Research Journal of Environmental and Earth Sciences 2(3): 118-127, 2010
ISSN: 2041-0492

Submitted Date: December 28, 2009 Accepted Date: February 17, 2010 Published Date: July 10, 2010

Vegetation Cover Change Monitoring Applying Satellite Data During 1972 to 2007

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Abstract: One of the influential tools in the study field of pasture and vegetation cover science is technology of remote sensing and satellite data. Satellite data have essential role in preparing needed information for different vegetation aspects studying. One of the applications of satellite data is to prepare the vegetation cover percentage map. In this studying order to prepare the vegetation cover crown percentage maps of Mouteh wildlife refuge between 1972 and 2007, the satellite data were used. Vegetation indices were produced using MSS sensors for 1972, TM for 1987, TM for 1998 and image of LISS III sensor for 2007. In this study cover crown percentage Map was provided by using indices, which could decrease the soil reflectance. At first corrections was performed on each images. To make correlation between cover crown percentage and satellite data, 290 plot data with appropriate distribution across the region were collected. By using data and several image processing cover crown percentage was estimated for previous years. For each image cover crown percentage models were produced by simple linear regression between produced vegetation indices from each image and field data calculated. Regarding to data analysis SAVI plant index had the highest correlation with cover crown percentage and selected for producing vegetation crown cover percentage. Using produced model from SAVI index vegetation crown, cover percentage maps were produced in four classes percentage for each year. Results showed that cover crown percentage had decreasing trend in this period.

Key words: Mouteh wildlife refuge, percentage of vegetation cover, satellite data, soil coefficient, vegetation indices

INTRODUCTION

Studies about the vegetation cover are first researches, which were done with satellite data in the field of natural resources management. The entrance of the first satellite of natural resources in 1972 into space gave us the possibility of preparing periodic images and analysis of vegetation cover (Alavi, 2005; Esteman, 1995). Vegetation has a special reflectance pattern, which is used to prepare vegetation indices. Vegetation indices give us different combinations of multi-spectrum satellite data to produce an image of vegetation cover. In Table 1, related equations of some vegetation indices are shown (Esteman, 1995; Pellikka *et al.*, 2004).

In different areas, according to characteristics of earth surface and amount of the vegetation cover, different indices are chosen in order to describe the vegetation cover situation. In various regions, different types of vegetation indices regarding to characteristics of lands and amount of vegetation cover crown will be chosen to describe plant cover status. In arid areas with scatter plant which soil reflectance is high, those indices should be chosen which are able to decrease amount of soil reflectance impact significantly (Ammarin and Jiahong, 2009; Esteman, 1995; Zahedi fard, 2004).

Overall plant cover indices could be divided into two groups: Slope-based and Distance-based Esteman (1995). Fig. 1A shows a slope-based index, which will trend to infrared band when amount of plant cover increases. In the related figure pixels with various cover crown made lines with different slopes. Some of them are TVI, NDVI and RVI indices. Fig. 1B shows distance-based pattern in which those pixels with cover crown get far away from soil line. Some of them are PVI_{1-3}, PVI, WDVI, TSAVI and MSAVI (Esteman, 1995).

SAVI index is a hybrid index of two-mentioned plant index. Its key is in soil coefficient (L). Soil coefficient varies between zeros for 100% plant to 1 for bare soil. Amount of this coefficient would be set to 0.5 in most investigations (Ammarin and Jiahong, 2009; Brondizio *et al.*, 1994; Esteman, 1995; Masoud and Koike, 2006).

However, in order to use satellite data in recognizing natural resource primarily affect of some factors such topography, soil reflex, atmospheric effects and so must be decreased or eliminated. Then should try to find the relation between this data and land phenomenon by using different method that such relation can establish between one of the vegetation specification such as covering crown, forage production and so from one side single

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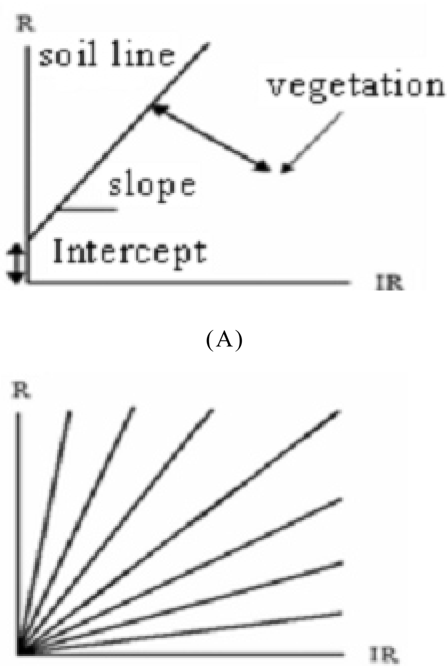

(A)

(B)

Fig. 1: Shows tow type of vegetation indices; (A) shows a slope-based index, and (B) shows distance-based pattern (Esteman, 1995)

bands or combination of ratio bands which is called vegetation index (Alexander and Millington, 2000). In most studies Information about past years vegetation condition is not available. So other ways should be applied to compare vegetation data such as vegetation indices (Rondeaux and Baret, 1996). Kamusoko and Aniya (2006) for change detection in Zimbabwe used TM, ETM^+ and MSS image. They geo-referenced ETM and MSS image to TM image with RMSe lower 1. They used post classification change detection methods for change detection and mentioned that atmosphere hasn't affect on post classification change detection result therefore didn't do atmospheric correction (Kamusoko and Aniya, 2006).

