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Monitoring of Rangeland vegetation changes in Alborz Province(Iran) using the simple ratio index

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Abstract

Vegetational dispersion and rate of changes over the time, showing the ecosystem succession is in regressive or progressive process. There are several ways of checking for changes of vegetation such as field studies and long-term inventory. Today, one of the ways that can help us in this process is using the satellite imagery and remote sensing instruments. In this study changes in rangeland vegetation of Alborz Province between years of 2000 and 2011 was monitored in seprated counties using satellite images of TM and ETM $^{+}$. the simple ratio (SR) index, and its relationship with the field data in 55 types of vegetation was investigated. Results showed that the index has a correlation with the actual vegetation in 0.05 level and has a minus correlation with the soil at the 0.01 level. Significantly Taleghan county has the highest density of vegetation. After that, there are other counties of Savojbolagh, Karaj, Eshtehard and Nazarabad, respectively. Comparing the averages from view point of similarity in the behavior of index changes showed that Taleghan, Savojbolagh and Karaj are classified in one group and Eshtehard and Nazarabad in a another group. Investigating the Process of vegetation changes showed that vegetation has reduced and then increased after 2000 to 2002. the amount of vegetation has also increased in 2011 compare with 2000.

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Introduction

Short-term evaluation of the program in form of inventory just have capability of describing and evaluating the range of sources in a rengeland over a year and cannot show the temporal changes in rangelands (Bedell and Cox,1994). Thus because of the the importance of temporal changes in grazing studies, some studies are doing as monitoring (Muir and Maclaran, 1997). Due to the capacity of satellite images, such as being timeliness, multi-spectral, duplicate, and enhancement the spectral resolution, spatial coverage and remote sensing, the monitoring and evaluating of rengelands and extracting of information such as the amount of vegetation, type and quantity of biomass is possible (Malo and Nicholson, 1990). Therefore it can be used for studying different stages of vegetation. Layers of precise and reliable information can be obtained by remote sensing (RS) technique. And GIS program as a computer technique has the resposibility of managing the layers and combining them together to achieve the goals of development and rehabilitation of natural resources by using informative layers and data. In addition, the remote sensing (RS) and GIS techniques in the field of studing and managing the natural resources, are cheaper than traditional methods, and with due attention to the fast action they provide, they are economically feasible (Zobeiri and Majd, 2009). Since the frequency of changes in quantity parameter such as composition, structure of vegetation and rengeland are affected by abiotic (e.g. climate) and biotic factors such as grazing, identifying the factors and removing them is important in decision-making about range management (Anderson and holte, 1981). Vegetation monitoring can help significantly in management and optimal utilization of rangelands by using satellite imagery. Vegetation indices are mathematical conversions which are defined by different bands of Landsat Multispectral and desinged for assessment of plant in satellite multi-spectral observations. This vegetation indices are based on the difference between red and near infrared bands, and the reason is the absorption of red light by existing pigments in chlorophyll which makes plants to have less reflection in red band and intense reflection in near-infrared bands (Fatemi and Rezaei, 2006). The common approach has been to correlate ground-measured leaf area index against the simple ratio (SR) (Jordan, 1969). Stenberg *et al.* (2004) reported that the vegetation index SR shows changes in vegetation better than NDVI in the two sites. The SR and NDVI indices, as a simple criterion to determine the presence and density of flora and vegetation studies, have wide acceptance in the related field of studies. Both of these indicators, are based on the density of vegetation in the red band and near-infrared, and the reason is the special spectral behavior of the plant in the two mentioned bands (Huete *et al.*, 2002). Given that most research focuses on NDVI and climatic conditions and vegetation are different, so it is necessary to examine the application of SR in this climate zone. The aim of this study is investigating the relationship between SR indexes with rengelands vegetation and examining the process of vegetation changes over the time.

Materials and methods

Study area

This study was performed in Alborz province's rangelands. Alborz province with 512668 hectares area located in the central part of Alborz Mountains. And it is the 0.31 percent of country's total land area. It is located in the northern part of the country, in the range of 35º 32´ latitude 36º 20´north latitude and 50° 9 ´and 51° 28´ east longitude from the Greenwich meridian. According to the latest divisions of the country, Alborz has 5 counties, 16 cities, 11 districts and 25 villages. The capital city is Karaj. Fig.1. shows the location of the study area. The total area of the province, 65.4% of pasture, agriculture 16.7% and 3.3% residential and industrial.

