WATER SCARCITY ANALYSIS USING GEOSPATIAL DATA AND RANDOM FOREST

Abstract

The climate change is responsible for the various disasters including the tsunami, flood, earthquake, and drought etc. Drought is most dangerous disaster which affects the billions of the peoples on the earth. It leads to the water scarcity problems in the regions. Therefore, the water demand hikes in the regions. Similarly, the unavailability of the water for the domestic, industry, and agriculture sector affects the national development. The region was faced a normal drought condition in a year 2016. Due to satisfactory rainfall was received in the region, therefore, next two years, the region does not face a problem of the water scarcity. Conversely, in the year 2019, the region was received the lowest rainfall in the 5 years, so that, the region was faced high severity of the drought conditions. Such type of conditions are responsible for the water scarcity problem in the region. The SPI was calculated by using the historical time series data of the 39 years from 1981-2019. The SPI value (1.14) for the year (2015-2016) shows normal drought. In contrast, the SPI value of -1.22 shows extreme drought because of the rainfall deficiency in the year 2019. The entire region was affected by the worst meteorological drought disaster in the year 2019 compared to 2016, which is mainly responsible for the water scarcity problems in the area. The LULC analysis shows that the vegetation cover was positively affected due to deficient rainfall in the year 2019. The second dominant area was fallow land which was increased by 23771H in 2019.

Keywords: LULC, Random Forest, SPI, Water Scarcity, Atmospheric correction

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I. INTRODUCTION

Water scarcity is a natural phenomenon which reoccurred in every climatic division of the world. Therefore, the millions of people's livelihood affect severely due to hydrological drought (Bhuiyan et al. 2008, Hao et al. 2013). The drought is classified into the three categories such as meteorological, hydrological and agricultural drought. The erratic rainfall behaviours or rainfall deficiency lead to the meteorological drought conditions (AghaKouchak et al. 2015). moreover, low rainfall leads to the reduction in the soil moisture. Therefore the crop cannot sustain the good health due to reduced soil moisture in the field such type of phenomena is known as agricultural drought(Wilhelmi & Wilhite 2002). The deficiency of rainfall is responsible for the reduced streamflow and unavailability of the surface water.

Such types conditions create the scarcity of water for drinking and irrigation, which leads to the hydrological drought. The monitoring and assessment of the drought are essential for the planning and decision making support to the government and non-government agencies. WMO (World Meteorological Organization) and IMD(Indian Meteorological Department) of India have recommended monitoring the meteorological drought can be effectively carried out using the drought indices like SPI (Standardize Precipitation Index), NDVI (Normalized Difference Vegetation Index)(Hayes et al. 2011, Wong et al. 2013).

The SPI was developed at Colorado state university, USA in the year 1993 which is useful for the rainfall analysis in every climatic division (McKee 1995, Naresh Kumar, et al. 2009, Livada, & Assimakopoulos et al. 2007). It provides the output at various time scales like the short term and long term scale by analyzing the historical rainfall dataset. The short-term interval is used to analyses the soil moisture. In contrast, the longer term is used to analyses water scarcity through the monitoring of water level of the river, reservoir, lake, and groundwater of the region (Hayes 1999). Therefore, the SPI is useful to analyses the land cover of region, monitoring and mitigation planning of the drought disaster (Hayes et al 1999). Similarly, the satellite provides the periodical observation of the earth, which is significantly useful for natural resource monitoring and change analysis. Various popular satellites provide periodical observation with the sizeable historical dataset of the earth surface such as MODIS (Moderate Resolution Imagining Spectroradiometer), AVHRR (Advance Very High Resolution Radiometer), Landsat, Spot, AWIFS, and Sentinel constellation the satellites (Rogan, & Chen, 2004, Reis 2008). In which, the sentinel series is a current constellation of the microwave (Sentinel 1) and Optical Remote Sensing(ORS) satellites (Sentinel 2A, 2B, 3). The microwave remote sensing satellite provides all-weather observation of the earth surface, which is highly useful for the defense- related application. Nowadays, it is also useful for agriculture applications like soil moisture monitoring, crop monitoring, irrigation management etc. (Ferraro et al. 1998). Generally, the optical RS satellite provides the observation into various bands like VIS (Visual infrared), SWIR (Shortwave Infrared) region of the electromagnetic spectrum. Therefore, it is significantly useful for the LULC change analysis which is essential for planning and decision making in various operations like settlement planning, disaster mitigation, agriculture, barren land estimation etc. (Treitz, & Rogan 2004, Chauhan, & Nayak, 2005, Yan et al. 2006, Merem, & Twumasi 2008). It has beneficial application for the agricultural like crop health monitoring, irrigation, crop acreage, yield estimation (Bastiaanssen et al. 2000, Ray, & Dadhwal 2001, Lakhankar et al. 2009, Wang & Qu, 2009; Doraiswamy et al., 2010).

1. **Remote Sensing:** Remote sensing is a significant technology for the human race, because it is actively used for the earth observation and exploration of the life in the universe. It is science of observation without being in a physical contact. It observes the objects through the sensors and analyzed the captured information through the specialized software's. The basic principle of the remote sensing and its utilization has explained in the figure 1.

2. **Energy Source:** The energy source is required for the object analysis because every object has a properties like transmission, emission, reflectance of the energy. The sensors is used to capture the reflectance of the objects. The sensors can be mounted on the satellite, balloons, or vehicle which provides the valuable information to the receiving stations. The Sun is a known as the natural sources of energy therefore the passive remote sensing sensor capture the reflected radiation from the objects. But the in the active remote sensing, the sensors uses its own source of the radiations to illuminate the objects.

