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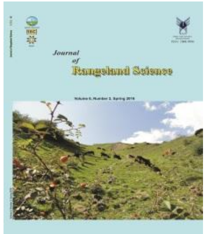


**Research and Full Length Article:**

# Investigation of Rangeland Changes Based on Landscape Metrics Analysis (Case Study: Kezab Rangelands, Yazd Province, Iran)

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**Abstract.** Adverse changes in rangeland vegetation can be considered as one of the criteria for land degradation. Some of these changes can be evaluated through monitoring the spatial changes of landscape parameters. This study aimed to investigate the landscape changes in Kezab rangelands of Yazd province, central Iran. Landsat satellite images of 1990, 2002, and 2013, and landscape metrics including Total Edge, Edge Density, Mean Shape Index, Number of Patches, Mean Patch Size, and Median Patch Size were used in this study. Landscape fragmentation was analyzed through calculating various metrics of landscape patterns using the FRAGSTATS software. This study was performed with a focus on landscape elements in poor and very poor rangelands. Results indicated a reduction in the area of rangelands with poor conditions and an increase in the size of rangelands with very poor conditions. The results showed that perimeter sum of spots in rangelands increased From 51.6 km in 1990 to 62 km in 2013. This increase in the perimeter showed further destruction of poor rangelands. This process was considerably seen in very poor rangelands and increased from 48.9 km in 1990 to 56 km in 2013. The process of Edge Density index changes confirmed the intensification of desertification in the region. Also, the number of patches in poor and very poor rangelands increased from 23 to 11 and from 4 to 10, respectively. The intensification of destruction has been shown in very poor rangelands. Rangelands were also changed in terms of other landscape parameters, eventually leading to the deformation of rangeland patches and the degradation process has been intensified in this region. According to the results of these studies, landscape changes of rangelands could be assessed at various time intervals to detect the factors affecting rangelands.

**Key words:** Rangeland, Landscape metrics, Landscape discontinuities, Kezab rangelands, Yazd

## Introduction

Over the past decades, human activities have a large impact on natural ecosystem resulting in unfavorable changes of ecosystem with significant ecological consequences (Apan *et al.*, 2002). Changes in land cover/land use as a result of complex interaction of structural and functional factors associated with a demand, technological capacity, and social communication have widespread effects on the landscape. Two fundamental aspects of landscape structure including composition and configuration of patches could be measured by landscape metrics. The metrics showed the landscape composition while examining the diversity and abundance of patches regardless of spatial characteristics and order. Generally, landscape configuration refers to the position of landscape components as well as component characteristics and spatial order at landscape level.

Landscape quantitative analysis is based on fragmentation process that is one of the most important landscape processes showing the impact of human activity and human interference on landscape structure and function (Ahern and Andre, 2003).

In fragmentation process, landscape is divided into smaller fragments or patches. In the beginning of the fragmentation, the biodiversity within the patches has increased due to the removal of dominant species. However, after a while, all the species in biological patches will be in the danger of extinction because of the disturbances of biological hierarchy (Forman, 1995).

From human point of view, higher fragmentation represents higher population density due to the greater access; therefore, there is more pollution in the regions.

Evaluation and prioritization of structural characteristics of species have ecological bases so that the species with high ecological values take a conservation priority to develop the habitats surrounding these species. Creating an ecological network by the expansion of native vegetation among remaining species will result in the establishment of ecological relationships and increase the ecological quality. For this purpose, knowledge of land cover types and human activities in different sectors, or land use as a planning database is of utmost importance. Land use changes have been studied in Iran and other countries and the majority of changes may be referred to the effects of human development on the destruction of natural areas. Palmer and Rooyent (1998) investigated the effects of land management on vegetation changes in Kalahari region. Their results indicated an almost uniform trend in the protected areas as well as degradation in the regions under intensive use. Landscape pattern changes in response to urban development were investigated by Weng (2007) in the United States using the metrics of mean patch size, patch density, Shannon evenness index and landscape percent.

In Iran, land use changes have been studied by numerous researchers (Tabibian and Dadrast, 2002; Iranmanesh, 1988; Ghiasvand, 1997; Barkhordari *et al.*, 2005 and Zebardast, 2004). Talebi Amiri *et al.* (2009) analyzed the degradation of Neka watershed using landscape ecology approach and found that the increased number of patches and decreased mean area of landscape were two important criteria in this analysis.

