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A Geospatial Approach for Assessing and Monitoring the Drought Condition in Chittur Taluk, Palakkad District, Kerala

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Abstract

Geo informatics played a vital role to assess and monitor the different types of natural hazards either natural or manmade. Temporal satellite data of two years has been systematically used to monitor drought assessment in Chittur taluk, Palakkad district. Rainfall, Soil moisture, increasing temperature and changes in vegetation are the most important parameters effecting drought. Thus, analysis of vegetation fraction and Moisture Stress Index (MSI) are essential in drought estimation using remote sensing. The digital indices using satellite data namely, Normalized Vegetation Index (NDVI), Vegetation Condition Index (VCI), Rainfall records, Moisture Stress Index (MSI) and Yellowness Vegetation Index (YVI) is very essential to assess the drought in Chittur taluk. The present study on "A Geospatial Approach for Assessment and Monitoring the Drought Condition in Chittur Taluk, Palakkad District, Kerala" has been technically estimated on drought condition in the area. In this study, the drought prone areas in the Chittur taluk were identified by using Remote Sensing and GIS technology and drought risk areas were to delineate by integration of satellite images, meteorological Information. Thus, this drought risk mapping can be useful to guide decision making process in drought monitoring and to reduce the risk of drought on any such kind of economic activities.

Key Words: Moisture Stress Index (MSI); Normalized Vegetation Index (NDVI); Vegetation Condition Index (VCI); Rainfall records, Yellowness Vegetation Index (YVI); Geospatial Assessment.

1. INTRODUCTION

Drought is a natural disaster which affects a wide range of ecological factors and activities related to agricultural, vegetation, human and wild life and local economies. Drought is an extensive period when a region receives a deficiency in its water supply, whether atmospheric, surface or ground water. A drought can last for months or years, or may be declared after as 15 days. Generally this occurs when a region receives consistently below average precipitation. It can have a significant impact on the ecosystem and agriculture of the affected region. Although droughts can persist for several years even a short, intense drought can cause significant damage and harm to the local economy. Precipitation deficiency, dry season, El Nino, Erosion and Human activities, climate change are the major causes of drought.

Drought can be classified in to four categories such as Meteorological drought, agricultural drought, hydrological drought, socio-economic drought. 'Hydrological drought is defined as a significant decrease in the availability of water in all its forms appearing in the land phase of the hydrological cycle'. It may be the result of long term meteorological drought that results in the drying up of reservoirs, lakes, streams, rivers and a declining ground water levels. The major parameters which are used to analyze drought condition are vegetation health, rainfall, evaporation, stream flow, and temperature and soil moisture. Drought indices are commonly used to assess the drought condition around the world because it is more functional than row data for decision making.

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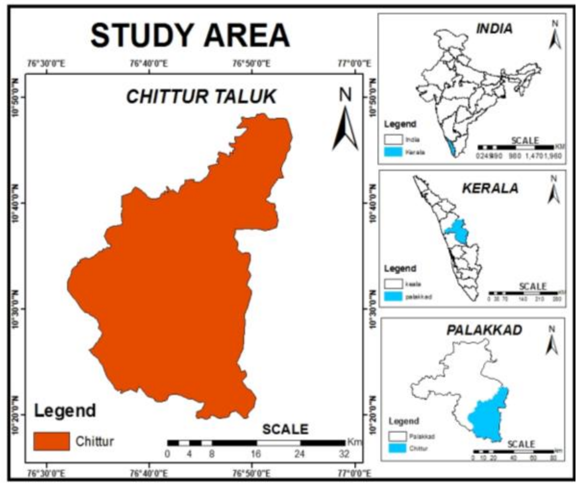
Sumanta Das et al (2003) were studied the systematically assessed that geospatial techniques have played a key role in studying different types of natural hazards either natural or manmade by using remote sensing techniques. S. K Jain et al, were focus on Identification of drought-vulnerable areas using NOAA AVHRR data, suggests that the Advanced Very High Resolution Radiometer (AVHRR) series of satellite was used for calculating brightness temperature (BT), NDVI and Water Supplying Vegetation Index (WSVI) and Murali Krishna Gumma et al (2012) has reveals that to map rice areas in Odisha from 2000-01 to 2010-11 using MODIS 250m 8-day time series data with spectral matching techniques and identify stress-prone rice areas in the state. Therefore the geospatial technique like remote sensing and GIS played a key role in assessing hydrological drought. Timely determination of the level of drought will help in effective decision making process in reducing the impacts of drought.

1.1 Study Area

Chittur is a taluk in Palakkad district of Kerala state. It is located at 76 ° 47 ’ E Latitude and 10° 42 ’ N Longitude Chittur taluk is bounded by kollengode taluk towards South, Palakkad taluk towards North, Malampuzha taluk towards North, kuzhalmannam taluk towards west. Chittur consist of 117 villages and 7 panchayats. It is in the 105 m elevation. The population of Chittur taluk 446778.

