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Analysis of TCI Index Using Landsat8 TIRS Sensor Data of Vaijapur Region

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***Abstract*—** Vaijapur tehsil has faced drought disaster for decades, because it comes in scanty rainfall region of Maharashtra state. The agricultural sector has faced high impact of drought, so that, the reduction in cropland and production take place. The satellite sensors are used to monitor an earth temperature from the space. The Landsat 8 Thermal Infrared Sensor (TIRS) provides temperature data of the earth surface with 16 days temporal resolution. The preprocessing of Landsat 8 images was performed using ATCOR tool. This research study investigates drought severity level in Vaijapur tehsil on the basis of the Temperature Condition Index (TCI). We have used Landsat 8 TIRS (Thermal Infrared) Sensor data, to extract the TCI of the year 2013-2014. We have collected rainfall and temperature data from Indian Meteorological Department (IMD) web portal.

***Keywords*—** Drought Indices; Landsat 8; TCI; ATCOR.

I. INTRODUCTION

Droughts are natural and multi-faces event, which has a direct impact on water resources, forestry, agriculture, hydro-power, health, socioeconomic activities, and livelihood [1, 2, 3, 4, 5, 6]. Failure of monsoon over the region can be responsible for agricultural drought [4]. The crop growth cycle is depends on the seasonal temperature and rainfall [4, 5]. High temperature reduces the soil moisture, which affect the crop health, when soil moisture is decreasing, then plant leaves can reduce the moisture loss with transpiration by closing stomatal [4, 6]. Remote sensing is a revolutionary technology, where the satellite is used for observation of earth from the space. [7].

Landsat series of satellites provides the 42+ years of temporal records of space-based surface observations since Landsat 1 in 1972 to Landsat 8 in (2015 present). Landsat provides visible, Infrared, Thermal data of global coverage in free of cost to promote research activity [8]. Now days Landsat 8 data have been used since its first launch to monitor the status and study the earth land cover changes, disaster management, and agriculture business with various government and non-government agencies. Agribusiness uses Landsat data to monitor the status of crops health and its production [8]. Landsat 8 TIRS data is an important to understand the impact of temperature on the earth atmosphere. Temperature is a critical factor for earth ecosystem and concern over the impact of climate change [9]. Thermal data are helping to study hydrology, evapotranspiration, regional water resources, and agricultural [10].

Thermal band is used to compute Land Surface Temperature (LST). Study of the LST helps to understand the effects of the temperature on the climate and it is also helpful for analysis of drought severity. LST is also called as the surface skin temperature of the earth. LST is a very important variable required for a wide variety of applications for instance climatological, hydrological, agricultural, biochemical and change detection studies [11]. The NOAA-AVHRR is the most widely applied space borne sensor for investigating drought, using the combining power of the Normalised Difference Vegetation Index and Land Surface Temperature Index [12]. The NOAA-AVHRR has coarse resolution, which is not useful to analyse drought condition at small scale. Landsat provides high resolution imagery of 30m, which is helpful to identify the drought condition in block and villages.

Traditionally, Drought monitoring has been based on data gathered from local weather stations, which lack the spatial coverage needed for real time monitoring and classification of drought pattern [13]. The rainfall along with temperature is used to determine the soil moisture condition, it is a key component for growth of the plant. Hence, Vegetation growth pattern change due to changes in rainfall and temperature. High temperature and low soil moisture increase water stress level, which is the primary reason of crop failure [14]. Satellite based drought indicators are useful for identification of drought zone and its severity. The NDVI is a popular index used in worldwide for predication of drought [15]. The moisture condition and thermal condition of vegetation can be detected by VCI and TCI index respectively [16]. Low value of TCI index represents the vegetation stress due to high temperature. The high value of TCI index indicates healthy vegetation. The TCI is an important to identify the soil moisture stress due to the high temperature and it help to analysis the effect of temperature on vegetation health [17]. TCI represents the relation

between the actual value of temperature and the temperature that occurred in the potential (LSTmin) and Stress (LSTmax) crop conditions within the same period [15, 19].

