR correspond to band 3 and 4 respectively. By normalising the difference in this way, the values can be scaled between values of -1 to +1. This also reduces the influence of atmospheric absorption. Water has an NDVI value less than 0, bare soils between 0 and 0.1 and vegetation above 0.1. The NDVI values are calculated for three years namely 200, 2005 and 2010 and represented in the figure IIa, IIb and IIc respectively. The result of NDVI shows the areas is less vulnerable in southern part and high vulnerable in north eastern part. The areal extent under negative values of NDVI increases from 2000 to 2010. The year 2000 and 2010 is having normal drought and the year 2005 is having healthy Vegetation.

vegetation.

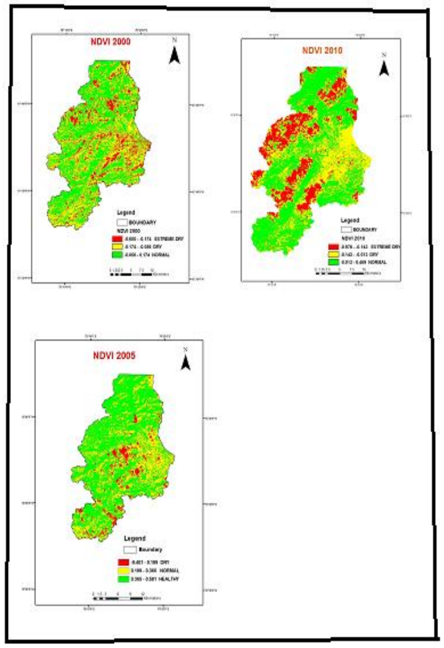

Fig 2: Map showing the NDVI Index for the year 2000,2005 and 2010

4.3. NORMALISED DIFFERENCE WATER INDEX (NDWI): The Normalised Difference Water Index is a veryimportant factor in estimation of water contents which is needed for soil moisture estimation using microwave methods (7). The NDWI images are also generated using the LANDSAT ETM+ in 2000,2005 and 2010 satellite images. The LANDSAT ETM+ Shortwave Infrared (SWIR) i.e. band5 is sensitive to moisture available in soil surface and crop canopy. In the beginning of the season, soil of 1-2 cm is a dominant factor determining the spectral reflectance and hence SWIR is sensitive to soil moisture. When the crop is grown-up, SWIR response is from the canopy. NDWI using SWIR can complement NDVI for drought assessment particularly in the beginning of the season. NDWI is derived using the formula,

NDWI = (NIR-SWIR) / (NIR+SWIR)

where NIR and SWIR are the reflected radiations in near infrared and shortwave infrared spectral bands respectively. Higher values of NDWI signify more surface wetness. NDWI is calculated for 2000, 2005 and 2010 and is given in figures 3 a, 3 b , 3 c respectively.

The result of NDWI shows less vulnerable areas in north east part of the study area. From NDWI index it is observed that the year 2000 and 2010 is a year of dry to normal drought and year 2005 shows that years of healthy vegetation

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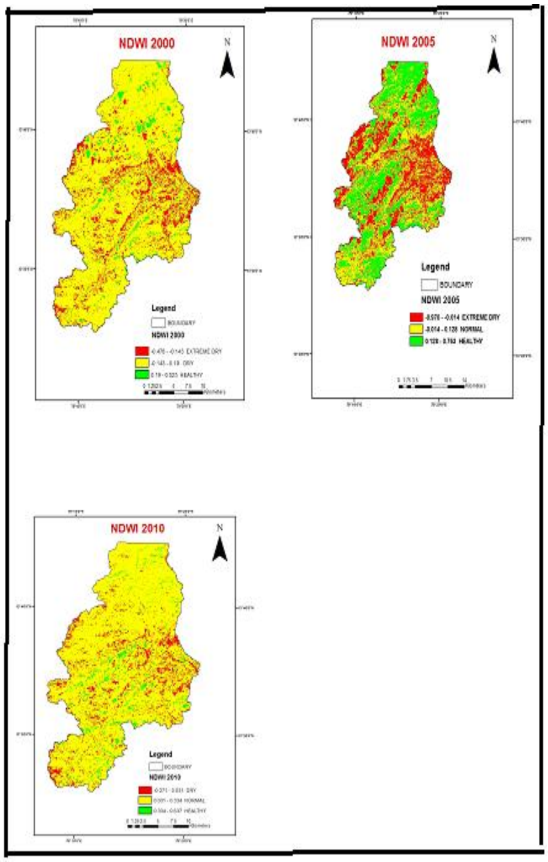

Figure 3. Map Showing NDWI for year 2000,2005 and 2010

5. ***RESULTS AND DISCUSSION***: The result of the present study of agricultural vulnerability in pallar basin is discussed below. The SPI, NDVI and NDWI value (2000, 2005 and 2010) as in figures shows dry area in the north eastern part. The low values of SPI, NDVI and NDWI are seen in the southern parts of the study area. This depicts that the North eastern part of the study area is dry and is agriculturally vulnerable.