They concluded that land use/cover conditions should be taken into consideration for proper management of land. Saffianian *et al.* (2010) analyzed the changes in shape and size of land uses in Isfahan using landscape metrics, and concluded that changes in spatial characteristics affected the ecological function of region and should be considered in landscape planning. Zhang *et al.* (2015) Characterized bi-temporal patterns of land surface temperature using landscape metrics based on sub-pixel classifications from Landsat TM/ETM+. Their results indicated that landscape metrics were sensitive to the variation of pixel values of fractional ISA[1], and the integration of LST[2] and LSMA[3].

Landscape metrics have provided a quantitative method for describing the spatial distribution and seasonal variations in urban thermal patterns in response to the associated urban land cover patterns.

Sun *et al.* (2016) expressed the spatio-temporal pattern of farmland changes in the arid lands using landscape metrics. Their results indicated that over two past decades, the area subjected to farmland expansion was significantly larger than that experiencing farmland abandonment.

The rapid expansion of farmland exhibited a concentrated pattern, and generally followed a layer-based development model. The study showed that the proposed research method effectively visualized and quantified the spatio-temporal dynamics of farmland changes.

Peng *et al.* (2016) identified main factors determining landscape metrics in semi-arid agro-pastoral ecotone and their results showed that the influences of human activities on landscape metrics surprisingly are not strong. Natural ecological factors involving temperature, precipitation and altitude had the greatest impact on landscape metrics values.

It seems that few studies have been conducted on landscape structural changes and its impact on desertification. Therefore, the objective of this study was to analyze landscape structure changes and the efficiency of landscape metrics in change trend analysis of Kezab rangelands, Yazd province.

## Materials and Methods

### Study area

The study area with an area of 1,176 km$^2$ is located in Kezab, northwest of Yazd province between longitudes of 53°42'41" to 54°13'4"E and latitudes of 31°45'22" to 32°07'30" N. Mean precipitation has been estimated as 75 mm during three years ending in 1990, 79 mm during three years ending in 2003 and 77mm for three years ending in 2013.

