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DETECTION OF VEGETATION CHANGES WITH NDVI AND EVI REMOTE SENSING INDICES OF THE GROWING SEASON IN PASTURES (CASE STUDY: PLAIN RANGELANDS OF GOLESTAN PROVINCE)

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ABSTRACT

In studies of environmental sciences and natural resources, vegetation should be continuously examined both quantitatively and qualitatively as a variable factor affecting biotic conditions, the importance of which is clear to researchers given that pastures cover most of the land areas globally. In this study, detection of vegetation changes was evaluated by the image subtraction method in NDVI and EVI vegetation indices of the growing season in plain rangelands of Golestan province. In this study, the MOD013Q1 product was used for vegetation sensing data of MODIS sensor images located on the deck of Terra satellite during 2000-2012 on the dates of the vegetation growing season in pastures of Golestan province. Results showed that the NDVI and EVI were complementary to each other in the detection of vegetation changes with a correlation value of 0.98%.Moreover, the EVI was not as accurate as the NDVI, resulting from a high reflectance in the infrared band relative to red band in arid areas.
Keywords: Pasture, Golestan Province, Image subtraction, EVI, NDVI, MODIS

Introduction

From an area of 164 million hectares in Iran, about 18.4 million hectares account for agricultural lands and gardens. It is noteworthy that of all Iranian pastures, only 9.3 million hectares are classified as good pastures. The area of Iranian pastures was reported to be about 94 million hectares according to Pabout (1965) and 90 million hectares based on the statistics published by the Forests, Pastures, and Watershed Management Organization, of which the shares of poor, intermediate, and good pastures are about 43.3%, 37.3%, 9.3%, respectively. In 1975, an area of 90 million hectares was estimated for pastures of Iran using satellite images by an American company, FMC, which is more accurate than other estimates due to using aerial images. There are about 46 million surplus livestock units in the pastures, and this number increases soil erosion in pastures. The population of pasture users is estimated to be 7.5 times the pasture capacity. Surveys indicate that a household needs at least 500 hectares of pasture within 7 months. Accordingly, 180,000 households can use the pastures of Iran, but 916,000 households currently exploit the pastures. Economically, the damage caused by the destruction of rangeland ecosystems is far greater than the production of fodder, meat, and other dairy products, and the continuous improper use and overexploitation destroys the water, soil, and rich carbon resources of this land. In fact, a substantial number of villagers and nomads utilize these pastures, and obviously any damage to the pastures is inevitably transferred to these users. Given the prominent role of pastures in soil protection, water, and environmental services, this issue should be considered with a realistic view in the estimation of the damage to pastures caused by droughts. In addition, there is a need for an appropriate strategy and action plan to be prepared to deal with drought and reduce its consequences, particularly in the natural resources sector.

Access to information in the shortest time and at the lowest cost is one of the important factors affecting decision making. In recent years, the focus of experts, managers, and decision makers has always been on the use of modern, low-cost, and rapid methods, such as remote sensing technology, due to the ability to identify phenomena (Alavi Panah *et al.*, 2011). Since the knowledge of the spatial distribution of drought indices and vegetation parameters is of paramount importance, remote sensing technology can be a suitable option in determining the parameters required for temporal monitoring due to spatial data collection in large-scale and up-to-date information.

The use of remote sensing technology can help to complete a wide range of projects globally, regionally, nationally, provincially, and locally with less cost and time. Additionally, the repeatability of satellite data retrieval

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within several hours to days during a month or a year has allowed the study of changes and monitoring of terrestrial phenomena. This capability has enabled related scientists and researchers to expand their studies and extend their findings to climate change, global fluctuations, and the measurement of environmental factors (Alavi Panah, 2013).