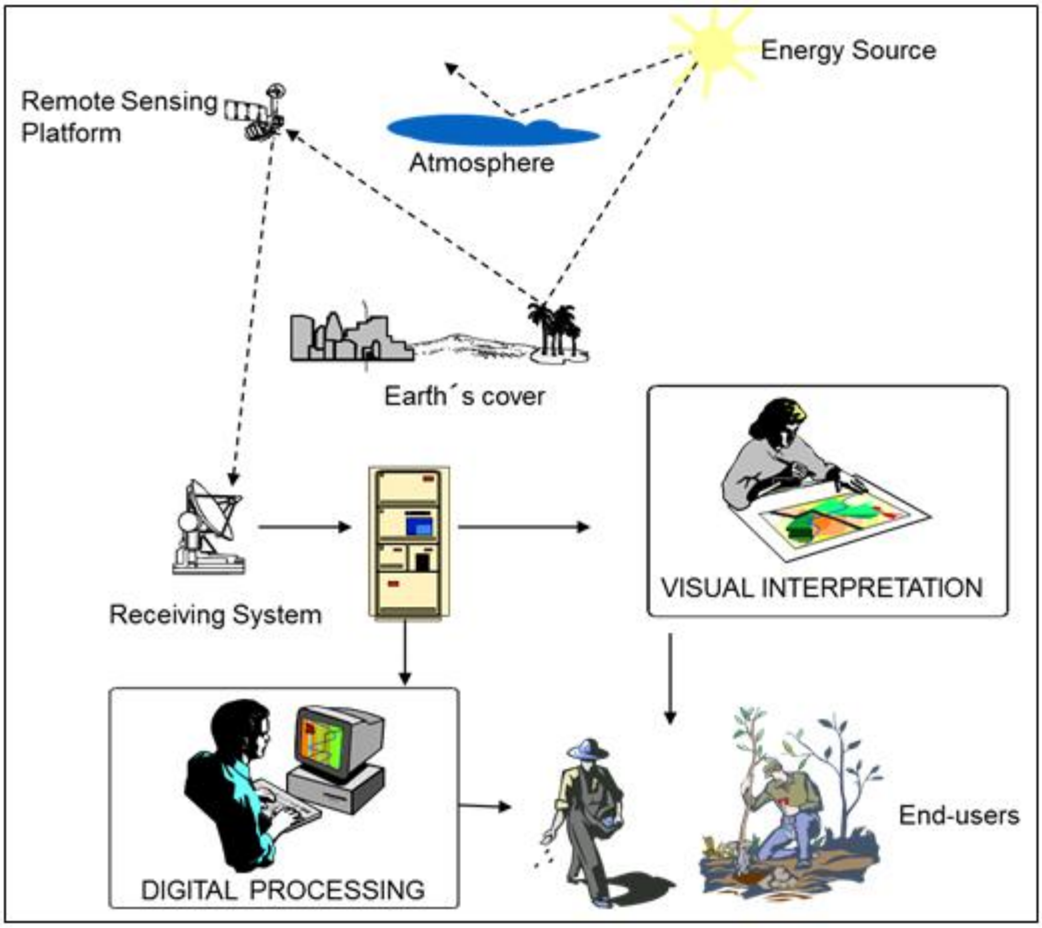

Figure 1: Elements of Remote Sensing

3. **Atmospheric Interaction:** The earth atmosphere helps to protects the man kind from the dangerous high frequency electro-magnetic radiations like gamma, X-ray, and Ultraviolet rays. It is composed of various layers of Ozone, water vapours, clouds and dusts. The sun energy is reflect, absorbed and scattered due to atmosphere when it reached to the surface of the earth and similar phenomena happens when it reached to the satellites.

4. **Earth Surface Interaction:** The earth surface absorbs the radiations to and from the object. It allows the specific range of the spectrum of the energy.

5. **Sensor:** The sensors are an electronic component which are specifically developed to capture the specific parameters of the objects. It can be mounted on satellite, vehicle or balloon based platform to capture the radiation from the earth surface.

6. **Earth Receiving Station:** The earth receiving stations are deploy to capture the data from the satellites. The station also provides the primary pre-processing of the raw satellite data. Furthermore, the processed data will be available to the end users.

7. **Visual Interpretation and Digital Image Processing (DIP):** The preprocessed satellite data is used for various applications including government, and non-government agencies. The various DIP operations are performed for the specific need of the applications. The visual interpretation is an essential procedure for a many classifications related research applications.

8. **Application:** The is a last element of the remote sensing elements is known as application. It is directly useful for the end users and stake holders of the organizations. Now days, the satellite remote sensing are useful for the many applications likes agricultural, ocean monitoring, disasters analysis, navigations, monitoring of the environment, artificial structures development, defense etc.

   It's an essential for the planning and decision making during the disaster like drought, flood, earthquake, tsunami.

II. WATER SCARCITY

The water scarcity is caused by the deficiency of the rainfall in the region. The regional response over the drought like conditions helps to decides the severity of the disaster. The drought is complex disaster which is occurring the in any part of the world.

According to Palmar, (1965), "Drought is an interval of time, generally of the order of month of the year in duration during which the actual moisture supply at a given place rather consistently falls short of the climatically expected or climatically appropriate moisture supply" (palmar, 1965).

