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DIGITAL IMAGE PROCESSING AN APPRAISAL OF CAPRICIOUS MONSOON CONDITION OVER SEMI ARID ZONE OF WESTERN INDIA: A REMOTE SENSING PERSPECTIVE

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ABSTRACT

It is observed that, large global changes have generally occurred as the result of natural forces and are beyond human influence or control. However, now mankind has also become powerful agent of environmental change (IPCC, 1995). The fourth assessment report of Intergovernmental Protocol on Climate Change (IPCC) projected that drought frequency may increase in many regions, especially in the regions where reduction in precipitation is projected (Kundzewicz et al., 2008). While the projections at global level clearly indicate the possible increase in the frequency of droughts and floods as a result of climate change (Burke et al., 2006, Alcamo et al., 2007) The drought frequency may increase in many regions, especially in the regions where reduction in precipitation is projected (Kundzewicz et al., 2008).

INTRODUCTION

The incorporation of remote sensing tools with Geoinformatics (GIS) an offer a powerful means of take out land features in satellite images for further decision making. The study region be processed and interpret to take out data about land-features demarcation (Forest-Vegetation cover, water bodies, agricultural and inhabited areas) in the study area. This study aims a lot of areas of application, i.e. Sustainable Watershed Management and Planning, Ecological organization and planning, Vegetation and other natural resource assessment, management and planning etc.

Remote sensing data, with that derivative from satellite images, are used for Land Cover analysis of area according to its significance in farming, forestry, manufacturing, recreational, and inhabited areas. NDVI (Normalized Difference Vegetation Index) and land use/land cover change of Man River basin within the year 1992 to 2009 is observed in the present study. The change was based on satellite imagery of the study region of Post Monsoon Season (November, December and January) by Lansat Thematic Mapper. This study primarily concern with the NDVI and Land use / Land cover change from the time periods 1992 and 2009. The NDVI map has been prepared by using QGIS 3.6.3. Visual Image Interpretation technique has been adopted for identifying the features of Land use/Land cover. The present study is the outcome of an initial attempt to assess drought vulnerability using long term rainfall and NDVI datasets separately and to understand the interrelations between the two. Rainfall based analysis leading to meteorological drought vulnerability and NDVI based analysis leading to agricultural drought vulnerability together constitute the drought vulnerability. The scope of the current paper mainly includes drought vulnerability assessment based on NDVI and rainfall and then comparing the NDVI response to rainfall in study region

STUDY AREA

The study area having noticeable portion of Semi-arid zone. The Geographical location of Man river basin from 16°50'30" North to 17°31'42'North latitudes and 74°22'30'' East to 75°30'30'' East longitudes. It is a part of South Maharashtra, lies in the district of Satara, Sangli and Solapur tahsils of

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Maharashtra State. The height of study area is 917m.From mean sea level. The Study region covers the total area of 4753 sq km.

The basin is located in the rain shadow zone of Western Ghats and receives a very low amount of average annual rainfall. Most of the villages in the basin are facing severe drought condition. Man is the main river in the region in the propinquity of Mahaadev Donghar ranges near Phaltaan in Satara district and run towards the west of Daahiwadi. In the end it turns towards Saangola and enters the Manghalweda area of Solapur district. The physiographic separation of the region includes knolls and Ghats on the western side and small plateaus and plains along the track of Man River. Geologically the study area is characterized by basaltic layer.

IMPORTANCE AND SCOPE OF THE STUDY

This study focuses on Sustainable Water, Forest, Soil, Agriculture and other natural resource management and planning etc. NDVI is interrelated with numerous ecosystem attributes that are of interest to researchers and managers. Also, because it is a ratio of two bands, NDVI helps compensate for differences both in illumination within an image due to slope and aspect, and differences between images due things like time of day or season when the images were acquired. Thus, vegetation indices like NDVI make it possible to compare images over time to look for ecologically significant changes. Because of its ease of use and relationship with many ecosystem parameters, NDVI has seen widespread use in almost all ecosystems. The uses include assessing or monitoring vegetation dynamics or plant phonological changes over time, biomass production, grazing impacts or attributes related to grazing management (e.g., stocking rates),changes in rangeland condition, vegetation or land cover classification, soil moisture etc.