II. STUDY AREA

Vaijapur is located in the scanty region of Marathwada. The entire agriculture of the Vaijapur tehsil has depended on seasonal rainfall. The population of the study area is 259601 as per 2001 Census. The average rainfall of Kharif season was 172.9 mm, 335 mm, of 2013, 2014 respectively.

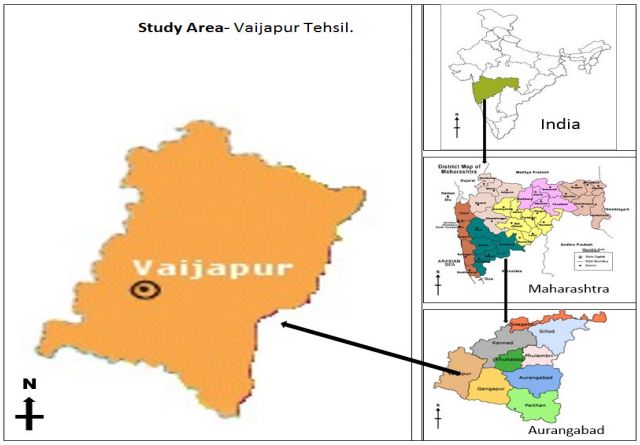

Figure 1. Study area source [19, 20, 21]

Vaijapur is located at latitude of 19°40' to 20°15' north and longitude of 74°35' to 75°00' east, covering an area of approximately 1510.5 sq. km which is shown in Figure 1 and fall in the Survey of India Toposheet No. 47 I/9, 47 I/13, and 46 L/16.

III. DATASET

Rainfall and Temperature data are collected from the Indian Meteorological Department portal. We have downloaded Landsat 8 satellite images from the United State Geological Survey (USGS) Earth Resources Observation and Science (EROS) Centre Landsat archive. The Landsat archive provides data through earth explorer web application developed by USGS. The Landsat archive provides Landsat 8 OLI and TIRS sensor data of Level 1 Terrain corrected (LT1) product. The Landsat product available in GeoTIFF file format in Universal Transverse Mercator (UTM). Landsat 8, data are available to download publicly, which is Geo-rectified and located in the standard Worldwide Reference System 2 (WRS2) grid.

Table 1. The dataset used for research study.

Landsat 8 Dataset			
Sr. No	*Path/Row*	*Year 2013*	*Year 2014*
1	147-46.	June, July, August, September,	June, July, August, September,

IV. METHODS

The methodology was prepared on the basis of literature survey. In the present study, we have used meteorological data, and satellite data for vegetation study.

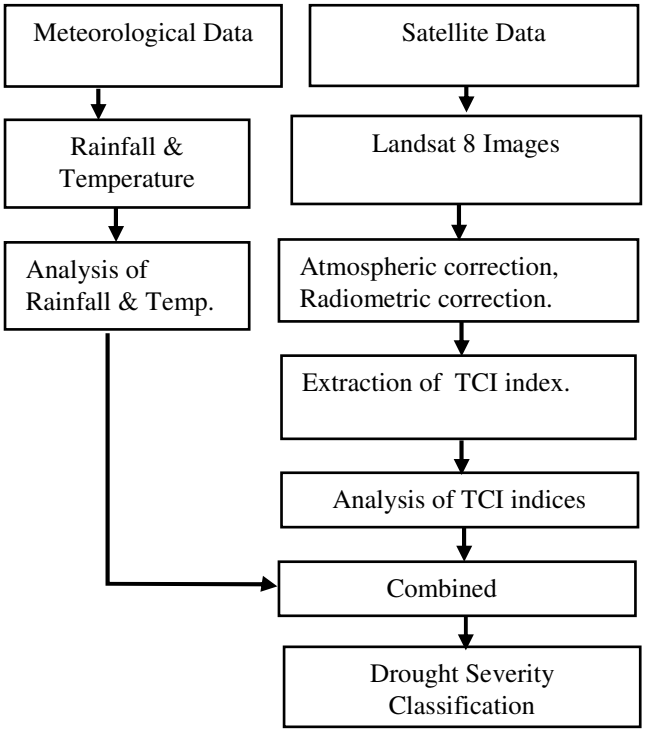

Figure 2. Methodology of research study.