Knowledge about vegetation status, such as its distribution, is of great importance. Collection of information about continuous vegetation changes by conventional methods is very difficult and costly. In this case, the use of satellite data allows extensive studies on vegetation. To reduce the effect of interfering factors on vegetation information and increase vegetation information, at least two bands can be combined to create a composite index called vegetation index (VI).Vis examine some vegetation characteristics, such as canopy features, biomass, and leaf area production with canopy percentage, which is principally a reflection of vegetation in the range of low visible light spectrum (0.43-0.66 μm) and near-infrared (0.7-1.1 μm).As such, three important characteristics of the leaf, viz. chlorophyll, physiological structure, and water content, have an important effect on its spectral reflectance. According to this important fact, the composition of visible and near-infrared spectral bands can help distinguish vegetation from soil and water surfaces (Alavi Panah, 2008).

These indices are a mathematical combination of multiple bands of digital satellite imagery that utilize significant differences in vegetation reflection at blue, red, green, and near-infrared wavelengths. The indices are simple mathematical operations, such as summation, subtraction, proportion, or other linear combinations that change the value of each pixel in different bands to a numerical index.

Due to the use of large-scale spatial data, the repeatability and satellite data retrieval at intervals of one to several days during the growth period or a year, and up-to-date data remote sensing technique has a significant ability at high temporal and spatial scales. The use of satellite data allows extensive study of vegetation (Jiang *et al*., 2008; Jing *et al*., 2006). In fact, the main goal of most remote sensing analyses used to study vegetation is to reduce the data of different spectral bands, which can represent such parameters as plant cover percentage, biomass, and leaf area index, to a single value per pixel. Indeed, a new prevalent view in the field of vegetation surveillance and monitoring is the use of remote sensing indices of vegetation.

In remote sensing, satellite data have far greater capabilities in monitoring and interpreting terrestrial phenomena at any spatial and temporal vegetation due to temporal, hourly, daily, monthly, and yearly monitoring, extensive, widespread, and regular (pixel by pixel) spatial coverage across zones, regions, and continents, and free and permanent access. Moderate Resolution Imaging Spectro radiometer (MODIS) products allow researchers to use new and different VIs (Townshend, 1994). The Enhanced VI (EVI) is a new MODIS product designed to increase the NDVI efficiency. The EVI addresses the issue of vegetation density and reduction of background soil effects, but it will take some time to assess its applications (Hot *et al*., 2002). Besides, indices of leaf area and primary crops have been designed to fulfill ecosystem productivity needs and carbon cycle research (Myneni *et al*., 2002). The efforts of MODIS specialists have led to the further development of using short infrared waves, fire tracking, ground cover changes, and ground surface temperatures. Atmospheric correction methods in MODIS represent advances in newer systems (Vermote *et al*., 2002). Intermediate infrared bands with medium resolution are usable. Land surface temperatures and Albedo/Bidirectional Reflectance Distribution Function (BRDF) products provide a new opportunity for climate modeling (Schaff *et al*., 2002).

Data of MODIS sensor, located on the deck of Terra and Aqua satellites, were used in this study owing to such features as spatial, zonal, regional, and continental coverage, as well as regular temporal ,hourly, daily, monthly and yearly coverage, and free and permanent access.

Lee *et al*. (2010) measured vegetation from field samples in three areas (pastures, shrub lands, and forest areas)with NDVI and EVI obtained from MODIS satellite imagery, and concluded that the NDVI was superior to the EVI in terms of correlation coefficient and error rate in the established regression equations.

Based on the aforementioned subjects, this study seeks to address the question of differences between NDVI and EVI in determining vegetation changes.

Materials and Methods

Area of study

Golestan province with an area of about 22,000 m^2 is limited to the Republic of Turkmenistan in the north, Mazandaran province and the Caspian Sea in the west, Semnan province in the south, and Khorasan province in the east. The geographical location and topography of this province have resulted in the effects of different climatic factors hence different climates can be observed in this province. As a result, the semiarid climate in the border strip and Atrak watershed to the temperate and semi-humid regions in the south and west to the cold mountain climate in the highlands and mountains can be seen in Golestan province. For this reason, precipitation is different in different areas of the province so that rainfall levels of 700 mm and about 200 mm are respectively reported in the southern and southwestern regions and in the northern areas and the border strip of the province. The average annual daily temperature varies from 7 °C at altitudes of 2000 m to 19 °C in Gonbad region. The average evaporation varies from 800 mm in the southern regions and the heights to 2000 mm in the border areas in the north of the province (Masoudi *et al*., 2007). Inthis province, the average long-term annual rainfall is 463 mm, which varies from 330 mm in the southern regions to 233 mm in the northern areas (Nikghouch and Heydarian, 2013).

