Journal of Hydrosciences and Environment
Available online at http://jhe.usb.ac.ir/

ISSN: 2345-5608

The Evaluation of Spatial Variations of Vegetation and Surface Temperature by Using Remote Sensing (Case Study: Fars Province, 2017-1967)

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A R T I C L E I N F O

Article history:

Received: *13July 2018*
Accepted: *8 November 2018*

Keywords:
Vegetation changes,
Landsat,
NDVI,
LST,
MODIS,
Fars Province.

A B S T R A C T

It is crucial for environmental planning, land management, and sustainable development to be aware of the quantitative and qualitative characteristics of land changes. The use of vegetation maps is one of the important pillars of generating information for macro and micro planning. The present study employed the time and place of vegetation in Fars province. The data were derived from Landsat satellite data of OLI and ETM sensors for a 30-year period from 1986 to 2017, and the NDVI index was calculated. Moreover, quantitative values were classified for qualitative changes in vegetation. The index was classified into three groups: rich, poor, and vegetation-free. Temperature changes at the ground level were calculated using MODIS imagery for the studied period. The results revealed that quantitative and qualitative changes of vegetation over the studied 30 years was significant so that the vegetation-free areas were increased by 107.49, the areas with poor vegetation were decreased by 366.56 hectares, and the rich vegetation cover was decreased by 455.55 ha. The largest reduction in the area was related to the lands with rich vegetation. Investigating the surface temperature of the province with MODIS imagery demonstrated the rise in the surface temperature. The temperature difference was more than 3° (from -2.8°C to 0.96°C), and the highest temperature drop was observed in the eastern and central areas of the province. Finally, to investigate the relationship between vegetation and LST, the annual contamination lines were plotted along with the difference in NDVI over the studied period. The results revealed that in most areas with lower temperatures, the vegetation cover was denser. The statistical analysis between drought and vegetation indicated a significant relationship between these two factors.

1. Introduction

Vegetation cover has been changed over time due to natural or human factors and this has affected the function of ecosystems. Therefore, it is important to detect, predict and protect such changes in an ecosystem (Pettorelli et al., 2005).

There are several methods to detect environmental changes, one of the most important ones being the use of remote sensing and geographic information systems (Koh et al., 2006). Satellite data is one of the fastest and least costly methods available for researchers to examine environmental changes. Examining and analyzing these data can provide insights into human interaction with the natural environment. Specifically, it can help to analyze multivariate images of humans to identify land cover (Feizizadeh et al., 2012). Vegetation indices are widely used as benchmarks for analyzing land cover variations such as vegetation and other factors (Magee et al., 2008; Oluseyi et al., 2011). One of the most useful vegetation indices resulting from satellite imagery is the normalized difference vegetation index (NDVI) (Zhou et al., 2010). This index is based on the difference in spectral reflections (red and near-infrared reflection bands) due to the vegetation situation (Hoersch et al., 2002). Studying the vegetation characteristics and relationships between plant species and environmental factors has always been a concern of ecologists (Friedel, 2012; Jabbar & Zhou, 2011; Mihalcea et al., 2008). A relationship has been documented between NDVI behaviors and surface temperature. Earth surface temperature is an important parameter that can be indicative of changes in the Earth's surface. Recently, this parameter has been considered in studies of climate change, global warming, environmental phenomena like agricultural drought, and also urban thermal islands (Maimaitiyiming et al., 2014; Zhou et al., 2010). Research on LST (Land surface temperature) shows that it is a function of the surface energy response in various phenomena of water, soil, vegetation and so on (Ramachandra and Uttam Kumar, 2010). Earth