Various factors need to quantify, such as radiometric correction, atmospheric correction. The present study investigates the relationship between rainfall & TCI in Kharif season of year 2013-2014. We have derived TCI from processed Landsat 8 images. Spatial model of TCI was prepared using spatial model tool available in ERDAS Imagine 2014 evaluation version. We have used ArcGIS 10.2.2 tool for preparation of maps.

A. *Pre-processing of Landset8 Dataset*

For satellite image preprocessing, we have used ATCOR algorithm which is used to extract the correct ground reflectance value of removing atmospheric noise. The ATCOR (ATmospheric CORrection) uses lookup tables based on MODTRAN4 [22]. The many versions of ATCOR were developed for preprocessing of satellite imagery [23, 24]. ATCOR 2 is used for flat terrain while ATCOR 3 handles, rugged terrain by integrating a DEM. [22, 25]. ATCOR 4 perform the combined atmospheric and topographic correction accounting for the angular and the elevation dependence of the atmospheric functions and

calculate surface reflectance and surface temperature based on the Geo-coded and ortho-rectified imagery [22, 26].

V. SATELLITE BASED DROUGHT INDICES

The satellite based drought indicators are widely used for identification of agricultural drought severity level [23, 24, 25, 26]. The range of severity level of satellite based drought indicators is shown in Table I.

Table 1. Drought Indices Range. Source [23].

Drought indices range				
Index	*Range*	*Normal*	*Severe*	*Healthy*
TCI	0 to 100%	50%	0%	100%

A. Temperature Condition Index.

The TIRS data are referred to as Landsat 8 "Band 10" and "band 11", which is corresponding to 10.9UM, and the 12.UM channels, respectively [27]. TCI is based on thermal data of band 10, band 11 of Landsat 8. The TIRS data have converted to brightness temperature (BT) using ACTOR. The TCI is used to compute temperature related vegetation stress [28, 29]. It is defined as Equation (1).

$$TCI = \frac{(BTmax - BT)}{(BTmax - BTmin)} * 100 \quad (1)$$

Where, BT, BTmax and BTmin are the brightness temperature derived from thermal data. Above formula shows a different response of vegetation to temperature. The range of the BT value measures in percentage. The 100% value of TCI indicates that healthy vegetation and value is less than 50% indicate the different degree of drought severity[30,31].

VI. RESULT AND DISCUSSION.

This research study reveals the drought severity condition by analysing Landsat 8 satellite imagery of Monsoon year 2013 and 2014. This multi-date Landsat 8 imagery is helpful to understand seasonal and spatial characteristics of Vaijapur tehsil.

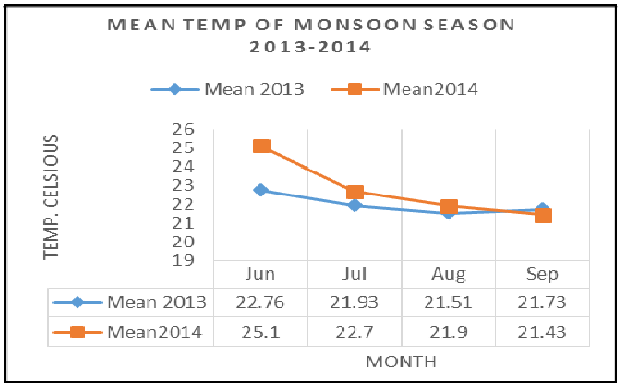

Figure 3. Mean Temperature of Monsoon Season.

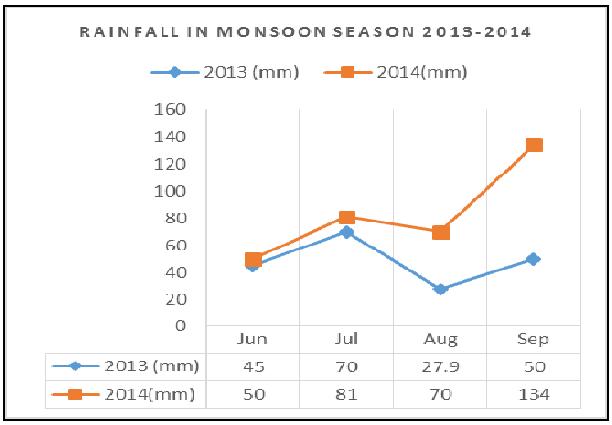

Figure 4. Rainfall during Monsoon Season.