Map 1: Study Area



2. METHODOLOGY

2.1 Data and Process

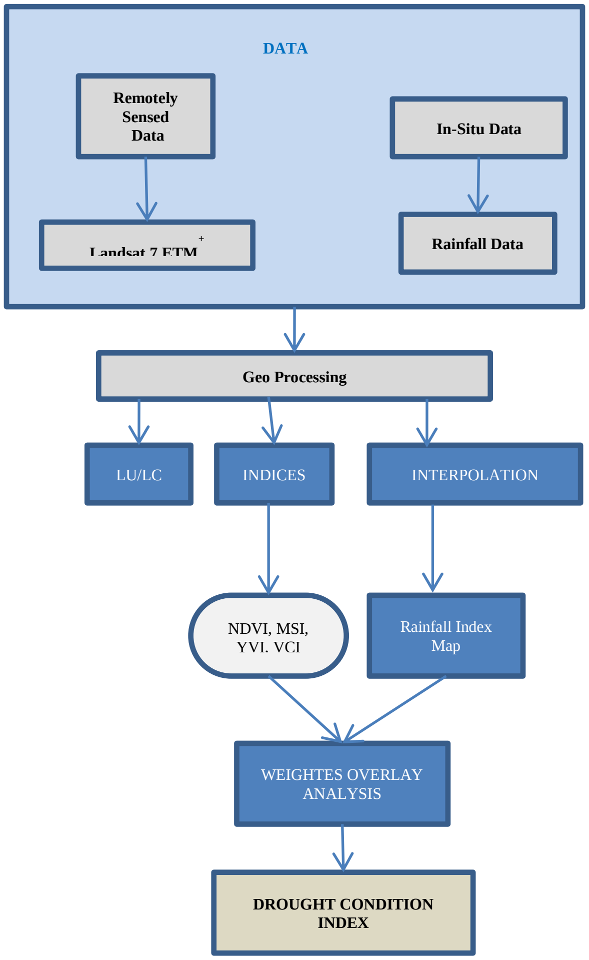
The first phase of the methodology is data collection. The relevant data has been collected from different sources. Remote sensing data is having a immense role in Hydrological drought study. In this study two years of satellite data has used between 2008-2014 .time period with two year interval .All satellite images (land sat 7 ETM+ 2008) ,(land sat 7 ETM+ 2014) has been downloaded from Global Land Cover Facility (GLCF) and EARTH EXPLORE. Seasonal rainfall data collected from Indian Meteorological Department (IMD) in 2008 and 2014.For this study drought map created with the help of LST, MSI, NDVI, Rainfall, VCI, YVI

Table 1: Data Used

S. No	Satellite	Sensor	Path &Row	Resolution	Data Acquisition	Year	Source
1	Landsat 7	ETM+	144-53	30	Sep-12	2008	GLCF
2	Landsat 7	ETM+	144-53	30	Feb - 22	2014	GLCF

The data used in the present study were both primary and secondary data satellite images and rainfall data. The satellite data has been acquired from GLCF under Defense Department USA and EARTH EXPLORE under the USGS**.** Rainfall data collected from Indian meteorological department (IMD).

Flow Chart



2.2 Software

The ArcGIS software is used for extraction of images with help of boundary as shape file, clipping of each zone. Data management tool used for and re-projection of images. And mainly the Arc MAP is used for mapping every feature and classified data. Earth Resource Data Assessment System (ERDAS) Imagine is a remote sensing application with raster graphics editor capabilities designed by ERDAS, Inc. for geospatial applications. In this project it was mainly used for image processing and classification. Interpreter tool was used for layer stack of images and change detection. GIS analysis tool was used for creating change matrix

3. TECHNIQUES USED

The study analyzed the following categories, i. Supervised classification (Land use &Land Cover (2008, 2014)), ii. Land Surface Temperature (To determine the Land Surface Temperature, iii. NDVI (Normalized Difference Vegetation Index), iv. Moisture Stress Index (To indicate the soil moisture condition), v. Yellowness Index (Direct Measure of Vegetation Abundance), vi. Rainfall (To show the rainfall), vii. Vegetation Condition Index (For Assessing the Severity of Agricultural Drought)

3.1 Supervised Classification

a) Land Use /Land Cover

Distribution of LU/LC cover in the year of 2008 shown in Map no.2**,** Classified the LU/LC from ETM+ satellite image. Classes have been created with help of signature editor tool. This Map shows six major LU/LC classes, namely, forest, settlement cultivable land, barren hills, waste land and water body. Southern part of Chittur taluk covered forest cover and barren hills. Major part of study area is covered by settlement and cultivable land, waste land and water body are the minimum features of the study area.