Pastures

There are generally two types of mountain pastures and plain pastures in Golestan province. The shape file of the main range of rangeland distribution in Golestan province (Fig. 1), prepared in as a map of the Natural Resources Department of Golestan province based on the latest changes related to 2014, is the scope of this research in the plain rangelands of this province.

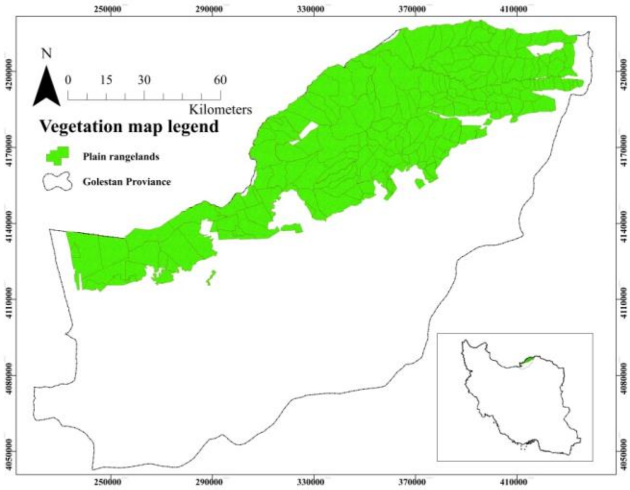


Fig. 1 : Distribution of pastures in Golestan province (adapted from General Department of Natural Resources of Golestan province, 2014)

Collection of required data

Remote sensing data

The MOD013Q1 product of MODIS sensor data located on the deck of TERRA satellite was used in this research. Based on the study area, 312 images (54 GB) in. hdf format were downloaded from the EOSDIS (Reverb | ECHO) website (one of NASA sites)for 2000-2012. These images were used by the optimal maximum vegetation index algorithm during a 16-day period from image 065 on March 6, 2000, to image 273 on September 30, 2012, based on the growing season in the plain rangelands of Golestan province, which is from mid-March to mid-June for annual species and from July to late September for perennial species. A scale factor was necessarily applied to use these bands and convert them to plant indices. According to the expression of the United States National Space Agency, the scale factor used in the product of MOD13Q1 images for NDVI and EVI was equal to 0.0001.

Remote sensing indices

Normalized difference vegetation index (NDVI)

One of the most important indices used in the study of vegetation is the NDVI, which is calculated using the band algorithm shown in Equation 1:

$$NDVI = \frac{R_{NIR} - R_{RED}}{R_{NIR} + R_{RED}} \quad ...(1)$$

where NDVI denotes the normalized difference vegetation index, R_{NIR} represents near-infrared reflectance, and R_{RED} indicates the red area reflectance.

Although the value of this index is theoretically in the range of -1 and +1, but it is practically less than 1 and more than -1. The values of this index approaches+1 for dense vegetation, but clouds, snow, and water are characterized by negative values. Rocks and barren soils that have similar spectral reactions used in the two bands are seen with values close to Zero. In this index, the typical soil is equal to 1. When the index distance is one pixel higher than the soil size, it indicates the vegetation density (Allison, 1989).

Enhanced VI(EVI)

Equation 2 shows the EVI band algorithm:

$$EVI = \left(\frac{P^*_{NIR} - P^*_{RED}}{P^*_{NIR} + C_1 P^*_{RED} - C_2 P^*_{BLUE} + l}\right)(1+L) \quad ...(2)$$

where EVI indicates enhanced VI, R_{NIR} represents near-infrared reflectance, and R_{RED} denotes the red area reflectance, R_{BLUE} is blue band, and the coefficients are L: 1, C_1:6, and C_2: 7.5.