In the year 2000, the values of SPI, NDVI and NDWI index has been calculated and it is shown that the three index shows the classification of dry to normal drought. The NDVI and NDWI index is high in north east part of the study area. The villages in this region suffers from drought.

In the year 2005, the value of SPI, NDVI and NDWI index has been calculated and it is shown that the three index shows the classification of Healthy vegetation to normal vegetation. The NDVI shows a wetcondition but it shows in north east part of the study area as dry and NDWI index is high in north east part of the study area it shows extremely dry in that region.

In the year 2010, the value of SPI, NDVI and NDWI index has been calculated and it is shown that the three index shows the classification of Normal to dry drought. The NDVI shows a extremely dry in north west part of the region and NDWI index is normal to dry in the study area. The region shows extremely dry .

Finally from the study of agricultural vulnerability, based on SPI,NDVI and NDWI shows that the year 2000 and year 2010 falls under dry area. From NDVI and NDWI it is observed that the north east part of the study area prone to more dry conditions when compare to other regions. The year 2005 falls under wet condition as per SPI and NDVI, but from NDWI the region north east of the study area shows dry.

6. ***CONCLUSION:*** From the above study it can be concluded that SPI, NDVI and NDWI are very useful for earlydetection of agricultural vulnerability and hence should be a better methodology for remote sensing based vulnerability assessment studies. The NDWI also showed a very good and consistent relation with current rainfall at regional scale. Rather NDVI showed a lagged relationship with rainfall. From the study it is shown that the year 2000 and 2010 comes under normal to dry year. The year 2005 shows the wet year as per SPI and NDVI but from NDWI The region north east part of the study area shows dry .

REFERENCES:

1. Krishna P.V., 1999, Vegetation Discrimination Using IRS-P3 WiFS Temporal Data Set–A Case Study from RampaForests, Eastern Ghats, A.P., Journal of Indian Society of Remote Sensing 27(3), pp. 149–153.

2. Mokhtari, M.H., 2005, Agricultural drought Impact assessment using Remote Sensing: A case study Borkhar district Iran, M.Sc. thesis, International Institute for Geo-Information Science and Earth Observation Enschede, The Netherlands.

3. Wilhelmi, V.O. and Wilhite, D.A., 2002, Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study, Natural Hazards, Vol. 25: pp. 37-58

4. Sumanta D., Malini R. C. &Sachikanta N., 2013, Geospatial Assessment of Agricultural Drought (A Case Study OfBankura District, West Bengal), International Journal of Agricultural Science and Research (IJASR), Vol. 3 No. 2, pp. 1-27.

5. Kaushaly R., 2011, Assessing agricultural vulnerability to climate change using NDVI data products, Geospatial Technologies For natural resource management, CRIDA, Hyderabad, pp. 345-362.

6. Tucker C.J., 1979, Red and photographic infrared linear combinations for monitoring vegetation, Remote Sensing Environment 8,pp 127–150.

7. McKee, T.B., Doesken, N.J. and Kleist, J., 1993, The relationship of drought frequency and duration to time scales. In:

8. Proceedings of the 8th Conference on Applied

Climatology, American Meteorological Society, Boston, pp. 179.184

9. Michael, J. H., Mark, D., Svoboda, D. A., 2000, Monitoring Drought Using the Standardized Precipitation Index, Natural Hazards and Disasters Series, Routledge Publishers, London, pp. 168–180.

10. Chakraborty, A. and Sehgal, V.K., 2010, Assessment of Agricultural Drought Using MODIS Derived Normalized Difference

11. Water Index, Journal of Agricultural Physics Division of Agricultural Physics, Indian Agricultural Research Institute, NewDelhi - 110 012, Vol. 10, pp. 28-36.

12. Riebsame, W. E., Changnon, S. A. Jr., and Karl, T. A., 1991, Drought and Natural Resources Management in the United States. Impacts and Implications of the 1987–1989 Drought, A Journal of Natura