Masoud and Koike (2006) in their study used SAVI index to provide vegetation cover crown map because the related area is desert with scarce vegetation. They mentioned that SAVI index can decrease impact of soil reflectance and soil coefficient was set to 0.5 in SAVI equation. Rondeaux and Baret (1996) found that MSAVI1 index has the most sensitivity to cover crown percentage and NDVI is second. They also found that soil has so impacts on received reflectance of plant.

One way to investigate land cover and land use changes is to compare them after classification satellite images (Ammarin and Jiahong, 2009; Johnson and Kasischke, 1998; Mundia and Aniya, 2006; Yang and Lo,2002). Post classification change detection is based on

Table 1: Calculating formula of some vegetation indices

Index	Formula
NDVI	$\frac{NIR-RED}{NIR-RED}$
$TSAVI_1$	$\frac{a.((NIR-a)(RED-b))}{RED+a.NIR-a.d}$
DVI	$a.NIR-RED$
PVI	$\frac{b.NIR-RED+a}{\sqrt{1+a^2}}$
PVI_2	$\frac{(NIR-a).(RED+b)}{\sqrt{1+a^2}}$
SAVI	$\left(\frac{(NIR-R)}{(NIR+RED+L)}\right).(1+L)$
RVI	$\frac{NIR}{RED}$
RATIO	$\frac{RED}{NIR}$
TVI	$\sqrt{\left(\frac{NIR-RED}{NIR+RED}\right)}+0.5$
WDVI	$NIR-(a.RED)$
MSAVI	$2NIR+1-\sqrt{2(NIR+1)^2-8(NIR-RED)}$

classified images in which images of two or more dates would be classified separately and then they would be adapted together so changed areas would be specified and map would be provided. The most important advantage of this method is ability of providing a matrix of changed data and decreasing outer impact of atmosphere and environmental differences between multi temporal images (Brondizio *et al.*, 1994, Yang and Lo, 2002). In post classification change detection accurate geometric correction and images classification has significant impacts on change detection result accuracy but atmosphere has no impacts (Mundia, and Aniya, 2006; Rondeaux and Baret, 1996; Soffianian *et al.*, 2008; Yang and Lo, 2002). Kamusoko and Aniya (2006) used post