This index rangesfrom−1 to +1. An advantage of this index is that it corrects the effects of background soil and reduces the atmospheric effects and aerosol dispersion through advancing by water reflection in the LAI (leaf area index) range (Lee *et al*., 2009). In fact, EVI is a modified NDVI that takes into account the soil adjustment factor (L) and C_1 and C_2coefficients. This method increases the sensitivity to vegetation areas and reduces the atmospheric effects (Justice and Huete, 1999). This method requires prior correction for the molecular portion and ozone absorbance for blue, red, and near-infrared band data, which are, therefore, are denoted by P^*.

Vegetation classification

Table 1 : lists the vegetation classifications for the NDVI and EVI used in this study.

Table 1 : Vegetation classification for NDVI and EVI indices

Numerical NDVI -EVI	Vegetation class	NDVI Index	EVI Index
0.1> …	Without vegetation	*	*
0.2 -0.3	Poor vegetation with barren soil background	*	*
0.3 - 0.5	Medium vegetation, shrubs, and low-intensive grasslands	*	*
0.5 - 0.6	Good vegetation, intensive pastures	*	*
0.6 - 0.9 , 1	Very good vegetation, forests, and managed areas	*	*

Image subtraction and determination of matrix of changes

One of the possible uses of VI images is to prepare images of changes and no changes based on the image subtraction method, which can reflect the vegetation changes. In this study, the image subtraction was used at two intervals in the growing season to determine the changes and no changes of vegetation (Tonekabil, 2004).

$$CPV_{jj}K = DN_{ij}k\,(1) - DN_{ij}k\,(2) + C \quad ...(3)$$

where CPVjjK represents image subtraction, DNij (1) and DNijk (2) are the brightness value of pixel i.j in band k on the first and second dates, respectively, and C is a constant.

In subtracted images, the histogram of brightness degrees is usually a normal distribution with a mean close to zero, and the brightness value of unchanged pixels is close to the mean and those distant from mean changes are in the positive and negative sequences with normal distribution (Gong, 1993). The matrix of changes, prepared based on the tables from these images, compares the change in each pixel in the month or year with the same month or the next year. In this study, the annual matrix of changes was used to classify vegetation in to five categories of free, poor, medium, good, and very good vegetation cover. Changes were determined as the number of pixels changed in each vegetation category from one year to the previous year, and recorded in a table.

Pearson correlation coefficient

Since an important goal in environmental science research is to describe and predict the occurrence of various phenomena and study their interrelationships, regression analysis and correlation coefficient are used to determine logical relationships between different variables. Correlation indicates the degree of relationship between variables, but regression analysis is a statistical method that examines the relationship between variables.

Many environmental data may not have a functional relationship in which one variable changes based on another one, and there is no reason to have a functional relationship. Thus, correlation analysis is used in such a case. The relationship between variables is examined by calculating correlation coefficients between them. In this study, Pearson correlation coefficient was used based on the type of data scale. Pearson correlation coefficient is one of the important coefficients to determine the correlation between two normally distributed variables with distance and proportional scales. This coefficient is denoted by r and varies between +1 and -1. The value of r indicates the intensity of the linear relationship between X and Y, and its sign reveals the direction of this relationship.

Equation 4 is used to calculate the Pearson correlation coefficient:

$$\mathrm{r} = \sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y}) \Big/ \sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2 \sum_{i=1}^{n}(Y_i - \bar{Y})^2} \quad ...(4)$$

where each of the NDVI and EVI was identified as independent variable X and dependent variable Y. To verify whether or not there is a significant correlation between the two variables, a significance test was performed on the calculated coefficients and the hypotheses were defined as follows:

$$\begin{cases} H_0: \rho = 0 \\ H_1: \rho = 0 \end{cases}$$

To test the hypotheses, the t-statistic with a degree of freedom of n-2 was calculated as Equation 5:

$$\mathrm{t} = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \quad ...(5)$$

where n is the number of samples. Finally, the hypotheses were accepted or rejected by comparing the critical t with the obtained t.

Software

In this research, the Java programming software, M_{RT} Modis Tool, was used for reflective bands in the VI calculation algorithm. Image subtraction and determination of the matrix of changes were carried out by the Idrisi selva software.