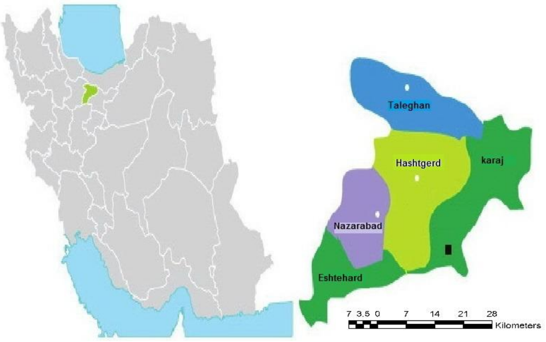

Fig. 1. Position of Alborz province in relation to the whole country.

Methodology

Equation 1 (Sellers, 1985):

$$SR=\frac{NIR}{RED}$$

NIR: Near Infrared band

RED: red band

In this study, images of Landsat5 (TM) and Landsat7 (ETM $^+$) satelites were used. Considering the maximum vegetation growth in Alborz Province, the images which were uesd belong to May from 2000 to 2011. The preprocessing steps included atmospheric and geometric correction using linear regression algorithmand Ground Control Point (GCP) (Santhosh *et al.*, 2011). In the present study, after geometric and atmospheric corrections, SR index images were calculated by using ENVI 4.8 software and equation (1). The output images of index had a short-range (0 to 30) (Sellers, 1985). To solve this problem, the output images stretch away the range of 0- 255 in a same time. At the end, the provinces, cities and rangelands borders were seprated from the output images by using ArcGIS10 software (Gorr *et al.*, 2010). A Number of data processing steps were taken before calculating indices and classifying them. In order to determine the borders of the rengelands of study area, the land-use map was prepared using images taken on May 29th 2011, and the border of rangelands separated from the other lands and its maps were prepared. To do this, among the classified methods, the most accurate and the most widely used method which was the maximum likelihood method were used (Richards, 1999). For preparing the map of rangelands situation, a combination of methods such as experimental, actual (educative) and visual interpretation were used. In order to compare the vegetation indices with field data, map data and vegetation percentage, bare soil percentage, rocks and gravel and the litter percentage of five watersheds in Alborz Province were prepared, and the data of vegetation and of bare soil percentage were compared with satellite imagery the same year. These five areas include the basin of Taleghan's dam 32000 hectares, Halghedareh 7950 hectares, Mehran – Joestan in area of 6350 hectares, Aghsht-Sorhe-Varde in area of 19700 hectares and Arangeh 10000 hectares. Criteria for selecting the mentioned ereas were dipersion in the province and precision of studies which were done before. In each plant type reference area was selected and then sampling plots(30 plots with 1 m^2 area) along four 100 m transects with 100 m distance from each other were located along North-South direction. To remove the slope effect in hills and mountainous area, sampling transects were located parallel to slope direction and vertical to slope direction. In these types direction of two transect was North-South and two transect was East-West. Sampling points were systematically selected with10m distances along each transecting. Number of plot by draw weight mean size of the dominant species and size by minimal area was obtained (Chambers and Brown, 1983). Statistical analysis were performed by using SAS 9.3 and SPSS19 software and Variance analysis methods in different years and areas and also comparing average with LSD1 test and correlation (Norusis, 2004).). LSD Uses t tests to perform all pairwise comparisons between group means. No adjustment is made to the error rate for multiple comparisons (Iqbal *et al.*, 2003).

Results

The index determination in separated years and cities and process of changes

After calculation of vegetation index, the simple ratios of index changes were studied in each county and in the month of May in each year as an indicator of the growing season. Fig.2. Shows the SR average zoning map of Alborz Province rengelands in separated counties in 2011. As it can be seen in the picture, in mentioned year, Southern cities have less vegetation than northern part of the province. Fig.3. shows average changes of vegetation index of simple ratio in seprated cities. Results show that vegetation decreases from 2000 to 2002, and increases from 2003 to 2009 and then it declines. Among the counties, Taleghan often has the most and Nazarabad has the lowest density of vegetation.

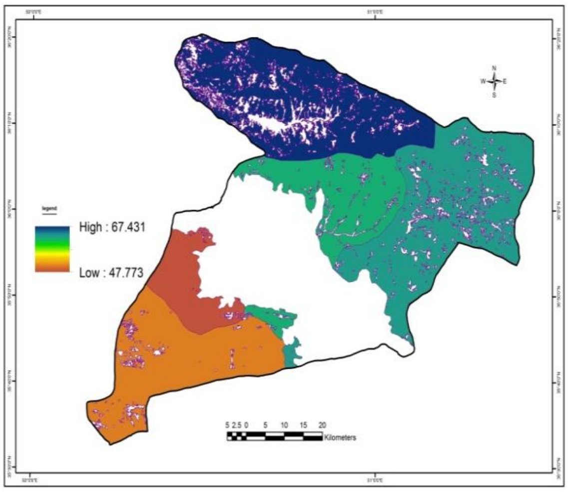

Fig. 2. SR average zoning in the province rangelands in the seprated county after Eemoval of other land uses in 2011.

