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EVALUATION AND MAPPING OF RANGELANDS DEGRADATION USING REMOTELY SENSED DATA

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ABSTRACT
The empirical and scientifically documents prove that misuse of natural resource causes degradation in it. So natural resources conservation is important in approaching sustainable development aims. In current study, Landsat Thematic Mapper images and grazing gradient method have been used to map the extent and degree of rangeland degradation. In during ground-based data measuring, factors such as vegetation cover, litter, plant diversity, bare soil, and stone & gravels were estimated as biophysical indicators of degradation. The next stage, after geometric correction and doing some necessary pre-processing practices on the study area's images; the best and suitable vegetation index has been selected to map rangeland degradation among the Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), and Perpendicular Vegetation Index (PVI). Then using suitable vegetation index and distance parameter was produced the rangelands degradation map. The results of ground-based data analysis reveal that there is a significant relation between increasing distance from critical points and plant diversity and also percentage of litter. Also there is significant relation between vegetation cover percent and distance from village, i.e. the vegetation cover percent increases by increasing distance from villages, while it wasn't the same around the stock watering points. The result of analysis about bare soil and distance from critical point was the same to vegetation cover changes manner. Also there wasn't significant relation between stones & gravels index and distance from critical points. The results of image processing show that, NDVI appears to be sensitive to vegetation changes along the grazing gradient and it can be suitable vegetation index to map rangeland degradation. The degradation map shows that there is high degradation around the critical points. These areas need urgent attention for soil conservation. Generally, it shows that the most parts of rangelands in studying area have been degraded. So conservation priorities on degraded rangelands have been recognized based on current degradation.

Keywords: Rangelands degradation, grazing gradient, remote sensing, Landsat Thematic Mapper, Iran.

INTRODUCTION

While rangelands degradation is usually one of the major problem in very large arid and semi-arid areas of Iran. Little is known of its extent, severity and causative factors. Current statistics of degraded rangelands aren't accurate. Also traditional techniques for degradation evaluation have seriously lost their credit. On the other hand, present techniques of degradation evaluation in Iran have lots of problems such as unrepeatable, time and cost consumption, etc. low precision techniques as aerial photographs interpretation could provide useful data; but their exactness is low and their repeatability aren't sufficient. So that, aerial photographs aren't completely useful method in monitoring of vegetation over time. In regards to above mentioned words, requirement to precise, repeatable, inexpensive and etc technique is very necessary for management of Iran's rangelands. Remotely sensed data are very useful tool for this purpose. Repeated data, vast cove, digital nature are some advantages of remotely sensed data. This article shows how vegetation index derived from remotely sensed data can be used in association with grazing gradient (i.e., systematic changes in vegetation cover with distance from critical areas) to identify extent and severity of rangeland degradation.

METHODS AND MATERIAL

Study site

Qazvin province in northern Iran is characterized by a semi-arid climate with cold winter, dry and warm summer. This study was conducted in Kolanjin River Basin, 120 Km west of Qazvin city ($35^{\circ}\ 24^{'}\ 16^{''}$ to $35^{\circ}\ 38^{'}\ 26^{''}$ N latitude and $49^{\circ}\ 24^{'}\ 48$ to $49^{\circ}\ 31^{'}\ 48^{''}$ E longitude). Total area of study site is 15636.6 ha. This site is situated at about 2211 M elevation. Average annual precipitation is 345 mm over the past 30 years, with an average annual temperature of 10° C. The area comprises communal rangelands (13392.76 ha), woodlands, farmlands, and gardens (2243.79 ha).

Ground based data collection

In this study localized data were collected around critical areas (rural villages and watering points) by using of 200 m transect and $3m^2$ plots. Collection of data was conducted on three general geographical directions (north, south and west)* around rural villages and on two directions (east and west) around watering points. Distance of transects on each direction was systematic; 100 m around village and 50 m around watering points. Then six quadrats were located on each transect by 40 m distance from each others. Factors such as vegetation canopy, plant diversity, litter, stone and gravel, bare soil were estimated in each quadrat as major bio-physical indicators of degradation. Coordinates of transects were saved in GPS. After doing some necessary operations on the data, changing trend of above indicators and their correlation with distance from critical areas were recognized.

Data sources

1) Satellite data: Landsat Thematic Mapper sub scenes have been used from tow years time span (1989 and 1998) (table 1). The images were acquired from Iranian Remote Sensing Center (IRSC).
2) Ancillary data

2-1) Topographic maps (scale 1/50000) prepared by National Cartographic Center (NCC).

2-2) Vegetation map of the study area was used to delineate vegetation type boundaries.

Table 1. Thematic Mapper sub-scenes for the study site.

Images	Path & row	Date*
1	166-35	2 July 1998
2	166-35	14 April 1998

* Date of two images is different. It is due to lack of simultaneous images in IRSC.

Geometric correction

Satellite data and other maps of interest have been processed using of IDRISI and Arc/Info image processing software. First, Land-sat TM sub scenes were re-sampled to

* Village and farmlands place on the eastern part of study site and there is no rangeland in this part.