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surface temperature can be calculated from the infrared radiation emitted from the surface by the Stephen-Boltzmann inverse equation (Taschner and Ranzi, 2002). In the past, it was used to measure temperatures at fixed stations or by infrared thermometers (Herb et al., 2008; Morawitz et al., 2006). This study investigated the relationship between LST and vegetation index in remote sensing for drought evaluation and achieved an inverse relationship between them.(Karnieli et al., 2010). However, remote sensing data are available widely, and it can be used to analyze the spatial distribution of energy balance components such as surface temperature and Albdeau (Neteler, 2010; Xiaolu and Cheng, 2011). The processing of satellite imagery of thermal circumference can contribute to studying the relationship between land surface temperature (LST) and surface biophysical properties, including vegetation (Gutman, 1990). Several studies have been conducted to monitor vegetation changes using remote sensing and its relation with climatic elements. Herb et al. (2008) extracted the ground surface temperature in different applications in three different regions of the United States using thermal flux relations. Karimi Firoozjaee and Moghaddam (2016) examined the relationship between temperature and land use using Landsat 8 satellite imagery. Their results showed that the radiation flux had a mean green correlation of 0.8 with NDVI parameters. Hashemi Dareh Badami et al. (2015) analyzed the development of thermal island in Rasht using time series of satellite imagery. They showed that in most studied areas, there was an increasing trend in the temperature at earth surface and a decreasing trend in a shortage of vegetation. The changes in agriculture and the use of gardens in the studied period have been more severe. Having all these in mind, the purpose of the present research is to evaluate the trend of vegetation and temperature changes in Fars province in a 30-year period (1986 to 2017) and to explore the causes of these changes by remote sensing and geographic information systems.

2. Materials and Methods

The studied area was Fars province with an area of 122608 km2 located between the latitudes of 27°2' and 31°42' N and longitudes of 50°42' and 55°36' E.

2.1. Satellite images used

This research used the MODIS satellite imagery as a low-resolution image with high-resolution time resolution capability. It is available free of charge on the Internet. Bandwidths 31 and 32 of these sensors cover each day with 1000x1000 square meters of about 100 hectares.Landsat ETM+ sensor was used to provide high-resolution imagery. The images of this sensor were prepared every 16 days from any point of the image; cell dimensions were set at 60×60 m2. Since Fars province has 11 zones, 11 images from Landsat were taken at the time of the visit.