Results

Estimation of NDVI and EVI

The results of annual NDVI and EVI of growing season in the plain rangelands of Golestan province during the statistical period of 2000-2012 are presented in Tables 2 and 3.

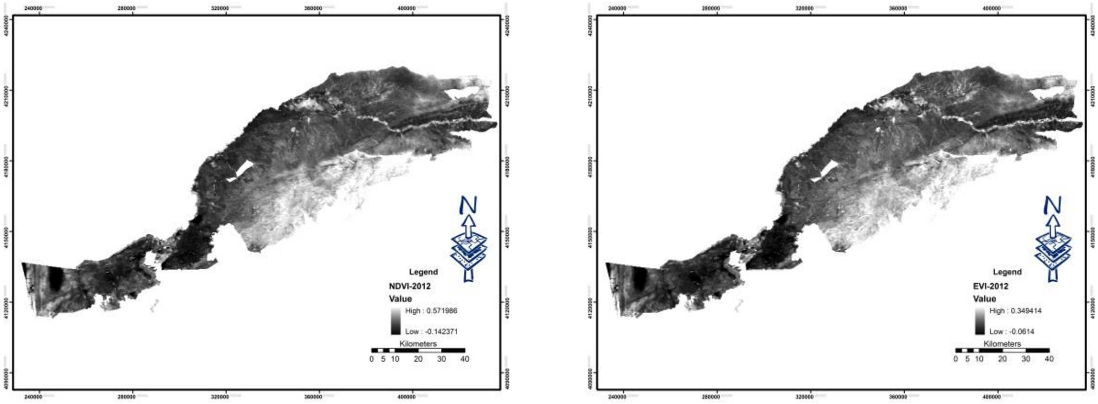
Table 2 : Calculated values of annual NDVI of growing season for stations in plain rangelands

Regions	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Inchehboron	0.20	0.18	0.15	0.37	0.28	0.22	0.21	0.29	0.16	0.14	0.27	0.19	0.30
Tarshekli	0.16	0.13	0.15	0.20	0.20	0.21	0.17	0.19	0.13	0.15	0.22	0.16	0.19
Maraveh tappeh	0.11	0.10	0.12	0.21	0.18	0.21	0.14	0.16	0.13	0.13	0.18	0.14	0.19
Ghazanqayeh	0.16	0.14	0.17	0.28	0.27	0.25	0.20	0.26	0.14	0.19	0.25	0.18	0.23
Dadeh-Alomchat	0.09	0.08	0.09	0.17	0.16	0.17	0.12	0.13	0.10	0.09	0.16	0.12	0.14
Houtan	0.22	0.19	0.22	0.31	0.28	0.30	0.27	0.28	0.27	0.21	0.26	0.20	0.24

Table 3 : Calculated values of annual EVI of growing season for stations in plain rangelands

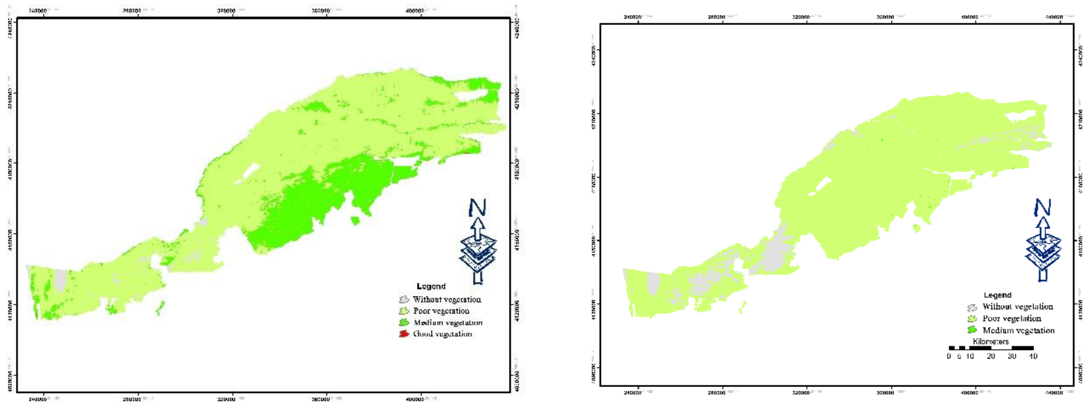
Regions	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Inchehboron	0.14	0.13	0.11	0.25	0.17	0.13	0.14	0.18	0.11	0.09	0.19	0.13	0.20
Tarshekli	0.12	0.10	0.11	0.14	0.14	0.15	0.12	0.13	0.10	0.10	0.16	0.11	0.13
Maraveh tappeh	0.09	0.08	0.09	0.14	0.12	0.15	0.10	0.11	0.10	0.10	0.14	0.10	0.13
Ghazanqayeh	0.12	0.11	0.14	0.21	0.18	0.17	0.14	0.18	0.11	0.13	0.17	0.12	0.15
Dadeh-Alomchat	0.09	0.08	0.08	0.13	0.12	0.13	0.09	0.10	0.08	0.08	0.13	0.09	0.11
Houtan	0.19	0.16	0.17	0.24	0.20	0.23	0.20	0.22	0.22	0.16	0.20	0.14	0.17