Superimpose images to a reverence recent and cloud free image. A geometric polynomial transformation model (first degree) has been applied on the image. Then, 1998 image is used to georeference other re-sampled subset (table 2).

Table 2. First degree polynomial transformation model (image to map, reference 1998).

X	TM 14 April 1998 20 GCPs		Y
a_0	-14019.76	-155262.5	b_0
a_1	0.0399	-0.000268	b_1

a_2	0.000103	0.03994	b_2
RMS	0.43	0.43	RMS
alpha	3.85	-90.38	beta

$X' = a_0 + a_1 x + a_2 y$ $\qquad$ $a = \sqrt{a^2 + b_1^{\ 2}}$ $\qquad$ $alpha = \cos^{-1}(a_1/a)$

$Y' = b_0 + b_1 x + b_2 y$ $\qquad$ $b = \sqrt{a_2^{\ 2} + b_2^{\ 2}}$ $\qquad$ $beta = \cos(90) - \cos^{-1}(b_1/b)$

After geometric and radiometric corrections based on a standardized approach and other pre-processing operations such as separation of rangeland from other land use, proper vegetation index has been selected among the NDVI, PVI, and SAVI for mapping degradation. For this purpose NDVI, PVI, SAVI images were produced based on following formulas in IDRISI software. Then, the boundaries of woodland, cultivated lands, gardens, and rangelands delineated. Other processing was done only on rangelands.

NDVI= NIR-Red / NIR +Red

SAVI= NIR-Red / (NIR + Red +L) *(1+L)

PVI= NIR sin (a- R cos (a)

a= 48.8^0 angle of soil line with NIR

L= 0.5 soil adjusted factor

Then the coordinates of transects were recognized on the images by transferring of data in GPS to the software. Average NDVI, PVI, SAVI were calculated along all transects on the images. Changes of vegetation indices have been recognized along grazing gradient by designation of their graph in Microsoft-Excel. Therefore, by comparison of changing trend of bio-physical indicators and vegetation indices, the suitable index is selected. The suitable index is one that has the same trend with ground data trend. Finally, rangeland degradation map has been produced by using of selected index and grazing gradient parameter.

RESULTS

1) Results of ground-based data

These results show that changing trend of bio-physical indicators around critical areas are as follows:

1-1- Vegetation cover: generally average vegetation cove increases with distance from rural villages. The relationship between vegetation cover and distance from villages was high significant (r=0.95, p-value<0.01). By increasing distance from villages percent of palatable plants increase and unpalatable plants decrease. Off course, there was no significant correlation between vegetation cover and distance from watering points (r=0.63, p-value>0.05). However, palatable plants and ratio of palatable to unpalatable plants increase by distance from water.

1-2- Bare soil: generally, average bare soil decreases with distance from rural villages till specific distance and then it has fluctuation. Relationship between them was very high (r=0.97, p-value< 0.01). There was no significant relationship between them around watering points (r=0.42, p-value>0.05).

1-3- Stone and gravel: there was no significant correlation between this physical indicator and distance from critical areas (r= 0.75, p-value>0.05 for villages; r=0.47, p-value> 0.05 for watering points).

1-4- Litter: the results show that average litter increases very much with distance from critical areas. Correlation coefficient between them around watering points and villages were r=0.99, p-value<0.001 and r= 0.96, p-value<0.01, respectively.

1-5- Plant diversity: diversity increases with distance from both critical areas. Correlation coefficient between them around watering points was r=0.96, p-value<0.01; and for rural villages was r=0.91, and p-value<0.05.

2) Results of image processing

Total RMS error resulted from geometric correction was less than 0.5 pixel. There were no any clouds or other atmospheric objects as fog on the images. Analyzing relationship between NDVI, PVI, SAVI and bio-physical indicators showed that NDVI has significant correlation with vegetation cover and other indicators (r=0.83, p-value<0.05) (table 3 , 4).

Table 3. Correlation coefficients of vegetation indices with vegetation cover around some rural villages.

Village	Vegetation index	correlation coefficient (r)		
		South	North	west
Astalaj	NDVI	75	74	55
	SAVI	34	46	10
	PVI	76	27	16
Gavzamin	NDVI	80	57	88
	SAVI	63	9	49
	PVI	0.02	3	25
Tu-abad	NDVI	78	52	92
	SAVI	71	42	72
	PVI	21	73	3