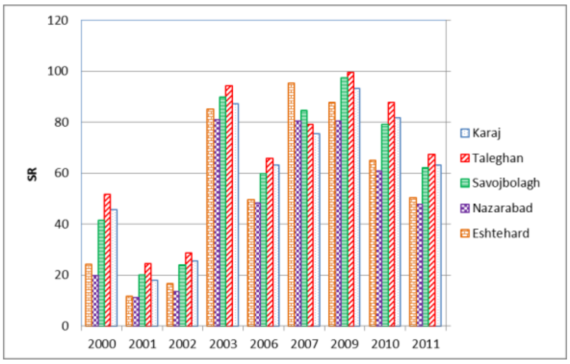

Fig. 3. Shows average changes of vegetation index of simple ratio in separated cities.

Correlation of satellite data with land data

In order to compare vegetation index with the field data, vegetation map of 5 watershed, and 55 types of plants in Alborz Province and vegetation percentage data and bare soil percentage were compared with satellite imagery. According to Table 1., the SR changes amounts are highly correlated with the percentage of vegetation and bare soil. The SR correlation is significant with the vegetation percentage at 0.05 percent level, and with bare negative soil percentage at the 0.01 level. Significant relationship of index with vegetation indicates the reliability of dedicated index to study the density of vegetation. Thus, the vegetation changes of rengelands erea of study can be monitored with 95 percent assurance, by using this index.

Table 1. Correlation between the index and the land data.

Factor		Per of Soil	Per of Cover	SR
Bare soil percentage	Pearson Correlation	1	-.858**	-.461**
	Sig. (2-tailed)		.000	.000
	N	55	55	55
Vegetation percentage	Pearson Correlation	-.858**	1	.380**
	Sig. (2-tailed)	.000		.004
	N	55	55	55
SR	Pearson Correlation	-.461**	.380**	1
	Sig. (2-tailed)	.000	.004	
	N	55	55	55

**. Correlation is significant at the 0.01 level- *. Correlation is significant at the 0.05 level

Variance analysis results

Variance analysis results in Table 2. shows that there are significant differences in the probability levels of less than 0.0001 in different years and also in different areas. In other words, SR index is so vary in different areas and different years. Analysis results show a high determination coefficient. Comparing averages shows that the areas have been devided into two parts from the vegetation density point of view, and vegetation amount of Taleqan, Savojbolagh and Karaj are as the same and Eshtehard and Nazarabad are also have similar behavior. Because the province rengelands densities of vegetation are in two different classes, each rangeland management policies should be different and suitable for ecological conditions of the region.

Table 2. Variance analysis results.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
year	8	31875.95	3984.49	129.69	0.0001<
location	4	1724.14	431	14.03	0.0001<
Error	32	983.18	30.72		
Total	44	34583.26			
	R2=0.972	CV=9.4	RMSE=5.54		

pr: probability

Table 3. Comparing averages with LSD test of the probability level of 0.05.

location	N	Mean	Grouping
Taleghan	9	66.556	A
Savojbolagh	9	62.1	A
Karaj	9	61.54	A
Eshtehard	9	54	B
Nazarabad	9	49.3	B

Table4. SR Annual changes grouping among Counties.

year	N	Mean	Grouping	
2009	5	91.76	A	
2003	5	87.6	A	B
2007	5	83.1		B
2010	5	74.93	C	
2011	5	58.18	D	
2006	5	57.34	D	
2000	5	36.6	E	
2002	5	21.68	F	
2001	5	17.14	F	

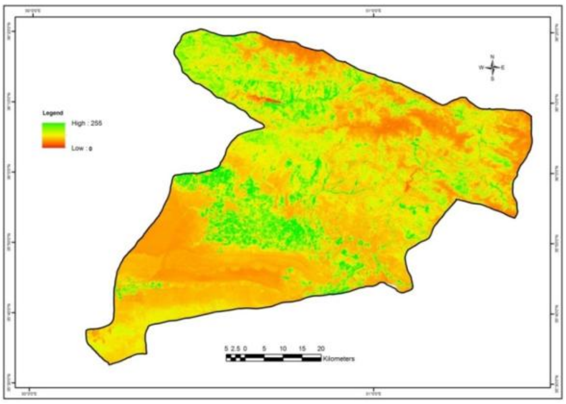

Fig. 4. Map of SR in May 2009.