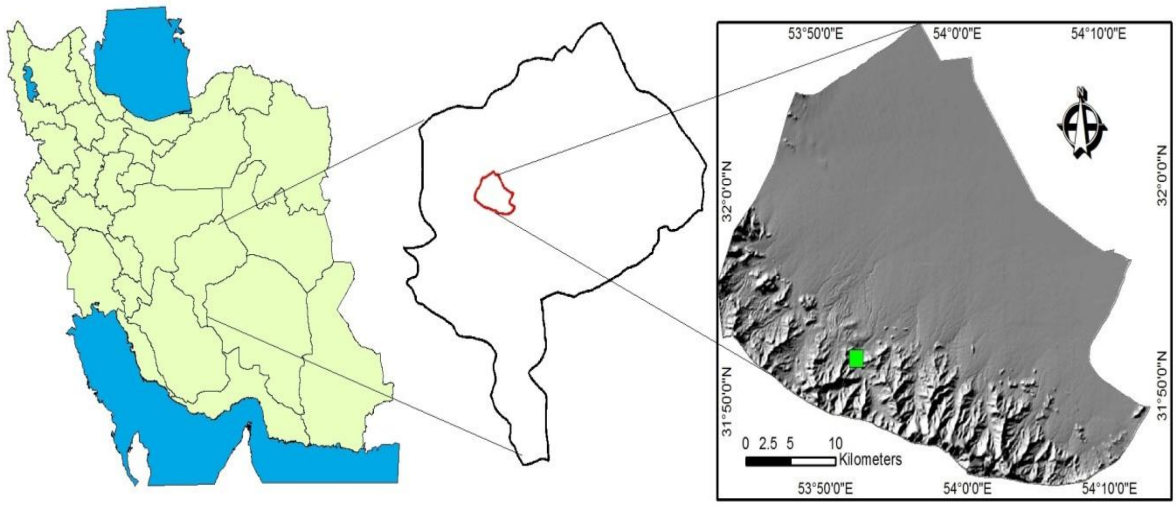



**Fig. 1.** Location of study area in Iran and Yazd providence

1- impervious surface area

2- land surface temperatures

3- linear spectral mixture analysis

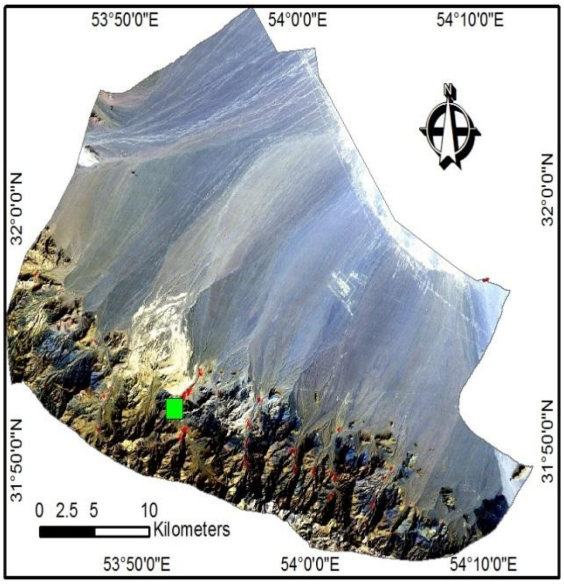
## Methodology

In the present study, remote sensing techniques were used in order to prepare the rangelands map. The maps derived from the Landsat images of 1990, 2002, and 2013 were used to assess the changes in these areas. Fig. 2, shows false color composite of the used images at various times. Since Landsat sensors are different in band number for 1990, 2002 and 2013, the bands with the same wavelength were used in color composite (the used bands were 1, 3, 4 in the 1990 images, 2, 3, 4 in 2002 images and, 3, 4 and 5 in 2013 images). Fig. 2 shows the used false color composite. Landscape structure changes were evaluated using FRAGSTATS software (a spatial pattern analysis software package).

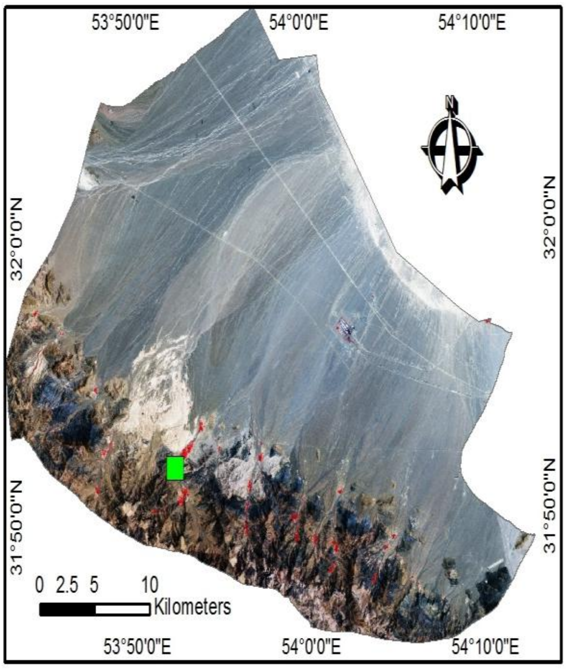
FRAGSTATS is a spatial pattern analysis program for the quantification of landscape structure including the composition and distribution. This program can be used for a wide range of landscape metrics (Original version published for the public in 1995). This software has quantified landscape heterogeneity easily and has shown a classified map or the continuous surface (FRAGSTATS, Mcgarigal & Mark, 994). To analyze and understand the landscape metrics in classes, it is recommended that a set of metrics may be considered in the analysis to understand and describe the ecosystems dynamics and landscape structure. After performing the atmospheric, radiometric and geometric corrections on the images, re-sampling was performed using the nearest neighbor interpolation method.

Then, using the band combination, a supervised classification with the maximum likelihood was applied. These steps were done using the ENVI 5.1 software. The accuracy of classification was checked through comparisons of existing land use maps and field study. Random sampling was used to classify data. According to the land use map and field visit observations, number of polygons was randomly recorded for each vegetation/land use group using GPS. The error matrix was used for the image classification accuracy assessment by the means of test samples through calculating statistical parameters such as total accuracy and Kappa coefficient (Fatemi & Rezaei, 2005).