Figures 2 and 3 show the vegetation and vegetation classes of EVI and NDVI in the plain rangelands of Golestan province in 2012.



(A) (B)

Fig. 2: A) NDVI and B) EVI in the plain rangelands of Golestan province in 2012



(A) (B)

Fig. 3: A) NDVI and B) EVI vegetation classes in the plain rangelands of Golestan province in 2012

Results of image subtraction and matrix of changes of NDVI index of the growth season

Table 4 represents the results of image subtraction and matrix of changes in the total area (hectares) of NDVI-based vegetation classes in the plain rangelands of Golestan province during 2000-2012. The total changes in the area of NDVI-based vegetation classes in the plain rangelands of Golestan province during 2000-2012 are also shown in Table 5.

Table 4 : Matrix of changes for the total area (hectares) of NDVI-based vegetation classes

Year	Without vegetation	Poor vegetation	Medium vegetation	Good vegetation	Very good vegetation	Total
2000	318/55	6324/97	312.76	0.00	0.00	6956.28
2001	897.17	5995.85	63.22	0.05	0.00	6956.28
2002	605.02	5891.68	459.58	0.00	0.00	6956.28
2003	105.13	4222.82	2626.08	2.25	0.00	6956.28
2004	62.36	4941.12	1949.21	3.33	0.27	6956.28
2005	136.74	5050.49	1765.25	3.65	0.16	6956.28
2006	122.95	6053.27	779.05	1.02	0.00	6956.28
2007	64.13	5226.19	1663.01	2.95	0.00	6956.28
2008	402.32	6432.84	121.12	0.00	0.00	6956.28
2009	292.79	5448.36	1214.54	0.59	0.00	6956.28
2010	57.21	4684.07	2213.13	1.88	0.00	6956.28
2011	161.37	6367.26	427.60	0.05	0.00	6956.28
2012	114.63	5228.23	1611.12	2.31	0.00	6956.28

The map of NDVI changes in all plain rangelands of Golestan province during the statistical period of 2000-2012 are presented in the appendices.

Table 5 : Percentages of total changes in the area of NDVI-based vegetation classes

Year	Without vegetation	Poor vegetation	Medium vegetation	Good vegetation	Very good vegetation	Total
2000	4.58	90.92	4.50	0.00	0.00	100.00
2001	12.90	86.19	0.91	0.00	0.00	100.00
2002	8.70	84.70	6.61	0.00	0.00	100.00
2003	1.51	60.71	37.75	0.03	0.00	100.00
2004	0.90	71.03	28.02	0.05	0.00	100.00
2005	1.97	72.60	25.38	0.05	0.00	100.00
2006	1.77	87.02	11.20	0.01	0.00	100.00
2007	0.92	75.13	23.91	0.04	0.00	100.00
2008	5.78	92.48	1.74	0.00	0.00	100.00
2009	4.21	78.32	17.46	0.01	0.00	100.00
2010	0.82	67.34	31.81	0.03	0.00	100.00
2011	2.32	91.53	6.15	0.00	0.00	100.00
2012	1.65	75.16	23.16	0.03	0.00	100.00

Results of image subtraction and matrix of changes for the EVI of growth season

Table 6shows the results of image subtraction and matrix of changes in the total area (hectares) of EVI-based vegetation classes in the plain rangelands of Golestan province during 2000-2012. The total changes in the area of EVI-based vegetation classes in the plain rangelands of Golestan province during 2000-2012 are also presented in Table 7.