Figure No: 01 Study Area location Map

RESEARCH PROBLEM

The study area is roughly semi-arid type of the climate considered by low rainfall with high rate of evaporation as well as uneven distribution of rainfall over a time and particularly vulnerable to droughts. Therefore, understanding of the spatial and temporal aspects of precipitation, surface-water and groundwater in such climatically-sensitive and water-scarce regions is one of the basic requirements for the optimization of agricultural practices, water resource management and drought hazard mitigation.

During non-monsoon season as well as during below normal monsoon years, availability of water in streams, aquifers and reservoirs declines remarkably and poses serious threat to agricultural productivity, livelihoods, and the rural economy. This zone is the epicenter of severe agrarian distress. For a long time, the livelihood of the residing population in this zone has heavily depended on dry land agriculture and animal husbandry. During the last 1-2 decades, the water-scarcity is increasing in these areas due to increasing human and cattle population, increasing pressure on land, excessive grazing by cattle, high intensification of arable lands, unsustainable consumption of groundwater, erratic climate and weather conditions, and climate change (Purandare, 2012; Kale et al., 2014).

OBJECTIVES

1. To understand the change in the pattern of NDVI during the variable Monsoon conditions.
2. To examine the change in the pattern of Standardized Precipitation Index over the study area.
3. To examine the relationship between NDVI and Standardized Precipitation Index over the study area.
4. To determine spatial characteristics of drought (drought return period) using SPI and NDVI.

METHODOLOGY

NDVI is a satellite product that dealings the vitality and greenness of vegetation on the earth's surface. It is calculated as the ratio of visible spectral wave bands to near-infrared spectral wave bands. Healthy, green vegetation has a high presence of chlorophyll pigment, which causes low reflectance in visible wave bands and high reflectance in near-infrared wave bands. The reverse is true in vegetation under stress. NDVI is a unit less index, with values ranging from −1 to 1. Healthy vegetation has the highest positive values, while bare soil, water, snow, ice, or clouds have NDVI values of zero or that are slightly negative. Vegetation under stress or with a small leaf area has lower positive NDVI values. Typically the NDVI values from healthy vegetation will increase as plant cover increases at the beginning of the growing season, reach a peak sometime during the middle of the growing season, and will then decrease as the season comes to its end (Mkhabela et al. 2005).

Normalized Difference Vegetation Index (NDVI) is calculated as a ratio between the red (R) and near infrared (NIR) values in traditional fashion. (NIR -R) / (NIR + R) In Landsat 5 & 7, NDVI = (Band 4 –Band 3) / (Band 4 + Band 3).

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

Upon the classification of NDVI image in various ranges based on the NDVI value following significant information can be extracted from imagery.

1. Barren rocks, sand, or snow show very low NDVI values (-0.1 to 0.1)
2. Shrubs and grasslands or senescing crops – 0.2 to 0.5
3. Dense vegetation or tropical rainforest – 0.6 to 0.9
4. Deep water- -1

The **Standardized Precipitation Index (SPI)** is a widely used index to characterize meteorological drought on a range of timescales. The SPI (McKee and others, 1993, 1995) is a powerful, flexible index that is simple to calculate. In fact, precipitation is the only required input parameter. In addition, it is just as effective in analyzing wet periods/cycles as it is in analyzing dry periods/cycles. The Standardized Precipitation Index (SPI; McKee 1993) is the number of standard deviations that observed cumulative precipitation deviates from the climatological average it can be calculated for any time scale.