Table: 2 Land use and Land Cover

LU/LC FEATURES	2008	2014
	Area(sq.km)	**Area(sq.km)**
Forest	304.632	236.2691125
Cultivable Land	182.2653	278.309925
Settlement	210.9681	250.213275
Water Body	29.3346	40.61475
Barren Hills	274.3164	243.182925
Waste Land	141.7059	91.84545
Total	**1143.2223**	**1140.43545**

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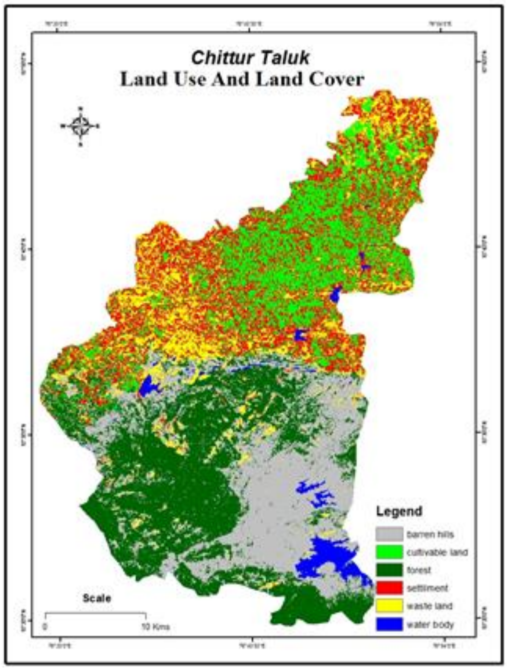
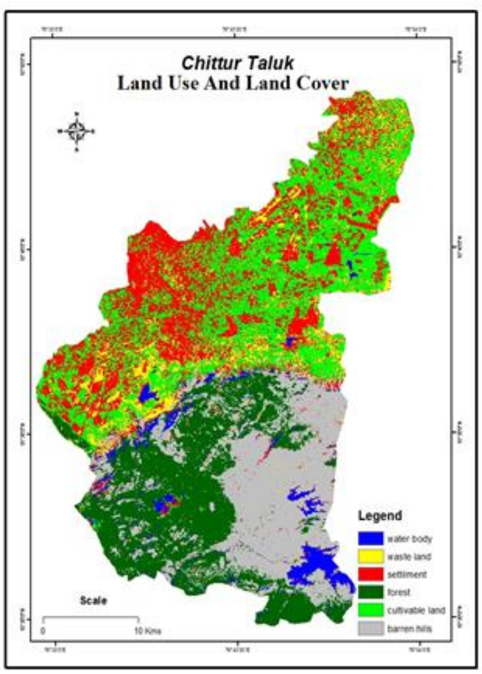
Map 2: Land Use Land Cover 2008

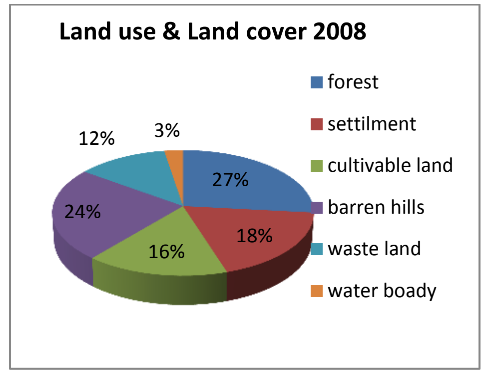


Map 3: Land Use and Land Cover 2014



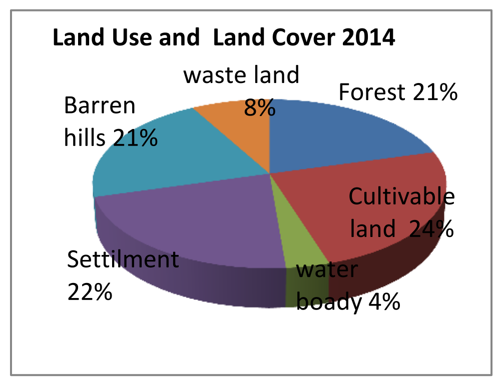
Most of the water harvesting structures is found in forest region where the presence of water concerns a perfect river system. When comparing with other features, built up area and road feature are laying in third and fourth

Chart 2: Land Use and Land Cover - 2008



place respectively. During the period of 2014 Chittur taluk has been overwhelmed in context of all the Level I classes, namely, Forest, Cultivable land, settlement and water body.

Chart 3: Land Use and Land Cover -2014



The presence of agriculture in 2014 has been as compare to the 2008. Thus, it is directly influenced on water, rainfall and temperature aspect during the period. In 2014 Chittur taluk has been witnessed that a boom changes in terms of land uses while 2008 is not. It has been increased over a period of time.