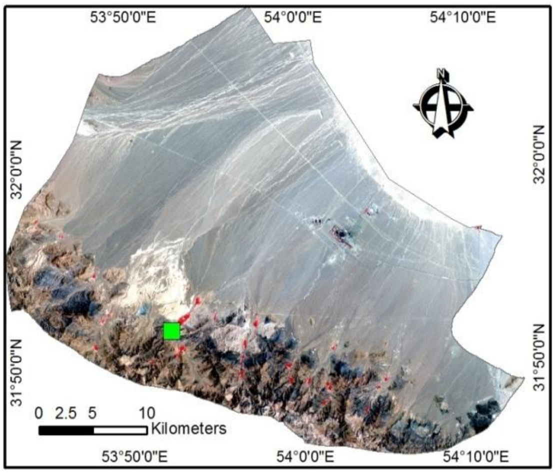
Then, majority filter was applied to obtain a uniform image and remove the scattered pixels on the images generated in the classification.




A: 1990, Green box is Kezab




B: 2002, Green box is Kezab




C: 2013, Green box is Kezab

**Fig. 2**. Used false color composite (a: 1990, b: 2002, c: 2013)

In this study, six landscape metrics including Total Edge, Edge Density, Mean Shape Index, Number of Patches, Mean Patch Size, Median Patch Size were used due to their ability to interpret the composition and spatial distribution of structural elements in the landscape (McGarigal *et al.*, 2002) (Table1). FRAGSTATS program (Mcgarigal & Mark, 1994) was used to calculate landscape metrics.

**Table 1.** The formula of landscape metric

| Name | Formula |
|---|---|
| Total Edge | $\sum_{k=1}^{M} \text{e } ik$ |
| Edge Density | $\frac{\sum_{k=1}^{M} \text{e ik}}{\text{A}}(1000)$ |
| Mean Shape Index | $\frac{\sum_{j=1}^{n}\left(\frac{p_{\text{Ü}}}{\sqrt[2]{\pi \times a_{\text{Ü}}}}\right)}{n_{\text{Ü}}}$ |
| Number of Patches | N |
| Mean Patch Size | $\frac{\sum_{j=1}^{n} a_{\text{Ü}}}{n_i}\left(\frac{1}{10000}\right)$ |
| Median Patch Size | 50%N |

**Where;** *e ik*: Total length of patches in the landscape in meters, N: The total number of patches in the landscape (except patches in fields), ni: The number of same patches in landscape, m: The number of same patches in landscape except outer boundary of landscape, m': The number of same patches in landscape and boundary of landscape, i: same patches, j: Number of patches, k: same patches, aij: The area of the patch ij in square meters, pij: The perimeter of the patch ij in square meters, A: The total area of the patch ij in square meters

## Results

The first part of research results has indicated some changes in rangeland conditions and other land uses in the study period. (Figs. 3, 4 and 5), show the map of rangelands and other land uses in the mentioned period. According to the purpose of study and the type of vegetation cover in the study area, five classes including rocky lands, horticultural and agricultural lands, poor rangelands, very poor rangelands and clay plains were identified.