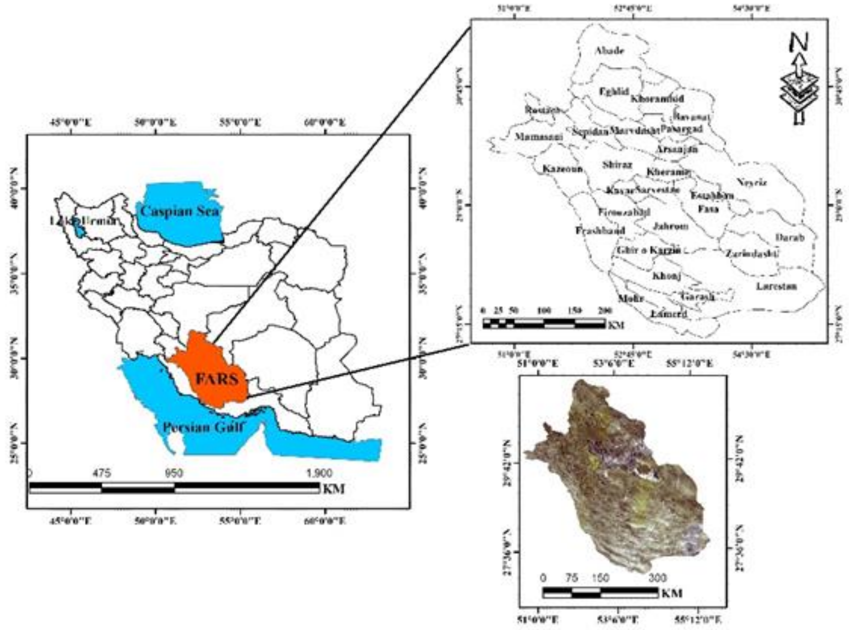

Fig. 1. Location of the case study

Table 1. Satellite imagery used for vegetation in 1986

Row	Path/Row	Sensor	satellite	Date	Band number
1	160-41	ETM^+	Landsat_5	25.05.1986	7
2	161-40	ETM^+	Landsat_5	13.06.1986	7
3	161-41	ETM^+	Landsat_5	13.06.1986	7
4	162-39	ETM^+	Landsat_5	19.05.1986	7
5	162-40	ETM^+	Landsat_5	19.05.1986	7
6	162-41	ETM^+	Landsat_5	19.05.1986	7
7	163-38	ETM^+	Landsat_5	02.06.1986	7
8	163-39	ETM^+	Landsat_5	02.06.1986	7
9	163-40	ETM^+	Landsat_5	02.06.1986	7
10	164-38	ETM^+	Landsat_5	02.06.1986	7
11	164-39	ETM^+	Landsat_5	02.06.1986	7

Table 2. Satellite imagery used for vegetation in 2017

Row	Path/Row	Sensor	satellite	Date	Band number
1	160-41	OLI	Landsat_8	26.05.2017	11
2	161-40	OLI	Landsat_8	18.06.2017	11
3	161-41	OLI	Landsat_8	18.06.2017	11
4	162-39	OLI	Landsat_8	01.05.2017	11
5	162-40	OLI	Landsat_8	01.05.2017	11
6	162-41	OLI	Landsat_8	01.05.2017	11
7	163-38	OLI	Landsat_8	16.06.2017	11
8	163-39	OLI	Landsat_8	16.06.2017	11
9	163-40	OLI	Landsat_8	16.06.2017	11
10	164-38	OLI	Landsat_8	22.05.2017	11
11	164-39	OLI	Landsat_8	22.05.2017	11

2.2. Atmospheric error correction

The atmospheric error occurs due to the absorption and dispersion of atmospheric particles. Atmospheric errors impair image details and reduce the power of the sensors. The strongest atmospheric effect is related to the distribution that highly depends on the wavelength. Consequently, the effect of the atmosphere in the bands of a sensor is not identical. The longer the wavelength, the less the effect of the atmospheric dispersion can be. The angle of the sensor is also another factor affecting the amount of atmospheric error. The atmospheric error in images taken at large or large wide-angle usually appears in a heterogeneous manner. At the edges of the image, the atmospheric errors are greater than the middle of the image because electromagnetic waves at lateral pixels should travel a longer path in the Correction of the atmosphere is required in cases that are less than the intensity of the signal sent from atmospheric effects. It can be divided into two general categories, namely generalized modeling modalities. In the modeling method, the atmospheric parameters affecting electromagnetic energy such as temperature, humidity, atmospheric pressure, etc. and their effect on the energy transmitted from the surface of the objects to the sensor are measured and influenced. In general, it is corrective, usually a way to reduce the relative correction of the image and atmospheric effect. In these methods, the requirement is usually applied to many parameters and the atmospheric correction is applied to the image approximately. The amount of atmospheric dispersion decreases due to the increase in wavelength, and so the amount of histogram shift is less in bands with longer wavelengths than the bands taken up at shorter wavelengths. The effect of the atmospheric effect is usually manifested as the appearance of a collapsible error resulting in a clear over image of the image reducing the resolution image – the so-called Haze error.

2.3. Normalized Difference Plant NDVI

This is one of the most famous and easiest vegetable indices that can be defined in terms of both red and infrared bands as below.

$$NDVI= (NER - RED)/ (NER + RED) \quad (1)$$

NDVI varies in different coatings; for example, for nicotine plants, NDVI values range from 0.05 to 0.1 for natural plant species, values range from 0.1 to 0.5 for herbal areas, rich from 0.5 to high. Water and ice have negative NDVI values, soils have values of less than 0.05, and clouds are usually close to zero. One of the major errors affecting the impact of NDVI on a region is the impact of clouds and atmospheric pollutants such as smoke, fog, and coke. If a pixel containing vegetation is dense, a spray cloud will be occurred dropping a lot in its NDVI amount and impairing the information about that pixel. Therefore, it could use a NDVI image at a time to reproduce the plant's vegetation. To cope with this problem, the calculation is usually done for a given time period of the NDVI values of the area, and the maximum amount available in the NDVI values of this period is ultimately recorded for each pixel. This is done by radiometric and geometric corrections using the ENVI software on the images.