3.2 Land Surface Temperature

LST is the temperature emitted by the surface and measured in Kelvin. It was greatly affected by the increasing greenhouse gases in the atmosphere. As it rises, it melts the glaciers and ices sheets in the polar region. Thus it leads to flood and sea level rise. Increase in LST also affects the climatic condition of the monsoon countries leading to unpredictable rainfall. The

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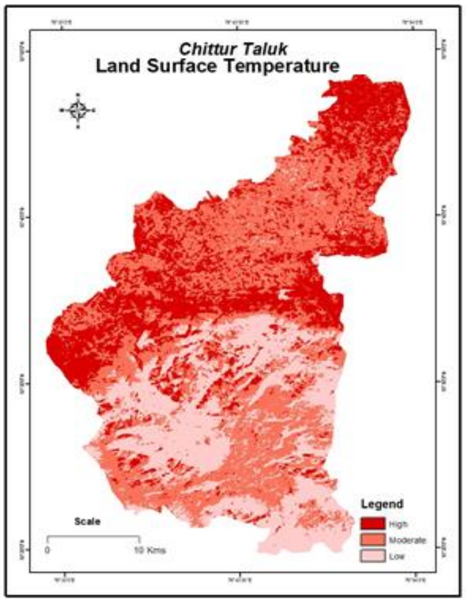
vegetation in the entire Earth surface will be affected by this. Land use/ Land cover (LU/LC) of an area can be used for estimating the amount of

Map 4: Land Surface Temperature -2008



Map 5: Land Surface Temperature -2014

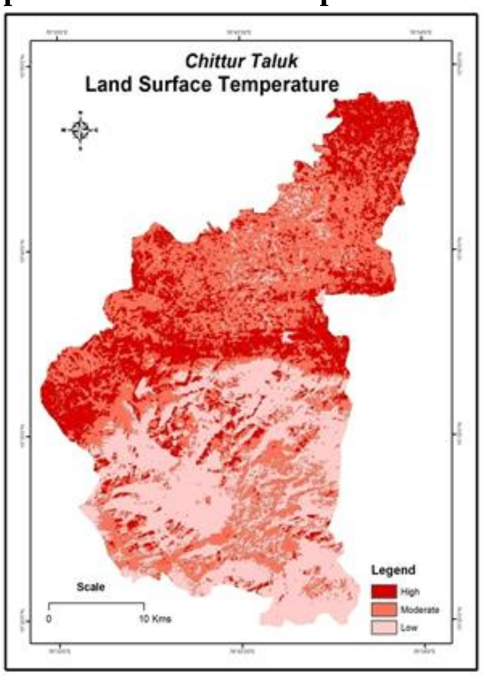


Table: 3 Land Surface Temperature

LAND SURFACE TEMPERATURE		
YEAR	**2008**	**2014**
High	313.94-336.35	300.12-313.21
Moderate	308.26-313.94	296.77-300.12
Low	293.71-308.26	288.12-296.77

LST. The natural and anthropogenic activities change the LU/LC of an area. This also influences LST of that area. As its value changes the local climate of the area also changes. It is an important phenomenon to be investigated. Hence, many researchers had calculated LST using various algorithms and techniques. In this project I realized with two temporal images like 2008-2014

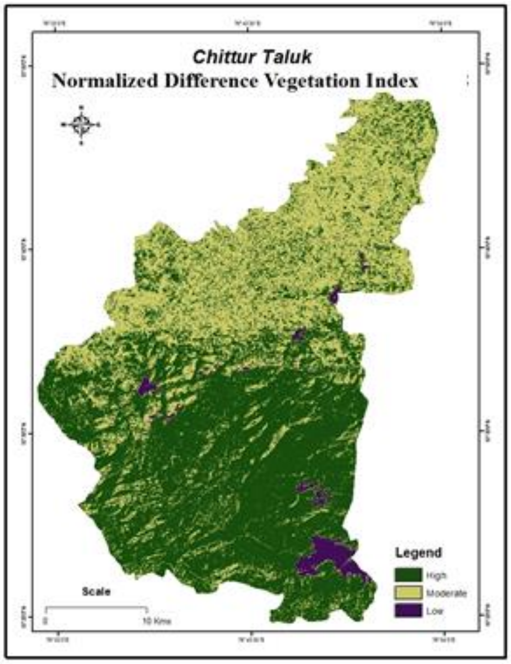
3.3 Normalized Difference Vegetation Index (NDVI)

Normalized Difference Vegetation Index (NDVI) computed for all the years to understand the change in the temporal dynamics of the vegetation cover in the study region. NDVI value ranges from values -1 to +1, where -0.1 and below indicate soil or barren areas of rock, sand, or urban built-up. NDVI of zero indicates the water cover. Moderate values represent low density vegetation (0.1 to 0.3) and higher values indicate thick canopy vegetation (0.6 to 0.8).