The vegetation growth is directly proportional to the soil moisture and weather conditions. Therefore, vegetation cover is highly useful for the identification of drought event, and it can be helpful to understand the water stress condition in prolonged area (Dong Jiang et al. 2013). Scanty or irregular rainfall reduces soil moisture level which is responsible for the reduction in the agricultural productions (Patel N.R. et al. 2012). The water scarcity arises due to meteorological and hydrological drought conditions in the region.

- **Meteorological or Climatological Drought:** The meteorological drought can be recognized on basis of historical rainfall data of the region. India receives the 73% rainfall during the monsoon season. If the rainfall received less than the threshold then regions start facing the various problems like water scarcity, low agricultural productions, migrations of the workers and imbalance the social harmony (J.O. Ayoade 2004).

- **Agro-meteorological or Agricultural Drought:** It is described in terms of crop failure when soil moisture is depleted highly so that reduction of the crop yield occur in the region (Lu Hao 2012). The Agriculturalist perspective of drought is that, when soil moisture is unavailable through precipitation or soil is inadequate to ensure ideal crop growth in the region. (J.O Ayoade 2004, T. Murali Krishna 2009).

- **Hydrological Drought:** It is occurring due to scarcity of the surface water or ground water for the normal operations in particular region (Mishra and Desai 2005). The hydrological drought is as a result of low or unviability of water flow in rivers and drainage. Hydrological drought has been defined in various research studies conducted by many researchers and the scientific community. It is defined as a significant reduction of water in the availability of water in all of its forms, i.e. Surface water, Stream, Lake, Reservoir and Ground water (I. Nalbantis · G. Tsakiris, 2009, Dalezios 2012). Now days, increasing population and national development is causing the high supply of the fresh water. Therefore, it is necessary for all countries to improve their capacity to manage water supplies during water-short years (Dalezios 2009).

- **Socioeconomic Drought:** The impact of droughts are defined in terms of loss from an average or expected return and can be measured by both social and economic indicators. The socio economic drought as observed in the case of Wilhite and Glantz (1985), is said to occur as a result of physical water shortage that ends up affecting people at individual scale. The greater demand for commodities than the supply of economic good may cause to worsen the situation.

Impacts of Water Scarcity: Deficiency of water is responsible for reduction of soil moisture from the cropland, so that crop production level minimizes. Droughts affects the reduction in a forest productivity, ground water, level, wild habitat, fish habitat, agribusinesses, farming, inflation rates and increases wild fire, water scarcity, migration, crimes, unemployability in the region (Khalil1 A. A 2013;Wilhite 2007, Riebsame, Changnon, and Karl 1991; Wilhite 2000; Mishra and Singh 2010) such type of the problems produce the negtative impact over the economy, environment and society(Wilhite 2007, Ning Zhang 2013).

- **Economic Impacts:** Scarcity of the water for the industry, domestic sector are responsible to slower down the national GDP growth (Murthy 2009). Therefore, management of the such type of disaster is become the priority of the nation.

- **Environmental Impacts:** Drought is responsible for the severe environmental impacts like soil erosion, water turbidity, degradation of the soil fertility etc. (Ali Akbar Shamsipour 2011). Similarly, the forest fire can be increases due to increment in the ambient temperature. Finally, such types of events are also responsible for the severe climate change on the planet (Merem et al. 2008).

III. STUDY AREA

Vaijapur is a taluka in Aurangabad district of Maharashtra state, India. Also, it belongs to Marathwada region which is known as drought prone area of the state. Vaijapur tehsil which 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, it is shown in figure 1.1. the average rainfall is 500.20mm whereas the average temperature ranges between the 34 ° C to 42° C. the Vaijapur is situated on the elevation of the 514m (1,666 ft.) above the sea level. The total 1,54,378 H. are the area of the Vaijapur whereas 1,21,830H area comes under the agriculture. Similarly, the Narangi Dam, Bordahegaon dam, Shivana Takli, Manyad, Bhatana, Kolhi Dams are the main source of the water for drinking and irrigation of the agricultural. The water level of the dam is depends upon the rainfall received in the monsoon season. The Toposheet no 47 I/9,47 I/13, 46 L/16 are used for the research study. Figure 2 shows the study area of the Vaijapur tehsil.

