DROUGHT MONITORING USING OPEN SOURCE REMOTE SENSING DATASETS

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KEYWORDS: Drought, Agriculture, LST, AMSRE, Soil Moisture

ABSTRACT

Droughts are more complicated phenomena occurs due to the lack of moisture. It has very harsh effect on the society's economy and livelihood. There are three types of drought viz. Agriculture, Hydrological and Meteorological. The occurrences of different droughts are depending upon different parameter but all are highly correlated. Agriculture drought occur when soil moisture decreases which cause serious impact on the crop's health and its productivity. Normalized difference vegetation index (NDVI), Land surface temperature (LST) and Soil moistures are different parameter used to study of drought, NDVI is used for monitor changes in vegetation whereas LST indicates about temperature of the different land's surface. Soil moisture one of the most valuable factor which indicate drought. In this study NDVI and LST calculated from Landsat dataset and soil moisture from AMSRE product, is used. The data was calibrated to standard pixel value and resampled in a homogeneous resolution. This study is conducted over the Indian state Maharashtra and Madhya Pradesh because of dependencies on agricultural activities and suffering from water unavailability which makes highly affected from drought. According to statistical correlation between different indicators visualizing toward the droughts in different parts of the state, and it is varying from year 2001 to 2016. South eastern part of Maharashtra getting higher LST whereas vegetation index and soil moisture is Low. The R^2 of LST and NDVI is more than 0.6 whereas NDVI and soil moisture index is > 0.7.

1. INTRODUCTION

Drought is one of the complex and creeping phenomenon, which occurred because of insufficiency in water storage and brings water shortage. It is a natural hazardous which occurred in all climate zones with widely variability in characteristics. Drought generally happened because of uneven distribution of rainfall, less rainfall, high requirement of water than the water availability or due to combination of all three. Prior estimation of drought might help to escape from the serious consequences of economy and ecology which contribute in country's growth. Accuracy in the assessment and prediction for drought is still one of the major challenge for the researcher's that's why the damage caused by drought is not specific in global domain.

There is multiple definition for drought, different researcher and organization defined drought according to their understanding as well as their perception. Some of the key definitions are: -

- The encyclopaedia of climate and weather (Schneider, 1996) – "an extended period – a season, a year, or several years – of deficient rainfall relative to the statistical multi - year mean for a region."
- The UN Convention to Combat Drought & Desertification (1994) – "drought means the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems."
- The World Meteorological Organization (WMO, 1986) – "drought means a sustained, extended deficiency in precipitation."
- The Food and Agriculture Organization (FAO, 1983) of the United Nations- "the percentage of years when crops fail from the lack of moisture."
- Palmer (1965) – "drought as a significant deviation from the normal hydrologic conditions of an area."8
- Gumbel (1963) - "drought as the smallest annual value of daily stream flow."
- Linseley et al. (1959) – "drought as a sustained period of time without significant rainfall."

Most of the research paper classified droughts into three categories i.e., Metrological drought, Hydrological drought and agriculture drought. The papers suggest that when any of these drought makes impact on the society and economic of the country then it is termed as socio-economic drought. So, it can further categories as: -

i. Metrological Drought
ii. Hydrological Drought
iii. Agriculture Drought

iv. Socioeconomic Drought

METROLOGICAL DROUGHT

"The metrological droughts are based on deficits in precipitation" (Dracup et al., 1980). Indian Metrological Department (IMD) defines it as, when the seasonal rainfall of an area received less than 25% of the long term climatological mean. IMD classify metrological drought into levels e.g., if the rainfall deficits less than 50% and greater than 25% then it is "Moderate drought" whereas it exceeds 50% of the normal then termed as "severe drought". As occurrence of precipitation varies region to region it estimated as region specific.

HYDROLOGICAL DROUGHT

"The occurrence of Hydrological drought is noticeable from the available water in the surface water resources due to reduce precipitation even or quality" (Hisdal and Tallaksen, 2003). Studies exposed that Hydrological drought are habitually trailed compare to Metrological drought. When the water surface of stream flow, reservoirs, rivers, lakes marked depletion from its minimum, it is considered as hydrological drought.

AGRICULTURE DROUGHT

"Agriculture drought refers to period with declining soil moisture content and consequent crop failure" (Mishra and Singh, 2010). The insufficiency of water from either metrological or hydrological sources declines the irrigation water for crop production. This water is supposed to be stored in the soil as soil moisture which is ultimately affected as well. Lack of moisture in soil leads to occurrence of agriculture drought, which cause due to serious crop stress and degrade the crop productivity.