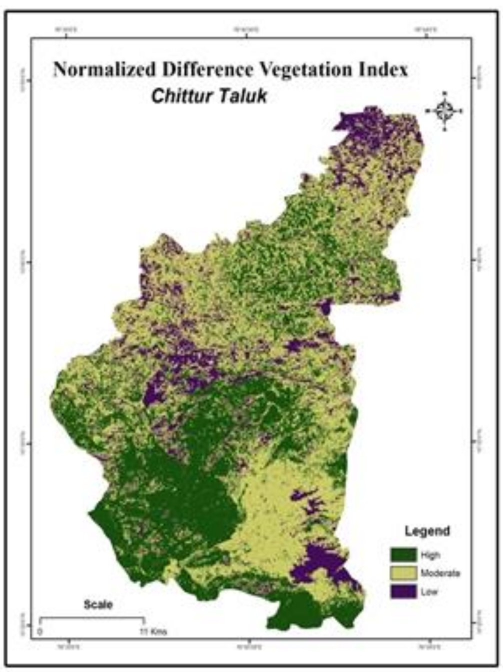
Table 4: NDVI

NDVI		
Year	**2008**	**2014**
High	0.16 to 0.59	0.17 to 0.50
Moderate	-0.16 to 0.16	-0.02 to 0.17
Low	-0.70 to -0.16	-0.51 to -0.02

Map 6: Normalized vegetation Index -2008



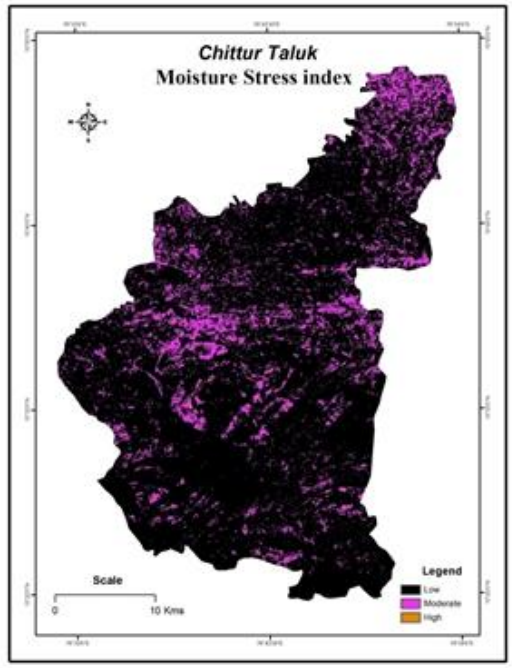
Map 7: Normalized Vegetation Index 2014



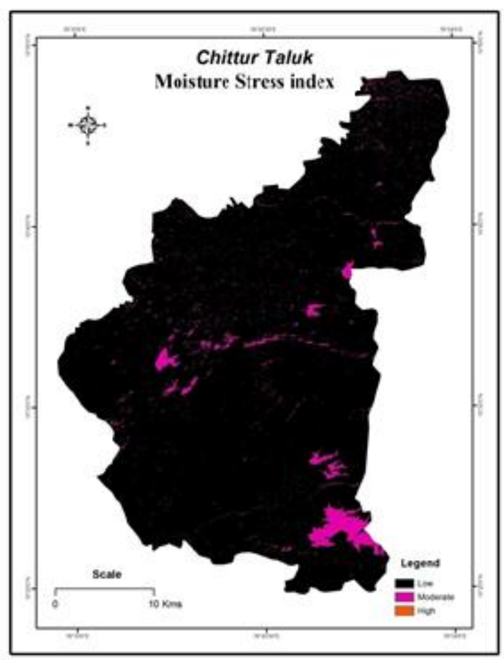
3.4 Moisture Stress Index (MSI)

Moisture Stress Index is used to determine the soil moisture condition during drought it is the good indicator of agricultural drought. It has been calculated by using MIR band NIR band of Land sat data. MSI value range starts from 0 to 4. It is computed as

Map 8: Moisture Stress Index -2008



Map 9: Moisture Stress Index -2014



MSI= BAND 7/BAND 4 (for Land Sat TM) equation MSI= BAND 8/ BAND 4 (for Land Sat ETM+) equation Where, (band 4 is NIR and band

7 is MIR for Land Sat TM) and (band 4 is NIR and band 8 is MIR for Land Sat ETM+)

Table: 5 Moisture Stress Index

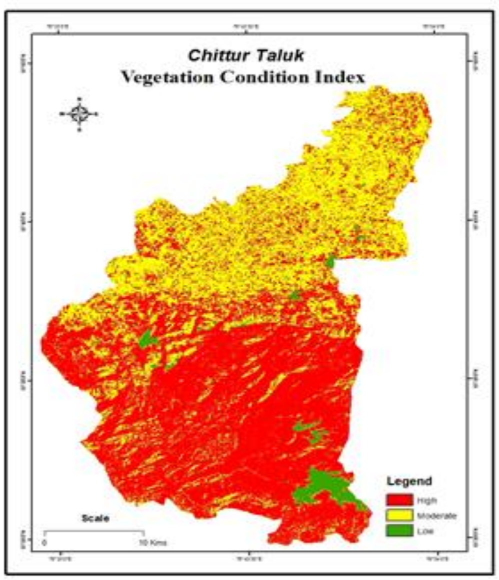
MOISTURE STRESS INDEX		
YEAR	2008	2014
HIGH	1-2	1-2
MODERATE	0-1	0-1
LOW	0	0