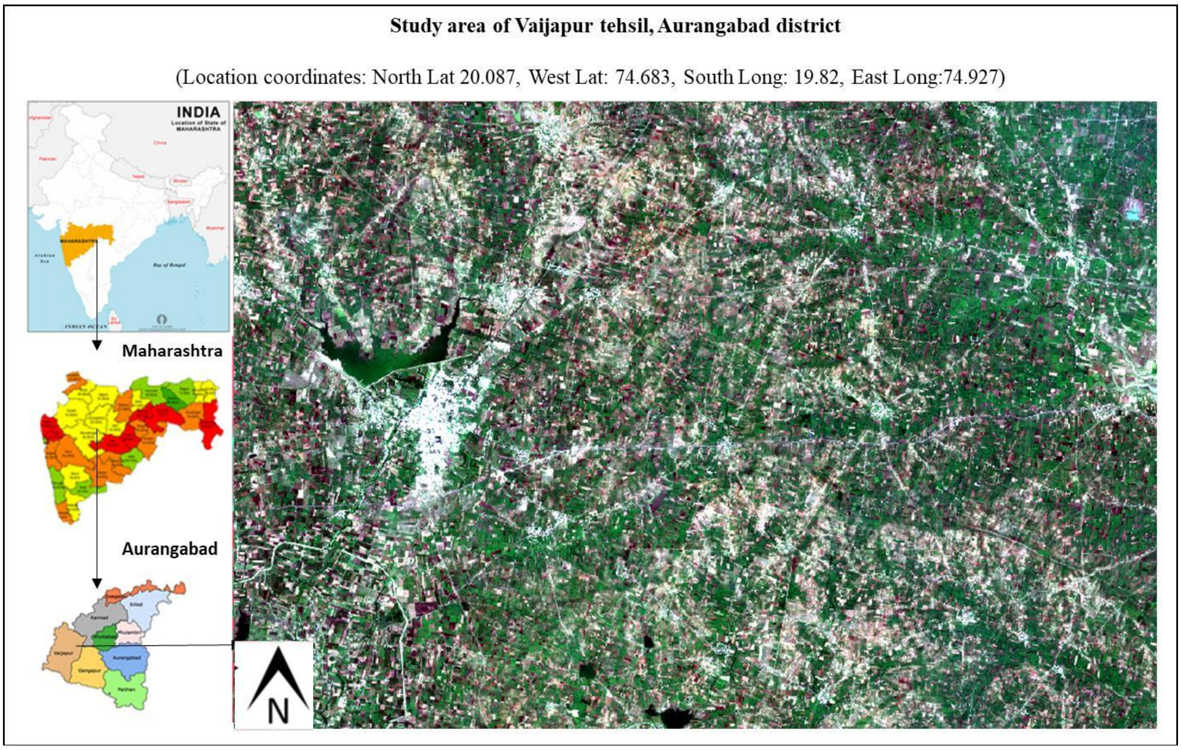

Figure 2: Study Area of the Vaijapur Tehsil

IV. VEGETATION INDICES

We have conducted the detailed literature survey before the carried out the research study. The literature survey helps to understand the progress of the researchers to solve the particular research problems. Similar, it also help to choose the right algorithms and techniques which is essential for the formulations of the methodology. We have reviewed the standard books and reputed publications from IEEE, Elsevior, Springer, Tyler and Francis. Following sections explore the various indices and classifications techniques for the analysis of the water scarcity.

1. **Dataset:** In this research study, the ancillary, precipitation, Toposheet, satellite and ground truth dataset was used for the investigation of the water scarcity affected region. The dataset information is shows in the table no 1

Table 1: Data Source Information

Data Sources			
No	**Dataset**	**Source**	**Detail**
1	Ancillary Dataset	http://mahaagri.gov.in/cropwatch	Government reports
2	Precipitation dataset	http://maharain.gov.in/	Time series dataset of the rainfall
3	Toposheet	http://surveyofindia.gov.in/ and SOI Office, Pune, Mah, India.	Toposheet of area, SOI office
4	Ground Truth data	GeoMapper APP or ODK collect app	It's an android app for the data collection.
5	Satellite dataset	https://scihub.copernicus.eu/	Sentinel 2 satellite dataset

- **Ancillary dataset:** Ancillary dataset includes the government reports, weather and ground truth information which is helpful for the experimental work and accuracy assessment.

- **Meteorological Dataset:** For this research work, the precipitation dataset was acquired from the government portal (http://www.maharain.org/met_data/). The weekly, monthly, and yearly statistics for the research purpose is available in the CSV(Comma Separated Value) format. The government has installed a AWS (Automatic Weather Stations) at revenue clusters of the Vaijapur region. Such types of dataset is an imperative for water scarcity related research study.

- **Toposheet:** The Toposheet no 47 I/9,47 I/13, 46 L/16 were procured from the SOI (Survey of India) office, Pune, Maharashtra, India. Toposheet is useful for the geometric correction of the satellite image. Additionally, it is also used to understand the topography of the region.

- **Ground Truth Dataset:** The Ground Truth (GT) points are essential for the water scarcity or drought research work. It includes the periodical observation of the region. Traditionally, the researchers uses the GPS (Global Positioning System) instruments and notebook to records the GT points during the field campaign. Now days, smartphone applications provides the better accuracy and management of GT data during the field campaign (MacDonald et al., 2016; Wittwer, & Griffith, 2011). The App can records the photographs, GPS (Global Positioning System) coordinates, land cover types and extra information related to the objects. (Hayes et al.,2005; Sreedhar et al., 2012).

- **Satellite Dataset:** ESA (European space agency) has launched a sentinel constellation of satellites for the various missions. In which the sentinel 2 multispectral satellite imagery is use to observe the earth in high spatial resolution. The sentinel 2 is a twin satellite A, B, which provides the high revisit time of 5day in a 13 spectral bands. It provides the data in various spatial resolutions like 10m, 20m and 60m spatial resolution with 290km swath area. Table 3.2 Showed that, the sentinel bands details. The sentinel 2 is a based on optical remote sensing which provides the data in a cloud free conditions in a day time. The data is available to download from the scientific hub and earth explorer USGS portal. The satellite imagery is free of cost available for the research purpose and scientific applications (Battude et al., 2016).

2. **Methodology:** Figure 3 shows the methodology of the conducted experiment. We have used rainfall and sentinel satellite images for the experimental analysis.

- **Meteorological Data Preprocessing:** Total 39 years (1981-2019) of monthly rainfall was stored into the CSV(Comma Separated Values) format. Furthermore, these information is given to the DrinC software which is used to computes the SPI index.