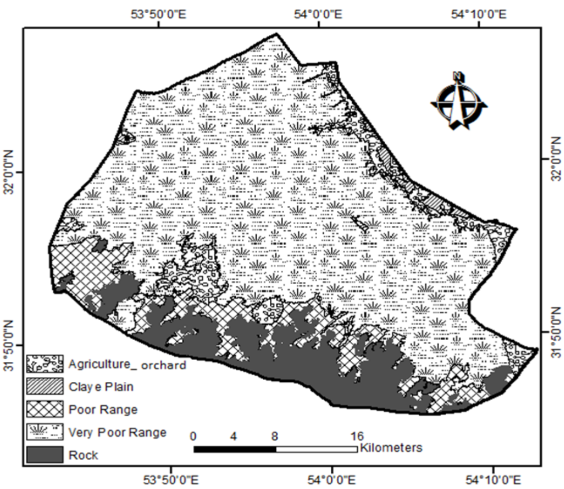



**Fig. 3.** Land use/cover map of study area in 1990

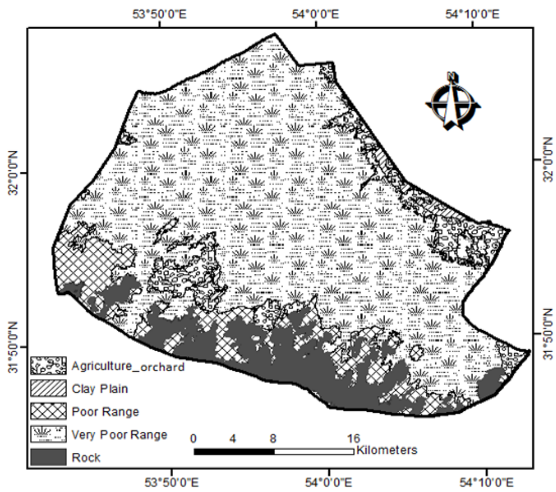



**Fig. 4.** Land use/cover map of study area in 2002

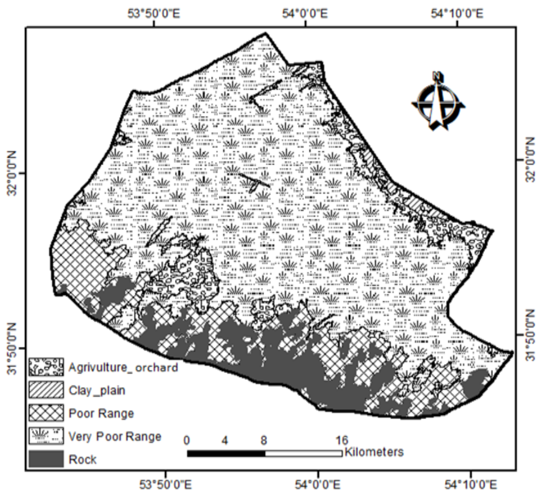



**Fig. 5.** Land uses / rangelands map of study area in 2013

After the generation of land use/cover map, the area of land use/cover classes was calculated. The area of poor rangeland was decreased but that of very poor rangeland was increased. Orchards and agricultural lands showed a small increase in the area and clay plain area remained the same across this period. These results are shown in Fig. 6.

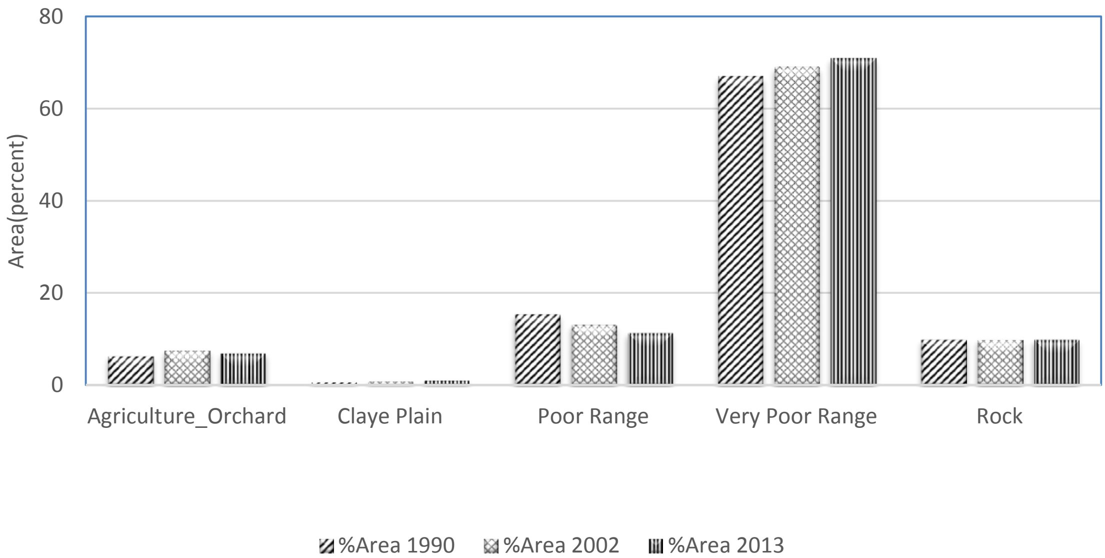



**Fig. 6.** The area of land uses/cover classes in different years

## Calculation of landscape metrics

Table 3 shows the landscape metrics of different land use classes in the study area. The Table results include the changes in these parameters: Mean shape index, Total Edge, Edge Density, Mean path size, number of patches and Median path size. The comparison results of landscape metrics during 23 years are presented in Table 3. Since the main purpose of this research is the assessment of rangeland condition changes according to the landscape metrics, these indicators have been studied on poor and very poor rangelands. Mean Shape Index in poor rangelands from 3.4 in 1990 has arrived to 3.04 in 2002 and 2.75 in 2013 indicating a decreasing trend. Actually, this reduction in poor rangelands was compensated in very poor rangelands.