SOCIOECONOMIC DROUGHT

"Socioeconomic drought is linked with failure of water resources systems to meet water demands and thus associating droughts with supply of and demand for economic goods (water)" (AMS 2004). This drought starts making impact on the livelihood and economic loss of the region.

1.1 DROUGHT STUDIES AND GEOSPATIAL TECHNOLOGY

Remote sensing and GIS is now a day's key techniques for the researchers as well as industrial hemisphere. There are varieties in satellites that are observing earth and monitoring different parameters by collecting datasets. With the help of that datasets enormous amount of information are extracted. These days this technique and tools are very much familiar for Drought assessment. Dataset from sensors like MSS, TM, ETM+, OLI, TRIS, MODIS, ASTER, AVHRR, AWiFS, AMSR-E etc. with different electromagnetic spectrum which are capable for measuring intensity, identification of location and severity of drought. Final product from these sensors are the raw products for drought related parameter like rainfall, soil moistures, Land Surface Temperature, crop health and coverage using NDVI etc. Different agencies of the world are maintaining day to day records and visualize it on public domain. Very much successful drought project National Agriculture Drought Assessment and Monitoring System (NADAMS) of India assessed by ISRO that visualize the information for droughts in India and helped the Indian Government for future planning.

This Study is focused on the following objectives:

- To map the drought affected areas.
- To look at the temporal change using visual interpretation.

The reason behind selecting this study objective is because, "According to Ministry of water resource 68% of country prone to drought at various scale."

- Drought is a part of the Climatic Cycle
- Drought events will likely be more frequent in the future.
- Drought Impacts are significant & widespread
- Many economic sectors are affected

2. STUDY AREA AND DATA

Maharashtra and Madhya Pradesh is two separate state of India. More than 200 Million of the total population, which is more than 15% of country's total population. The total geography area of the study area is approx. 616,000km² which covered approx. 19% of country's total area and extends from 23°25'N to 77°417'E. More than 15 major and minor rivers flow through this state some major rivers are Krishna, Godavari, Narmada, Tapti, Shipra etc. About 60%

of the total population's income is depend on the agriculture and these states are heavily affected by drought after Rajasthan.