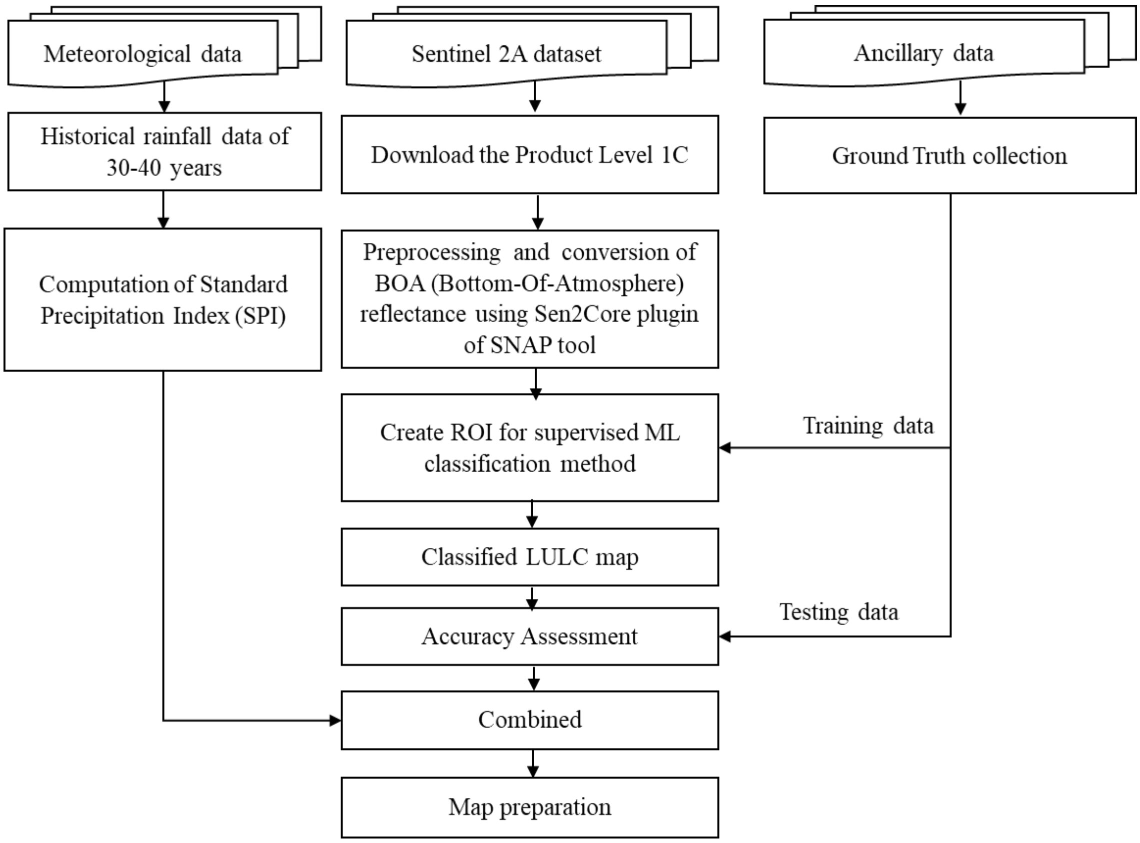

Figure 3: Methodology Used in the Present Research Study

- **Standardized Precipitation Index(SPI):** The standardized Precipitation Index(SPI) is based on the gamma density function, which analyses the short term and long term meteorological drought episode of the region. The SPI is a primary variable in the early drought monitoring system (Sobral et al. 2019). The THOM method (Thom 1958) was used for the computation of the β and α parameter. In contrast, the αi indicates the yearly rainfall values. Moreover, the cumulative probability F(αi) at αi precipitation was computed using the gamma cumulative distribution function. Finally, the conversion of F(αi) to a standard normal random variable (SPI values) along with the calculated mean value to the zero(0) and variance to one (1) was noticed. The SPI provided the range of +2 to -2, including the seven classes, which indicated the meteorological drought category. The positive values show the normal to wet condition, whereas negative values show the normal to extreme dry condition.

Table 2: SPI Criteria

SPI Range	Drought classes
2.0to +∞	Extremely wet
1.5 to 2.0	Very wet
1.0 to 1.5	Moderate wet
-1.0 to1.0	Near Normal
-1.5 to -1.0	Moderate drought
-2.0 to -1.5	Severe drought
-∞ to -2.0	Extreme drought

- **Satellite Data Preprocessing:** The results were analyzed for the investigation of the meteorological droughts with the help of Sentinel satellite imagery. The SNAP (Sentinel Application Platform) software tool was used to preprocess and classify the satellite image dataset. The preprocessing operation includes the atmospheric, radiometric and geometric corrections of the Level 1C product images. The sen2core plugin of the SNAP was used for the preprocessing of sentinel images. The TOA (Top-Of-Atmosphere) values convert into the BOA(Bottom-Of-Atmosphere) which is known as the Level 2A product level of the sentinel.

- **Ancillary Data for Training and Testing:** The training and testing data was created by using the Ground Truth (GT). The GT data was recorded during the field campaigning in the area. These information is used for the creation for the ROI (Region of Interest) of the spatial features. These information is helpful for the identification of classes. Furthermore, the Supervised classifier uses the ROI as a training data for the classification. Finally, the accuracy assessment is used to validate the accuracy of the classifier by using the testing data.