Mean Shape Index in very poor rangelands from 1.83 in 1990 has arrived to 2.35 in 2002 and 2.65 in 2013 that shows an increasing trend. Total Edge Indicator had an increasing trend in both rangelands. This indicator represents the length of any feature edges. Edge Density Indicator has been increased in poor rangelands and it first has had a decreasing trend and then an increasing one in very poor rangelands. Mean Patch Size Indicator has had a decreasing trend in poor rangelands; on the other hand, in very poor ones from 1990 to 2002, it has had an intense decreasing trend but from 2002 to 2013, it has increased slightly. The Number of Patches in poor rangelands has a decreasing trend and in very poor rangelands, it has an increasing trend. Median Patch Size in poor rangelands has reduced firstly and then increased slightly. These indices in very poor rangelands generally have a decreasing trend. It should be noted the results of these indices in the other land uses are shown in Table 2. Since mountainous and rocky areas have had no changes in short time, a map of rocky areas might be drawn as mask firstly and applied in all time periods equally. Changes in the rangelands and vegetation conditions are more likely to be one of desertification indicators. Reduction of rangelands level, increase number of spots and density edge can be considered as the indicators of desertification in the vegetation section. Therefore, the results analysis of Table 3 shows the intensification of desertification in the region from 1990 to 2013.

**Table. 2.** Landscape metrics of different land use classes in the study area

| Name | Class | Mean Shape Index | Total Edge | Edge Density | Mean Patch Size | Number of Patches | Median Patch Size |
|---|---|---|---|---|---|---|---|
| | Unit | (none) | (meter) | (m/ha) | (ha) | (none) | (ha) |
| 1990 | Agriculture- Orchard | 2.60 | 340093.6 | 2.893 | 474.4 | 14 | 42.49 |
| | Clay Plain | 2.10 | 61935.5 | 0.527 | 124.8 | 8 | 113.11 |
| | Poor Rangeland | 3.40 | 516252.5 | 4.391 | 1366.8 | 23 | 310.77 |
| | Very Poor Rangeland | 1.83 | 489071.0 | 4.160 | 20282.0 | 4 | 463.61 |
| | Rock | 2.89 | 385623.5 | 3.280 | 915.4 | 15 | 147.49 |
| 2002 | Agriculture- Orchard | 2.29 | 373698.6 | 3.178 | 429.8 | 16 | 6.77 |
| | Clay Plain | 2.04 | 95722.6 | 0.814 | 89.2 | 15 | 61.33 |
| | Poor Rangeland | 3.04 | 616690.4 | 5.244 | 817.7 | 19 | 106.92 |
| | Very Poor Rangeland | 2.35 | 535403.2 | 4.808 | 8233.2 | 8 | 41.4 |
| | Rock | 2.89 | 385623.5 | 3.280 | 915.4 | 15 | 147.49 |
| 2013 | Agriculture- Orchard | 2.98 | 347179.6 | 2.952 | 596.3 | 21 | 85.14 |
| | Clay plain | 2.01 | 78706.1 | 0.669 | 94.1 | 13 | 17.74 |
| | Poor Rangeland | 2.75 | 620920.6 | 5.279 | 735.5 | 11 | 139.34 |
| | Very Poor Rangeland | 2.65 | 565498.2 | 4.553 | 9867.9 | 10 | 42.35 |
| | Rock | 2.89 | 385623.5 | 3.280 | 915.4 | 15 | 147.49 |