2.3.1. Data used to calculate ground surface temperature, LST or ground temperature

Product MOD11A1: This product receives the Earth's surface temperature data LST and its estimations from the Terra satellite. The timeframe for this satellite product has been since 06.03.1986 up to now. This product is supplied in hdf format and with a sine image system for the users. With respect to the location, this product has a resolution of 1 km. On the other hand, it can be said that the Modused sensor uses the MYD11A1 / 2 products to estimate the surface temperature of the LST from the Akvavia satellite.

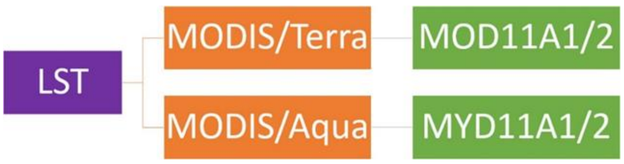

Fig. 2. MODIS Process Flowchart to calculate LST

MODIS was received from the site on the daily basis; then, it was multiplied by the scaling factor to Kelvin in order to give the image. So cut down 273:15 in order to convert Kelvin to Celsius. During this process, the temperature was extracted on a daily basis and to convert these data to monthly data, daily data were collected and then the monthly average was extracted from these data. Then, these data were averaged to give the average annual temperature. Given the fact that the meter is not a pixel, the size of MODIS images is not very high; therefore, to improve the quality of images and output the maps, by creating a file, create at the surface of the area 500 virtual stations and the amount of temperature from the satellite images extracted and then the zoning was done based on IDW.

The SPI drought index is used to calculate the monthly rainfall data of the synoptic stations to be prepared. For each station, the rainfall data is appropriate using the gamma function. This standard is performed by the SPI-SL-6 software.

2.3.2. Standard Precipitation Index (SPI)

The basis of the standardized rainfall index is to calculate the probability of occurrence of rainfall for all time scales, but it is most often used at the time scale of 1, 3, 6, 12, 24 and 48 months. It is one of the most important global indicators for drought.

$$Z = \frac{pi - \overline{X}}{s} \qquad (2)$$

Where z is the standardized rainfall index, pi is yearly precipitation, is mean long-run rainfall and s is standard deviation of rainfall.

Drought classification is expressed using the SPI index in Table 3.

Table 3. Drought classification using SPI index

SPI index	Condition
+2	Very severely wet
1.5 - 1.99	Severely intense
1 - 1.49	The average wet
-.99 - .99	Close to normal
-1.49 - -1	Moderate drought
-1.99 - -1.5	Severe drought
-2	Very severe drought

3. Discussion

To investigate the quantitative and qualitative changes of vegetation over 30 years, the output maps were classified into three classes, namely rich vegetation, poor vegetation, and no vegetation. The NDVI vegetation index is one of the most useful vegetation indices and its beneficial effect has been reported in many studies by various researchers. The numerical value of this index fluctuates between +1 and -1 and it is proven that the closer it gets to +1, the more increase is observed in the vegetation cover. Figures 3 and 4 show the vegetation maps. Through examining the numerical value of the NDVI index in the software and according to Figures 3 and 4, the red part has a higher positive value than the other parts indicating larger vegetation. Moreover, the green-colored parts have smaller positive values placing in the poor vegetation class. Then, the percentage of the area allocated to each class for each year was calculated and the resulting numbers were compared with each other (Table 4).

The results of the comparisons showed a decrease in vegetation cover in 2017 with respect to the base period, i.e. 1986. In addition, an increased was observed in vegetation-free areas. The largest reduction occurred in richly vegetated lands from 49,530 ha in 1986 to 74.94 ha in 2017.