3.5 Vegetation Condition Index

The Vegetation Condition Index values between 50 to 100% indicate optimal or above normal condition. At the Vegetation Condition Index values of 100% the NDVI for this month (or week) is equal to NDVI maxi Different degree of a drought severity are indicated by Vegetation condition index values below 50% .The resulting vci percentage

$$VCI = \frac{(NDVI - NDVIMIN)}{(NDVIMAX - NDVIMIN)} \times 100$$

Map 10: Vegetation Condition Index -2008



Map 11: Vegetation Condition Index -2014

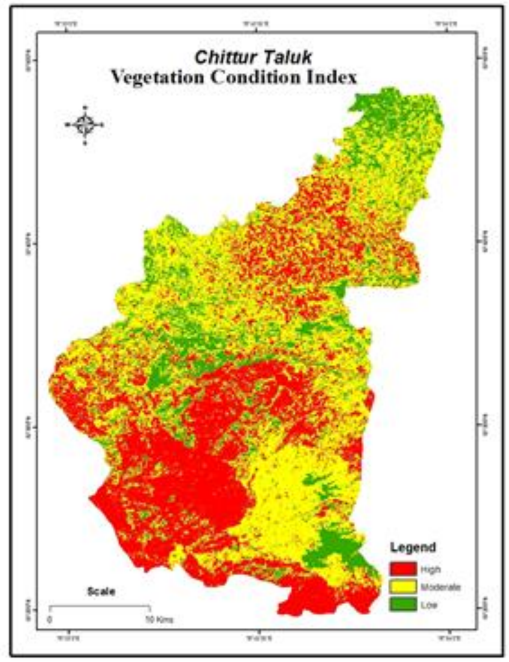


Table 6: Vegetation Condition Index

VEGETATION CONDITION INDEX		
Year	2008	2014
High	0.0122 - 0.018	67.45 – 99.10
Moderate	0.007 - 0.0122	48.62 – 67.45
Low	-0.0006 –	-0.005 – 48.62

3.6 YELLOWNESS VEGETATION INDEX

Yellowness Vegetation Index (YVI) is linear combination of the six reflecting wave bands. The YVI coefficients with the highest values are for the red (negatively loaded) and the near infrared (positively loaded) wave bands. The YVI is a more direct measure of vegetation abundance.

YVI= - 0.16263 * band1 - 0.040639 * band2 - 0.85468 * band3 + 0.05493 * band4 + 0.24717 * band5 - 0.11749 * band7 equation (Land sat Tm)

YVI= - 0.16263 * band1 - 0.040639 * band2 - 0.85468 * band3 + 0.05493 * band4 + 0.24717 * band5 - 0.11749* band8 equation (Land sat ETM+)

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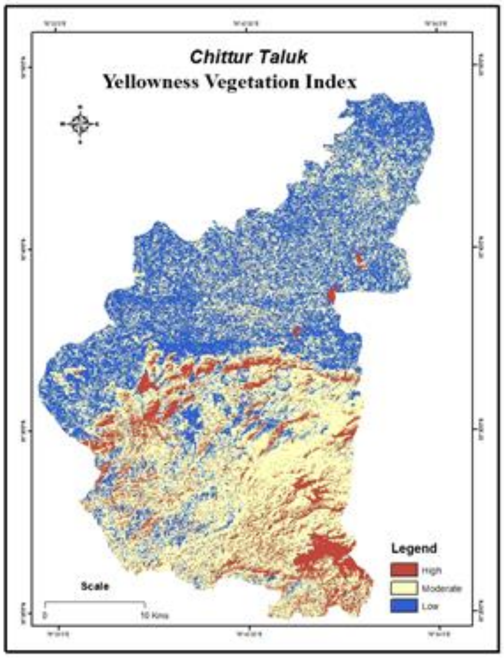
Map 12: Yellowness Vegetation Index -2008



Map 13: Yellowness Vegetation Index -2014

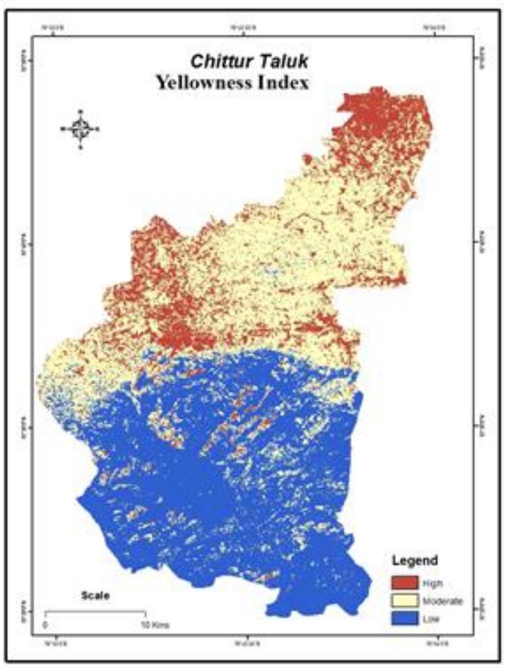


Table 7: Yellowness Vegetation Index

Yellowness Vegetation Index		
Year	2008	2014
High	1,362,911.25 to - 660533.88	674.70 t0
Moderate	-660,533.88 to -508,668.4963	440.43 to 674.70
Low	-508,668.50 to –152734.o156	156.47 to 440.43