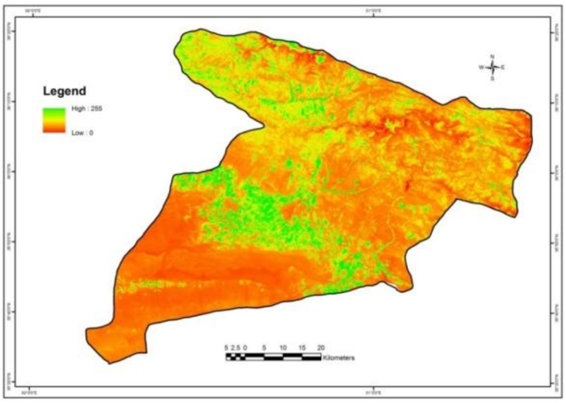

Fig. 5. Map of SR in May 2001.

Comparing the vegetation average between different years

Comparing the different years with the LSD test at the level of 0.05 was carried out. According to Table 4., the highest vegetation average was in 2009 and 2003, and the lowest was in 2002 and 2001 .Vegetation density in 2009, 2003 and 2007 are approximately equal. The years 2011, 2006, 2001 and 2002 are all in a same group. Fig.4. show the state of vegetation in May.2009 by using a simple ratio and Fig.5. shows the state of vegetation by using a simple ratio in May 2001.

Discussion

Almost all investigators have introdused remote sensing of data and satelite data as a powerful tool in monitoring of plants and field studies, and they know it useful for calibration of data in large scale (Graetz, 1987; Pickup, 1989; Tueller, 1987). The most common case of vegetation remote measurement is the vegetation assessment by using plant indices (Bannari *et al.,* 1995; Pickup *et al.*, 1993; Purevdorj *et al.,* 1998; Thiam and Eastman 2001). Lots of vegetation spectral indices have been peresented for evaluation of quantitative and qualitative vegetation. But choosing the best indicator for the vegetation quantitative analysis is the most important problem of the users. In arid and semi-arid areas using vegetation indices which the red and infrared bands are used in them are more apropriate for the vegetation studies in these areas (Jafari *et al.* 2007). Used indicator in this study is the one which utilizes from red and infrared bands. Comparing the map of 5 watershed vegetation and 55 types of vegetation with SR indices indicated that the indices have significant correlation with actual vegetation at the 0.05 level and negative correlation with soil at the 0.01 level. The results of this study showed that this index is apropriate for monitoring of vegetation, and in other words it explaines 95 percent of the vegetation changes by using Landsat TM bands of 3 and 4, and also it is consistent with Stenberg and Huete results,they have introduced SR index as a reliable indicator for vegetation assessment (Huete *et al.,* 2002; Stenberg *et al.,* 2004). On the same basis, the index was used to monitor changes in vegetation. The results showed that, in Alborz Province, vegetation decreases from 2000 to 2002 and increases from 2003 to 2009, and then it decrease again. Among the counties, Taleghan has always the highest and Nazarabad the lowest vegetation density, in general, the amount of vegetation has increased in 2011 in campare with 2000, and searching about the reason of these changes is necessary. In this regard, Anderson and Holte (1981) focus on the importance of other ecological factors in rangeland management. Comparing averages shows that the areas based on the vgetation density are divided into two groups, and Taleghan, Savojbolagh and Karaj are in one group and Eshtehard and Nazarabad are in another group. Because province rangelands are in two different classes based on vegetation density, each different rangeland management strategies should be appropriated to the ecological conditions of the region. Comparing averages in different years showed that the highest vegetation average is belonging to 2009 and 2003, and the lowest is belonging to 2002 and 2001. The vegetation in 2009, 2003 and 2007 are almost identical. Also 2011, 2006, 2001 and 2002 are all together in the same group, which represents an idenical density of vegetation. Muir and his colleague's expresse about the importance of monitoring vegetation that the short-term assessment which is done in the form of statistical and study programs can only describe and assess a rangeland resources throught a year and cannot show the temporal changes of rangelands. Because of the importance of temporal changes in rangeland studies, these studies should perform in monitoring form (Muir and Maclaran, 1997). Because of the importance of monitoring the vegetation changes in rangelands management and crisis prediction, vegetation changes can be monitored by using appropriate indicators and the suitable program can make for vegetation management and deal with its effects by analysing the results. Given that, Nazarabad and Eshtehard have lowest mean percentage vegetation and have little potential of Range Management. It is suggested that these areas could be allocated to other land uses such as residential and industrial and Taleghan areas, Savojbolagh and Karaj are assigned to Range Management. With this method, the ranges of each province or city or area can be monitored and depending on the amount of vegetation that can be obtained from the analysis of the images, management of user type can be selected for each region. Our rangeland of temporal and spatial evaluations focus on a small part but this way can the wider and longer time periods to assess rangeland vegetation. This paper presents a model for the broader rangeland study with the help of satellite imagery offers.

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