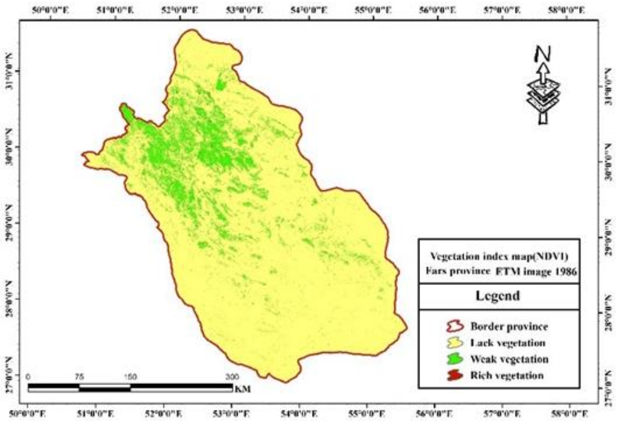

Fig. 3. Vegetation map of Fars Province, 1986

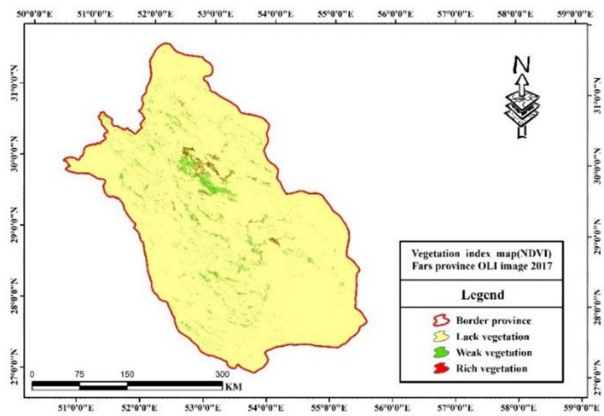

Fig. 4. Vegetation map of Fars Province, 2017

Table 4. Area of vegetation classes

Vegetation	Area (ha)		Area (%)	
	1986	2017	1986	2017
No- vegetation	118449.1	119342.36	96.41	97.14
Poor vegetation	3802.66	3436.10	3.09	2.79
Rich vegetation	530.49	74.94	0.49	0.06

In the studied years (1986-2017), there have been considerable changes in the vegetation of the studied area (Table 4). Most changes were related to the richly vegetated lands, which has been shrunk significantly. The area changes and the amount of vegetation lost are shown in Figure 5.

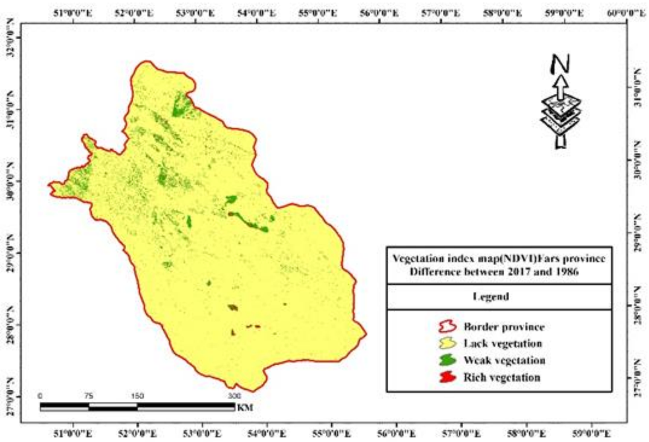

Fig. 5. Vegetation changes from 1968 to 2017

The vegetation cover was observed to be dense in the north and northwest of the province in 1986, but in 2017, it was drawn to the central and southwestern regions. In 2017, vegetation cover has become a delicate and widespread crop cover in a wide range.

Table 5. Difference in vegetation cover in 1986 and 2017

Vegetation	Hectare
Lack vegetation	107.49
Poor vegetation	366.56
Rich vegetation	455.55

Ground surface temperature was calculated using the MODIS images for the studied area and extracted from the maps in the GIS software. Given the availability of MODIS images since 1986, the base year 1986. The surface temperature map at this time interval (Fig. 6 and 7) estimates that the exact surface temperature was between 9.89-39.2°C and 9.89-37.9°C in 1986 and 2017, respectively.