Table 1. SPI values

2.0+	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 and less	extremely dry

Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation. Drought, according to the SPI, starts when the SPI value is equal or below -1.0 and ends when the value becomes positive. Ref.Guttmann, N. B., 1999: Accepting the Standardized Precipitation Index: A calculation algorithm. *J. Amer. Water Resource. Assoc..*, **35(2)**, 311-322.

The occurrence of drought is mainly a climatic phenomenon which cannot be eliminated. However, its effects can be reduced if actual Spatio-temporal information related to crop status is available to the decision makers. The present study attempts to assess the efficiency of remote sensing and GIS techniques for monitoring the Spatio-temporal extent of agricultural drought. In the present study, Rainfall and NDVI data were used for monitoring agricultural drought through NDVI based Vegetation Condition Index.

METHODOLOGY CHART

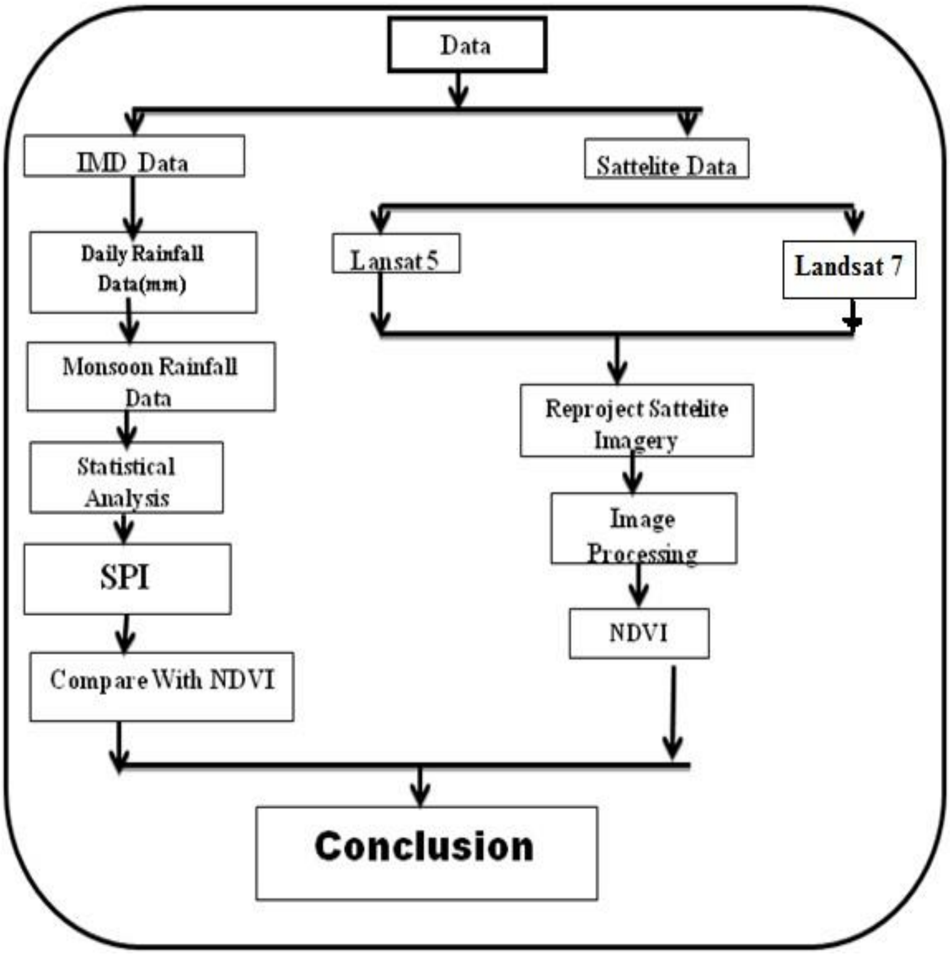


Figure No: 02 Methodology Chart

DATA SETS

The Secondary Data has been collected from the following sources

1. USGS Earth Explorer (Satellite Images)

2. *INDIA METEOROLOGICAL DEPARTMENT (Daily Rainfall Data) from 1992-2010*

Table No.: 2 SATELLITE DATA

Sr. No	Data used	Resolution (Meter)	Data source
1	Landsat-5 TM,	30	USGS Earth Explorer
	Path 146, Row 048		
	1992		
2	Landsat-5 TM,	30	USGS Earth Explorer
	Path 146, Row 048		
	1993		
3	Landsat-5 TM	30	USGS Earth Explorer
	WRS-2,		
	Path 146, Row 048		
	1994		