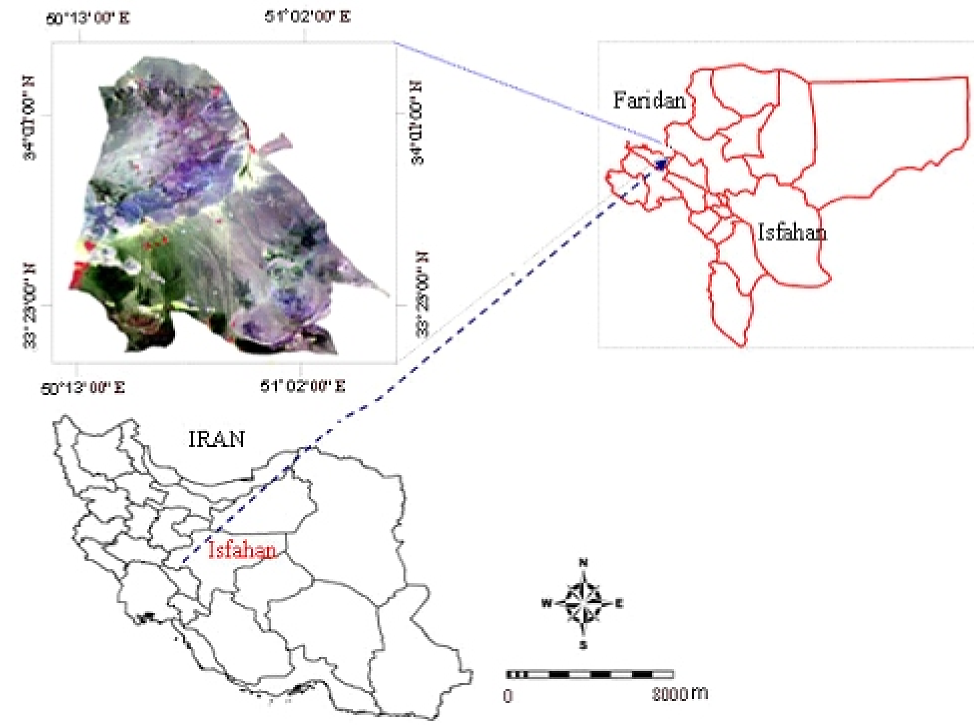

Fig. 2: Geographical position of the studied area

classification change detection methods for change detection and mentioned that atmosphere hasn't affect on post classification change detection result therefore didn't do atmospheric correction. Mundia and Aniya (2006) in his investigation of a region in Nairobi to show changes, used ETM^+ data sensors of 1997, TM data of 1988 and MSS data of 1976. For geometric correction first TM image was geo-referenced by using 1:50000 topography map for 1988 and with 30 ground control points between image and map with RMSe less than 0.5, then they geo-referenced MSS and ETM^+ images by using common points with TM image and they changed spatial resolution to 30m by using re-sampling method. They showed impacts of spatial resolution and spectral resolution ability to show changes and used post classification change detection method (Mundia and Aniya, 2006). Brondizio *et al.* (1994), Kamusoko and Aniya (2006) and Soffianian *et al.* (2008) also used same methods. The aim of this study is to prepare the cover percentage map of the vegetation and their changes detection during 1972-2007.

MATERIALS AND METHODS

Study area: Study area is the Mouteh wildlife refuge located in Isfahan province with approximate measurement of 204000 hectare. This site from northwestern reached to Meime town and from southwestern to Delijan city. It is located in 50º 13′ to 51º 02′ eastern longitudes and in 33º 23′ to 34º 01′ northern latitude (Soffianian *et al.*, 2008). This site with an altitude of 1500 to 3000 m is fluctuating. Climate of site, according to Do marten method is semi-dry. The absolute minimum of temperature is -29ºC in February and its absolute maximum is +40ºC in July and August. The average rainfall of the site is 263 mm, which its maximum is 58.2 mm in May and its minimum in summer is between 0.1 to 3 mm. totally raining in the site starts in November and continues until June. Plant communities of this site are included of dry and semi-dry areas plants. The site is located in vegetation habitat area of Iran-Tourani (stepped, semi-stepped and high mountains sites) that mostly includes of stepped fields covered with short bushes in slope (Soffianian *et al.*, 2008). Fig. 2 shows the geographical situation of site. Plant communities existing in the site are relatively restricted. Table 2 shows the scientific names of 20 dominant plant communities of the site.

Field sampling: In this study, appropriate areas for collecting information on plant cover were specified by using experiences from previous investigations and our field study. Contemporary with the LISS III image scanning, plant cover sampling was performed by using plots with method of two main diameters estimation of canopy plant cover. Regarding to extent of each type, at least 5 plots with 100m distances from each other were

Table 2: Main plant communities of the study area (Borhani, 2000)

Community	Community
Ephedra,	*Acantolimon*
Eremurus	*Alhagi*
Euphorbia	*Anabasis*
Halocnemum	*Artimisia*
Hertia	*Astragalos*
Limonium	*Atriplex*
Noaea	*Carex*
Pteropyrum	*Cousinia*
Peganum	*Dorema*
Stipa	*Scariola*

chosen. Plots were at least 200m from roads, residential areas and rivers. Least effective area method was used to specify plot dimensions (3m ×7m). Coordinates of center of each plot were collected by GPS. Each plot has information about: percentage of canopy plant cover for all plant types in plot, stone percentage, bare soil for 290 plots in late May and early May. 80 plots were chosen to study provided maps.

Used data: In this investigation information of more than 200 images were studied and data with appropriate quality and similar ability of spectral and spatial resolution were chosen. Time period of 1972-2007 was chosen because all satellite data and images were accessible. Data for MSS of 1972, TM for 1987 and 1998 and LISS III for 2007 at the same time of field sampling were prepared. In addition, the Digital Elevation Model (DEM) 1:25000 of the site was used.

Pre-processing stage: Geometric correction on each image was performed with Root Means Square error (RMSe) less than 0.8 of pixel. The newest image was geo-referenced to 1:25000 topography map with RMSe equal to 0.5 pixel and by using 30 control points with good dispersal and then TM image for 1998 with 20 control points geo-referenced to first image and other images were geo-referenced to gather. Image resolutions were converted to 30m by using re-sampling method when images were geo-referenced. Topography correction was performed by using DEM of area and image Meta data because some parts were mountains.

Preparing the percentage map of the vegetation cover: In order to preparing the cover percentage maps, with the use of existing satellite images, vegetation indices of Table 1 were prepared.

In preparing vegetation indices of MSAVI1, $PVI_{1\text{-}3}$, PVI, WDVI, TSAVI, and DVI, the concept of soil line were used. In this purpose, density slicing was done on the NDVI index; soil layer was separated from image. Then with the use of soil layer and doing linear regression between red bands (band 2) as independent variable X and near infrared band (band 3) as dependent variable Y, the soil line equation was prepared in order to produce PVI2, PVI3, TSAVI indices.

$$Y= 1.38X+0.72 \tag{1}$$

In order to produce, PVI, PVI1, DVI, MSAVI11 indices, linear regression was done between red bands as dependent variable and infrared band as independent variable. Then soil line equation was produced.

$$Y= 0.71+0.23 \tag{2}$$

With the use of line slope and intercept of the produced soil equation, producing the vegetation indices were done by usage of two bands of red and infrared.