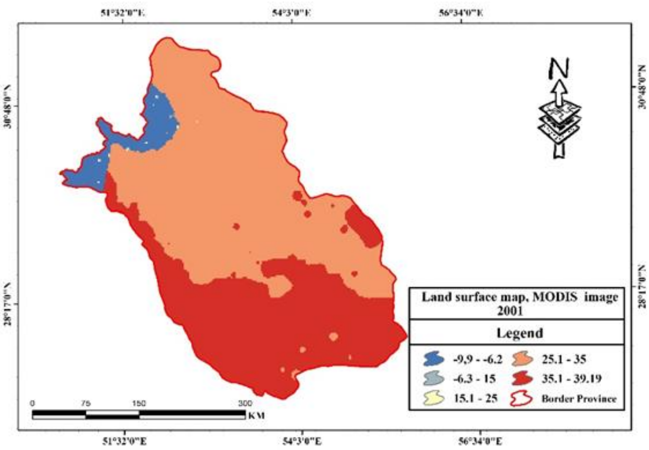

Fig. 6. Land surface temperature map using MODIS images, 2001

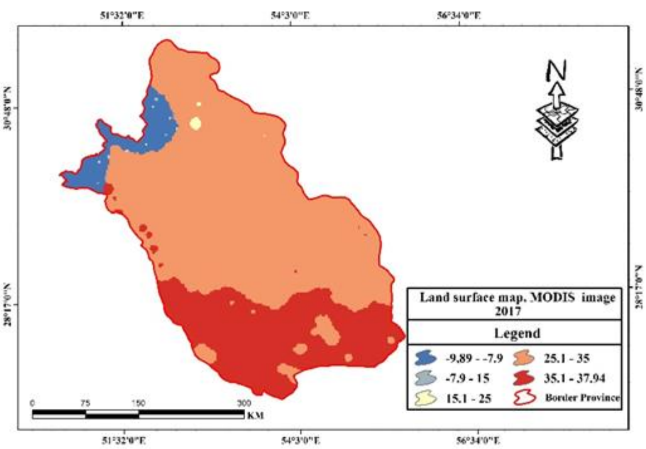

Fig. 7. Earth surface temperature map using MODIS images, 2017

As can be seen, the Earth surface temperature has decreased from 1986 to 2017, and this temperature drop is more pronounced in the western and southwestern regions of the province. The maximum surface temperature is in the southern cites of the province in each both years. In what follows, the study of ground temperature using MODIS images calculated. The difference in LST in Fars province over the studied period was extracted, and the corresponding map was used in the GIS software. The range of temperature variation is between -85.2°C and 0.96°C. It has been observed that the highest temperature drop in the eastern provinces of the province. The western and southern regions of the province have a high temperature range (Fig. 8).

Finally, to examine the relationship between vegetation and LST, the annual contradictory lines were combined with the difference in NDVI in the pertinent years (Fig. 9). The global temperature rise due to climate change is expected to be 0.5°C over 100 years. Due to the fact that the vegetation decreases with increasing temperature, as well as the increase of vegetation, it decreases the surface temperature, here the vegetation decreases the surface temperature. Due to the global temperature increase (0.5 ° per 100 years), 0.1 ° C of the calculated temperature in the course of climate change and 0.9% of the land use and vegetation changes. As you can see, vegetation is denser in most areas where the temperature is lower. The plant is relatively more visible in this area. In a similar study, Ahmadi et al. (2015) used remote sensing data to study the surface temperature in relation to vegetation and urban land use in the city of Ardabil using Landsat images. The results showed that the correlation coefficient of surface temperature (extracted from the imagery) with the weather temperature of the weather stations was 0.79 and the correlation of the air temperature of the stations with the extracted air temperature was 0.99.