4	Landsat-5 TM, Path 146, Row 048 1995	30	USGS Earth Explorer
5	Landsat-5 TM, Path 146, Row 048 1996	30	USGS Earth Explorer
6	Landsat-5 TM, Path 146, Row 048 1999	30	USGS Earth Explorer
7	Landsat-5 TM, Path 146, Row 048 2000	30	USGS Earth Explorer
8	Landsat-5 TM, Path 146, Row 048 2002	30	USGS Earth Explorer
9	Landsat-5 TM, Path 146, Row 048 2003	30	USGS Earth Explorer
10	Landsat-5 TM, Path 146, Row 048 2009	30	USGS Earth Explorer

RESULTS

The present study is concern with the analysis of correlation between the SPI values and NDVI over the study region. The following result shows the positive correlation between these two elements for the selected time span.

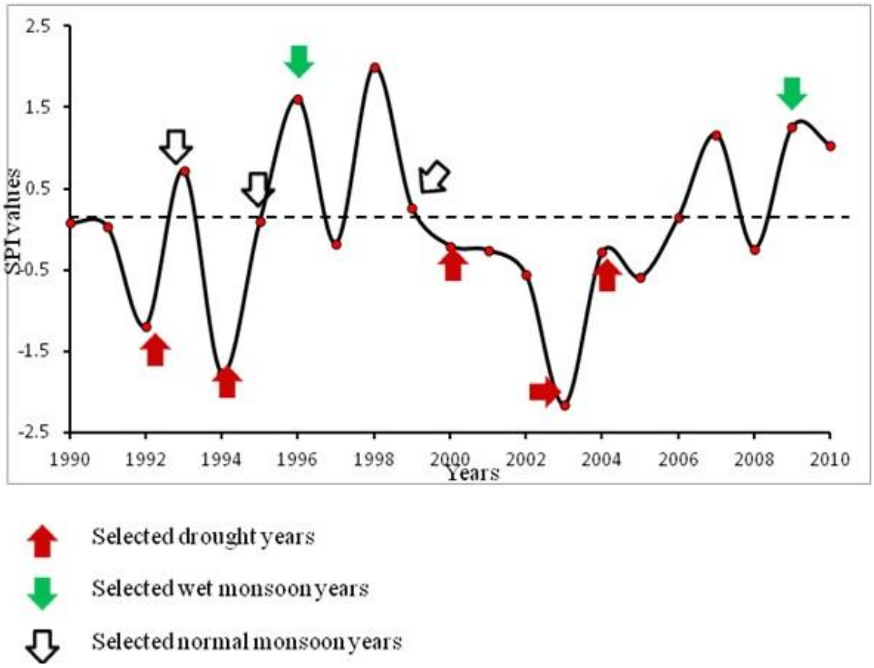
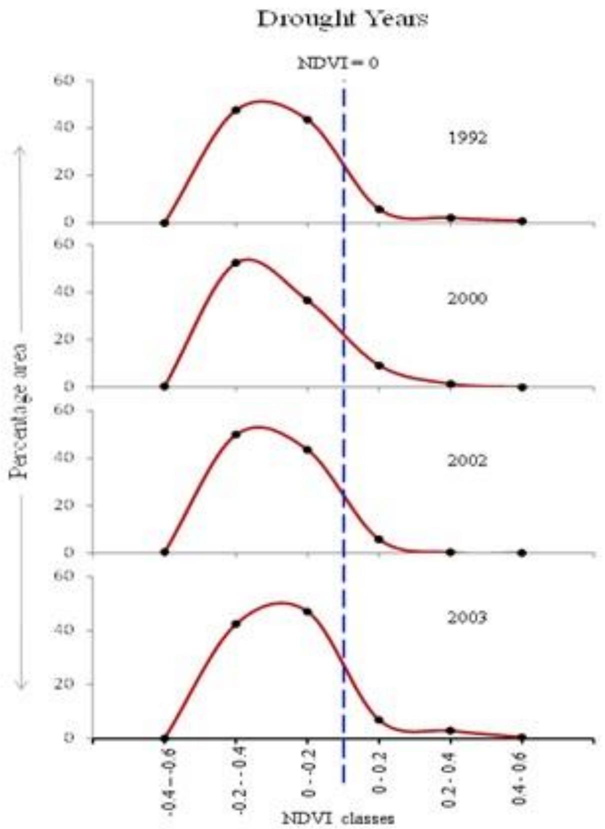