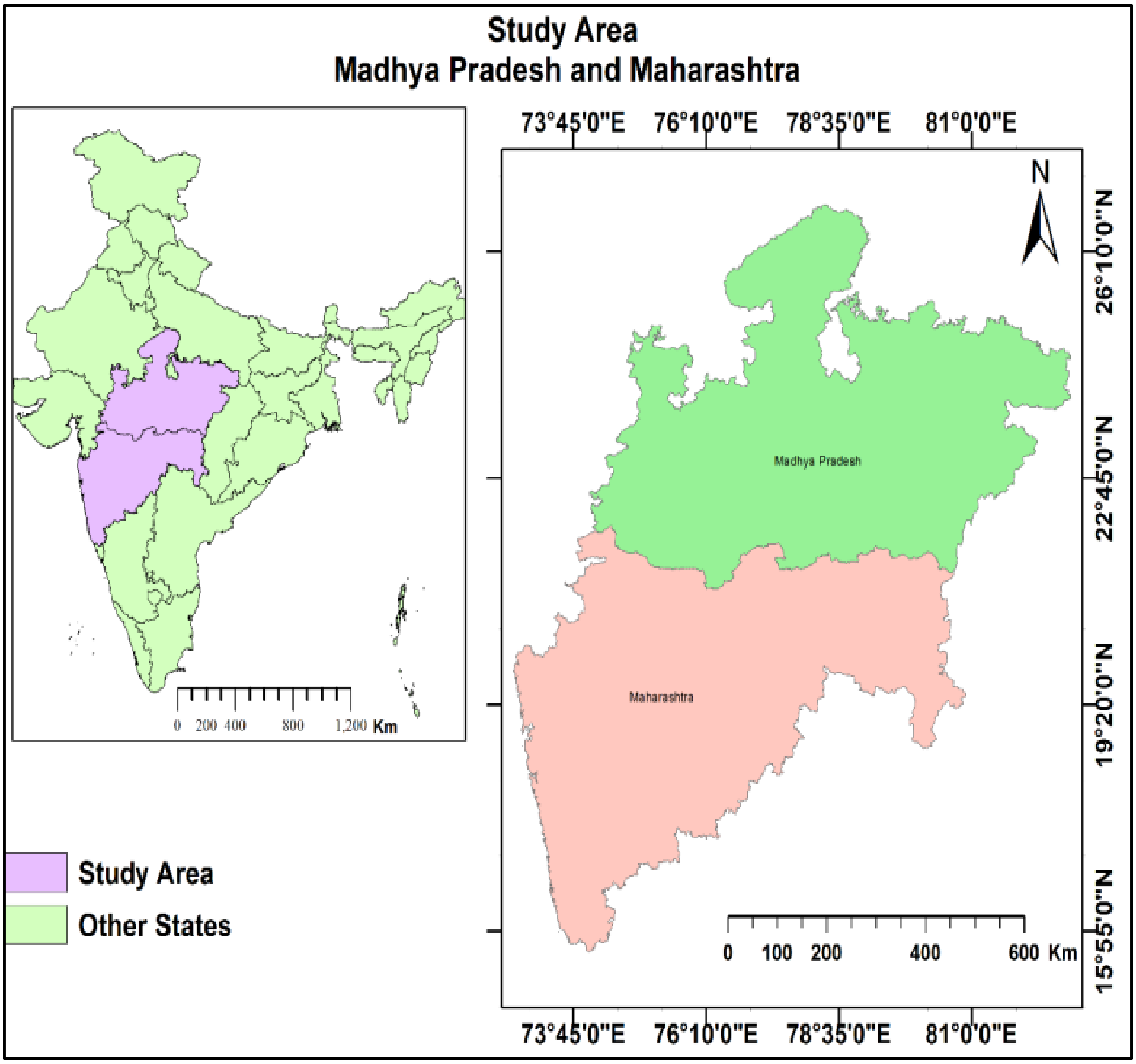


Figure 1 Map of Study Area

MODIS PRODUCT

MODIS (or Moderate Resolution Imaging Spectro radiometer) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites. MODIS vegetation indices, produced at different temporal resolution and at multiple spatial resolutions, provide consistent spatial and temporal comparisons of vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure. The vegetation indices are retrieved from daily, atmosphere-corrected, bidirectional surface reflectance. The Land Surface Temperature (LST) and Emissivity daily data are retrieved at 1km pixels by the generalized split-window algorithm. The product is comprised of LSTs, quality assessment, observation time, view angles, and emissivity.

SOIL MOISTURE

The derived soil moisture from AMSR-E is used for this study. The Soil Moisture is derived from AMSR instrument. The EOS AMSR is a modified version of the AMSR developed for ADEOS-II. Advanced Microwave scanning radiometer installed aqua sensor over the Japanese's satellite. Soil moisture retrievals represent averages over the horizontal retrieval trailed area. "The retrieval algorithm does not explicitly model effects of topography, snow cover, clouds, and precipitation. Other potential error sources include anomalous inputs from bad radiometric data and low-level processing errors. The processing algorithm includes checks to identify these and other anomalies and assign appropriate flags (Njoku 1999)" the thickness of the soil sensed was of the order of a fraction of the observation wavelength, and surface roughness and vegetation produced a significant attenuation of sensitivity, limiting the ability for estimating soil moisture at C-band .

Table 1 **Data Specification**

	Spatial Resolution	Temporal Resolution	Sensor
NDVI	5km	Monthly	MODIS
LST	5km	Monthly	MODIS
Soil moisture	25km	Daily	AMSRE

3. METHODS