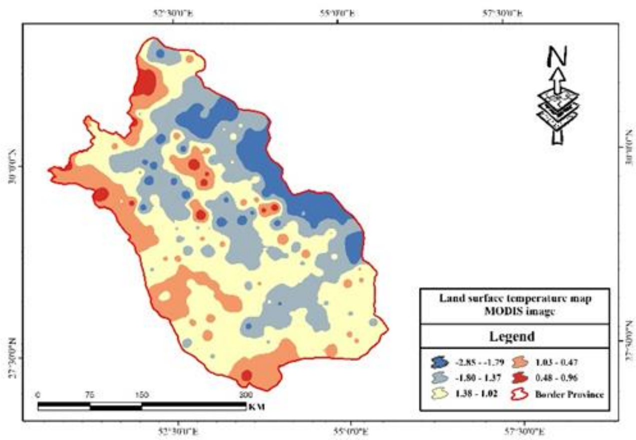

Fig. 8. Earth surface temperature variation in the pertinent years

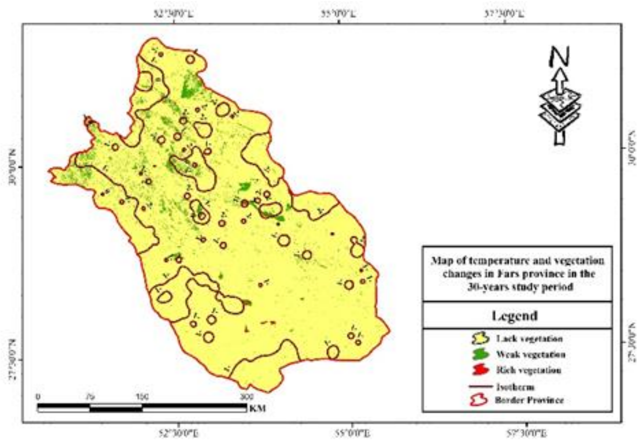

Fig. 9. Map of temperature variations and vegetation

In the next section, drought is calculated for the 1986-2017 period. At the end, the relationship between drought and vegetation in the relevant years is considered.

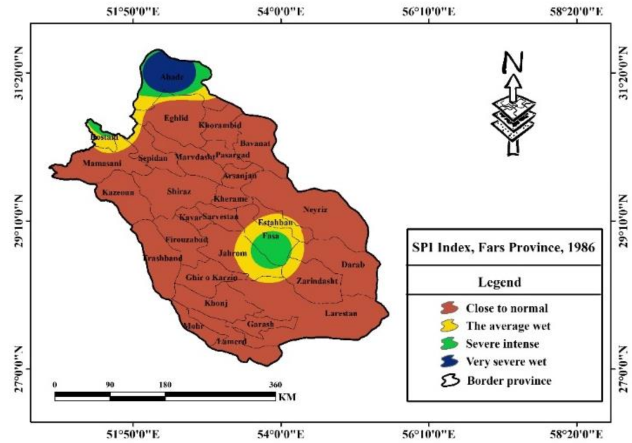

Fig. 10. SPI index of Fars Province, 2017

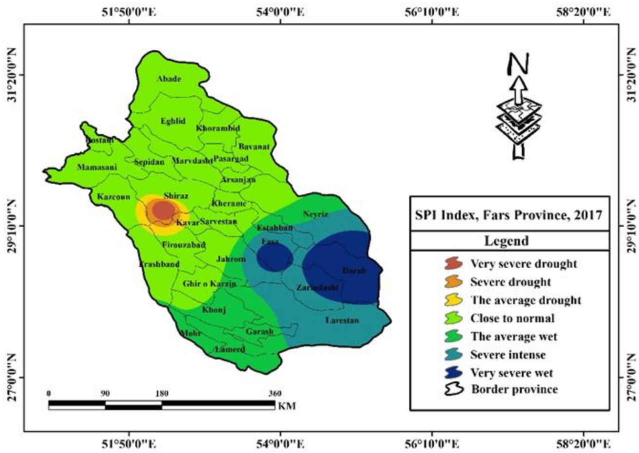

Fig. 11. SPI index of 2017 Fars Province

In 1986, it was in a near-normal state. Most of the province's provinces, Estahban and Fasa, are part of the central areas, as well as a small part of the northern cities of the province in moderate and severe conditions, and only part of the northern Abadeh area is enormous.This year, Fars province did not face drought. In 2017, we witness a very severe drought and a moderate drought located in the vicinity of Shiraz. The surface is close to normal, and it includes a large part of the province: including the northern and northwest and eastern regions, and even the areas of the centers overlooking the south. The only parts of the province that were threatened were the southern and southwestern parts of the province, which included very severe mildew, severe and moderate.