In order to analyze the amount of vegetation cover percentage of each quadrats with vegetation indices, assimilation of simple linear regression was done between quadrats cover as dependent variable and same quantities of each quadrats in vegetation index as independent variable. Among vegetation indices, SAVI index had the highest amount of relation coefficient with vegetation cover. So, in order to preparing percentage map of vegetation cover, this index was used. With attention to extent of vegetation cover percentage which was reached from sampling in site and included quantities of 0 to 100% and also with attention to abundance of quantities from sampling, the quantities of vegetation cover were divided into four category (0 to 10%, 10 to 20%, 20to 40% and more than 40%). Threshold for each class in vegetation index was estimated by using provided model from SAVI index. The vegetation cover map by reclassing and by usage of reached threshold was prepared on SAVI index. Since the direct relating of sampling quantities of 2007 with the past was not possible, to prepare the model of the vegetation cover percentage of 1972, 1988, 1998, it was considered that SAVI index has also the same high correlation with the cover crown percentage in those years. Then the maps of mentions years were done in this way in which the percentage of vegetation cover in restricted area that because of protecting was not destroyed and also areas with fixed vegetation cover such as *Tamarix* sp. and *Phragmites* sp. were chosen as quantities of more than 70% cover and also with comparing SAVI image and FCC image of 2007 and SAVI and FCC of considered times, their cover were estimated. Then same quantities of chosen spot reached in SAVI index and with simple linear regression analyze of back stage prepared vegetation cover models for each image.

By doing studies and analysis on topography maps and by doing windows on farmas and orchad having regular geometric shape, orchad and farms were separated from *Tamarix* sp. and *Phragmites* sp. To analyze the accuracy of the percentage map of vegetation cover of 2007, 80 quadrats which were not used in preparing the model of vegetation cover, were chosen by chance and then accuracy of made maps were analyzed with the use of those spots and Kappa Coefficient, Total Accuracy, Omission and comission error were analyzed.

Finally, to analyze the quality and quantity of changes, the maps were overlaied on each other and changes trend were specified by post classification change detection methods.

RESULTS AND DISCUSSION

Since the most parts of the Mouteh wildlife refuge's vegetation cover are Oshkoobe, therefore sampling was done with quadrats and by measuring method on two main diameters. The space of each quadrats in each site and vegetation type were chosen by minimum effective space method. Borhani (2000) in his studies used the same method, for sampling the amount of vegetation cover density. In this study with attention to intense, suddenness changes of vegetation cover, in neighborhood of roads, and floodways the minimum distance of 200 m was considered. To form a correlation between spatial resolution and field sampling, sampling was done in the sites which vegetation cover had minimum variation and included an approximately wide and congenial vegetation cover. By considering this point, the variance of the amount of between quadrats in each sampling place reached the minimum James *et al.*, (1976). Therefore, there was ability to allocate vegetation cover crown percentage of sampled plots to large area of sensors spatial resolution. Therefore, neighbor pixels of sampling location had similar canopy cover as sampled plots. Therefore pixel value which plot locates in it describes reflectance of sampled cover percentage in regarded plot (Khajeddin and Yeganeh, 2008; Mundia and Aniya, 2006; Pellikka *et al.*, 2004). Khajeddin and Yeganeh (2008) in his study, emphasizes on proportion of sampling method and the local separation power of weighing.

Mouteh wildlife refuge is located in a semi-desert area, so with attention to spars vegetation cover in most parts of refuge, the reflectance of soil is higher than vegetation cover reflectance (Jianwen and Bagan, 2005). In this study in order to reduce the effect of soil reflectance, indices were used in which the effect of soil is reduced. In order to prepare Distance Based indices with preparation soil equation.

Table 3 shows the prepared vegetation cover model with usage of vegetation indices from LISS III image.

As shown in the Table 3, the PVI_3, PVI_2, PVI_1, PVI, DVI, $MSAVI_1$, and WDVI have high R^2. In this Table, the variable Y is considered as vegetation cover and variable X is considered as vegetation index. The NDVI index has average R^2 and is less than analyzed indices. SAVI plant index had the highest description coefficient of canopy plant cover and Kappa coefficient in this area. In this study correlation between percentages of vegetation cover crown and plant index were investigated alongside description coefficient and it showed that provided indices had meaningful correlation with vegetation cover crown at 0.01 levels. SAVI index, is used in purpose of reaching the minimum difference of spectral vegetation cover reflex that cause to several of soil background prepared (James *et al.*, 1976). Masoud and Koike (2006) noted in his study that this index has capability in showing scattered plant cover through desert areas. Huete (1988) described SAVI index as a hybrid index of distance and slope based indices. Because SAVI description coefficient of vegetation covers, crown percentage was very high in the region it was used to provide cover crown percentage map in 2007. Rondeaux and Baret (1996) used distance-based indices to provide canopy plant cover map and also to reduce soil reflectance impact and described them as useful factors in decreasing soil reflectance impact. Because there was no data from plant cover status for previous years in study area, assumed that related index has the highest correlation with plant cover for period of 1972-1998. To make correlation between vegetation crown cover and SAVI index, therefore canopy plant cover in core area which had low changes because of protection, and also visual interpretation of FCC for each image and regarding to ground collection of plant cover in 2007, amount of cover crown percentage was estimated theoretically in more than 100 areas. Plant cover model was provided by performing linear regression between vegetation cover crown and corresponding amounts of chosen plots in SAVI index for each year. Table 4 shows provided models by using SAVI index and their correlation coefficient.