Table 6 : Matrix of changes in the total area (hectare) of EVI-based vegetation classes

Year	Without vegetation	Poor vegetation	Medium vegetation	Good vegetation	Very good vegetation	Total
2000	1737.23	5218.46	0.59	0.00	0.00	6956.28
2001	3558.72	3397.03	0.54	0.00	0.00	6956.28
2002	2064.91	4885.90	5.47	0.00	0.00	6956.28
2003	444.13	6452.21	59.94	0.00	0.00	6956.28
2004	503.05	6438.36	14.87	0.00	0.00	6956.28
2005	700.81	6242.17	13.31	0.00	0.00	6956.28
2006	1192.32	5761.98	1.99	0.00	0.00	6956.28
2007	722.76	6186.09	47.44	0.00	0.00	6956.28
2008	2156.03	4799.45	0.80	0.00	0.00	6956.28
2009	1702.78	5250.28	3.22	0.00	0.00	6956.28
2010	427.71	6432.57	96.01	0.00	0.00	6956.28
2011	1472.18	5483.94	0.16	0.00	0.00	6956.28
2012	604.53	6345.15	6.60	0.00	0.00	28.6956

The map of EVI changes in all plain rangelands of Golestan province during the statistical period of 2000-2012 are presented in the appendices.

Table 7 : Percentages of total changes in the area of EVI-based vegetation classes

Year	Without vegetation	Poor vegetation	Medium vegetation	Good vegetation	Very good vegetation	Total
2000	24.97	75.02	0.01	0.00	0.00	100.00
2001	51.16	48.83	0.01	0.00	0.00	100.00
2002	29.68	70.24	0.08	0.00	0.00	100.00
2003	6.38	92.75	0.86	0.00	0.00	100.00
2004	7.23	92.55	0.21	0.00	0.00	100.00
2005	10.07	89.73	0.19	0.00	0.00	100.00
2006	17.14	82.83	0.03	0.00	0.00	100.00
2007	10.39	88.93	0.68	0.00	0.00	100.00
2008	30.99	68.99	0.01	0.00	0.00	100.00
2009	24.48	75.48	0.05	0.00	0.00	100.00
2010	6.15	92.47	1.38	0.00	0.00	100.00
2011	21.16	78.83	0.00	0.00	0.00	100.00
2012	9.52	91.38	0.10	0.00	0.00	100.00

Results from the correlation between NDVI and EVI

The average annual values of vegetation in the growing season for each of the EVI and NDVI are displayed in Table 8. Figure 4 shows the graph of mean annual changes of NDVI and EVI for easier detection of the relationship between the indices. The correlation coefficients between NDVI and EVI are also shown in Table 9.

Table 8 : Average annual correlation coefficients of NDVI and EVI

Year	EVI	NDVI
2000	0.13	0.16
2001	0.11	0.14
2002	0.12	0.15
2003	0.19	0.26
2004	0.15	0.23
2005	0.16	0.23
2006	0.13	0.19
2007	0.15	0.22
2008	0.12	0.16
2009	0.11	0.15
2010	0.16	0.22
2011	0.12	0.16
2012	0.15	0.22