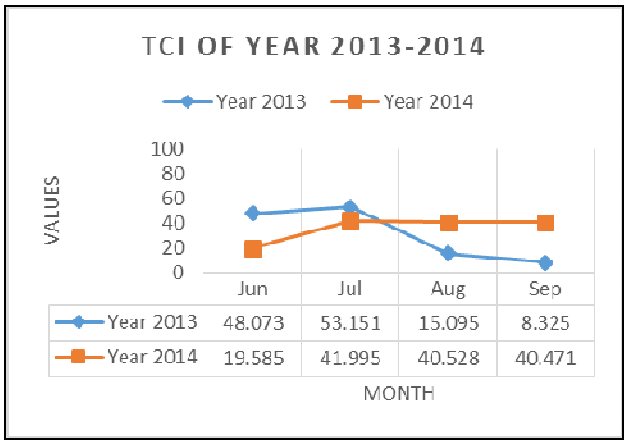

Figure 5.TCI values of year 2013 and 2014.

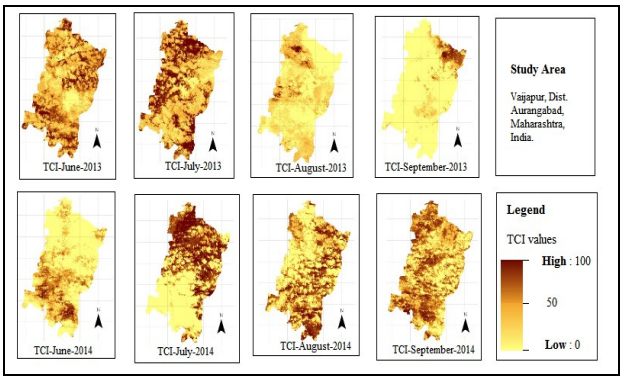

Figure 6. TCI images of Study region.

The agricultural businesses are depending upon rainfall and temperature. Figure 4. Shows that, in the month of June, the rainfall was much below the average monthly rainfall. The entire tehsil was suffering from a drought condition in June-July month, so that Kharif crop was affected by drought severely. Due to further lack of precipitation in the month of July, the crop could sow and those sown have been badly affected by lack of water.

The high value of TCI index indicates that the healthy condition of the crop. The TCI value of the year 2013 and 2014 are below the normal range. Figure 4, Shows that rainfall in Kharif season of year 2013 and 2014. Since the rainfall was less than normal, temperature remains high, as a result low TCI values are 15.095, 8.325 in year 2013found in August, September respectively. The value of TCI was less than 50 % in June, July and August month, i.e. crop health was below the normal which is shown in figure 6. The high value of TCI index indicates the healthy condition of the crop. The TCI value of the year 2013 and 2014 are below the normal range. The value of TCI in June 2014 was 19.585, which lowest in Kharif season, i.e. indicates that June month was affected by extreme drought. The value of TCI of the month July, August, September of 2013 was lower than 2014, which is indicating that year 2013 was affected by extreme drought than year 2014. The TCI variations show that, in the months of June, July, August and September the crop was stressed and conditions of drought have developed.

VII. CONCLUSION

- The TCI shows the variations in June, July, August and September it indicates that the crop health was stressed and conditions of drought have been developed.
- The value of TCI was 19.585 in June 2014 which was low in the beginning of Kharif season. The value of TCI of the month July, August, September of 2013 was lower than 2014, which is indicating that year 2013 was affected by extreme drought than year 2014.
- It is observed that, the rainfall in June month was less than 50mm in year 2013-2014, which is not enough to sow Kharif crop in the study region. It is observed that the farmer has sown twice due to failure of crop or late arrival of monsoon rain in the year 2013.
- Landsat 8 TIRS data can be used for temperature study of small regions like village and tehsil because of its high resolution.
- It is observed that, rainfall throughout the Kharif season was below the average, so that it is responsible to generate drought condition in the study area. Hence it is proved that Landsat 8 Thermal Infrared data can be used for drought severity identification.

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