The methodology followed for this study is shown in figure 2. The satellite image generated NDVI, LST and soil moisture is preprocessed to make equivalent spatial resolution and further processed for anomaly preparation using GIS software. Figure 3 tells about step wise procedure to generate result from the beginning till end of the whole process.

3.1 Normalized Difference Vegetation Index (NDVI)

"The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyses remote sensing measurements and assess whether the target being observed contains live green vegetation or not. NDVI was first used in 1973 by Rouse et al. from the Remote Sensing Centre of Texas A&M University. The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands."

$$\text{NDVI} = \frac{NIR - RED}{NIR + RED}$$

3.2 Land Surface Temperature (LST)

"Surface temperature defines the measures of hotness and coolness of any landscape surface. Before the evolution of satellite technology, it was measured using a thermometer, which has to be in physical contact with the surface. But now, we can calculate it by sensing radiation and emission with the help of thermal sensors. The brightness temperature along with emissivity and constant value (Planck's constant, Stefan-Boltzmann constant and the velocity of light) is processed in a combined formula."

$$Surface\ Temperature = \frac{T_B}{1 + \left(\lambda\ x\ \frac{T_B}{\alpha}\right)\ln(\varepsilon)}\ (Source: -Artis(1982))$$

Where:

$\mathbf{T_B}$ = Brightness Temperature

$\boldsymbol{\lambda}$ = wavelength of emitted radiance

$\boldsymbol{\varepsilon}$ = Emissivity (0.92)

$\boldsymbol{\alpha}$ = hc/k (14380)

Where:

h= Planck's constant

c= velocity of light

k= Stefen Boltzman constant

3.3 Soil Moisture

"Soil moisture monitoring is generally a superior executive mean for agricultural drought assessment than precipitation (www.fao.org). In India, rain-fed agriculture dominates over irrigated agricultural systems, due to which precipitation is considered as the indicator for agricultural drought."