The vegetation cover percentage map of each year with the usage of made models was prepared for the years of 1972, 1987, 1998, 2007. Fig. 3 to 6, in order show the vegetation cover map of these years: 1972, 1987, 1998,

Table 3: Produced vegetation cover crown percentage models using vegetation indices

vegetation index	model of vegetation cover	R^2	Kappa coefficient
SAVI	Y = 392.7X + 64.66	0.78^{**}	0.79
NDVI	Y = 179.3X + 24.89	0.77^{**}	0.78
RVI	Y = -97. 41X + 125.43	0.76^{**}	0.75
DVI	Y = 0.72X – 7.7	0.7^{**}	0.16
PVI_1	Y = 1.26X – 7	0.69^{**}	0.21
PVI_2	Y = 1.11X + 30.17	0.67^{**}	0.015
PVI_3	Y= 0.89X -14.46	0.63^{**}	0.087
PVI	Y = 1.26X + 7.02	0.7^{**}	0.25
$TSAVI_1$	Y = 164/97 + 33	0.77^{**}	0.78
WDVI	Y = 0.44X + 400	0.49^{**}	0.71
$MSAVI1_1$	Y = 11.3-32.7	0.63^{**}	0.71

** Correlation is significant at the 0.01 level.

Table 4: Selected models from analyzed regression to prepare the percentage map of the vegetation cover

SAVI index	Equation	R^2
TM – 1998	Y= 2 40.95x + 16.13	0.73
TM – 1987	Y= 333.46x+25	0.89
MSS – 1972	Y = 285.79x + 27	

** Correlation is significant at the 0.01 level

Table 5: Matrix of The accuracy of prepared vegetation cover map with the use of LISS III image 2007

	0-10%	10-20%	20-40%	40%<	Total pixel	Commission error	Producer accuracy
0-10 %	96976	1455	15	43	98489	0.015	0.61
10-20%	8294	28246	441	54	37035	0.237	0.762
20-40%	173	2027	3859	239	6298	0.387	0.8
40%<	81	0	54	5776	5911	0.022	0.977
Total pixel	105524	31728	4369	6112	147733		
Commission error	0.081	0.109	0.116	0.055			
Producer accuracy	0.918	0.089	0.883	0.945			

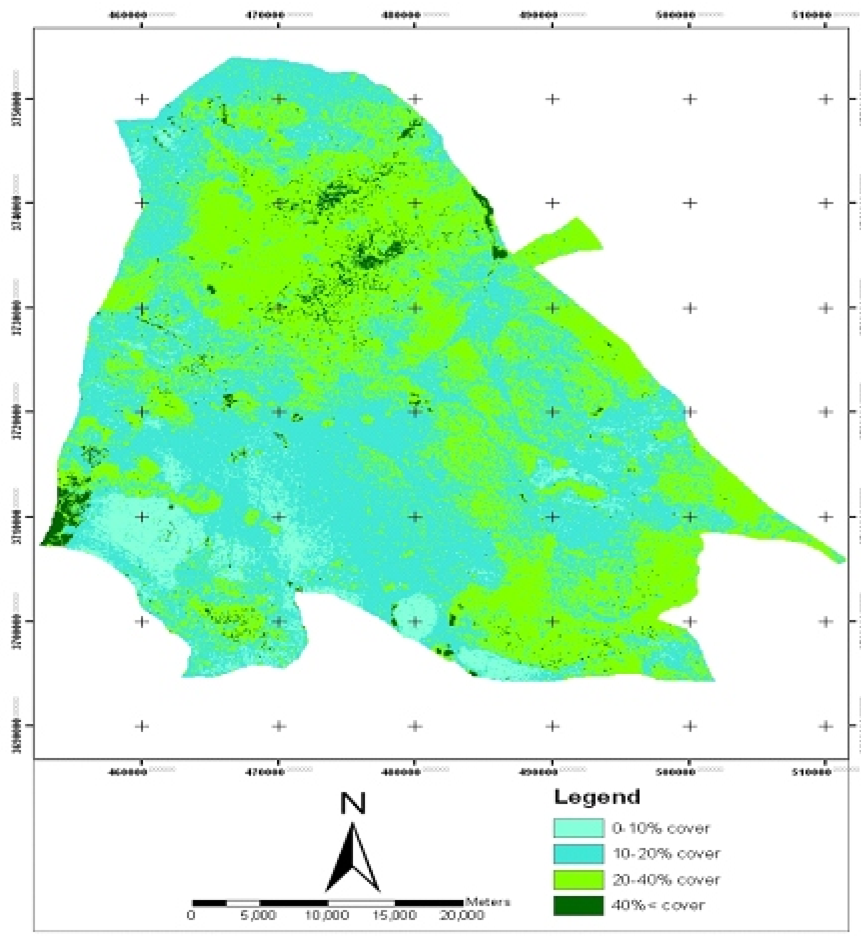

Fig. 3: The percentage map of vegetation cover in (1987)