Figure No: 03 SPI during Year 1990 to 2010

The figure no. 03 shows the relationship of the SPI values to the positive relationship with the selected wet monsoon and normal monsoon years. While negative relationship with the selected drought years. Further it shows in the year 1993, 1995 and 1999 for the normal monsoon years the SPI values are around '0' compare to year 1992,1994,2000,2003 and 2004 for selected drought years having negative SPI values vice versa in the years 1996 and 2009 having positive SPI values means the period having high rainfall than all selected years. The figure no.04 shows the correlation between Drought years and NDVI. Higher frequencies of the negative values suggest the poor vegetation condition in the year 1992, 2000, 2002and 2003 mainly meteorological drought was occurs in the above said years.

The figure no.05 shows the correlation between Normal Monsoon years and NDVI. Higher frequencies around '0' values suggest the poor vegetation condition in the year 1993, 1994, and 1995 mainly normal monsoon condition prevails over the above said years.



Higher ferequency of negative NDVI values suggest poor vegetation contitions in :
1992,
2000,
2002,
2003

Figure No: 04 Drought Years and NDVI Correlation

The figure no.06 shows the correlation between Wet Monsoon years and NDVI. Higher frequencies of the positive values suggest the poor vegetation condition in the year 1996, 1999, and 2009 mainly very high rainfall condition prevails over the above said years. The occurrence of drought is mainly a climatic phenomenon which cannot be eliminated. However, its effects can be reduced if actual Spatio-temporal information related to the climatic condition is available. The NDVI pattern of the study area during the Drought years 1992 and 2003, during the normal monsoon years 1994 and 1995 and also it shows the NDVI pattern of the year 1996 and 2009 for the wet monsoon period. In the first case of the NDVI pattern it depicts as a barren rocs portion having very low NDVI values. During the normal monsoon years 1994 and 1995 vegetation cover having green shrubs with average agricultural crops and grassland in dry summer. In the year 1996 and 2009 for the wet monsoon period NDVI pattern having dense vegetation cover with good agricultural crops.