3.4 Anomaly preparation

"Anomaly means percentage deviation of the value of a parameter (soil moisture or vegetation index) from its long-term mean."

$$Xa = [(Xs - Xm)/ Xm] \times 100$$

where,

Xa = is the anomaly of a monthly composite image,

Xs = is the that particular month composite image,

Xm = is the long term mean of the monthly time step for which the anomaly is being derived.

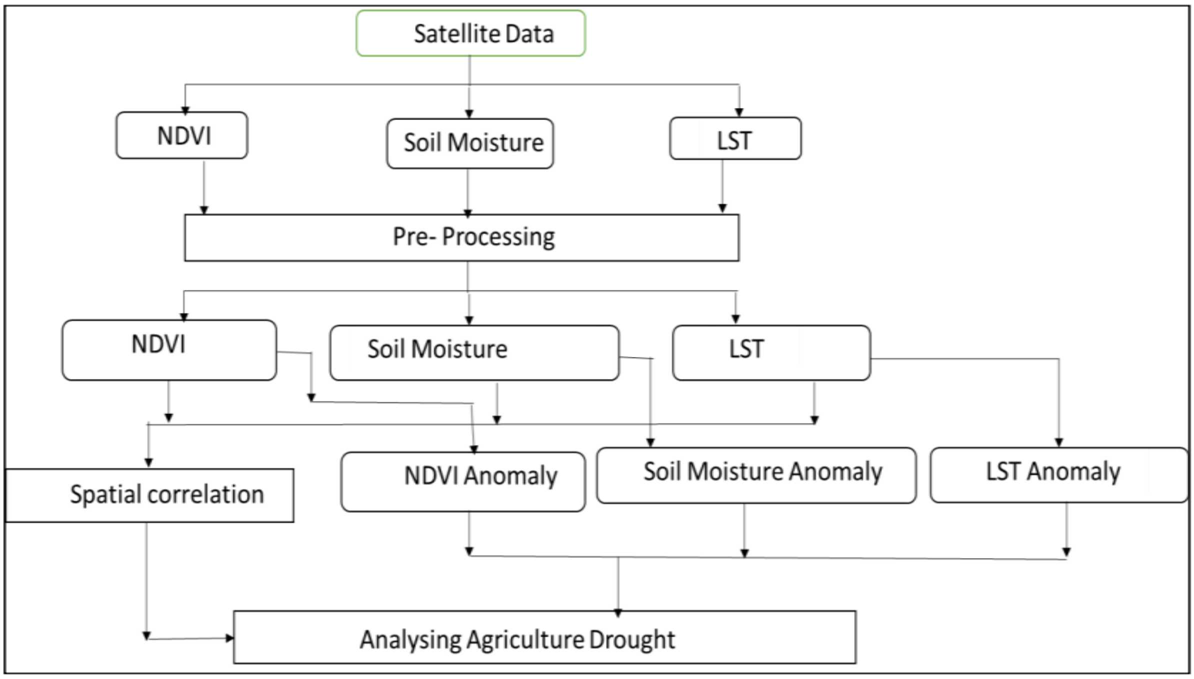


Figure 2 **Flow Chart of Methodology**

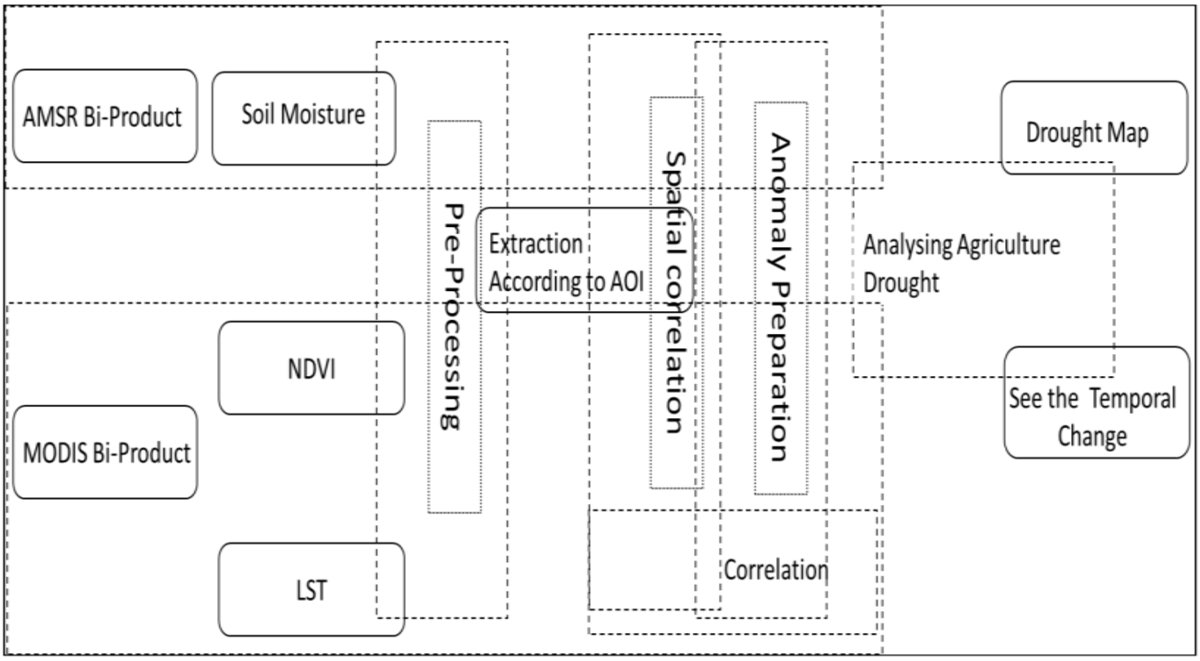
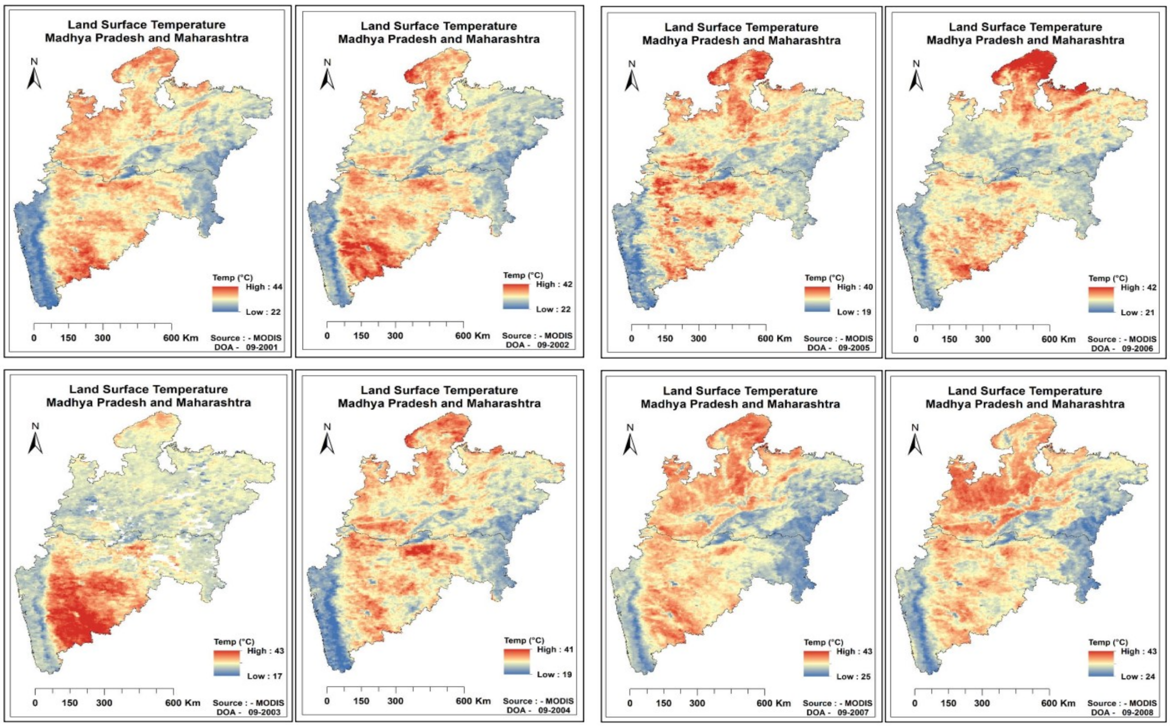


Figure 3 **Procedure and steps followed in this study**

4. RESULT AND DISCUSSION

Land surface temperature is one of the major parameter that is sufficient to forecast any variations in climate. Due to increase in surface temperature the rate of sublimation and evaporation gets affected, and the moisture of soil evaporates which make it dryer. It is very necessary to presence of moisture in soil for healthy crop. From year 2001 to 2016, overall variation of the temperature gets higher which degraded the agriculture quality and increased the water crises for both state.