and 2007. These maps show that most covers of more than 40% and 20 to 40% are located in safe and mountainous sites of Mouteh village and mountains of the southern part of site. In these images, the central pastoral places in site have mostly cover of between zero to 10% or 10 to 20%. To examine the accuracy of the produced maps, we used the 80 plot data, which were not applied in producing map that their cover crown percentage estimated for other images base on false composite color and vegetation indices that were produced for each image. Table 5, shows the error matrix of the vegetation cover percentage of 2007. Kappa coefficient was calculated between 0.7 and 0.8 for other maps. Soffianian *et al*. (2008) and Yang and Lo (2002) also reported in his study that according to unavailability of information about past time of site, he was satisfied with a general overview of the map accuracy.

Table 6 shows the classes' space of the vegetation cover percentage in each year studied. According to this Table, in 1972 cover of class 2 by including 72% of the study area has the most area. Also in the 1987 cover of 10-20% by including 51% of the whole site, forms the most cover of the site.

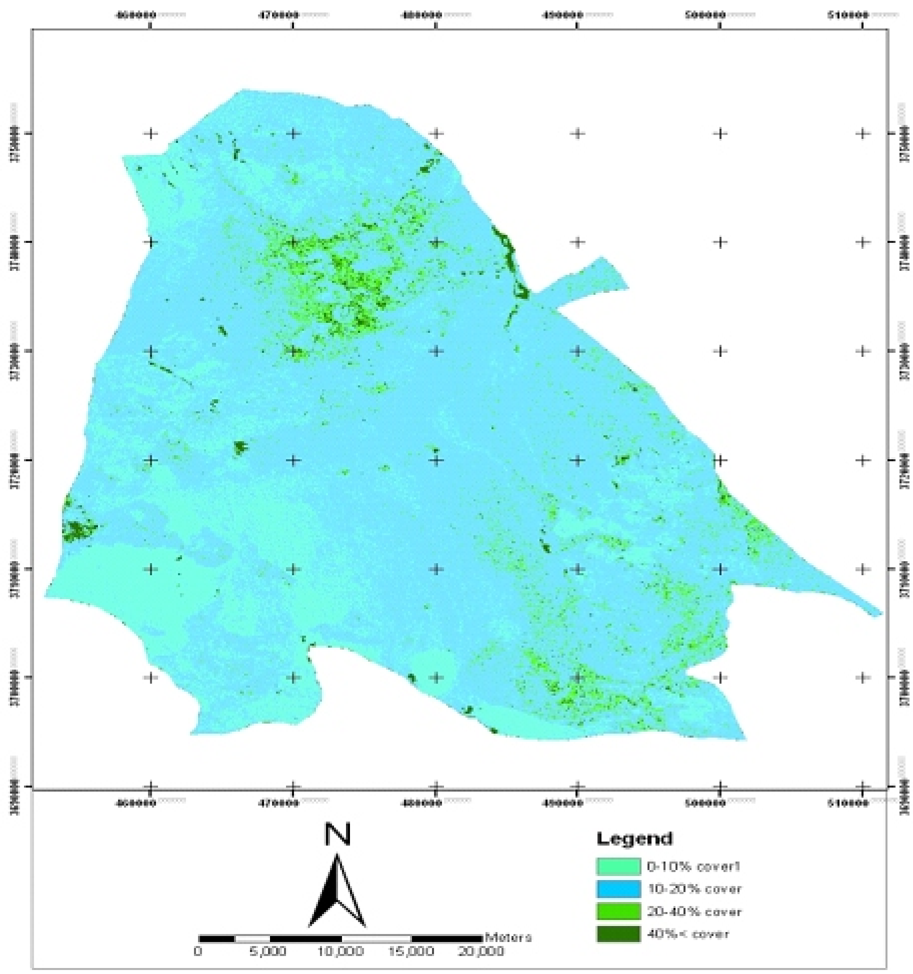

Fig. 4: The percentage map of vegetation cover in (1972)

Table 6: The classes' space of the vegetation cover during 1972 to 2007

	Satellite data			
(%) Cover	MSS-1372	TM-1987	TM-1998	LISS III-2007
0-10	40162	12921	102370	95597
10-20	150136	104110	65117	64186
20-40	10808	81126	32721	37712
40<	2463	3353	1411	4250