## Discussion

Landscape metrics as quantitative indicators of environment can be used in sustainable land use planning. In addition to land cover changes during 2002 to 2013 period, spatial characteristics of land use classes also changed. In other words, the shape and size of land use/cover were affected by land use conversion. Landscape metrics including class area, patches density, number of patches, mean patch size, edge density, and mean shape index were efficient in the analysis of land cover changes. This is in accordance with the findings of Lausch and Herzog (2002). The results showed that mean patch size has decreased in poor rangelands; this means that poor rangelands have been destroyed. Also, the destruction impact of spot size corresponds with the results reported by Matsushita *et al.* (2006) and Weng (2007). The spot perimeter increased in poor rangelands from 1990 to 2013. Increase in the spot perimeter causes an increase in the destruction length and direction of rangelands. This trend can be seen in very poor rangelands. This trend can be seen in the Edge Density parameters. This study showed that landscape metrics can be used in land use changes. These results corresponded with those found by Tagil (2007). Landscape analysis in this study indicates the effects of human activities in addition to natural factors on landscape changes, providing information on the policies related to land uses. Land fragmentation, especially rangelands and agricultural land is one of the indicators of land degradation. Using land shape metric indicators can be one of indicators showing the processes of land degradation and desertification. Increased areas of very poor and poor rangelands have increased the number of spots in grasslands and agricultural lands and also, the increased perimeter and ratio of perimeter to area are the signs of land degradation and desertification from 1990 to 2013. Therefore, it is necessary to do exact planning in order to combat the desertification process in this region.

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# بررسی تغییرات عرصه‌های مرتعی بر اساس تجزیه و تحلیل متریک‌های سرزمین (مطالعه موردی: مراتع کذاب، استان یزد )

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**چکیده.** وجود تغیرات نامناسب در عرصه‌های مرتعی را می‌توان به‌عنوان یکی از معیارهای تخریب سرزمین در نظر گرفت. بخشی از این تغییرات را می‌توان با استفاده از پایش تغییرات بوم‌شناسی سیمای سرزمین ارزیابی نمود. این مطالعه به‌منظور بررسی روند تغییرات پارامترهای سیمای سرزمین در مراتع دهستان کذاب استان یزد، انجام شد. به‌منظور تهیه نقشه‌های پوشش سرزمین و تحلیل تغییرات، به‌ترتیب از تصاویر ماهواره لندست در سال‌های ۱۹۹۰، ۲۰۰۲ و ۲۰۱۳ و متریک‌های مساحت طبقه، کل لبه‌ها، تراکم لبه‌ها، متوسط شاخص شکل، تعداد لکه‌ها و میانگین اندازه لکه‌ها استفاده شد. به‌منظور آنالیز گسستگی چشم انداز، متریک‌های متنوع الگوی چشم انداز در سطح کلاس با استفاده از نرم‌افزار FRAGSTATS محاسبه شد. در این مطالعه، وضعیت عناصر سیمای سرزمین در مراتع درجه دو و سه منطقه مورد مطالعه، مدنظر بوده است. نتایج این تحقیق نشان‌دهنده کاهش مراتع درجه دو و افزایش مراتع درجه سه بوده است. همچنین بررسی تعداد لکه‌ها نشان دهنده تخریب مرتع و ایجاد گسستگی بین مراتع مختلف، می‌باشد. نتایج این تحقیق نشان داد مجموع محیط لکه‌ها در مراتع از ۶/۵۱ کیلومتر در سال ۱۹۹۰ به ۶۲ کیلومتر در سال ۲۰۱۳ افزایش یافته است. این افزایش محیط نشان می‌دهد محیط بیشتری از مراتع فقیر در معرض تخریب قرارگرفته است. این روند در مراتع خیلی فقیر بیشتر بوده و از ۴۸/۹ کیلومتر در سال ۱۹۹۰ به ۵۶ کیلومتر در سال ۲۰۱۳ افزایش یافته است. روند تغییر شاخص تراکم حاشیه، تشدید تخریب را در منطقه تایید می‌کند. مجموع تعداد لکه‌ها در مراتع فقیر از ۲۳ به ۱۱ و در مراتع خیلی فقیر از ۴ به ۱۰ افزایش یافته است که تشدید تخریب در مراتع خیلی فقیر را نشان می‌دهد. بعلاوه مراتع موجود از لحاظ سایر پارامترهای سیمای سرزمین نیز دستخوش تغییراتی بوده است که در نهایت موجب تغییر شکل لکه‌های مرتعی شده و موجب تشدید فرآیند تخریب در این منطقه می‌گردد. با استفاده از نتایج این تحقیق می‌توان تغییرات وضعیت مراتع را ارزیابی و فاکتورهای موثر بر آن را آشکار ساخت.

**کلمات کلیدی:** اراضی مرتعی، متریک‌های سیمای سرزمین، گسستگی سیمای سرزمین، دهستان کذاب یزد