The health of vegetation is calculated with the help of vegetation index, as it is one of the major indicator of agriculture drought. The scale of vegetation index varies from -1 to 1, 1 indicates healthy and dense vegetation as it decreases to -1 it says decrease of vegetation health to no vegetation. There is variation in yearly vegetation index. From year 2001 to 2016 changes introduced in agriculture.



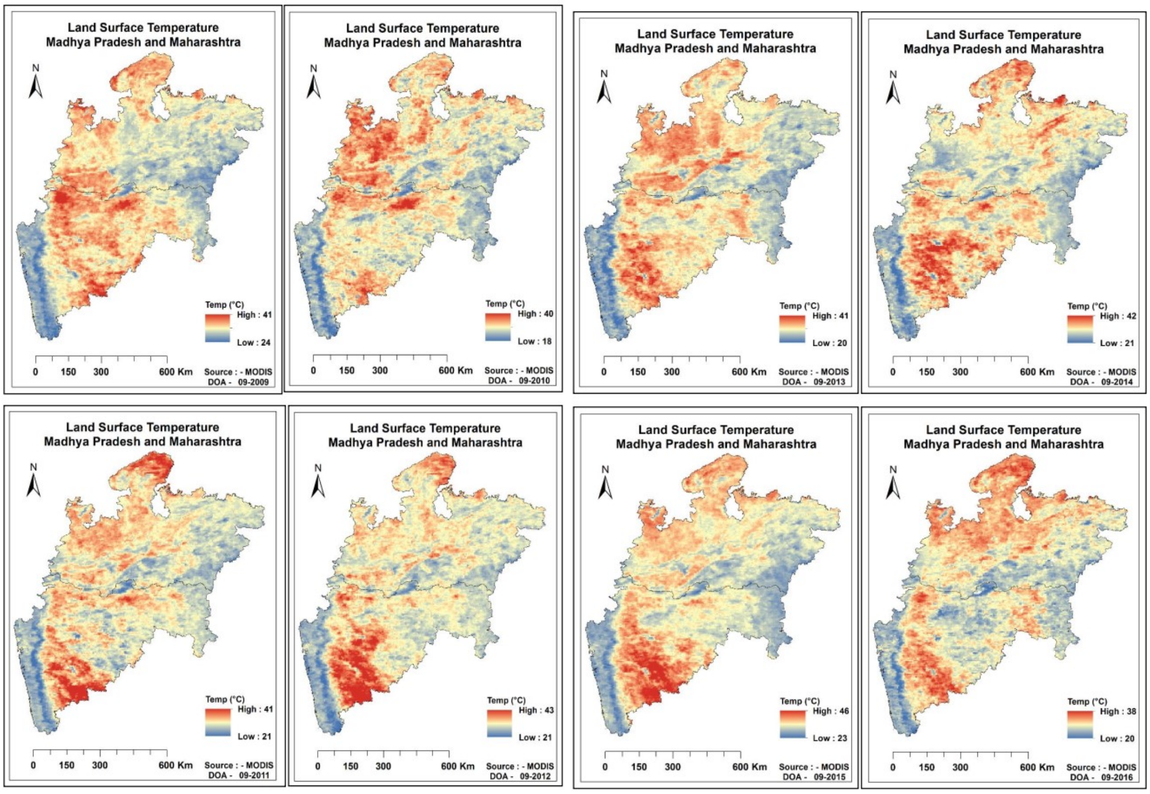
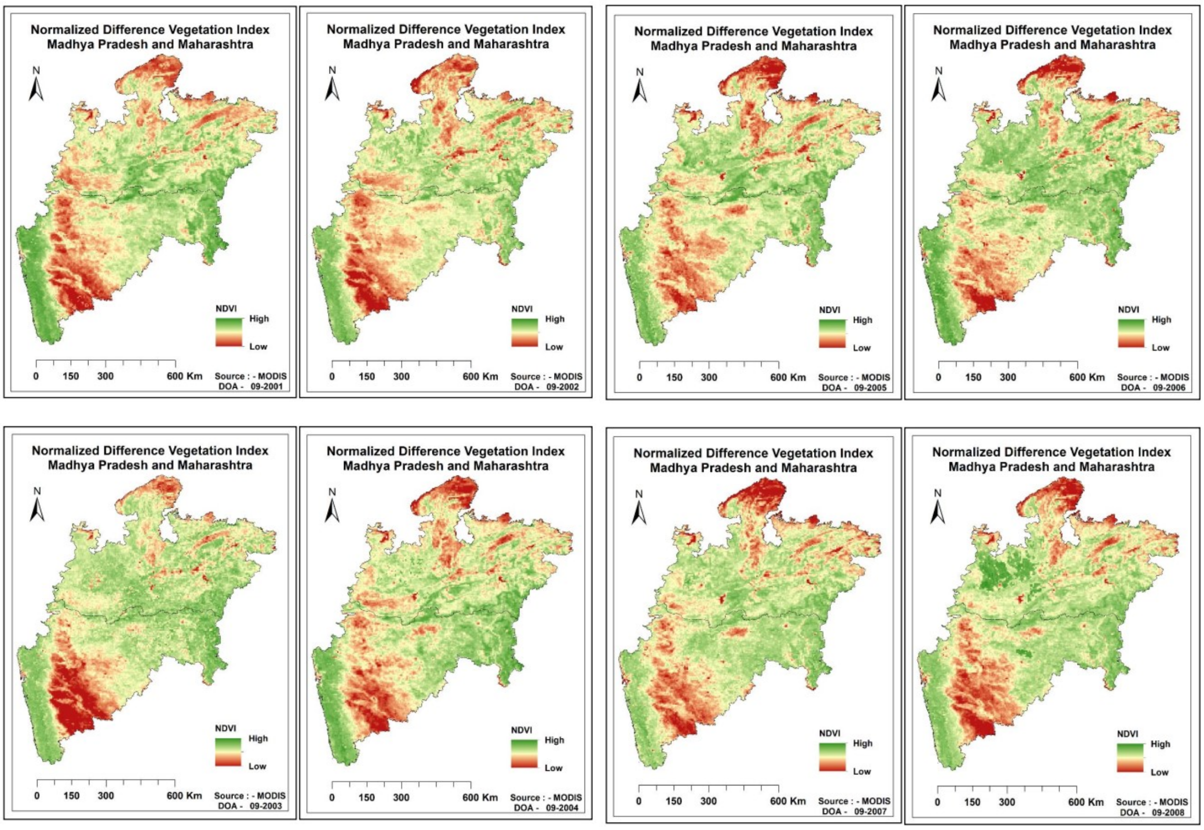