Table 7: The table of changes trend during 1973 to 1987

(%) Cover	0-10	10-20	20-40	40<
0-10	11777	25850	2632	89
10-20	1599	77286	69302	1865
20-40	9	1311	8631	795
40<	13	208	1486	620

Table 8: The table of changes trend during 1987 to 1998

(%) Cover	0-10	10-20	20-40	40<
0-10	12451	311	137	12
10-20	71579	27818	4450	114
20-40	17895	36584	25906	545
40<	239	318	2093	640

Table 9: The table of changes trend during 1998 to 2006

(%) Cover	0-10	10-20	20-40	40<
0-10	73640	23238	5089	224
10-20	18574	31834	14116	454
20-40	3002	8913	17929	2763
40<	96	110	446	679

Table 10: The table of changes trend during 1972 to 2007

(%) Cover	0-10	10-20	20-40	40<
0-10	33036	4565	2033	289
10-20	63081	55124	28857	2628
20-40	960	3536	5515	748
40<	218	415	1183	544

Furthermore, in 1987 cover of 20-40% also had a great share of the site. In the years of 1998 and 2007 cover of less than 10 percent forms the great part of the site. In order to analyzing the changes trend of vegetation cover, the cover percentage maps of the years were overlaid on each other and their quality and quantity were reviewed. Thus, firstly the map of 1987 was overlaid on

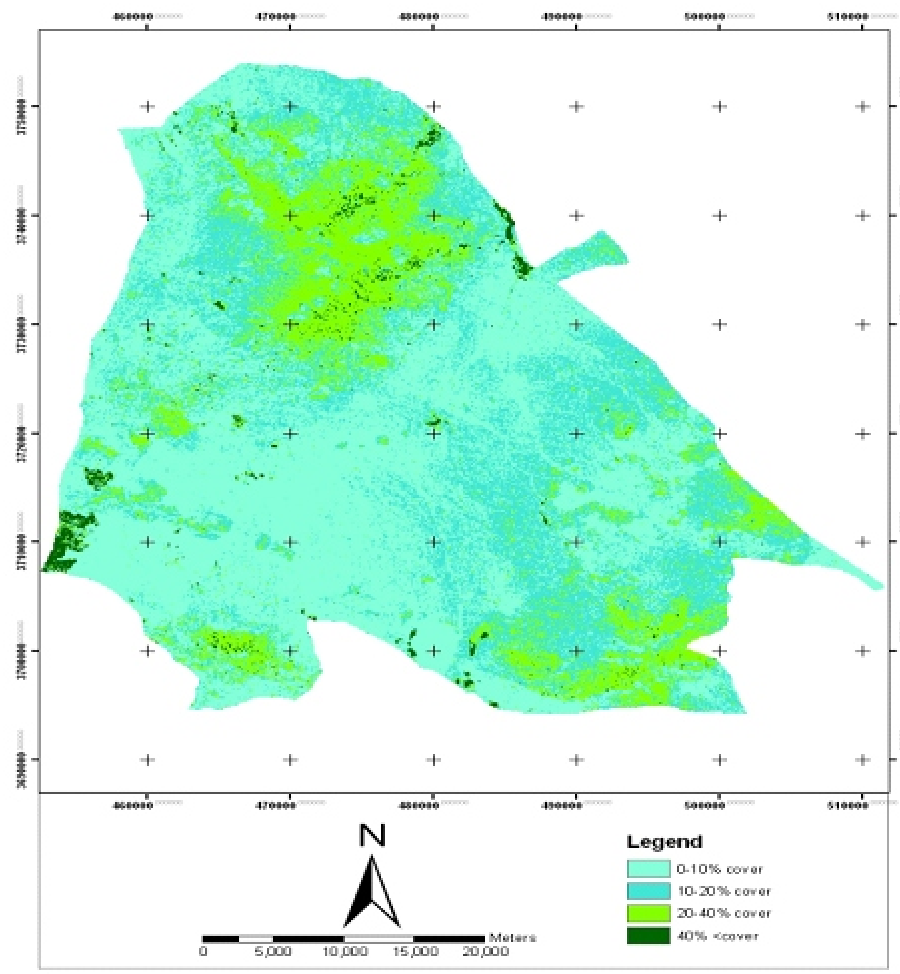

Fig. 5: The percentage map of vegetation cover in (1998)

the map of 1972. Results showed that in this period the most changes were in class 2 of cover its main purpose is to increase the cover crown percentage and changing to class 3 of cover and also the class of 20-40% had a growth trend. Precipitation information for this time showed a wetness year in 1986 (Table 7).

Analyzing the result of overlaying maps of 1987 to 1998 shows that in this period, the most changes were in classes 2 and 3 of vegetation cover and they are falling to their lower classes (Table 8).

Analyzing the result of overlaying maps of 1998 to 2007 shows that in this period, the most changes are in classes 1 and 2 of vegetation cover and is in trend of raising the class 1 to upper classes and changing class 2 to cover classes of 1 and 3 (Table 9).