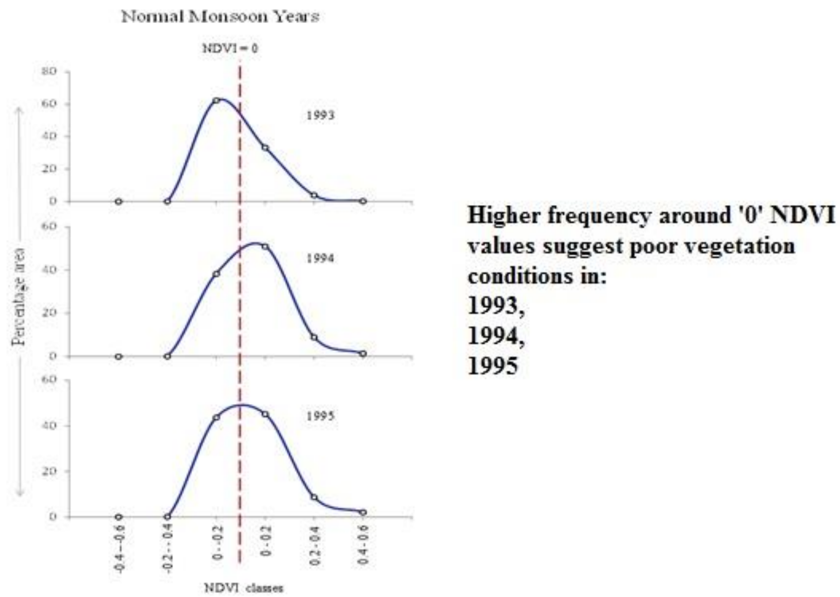


Figure No: 05 Normal Monsoon Years and NDVI Correlation

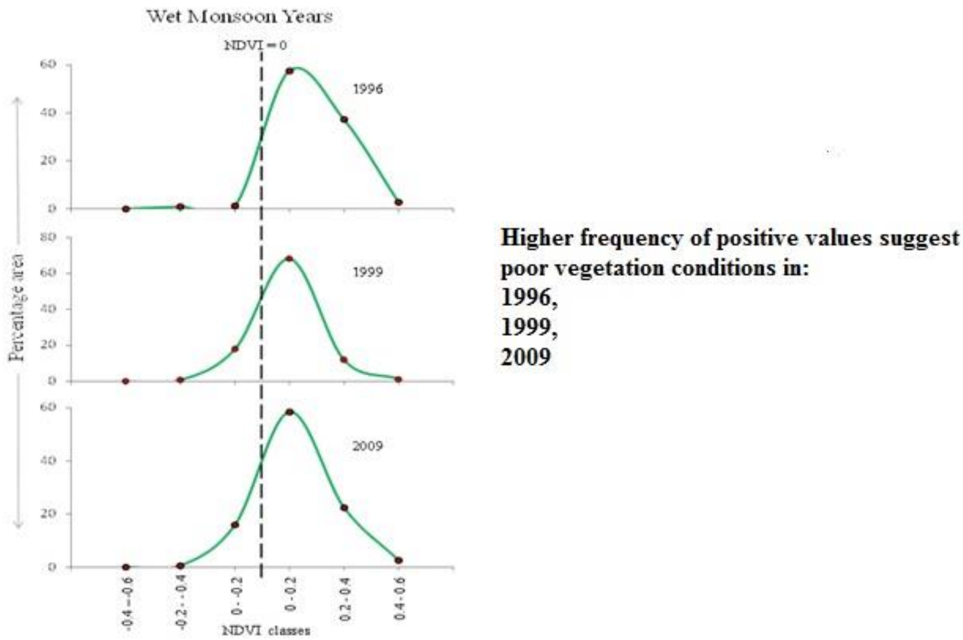
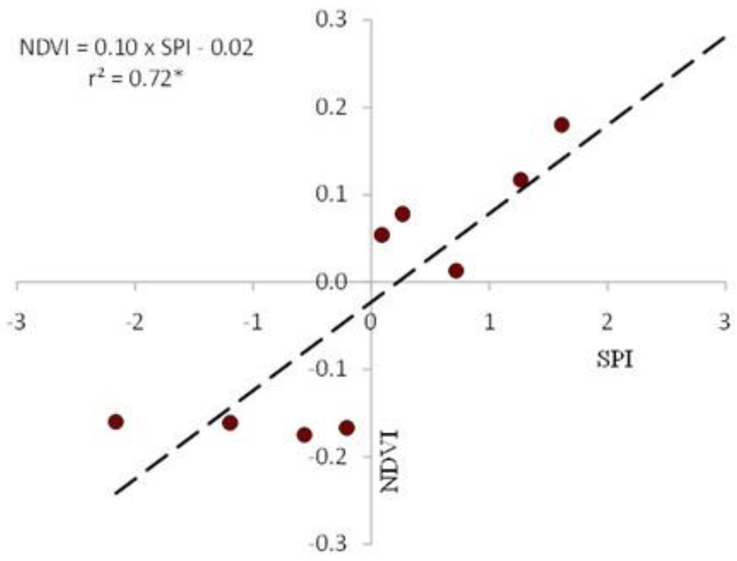