Figure 4 Land surface temperature of September for every year of study



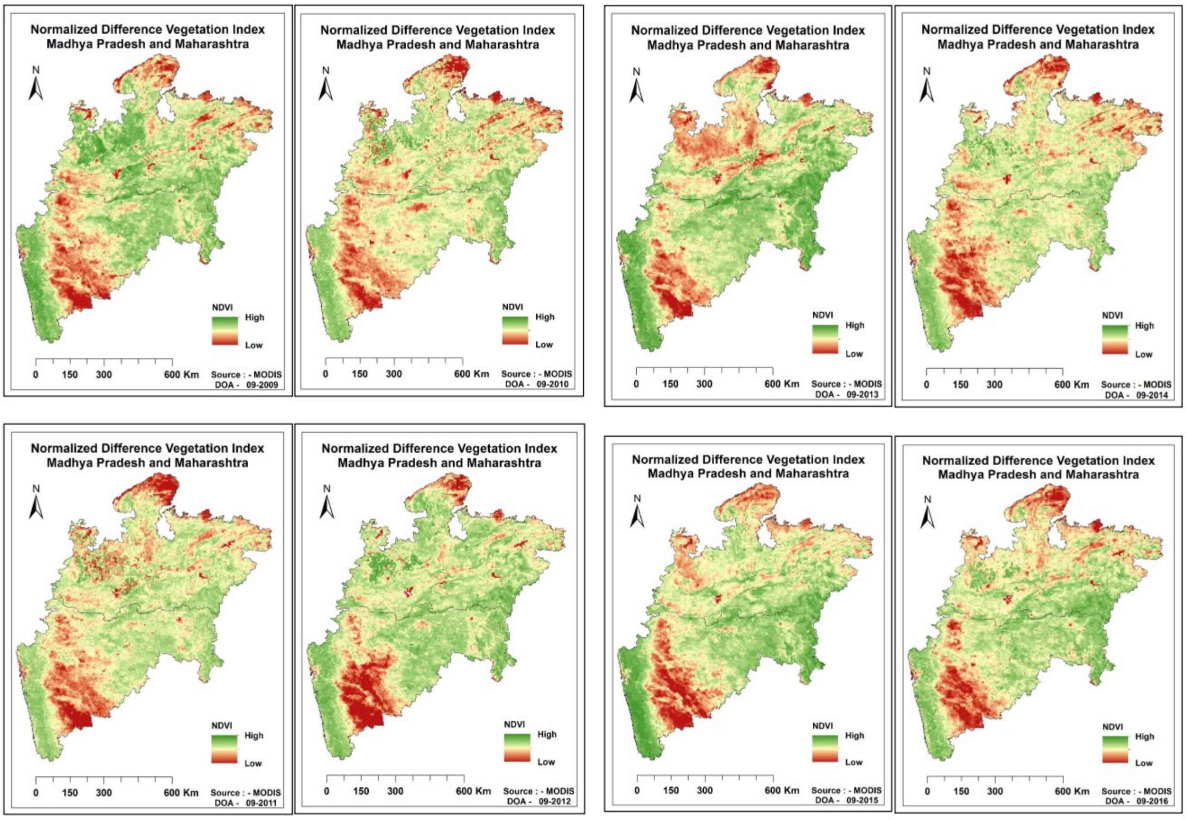


Figure 5 NDVI map of September month for every year of study

5. CONCLUSION

The main objective of this study is to map the drought affected area using different geospatial parameters and visualize the temporal changes in the study area. The health of vegetation is calculated with the help of vegetation index, as it is one of the major indicator of agriculture drought. The scale of vegetation index varies from -1 to 1, 1 indicates healthy and dense vegetation as it decreases to -1 it says decrease of vegetation health to no vegetation.

There is higher correlation between the land surface temperature and the normalized difference vegetation index. This study is unable to find any higher correlation between soil moisture and the vegetation health. It indicates there must be need of depth of research for the accurate result.

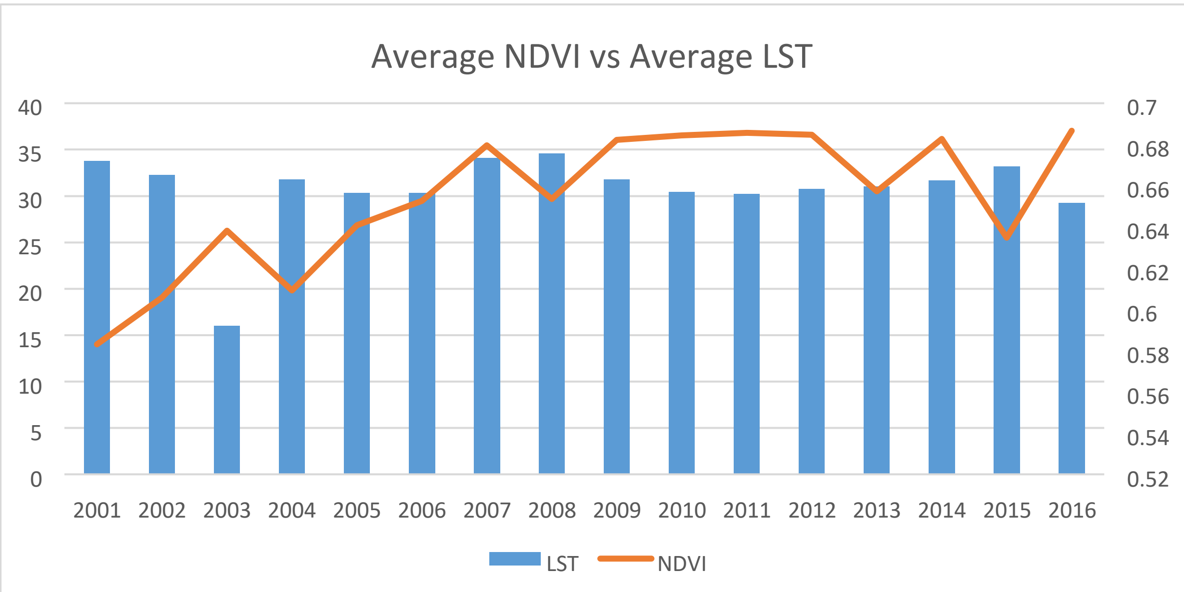


Figure 6 Yearly mean NDVI and LST variation

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