Kolanjin	NDVI SAVI PVI	60 57 32	67 49 62	86 17 54

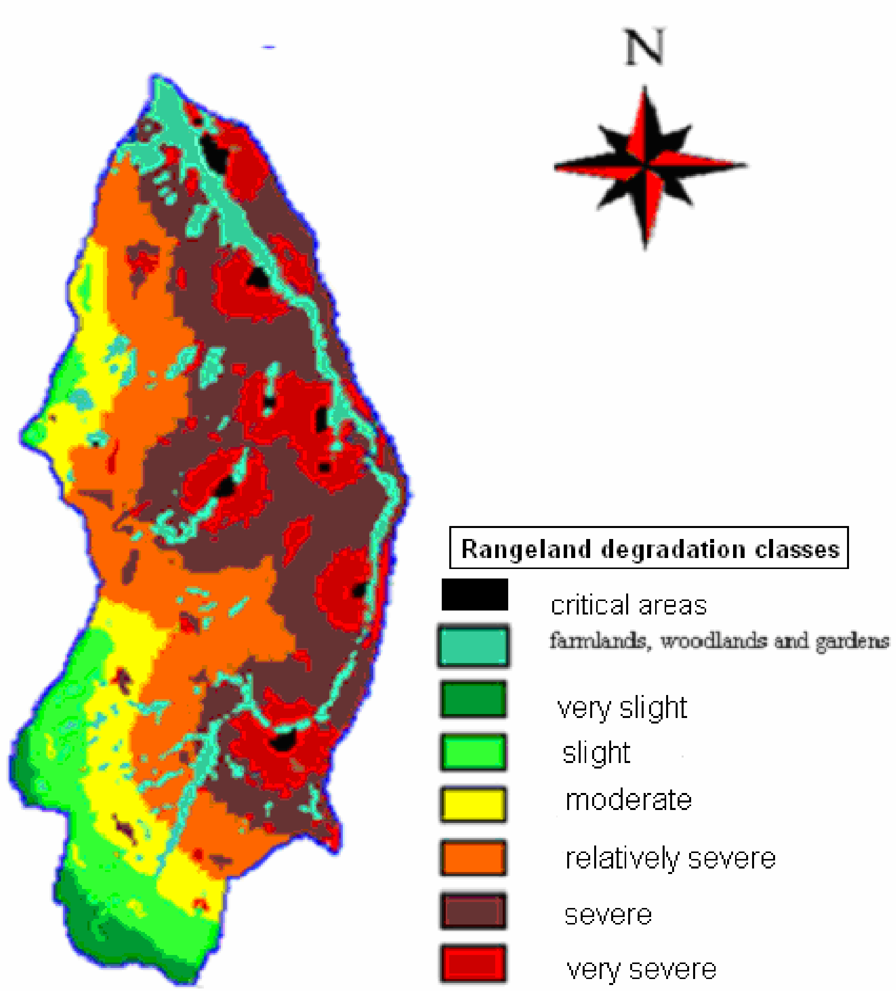
Table 4. Correlation coefficient of vegetation indices with vegetation cover around some watering points.

Village	Vegetation index	correlation coefficient (r)	
		west	east
Kharabeh-kahriz	NDVI SAVI PVI	74 74 62	92 72 2
Saru-kurd	NDVI SAVI PVI	51 64 66	94 96 36
kolanjin	NDVI SAVI PVI	88 36 46	60 65 57

So that, by using of NDVI image and distance from critical areas, degradation map was produced (map 1). The degradation map showed that there are six degradation classes on the rangelands (table 5).

Table 5. Extent and severity degradation classes which were recognized on the map.

Degradation class	Degradation severity	Area (ha)	Percent
I	Very slight	556.92	4.16
II	Slight	1490.04	11.13
III	Moderate	223.064	1.7
IV	Relatively sever	3422.97	25.6
V	Severe	5267.61	39.3
VI	Very severe	2432.16	18.16



Map 1. rangelands degradation map of study area

Histogram of the degradation map showed that large area of rangelands in the study site is located in class V, severe degradation. Also, rangelands around critical areas have degraded very severe, class VI. Generally rangelands degradation decrease with distance from critical areas. Regression analysis of multi-temporal images to detect degradation over time showed there is no significant correlation between their NDVI maps due to difference in date of images ($r= 0.5$, p-value>0.05). Namely, since the old image belonged to July (summer) and the last image belong to April (spring); then vegetation cover is very different in the summer and spring in semi-arid areas because of natural conditions. It should be noted that the same dated images of study area were unavailable in IRSC. We strongly recommend using of simultaneous images to detect changes over time.

Discussion

Our mapping showed that large areas (39.3%)of the study site is subject to severe degradation. Rangelands subject to very slight degradation forms 4.16 percent. Slight degradation occurs in mountainous areas and high lands. As the degradation map shows, most of the slight degraded rangelands are located in high lands which are inaccessible for livestock. So that, slight degradation in the site due not to accurate management of rangelands. The reasons of degradation of most rangelands are over stoking, early grazing and untimely grazing. Continuous grazing system is the most common system in the study site. Degradation map has enabled us to identify priority areas for conservation and improvement. Rangelands around critical areas need urgent attention for soil conservation and vegetation improvement. Degradation near to critical areas is clearly related to human activities such as up-rooting plants, over grazing, soil trampling and farming activities. This study utilized a "bottom-up" framework as an alternative to the traditional "top-down" scientific approach for problem solving in range management (Shrader-frechette and Mccoy 1993). Top-down monitoring of rangelands using remote sensing has typically used coarse resolution spectral data and poorly ground based data on rangelands. In contrast, collecting ground data in well defined quadrats and correlating it directly with satellite digital imagery circumvents the problems associated with top-down approach. In general, remote sensing data must be accompanied with ground based data to map vegetation change. Otherwise, the results won't be reliable. As a result, this study was able to evaluate the potential of remotely sensed data for assessing rangelands degradation.

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