Figure No: 06 Wet Monsoon Years and NDVI Correlation



Statistically significant relationship between SPI and NDVI suggest dependency of vegetation cover(including agriculture area) on the monsoon rainfall

Figure No: 07 Significance of NDVI and SPI

Above graph (Figure No: 08 Significance of NDVI and SPI) shows the statistical significance between the SPI and NDVI we found that there is a positive significance between vegetation cover and monsoon rainfall.

DISCUSSION

The variations in the SPI are well reflected in the NDVI over the Man River Basin. The monsoon precipitation over the Man River Basin is the chief determinant of the vegetation cover (including agricultural crops). The meteorological droughts can be verified by the NDVI over the study area. The NDVI for study periods provides a good measure of the monsoon condition. Water deficiency status can easily detect in the basins by analyzing NDVI spatial patterns and SPI.

The study area is roughly semi-arid type of the climate considered by low rainfall with high rate of evaporation as well as uneven distribution of rainfall over a time and particularly vulnerable to droughts. Therefore, understanding of the spatial and temporal aspects of precipitation, surface-water and groundwater in such climatically-sensitive and water-scarce regions is one of the basic requirements for the optimization of agricultural practices, water resource management and drought hazard mitigation in the study area.

During non-monsoon season as well as during below normal monsoon years, availability of water in streams, aquifers and reservoirs declines remarkably and poses serious threat to agricultural productivity, livelihoods, and the rural economy. This zone is the epicenter of severe agrarian distress. For a long time, the livelihood of the residing population in this zone has heavily depended on dry land agriculture and animal husbandry.

CONCLUSION

The Man river basins of western India have always faced the problem of deficient and uncertain rainfall. It is observed that the increasing water scarcity in this region in recent decades unexpectedly. This study was undertaken to establish whether the scarcity is due to decline in the monsoon rainfall. Although the most extreme and widespread hydro meteorological droughts occurred in this area in last two decades, the hydrological and statistical analyses do not provide any support to the view that the increasing water scarcity in the region is due to a significant shift in the monsoon regime or decline in the assured or dependable rainfall that's why there is a need to study the NDVI pattern over a Study region. The Agricultural distress could be minimized only by adopting sustainable management of water resources and hydro climate-specific optimization of agricultural practices.

An attempt is made in this study to analyze the NDVI into two broad classes of 'More Vulnerable' and 'Less Vulnerable' to Agricultural drought. Pixel wise NDVI derivatives such as integrated NDVI, inter-annual variability of NDVI and probability of occurring low NDVI, have the potential to characterize the agricultural drought vulnerability. Analysis of SPI derived from long term SPI characterizes the meteorological drought vulnerability in terms of drought frequency and drought persistence. Integration of rainfall with NDVI has resulted in grouping of the study area on the basis of response patterns. Thus, the study as an initial attempt to assess the agricultural drought vulnerability has resulted in sensible patterns of vulnerability which are in general in agreement with ground situation, indicating scope for more detailed analysis.

An integrated approach encompassing rainfall, cropping pattern, irrigation support and geospatial NDVI could lead to a robust approach for assessing agricultural drought vulnerability. Such an attempt will be of immense use to revisit the existing drought prone districts/blocks. Rationalization of criteria for drought vulnerability based on integrated and geospatial approach would strengthen the existing drought management mechanisms.

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