Table 6. Numerical Values and SPI Index Status, Shiraz

Condition	SPI Index	Year
Close to normal	.90	1986
Moderate drought	-1	2017

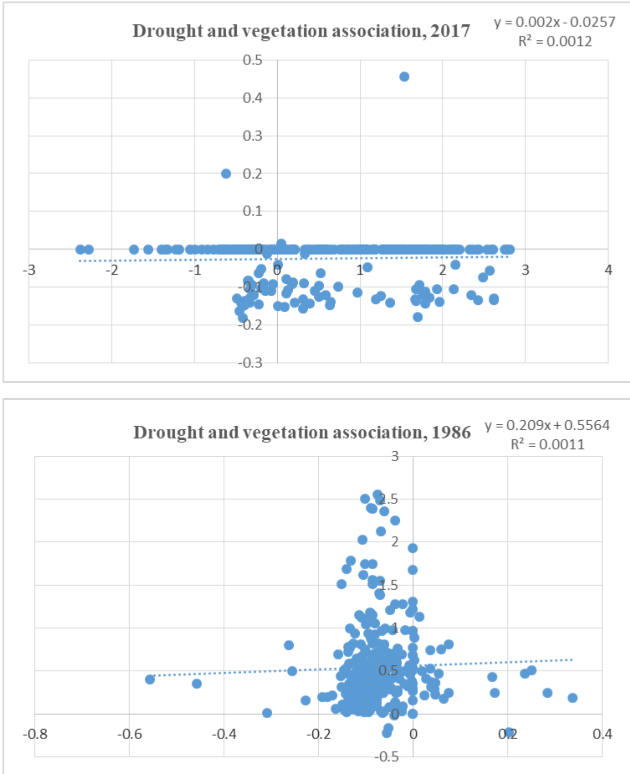

Fig. 12. Relationship between SPI Index and Vegetation

Finally, the relationship between vegetation droughts was measured. According to the above diagrams, there is no significant correlation between drought and vegetation in the studied years. Therefore, there is no significant relationship between the two indices.

4. Conclusion

Today, gaining knowledge about vegetation cover and its health plays an important role in soil management since planting systems play a significant role in environmental pollution such as more CO_2 emission as well as the quality and degradation of soils and surface water and underground waters. Besides, vegetation cover in agricultural and pastureland in each region is directly related to the implementation of correct management of crops, water and soil. Increasing NDVI means that the frequency of vegetation cover is increasing and land cover is becoming homogeneous. However, the reduction of NDVI reflects more diverse phenomena, i.e. water, open space, bare soil, construction, etc., and heterogeneous mosaic of the land. The use of ground stations to calculate and analyze meteorological data has limitations despite their proper precision. The most important limitation of this information, which can be used to calculate the temperature, is the input error for ground surfaces, far from the meteorological station, reaching over 5 degrees Celsius. Furthermore, in large parts of the earth, not only it is impossible to create a meteorological station, but it is also impossible or difficult to access the station's data easily.

Given the above problems, the use of remote sensing data can alleviate the problems caused by ground stations in most parts of the earth to estimate meteorological parameters. The findings of the present study indicated that vegetation cover influences the Earth surface temperature. Since the vegetation of the region shows the climatic conditions, soil type, economic and social status, the history of the exploitation of the pastures, the effects of management factors and, in general, the relationship between humans, the environment and plants is an important factor for Conversion of energy, radiation energy, into other forms. After all, further studies are suggested to be conducted on factors hindering the management of the degradation of pasture and vegetation cover.

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