- **Supervised Random Forest (RF) Classification:** Breiman has invented the classification and regression tree technique called as Random Forest. It creates the random and iteratively sample data and variables to generate a large group of points which is known as the forest of classification trees. RF is based on ensemble learning technique and built upon multiple decision trees(DCT). Each DCT is developed using the original training dataset of subset, which is validated by the remaining part of training features of the algorithm. RF work as similar to the Maximum Likelihood (ML) classifier where it creates the cluster of data based on similar spectral values. RF required the two essential parameters like (i)Input file (ii)number of trees, (iii)the maximum number of samples per class (default value is 5000) (iv)vector training (v) feature band selection. The RF is based on the Gini index as attribute selection measure, which measures an attribute's impurity with respect to the classes.

- **Land Use Land Cover:** The Land use is defined as total land used by human being from the total land cover of the region. The LULC is an important for the decision making and policy development for the region. These information is very crucial for the government agencies and non-government agencies. Furthermore, the government utilizes the information for the disaster analysis and mitigation strategies.

V. RESULT AND DISCUSSION

1. **Water Scarcity Analysis:** In the year 2016, the study area was received 612mm rainfall in the monsoon season. Figure 4 shows the SPI value -0.46, which indicate the normal drought condition in the area. Therefore, the year was declared a normal drought year by the government of India. Consequently, a total of 358mm rainfall was received in a 2018 and 540mm in 2019, which is extremely low for two years. Such type of condition created the water scarcity problems in the entire region. The SPI value -1.22 shows that the area was affected by severe drought conditions.

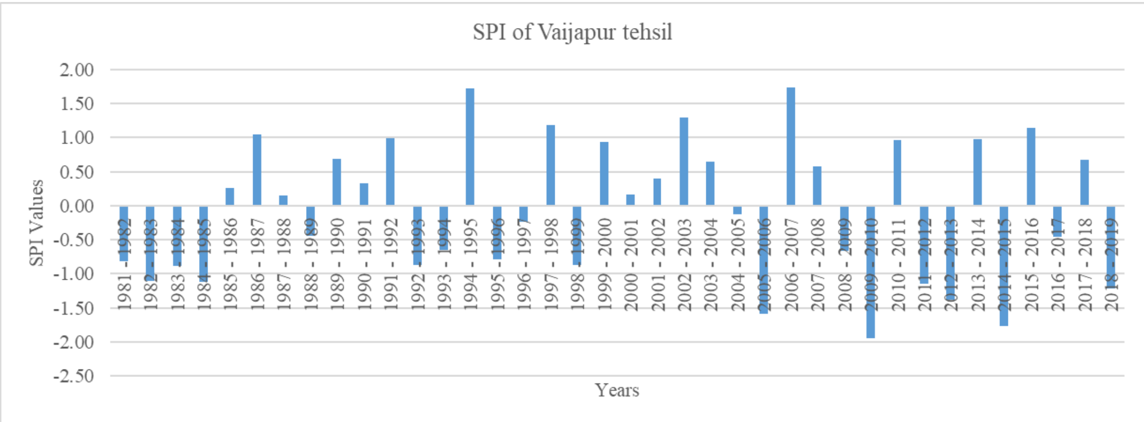

Figure 4: SPI of Year 1981-2019

The results shows that, the drought episosed recoccured in every 4-5 years which means the region is vulnerable to the drought conditions. During the field campaign, we have noticed that, quality of the soil and water was dastically damaged due to high frequency of the drought disaster. Such type of condition damages the vegetation cover of the region. The agricultural sector was faced many problem during the cultivation of the Kharif and Rabi crops. The entrie agriculutral sector of the tehsil is based on the monsoon rainfall. Therefore, the network of the canal, river and water reservior are purely depend on the rainfall received in a rainy days. It is also seen that, the year 2008 to 2018, the region has faced 7 extreme drought years, which is responsbile for the distirbance of the land cover of the region. The drought of 2009, 2011, 2018, were the worst drought years among them. Such types of cacadening events of the drought is highly responsible for the water scasity problem in the region. The deficency of the water is directly responsible for the reducition in a agricultural productions. Furthermore, the regional vegetation cover has dastically damaged due to unavaibility of the water.

2. **Analysis of the Land Cover Using Satellite Remote Sening:** For this research study, we have used the sentinel satellite dataset. The image is converted to the FCC(False color composite) for the visual interpretation. The visual interpretation provides the valuable

information by highliting the spatial features of the objects like water, vegetation, bare soil, barren land and dense forest.