3.7 Rainfall Map

Rainfall map is showing the quantity of rain falling within a given time, it is in a year wise or monthly wise. Rainfall shows the quantity of precipitation deficit at a different time scale, and can also help assess drought severity. Meteorological data were used to generate rainfall map

Map 14: Rainfall -2008

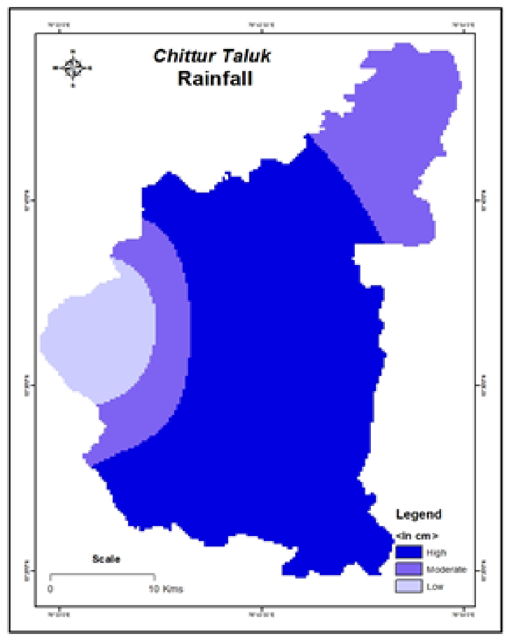


Table 8: Rainfall data

Rainfall		
Year	2008	2014
High	164.42 – 200.41	147.81 - 179.122
Moderate	108.37 - 164.42	123.07 - 147.81
Low	49.97 – 108.37	86.66 - 123.07

Map 15: Rainfall -2014

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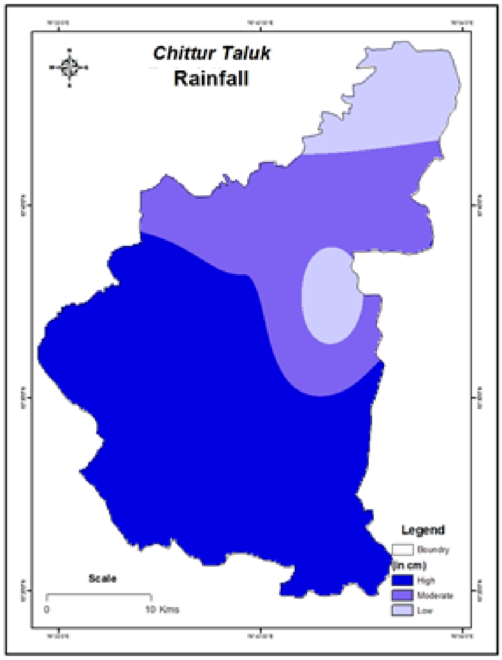
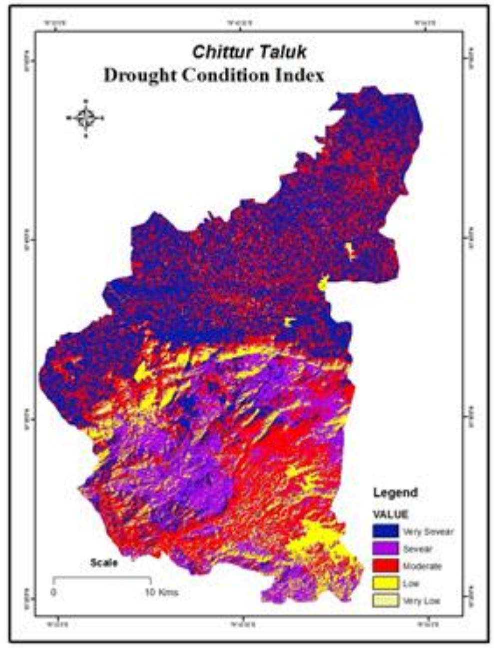