Analyzing the general trend of changes during 1972 to 2007 shows that generally in studied period the percentage of vegetation cover had a decreasing trend. In this period cover crown of class 2 had the most changes and was decreasing to cover of class one from 71% of the site to 31% in 2007. Also during this period, covers of classes 3 and 4 were increased in safe areas (core area) of the refuge (Table 10).

CONCLUSION

Selecting satellite images is one of the most important steps in remote sensing studies. In this study first image of MSS sensor, which was taken by quality, was used. Regarding to scale and purpose of study other images from TM and LISS III were selected. Yang and Lo (2002) describe that scale and purpose of study are important in selecting type of images. Regarding to the importance of investigating situation of plant cover in protected areas, we tried to provide images in spring and June in which plant cover has maximum cover crown (Khajeddin and Yeganeh, 2008; Jianwen and Bagan, 2005). Performing accurate geometric correction on images has significant impacts. Therefore performing an accurate geometric correction on images to establish sampling location in its

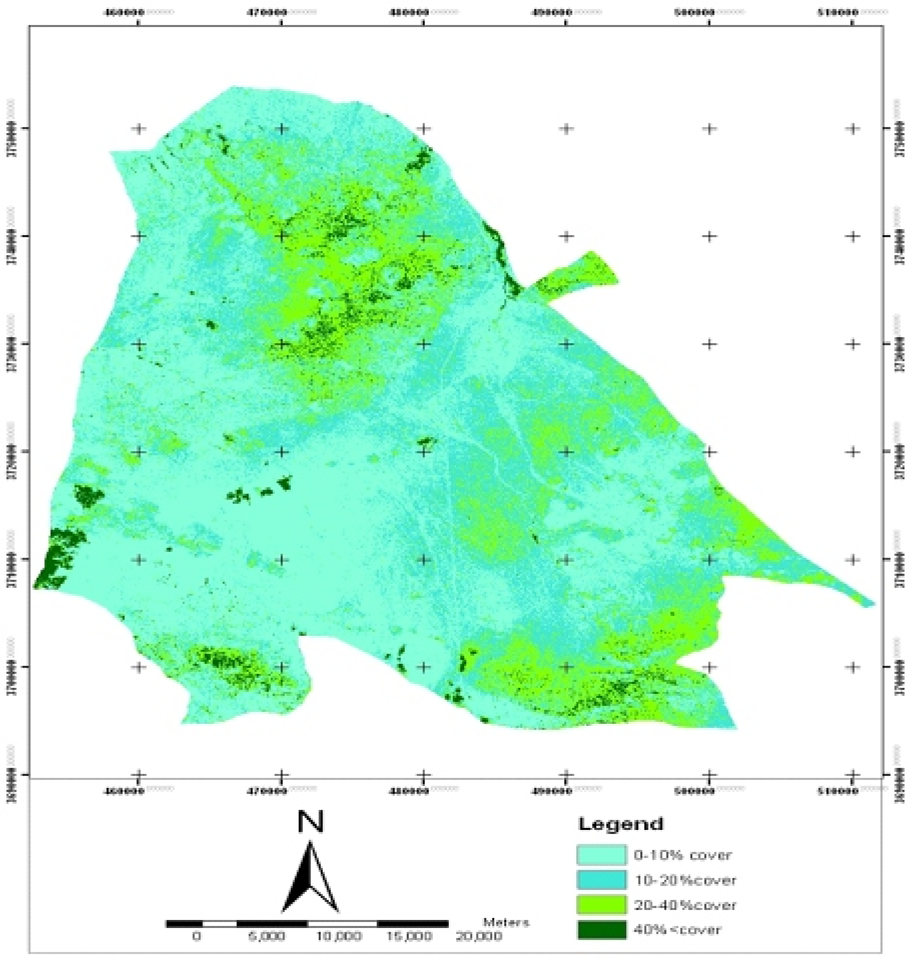

Fig. 6: The percentage map of vegetation cover in (2007)

actual place is so important (Esteman, 1995; Mundia and Aniya, 2006; Zahedi fard *et al.*, 2004). As expected before regarding to scattering plant in area distance based indices which soil factor is considering in them had high description coefficient and more than slope based indices (Esteman, 1995). In this study SAVI index perfectly described vegetation, cover crown percentage by using soil coefficient (L). Comparing the area for cover crown classes during study showed that cover crown is variable in this period. Regarding to investigations various factors like pasture of animals, famine, wetness, direct interference by humans have impacts on cover crown percentage in the study area. Considering that there was no data of plant cover from the past investigating plant cover by using traditional methods in past years wasn't feasible but remote sensing data made it possible therefore we can see importance of these data (Rondeaux and Baret, 1996; Yang and Lo, 2002). To study change detection in investigations, which use sensor data with different spatial and radiometric resolution, it is possible by using post classification change detection method. As post classification change detection of images atmosphere hasn't impacts on results and there is no need for atmospheric correction (Alavi *et al.*, 2004; Brondizio *et al.*, 1994; Mundia and Aniya 2006; Yang and Lo, 2002).

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