Figure 5: FCC Image of the 2016

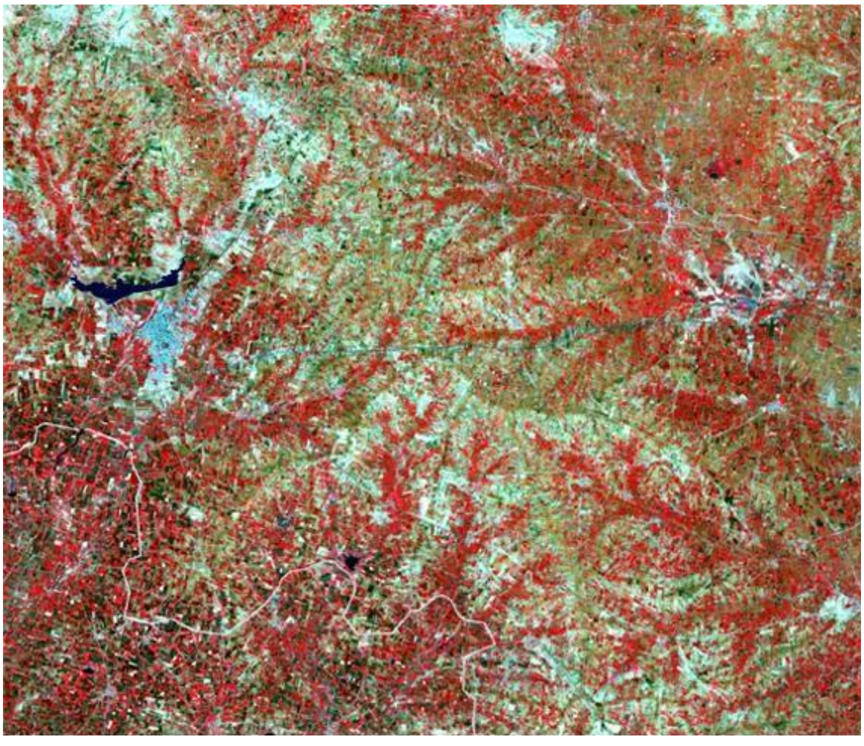

Figure 6: The FCC Image of Year 2019

Figure 5 show the FCC image of the study area of the year 2016. The color of the FCC are the oppposite to the NCC(Natural Color Composite) image, whereas red color indicate the vegetation, black or dark blue shows the water, green color shows the bare soil, and cyan color shows the bare stone or residensial area. The barren land or fallow land is showed by the fainth green color. The dams are clearly visible in the year 2016, where as many ponds and small dams are barely visible due to unavaibility of the water or small amount of turbid water. The avaibility of the water is responsible for the increment of vegetation or agricultural crop cover. In Figure 5, shows the presence of the vegetation in a red color, whereas, the figure 6. Shows the sparce vegetation is in the region. Similarly, the soil is exposed more due to loss of vegetation cover which includes the crops and grass on the barren lands. We have observed the changes during the field campaign in the area.

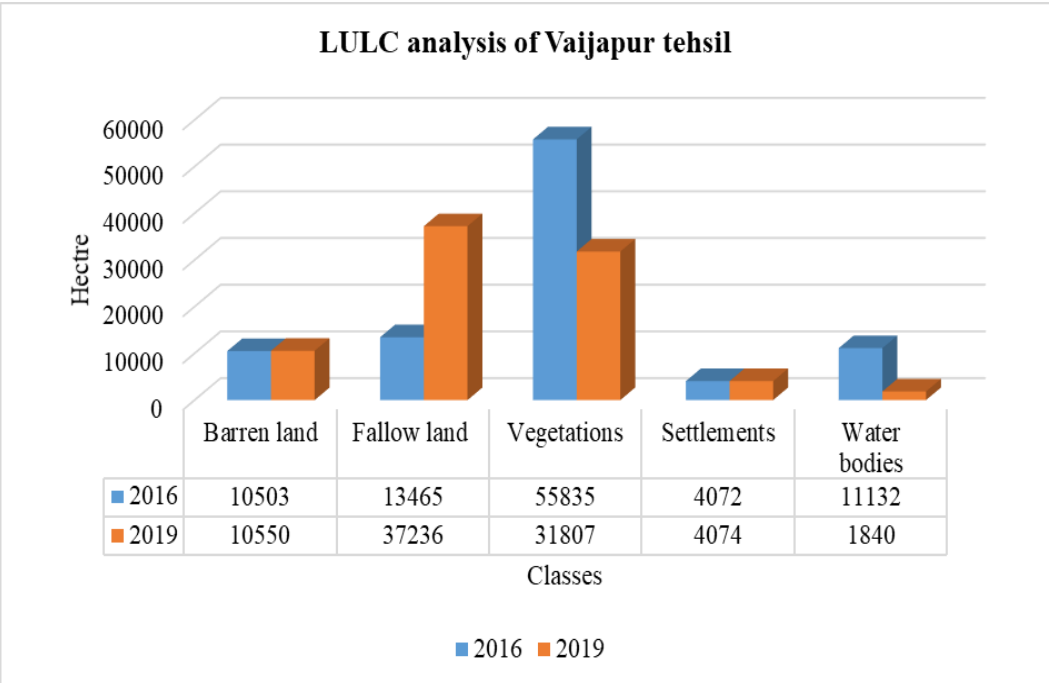

Figure 7: LULC Classification Using Random Forest (RF) Classifier

Figure 7 shows the obtained result of the RF classifier. The minor changes are found in the settlement class and barren land class in 4 years because there is massive constructions were observed in the region. The most of the area comes under the rural region therefore, the changes were negligible for the classification. The barren land class is a non-fertile or non-cultivated land for the agricultural sector. Generally, the barren land can be utilized for the agricultural after the proper establishment of the canal network or irrigation management program.

However, significant changes were found in the fallow land, vegetation and water class. These land cover classes are susceptible to the amount of rainfall received in the region. In 2016, the fallow land was classified as 13465H, which was highly increased by the 23771H in the year 2019. The sowing was partially completed, or sown crops were damaged due to the deficient rainfall.

Therefore, the agricultural productions were steepest declined in 2019. Total 55835H area was classified as the vegetation cover in the 2016 and 31807H in 2019, which shows that the total 18599H vegetation cover was utterly damaged due to water stress. These changes are clearly visible in a figure 5,6, 8. Similarly, the water bodies were classified as 11132H in 2016 due to sufficient rainfall in 2016. However, in the year 2019, the total 1840H area was classified by the classifier. Figure 8 (A)(B) shows the classified map of the year 2016 and 2019, which clearly, shows the land cover changes in both the year.