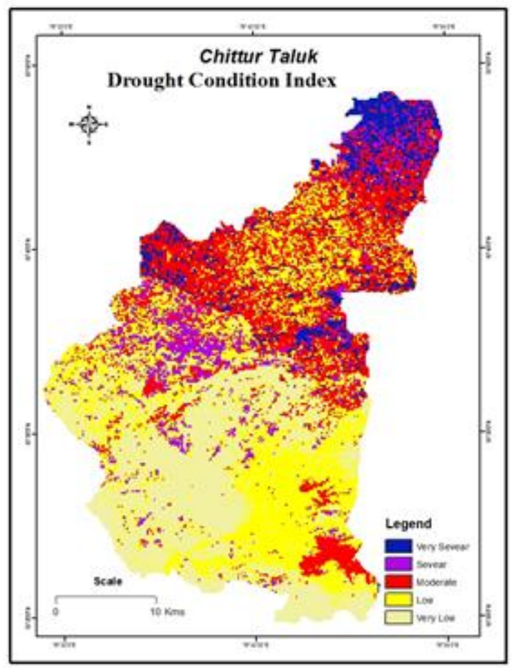
4. RESULT AND DISCUSSION

- The analysis of Land sat images of years 2008 and 2014 revealed that land use and land cover of the catchment of study area has changed over 2 years.
- NDVI study illustrate that vegetation condition can be used as indicator for drought condition of an area
- From LST images of two different years suggest that temperature in both the years are seems to be high. It has strongly and positively correlated with drought condition in Chittur taluk.
- Low rainfall is usually the cause of drought, but high temperatures may also be involved. Drought as related to precipitation may be a result of several growing days without precipitation, low seasonal precipitation, or abnormally low annual precipitation.
- Thus, the present study examines that drought condition in 2008 is extremely high while 2014 is not. It has been positively and negatively dealt with both primary and secondary aspects.

Map 16: Drought Condition Index -2008



Map 17: Drought Condition Index -2014



- Drought prone areas in Chittur taluk were identified by using Remote Sensing and GIS technology and drought risk areas were to delineate by integration of satellite images, meteorological information and crop yield data.

4.1 Suggestions

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The present study assessed that the component of the drought may affect large region and causes structural damages .To suggest followings are the main components,

- ***Prediction:*** Prediction can from climate studies which use coupled ocean /atmosphere models. Soil moisture assimilation of remotely
- ***Monitoring:*** Monitoring exists in countries which use ground based information such as rainfall, weather, crop and water availability. Satellite data collected by ground systems
- ***Impact assessment:*** It's carried out basis of land use type, demographic and existing infrastructure, it's effected on agricultural yield, public health, and water quantity and quality
- ***Response:*** Improved drought monitoring better water and crop management Drought preparedness can be accomplishing with the following practices
- ***Soil water conservation:*** Minimize the disruption of soil structure, composition and natural biodiversity, its reducing erosion and soil degradation, surface runoff, water pollution.
- ***Contour bunds, trenches and stone walls:*** These features prevent soil erosion and obstruct the flow off run off. It retained water increases soil moisture and recharges the ground water
- ***Check dams:*** Type of check dams are the brush –wood dam, the loose-rock dam
- ***Percolation ponds:*** These features store water for livestock and recharge the ground water.

4.2 Recommendations for Future Work

The study has identified an approach by which drought can be identified using remote sensing and GIS. The drought maps are of great importance as they can be used subsequently for preparing action plan for providing relief measures to drought affected areas. Thus, the future direction of research can be enumerated as follows:

a. Prioritization of critical parameters related to drought condition.
b. Preparation of short and long term action plans
c. Definition of a well-defined drought classification based on numeric indices

5. CONCLUSION

Agriculture remains by far the most vulnerable and sensitive sector that is seriously affected by the impacts of climate variability and climate change, which is usually manifested through rainfall variability and drought. Rainfall is one of the climatic variables that largely determine the occurrence of drought and also influences the growth and development of vegetation's which is reflected by NDVI. In this study, the drought prone areas in the Chittur taluk were identified by using Remote Sensing and GIS technology and drought risk areas were to delineate by integration of satellite images, meteorological information. The role of satellite derived index for drought detection has been exemplified by integrating meteorological data showing in rainfall map. It is found that the temporal variations of NDVI anomaly, VCI, LST and MSI are closely linked with Rainfall and a strong linear relationship exists between them. Satellite derived drought-monitoring indices have also been correlated with rainfall data. The seasonal pattern of rainfall, temperature and NDVI, suggest that the North part of the Chittur taluk is a low rainfall and high temperature area, where the presence of vegetation and forest cover is low and the corresponding and NDVI values is also low whereas LST is higher. Thus it can be said that, NDVI index and precipitation index & MSI index and LST shares a strong correlation. Agricultural drought risk can be viewed as a product of both exposure to the climate hazards and the vulnerability of farming or cropping practices to drought conditions. In view of this, agricultural risk zone map produced by integrating all drought frequency maps derived from all drought indices. Considering the spread and frequency of droughts in the region on the one hand, and the lack of ground climate observations and technical capacity in the countries of the

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region to deal with droughts on the other, such a system could play an invaluable role for drought preparedness, while identifying appropriate sites for specific adaptation and mitigation actions.

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