Table 9 : Correlation coefficients between NDVI and EVI

Correlation	EVI	NDVI
EVI	1.00	
NDVI	**0.98	1.00

**Significant at a level of 0.05

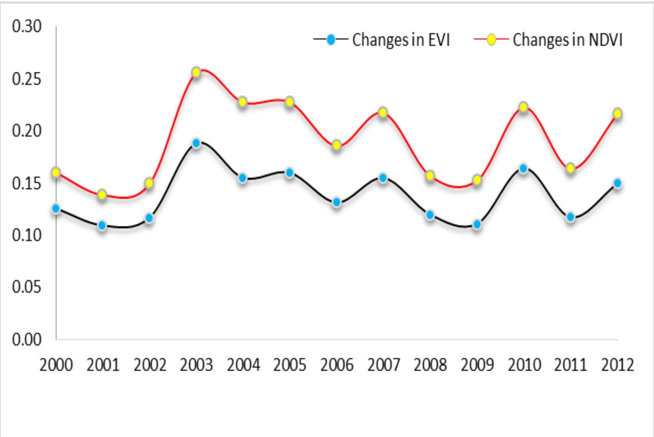


Fig. 4 : Changes in NDVI and EVI

Discussion

One of the main parameters for the development of drought models (agriculture, meteorology, and hydrology) is to define an index for describing the vegetation status of a region. Changes in the composition and distribution of vegetation are effective factors in schematic changes on a local, regional, and global scale, and it is of paramount importance to recognize these changes with the help of multi-temporal satellite data in environmental research projects and the adoption of management policies.

In this study, results of NDVI and EVI estimated at all stations in 2012 indicated a humid and perfectly humid year. Corresponding to these, maximum values of NDVI and EVI decreased from 2000 to 2001. On the one hand, maximum values of NDVI and EVI increased from 2011 to 2012, which indicates an increase of rainfall in 2012.

The results also showed that the fluctuations of the humidity situation are generally very high in the province, so that it under went frequent changes from 2006 to the end of 2011. Additionally, at least three moisture conditions were observed in the province in each water year, which is consistent with that of Mosaedi *et al*. (2008).

According to the results of image subtraction and matrix of changes, the NDVI-based area of vegetation classes were without vegetation from 2000 to 2001, which increased from 4.58% in 200o to 12.90% in 2001.In contrast, the medium and poor vegetation classes in the NDVI decreased by 4% in 2001 relative to 2000, which is in line with that of Mirmousavi and Karimi (2013). On the one hand, all stations were covered by wet and completely wet events from 2011 to 2012. Thus, the area of the average vegetation class in the NDVI changed from 427.60 ha to 1611.12 ha in 2011, and good vegetation class increased from 0.05 ha in 2011 to 2.31 ha in 2012, clearly indicating moisture changes in 2012 compared to 2011, which corresponds to that of Mirmousavi and Karimi(2013).

Image subtraction with the EVI for 2001 revealed that the vegetation-free class increased by 26.19% in 2001 in comparison to 2000. In the wet and completely wet year of 2012, the medium and poor vegetation classes increased by 0.1%and 12.55%, respectively, as opposed to 2011.

Changes in satellite images were detected and determined using the image subtraction method, which is easy to use and analyzes the results clearly, which is in agreement with that of Mirmousavi and Karimi(2013).However, results of this method were inconsistent with studies of Lu *et al*. (2003) and Ebrahimzadeh *et al*. (2013) due to the inability to analyze the details of changes and the need for determining a threshold.

According to the results, NDVI and EVI for MODIS images can be a good alternative to meteorological indices. NDVI and EVI complement each other in global vegetation studies and improve the detection of vegetation changes and the extraction of canopy biophysical parameters. Ifan index is not as accuracy as NDVI, it is due to a high band reflectance in infrared band compared to red band in arid areas.

EVI is used to improve NDVI by optimizing vegetation signals in the range of LAI, and blue band reflection to correct soil background signals and reduce atmospheric effects (including particulate matter).

The relationship between MODIS plant indices and climatic factors cannot be examined alone, because MODIS has low spatial resolution and does not reflect properly climatic changes in each cell. Besides, atmospheric effects are not noticeable in plain, uniform, and smooth areas.

Since each of the indices studied for the image has certain disadvantages and advantages, it is necessary to consider the most appropriate method, type of sensor, characteristics and conditions of the study area, knowledge of the type, vegetation level, and the type of regional land uses. Moreover, the simultaneous use of several indices provide better results in the detection and separation of vegetation level.

The use of the EVI instead of the NDVI may be less accurate due to a high reflectance of the NDVI in the infrared band than in the red band in arid areas.

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