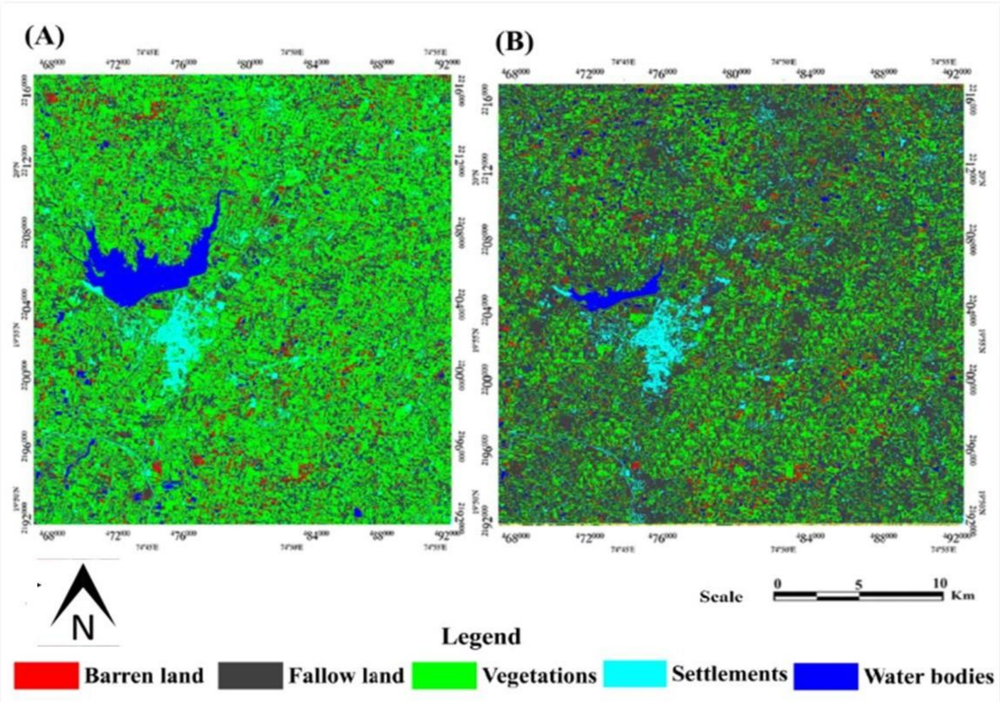

Figure 8: (A) LULC Map of 2016 (B) LULC Map of 2019

3. **Accuracy Assessment:** Accuracy of the RF method was accessed using confusion matrix, which is useful for assessing the classifier (Vibhute et al. 2016; Gaikwad et al. 2019). In this research study, we have computed the Overall accuracy (OA), producer's accuracy (PA), user's accuracy (UA) and Kappa values of the year 2016-2019. It is shown in Table 2. The RF method's overall accuracy was determined to be approximately 92% with a Kappa coefficient as 0.9 for 2016. Alternatively, corresponding values of accuracy and Kappa coefficient were 88.69% and 0.85 respectively for 2019. The fallow land and barren land has showed the low accuracy in the classification due to the pixel mixing problem. If it found that, the spectral characteristics of the soil is same in a both class therefore, the classifier could not class the both the classes due to the similar pixel values. Similarly, these classes can be mixed with the settlement due to the similar spectral values of the concrete, bare stones area in the region. It is also found that, the north side of the region has a hill region with the stone area. The vegetation and water class generate the higher accuracy due to distinct feature of the spatial objects.

Table 3: Error Matrix

Error Matrix												
Class	**Barren Land**		**Fallow Land**		**Vegetation**		**Settlements**		**Water bodies**		**Total**	
	2016	2018	2016	2018	2016	2018	2016	2018	2016	2018	2019	2018
Barren land	130	120	16	26	0	0	0	0	0	0	146	146
Fallow land	15	35	150	130	0	0	0	0	0	0	165	165
Vegetation	10	5	0	0	140	145	0	0	0	0	150	150
Settlements	0	0	20	20	0	0	130	130	0	0	150	150
Water bodies	0	0	0	0	0	0	0	0	150	150	150	150
Total	155	160	186	176	140	145	130	130	150	150	761	761
PA (%)	83.87	75	80.64	73.86	100	100	100	100	100	100		
UA (%)	89.04	82.19	90.9	78.78	93.33	96.66	86.66	86.66	100	100		
Overall accuracy-2016 =91.98%, 2019= 88.69, Kappa Value-2016=0.9, 2019=0.85												

VI. CONCLUSION

The region was faced a normal drought condition in a year 2016. Due to satisfactory rainfall was received in the region, therefore, next two years, the region does not face a problem of the water scarcity. Conversely, in the year 2019, the region was received the lowest rainfall in the 5 years, so that, the region was faced high severity of the drought conditions. Such type of conditions are responsible for the water scarcity problem in the region.

The SPI value (1.14) for the year (2015-2016) shows normal drought. In contrast, the SPI value of -1.22 shows extreme drought because of the rainfall deficiency in the year 2019. The entire region was affected by the worst meteorological drought disaster in the year 2019 compared to 2016, which is mainly responsible for the water scarcity problems in the area. The LULC analysis shows that the vegetation cover was positively affected due to deficient rainfall in the year 2019. The second dominant area was fallow land which was increased by 23771H in 2019. The land cover is a highly vulnerable to the drought conditions due many reasons like less forest, low canal network, improper cultivation practices, poor management of water for the irrigation and drinking purpose in the region. The crop land of the entire region is based on the rainfall therefore, farmers, could not sow the crop in a Rabi season.

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