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Assessing the desertification trend using neural network classification and object-oriented techniques

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Abstract*:* Desertification consists of decline in production and ecological activities, which may happen due to either natural or unnatural (human) factors.This phenomenon is more evident in arid and semi-arid areas. The aim of this study is to assess the desertification trend using neural network classification and object-oriented techniques in Changouleh watershed which covers an area of 9949 hectare and is located in the south of Ilam province. For this study, TM and ETM+ satellite images of 1984 and 2013 were used. After conducting geometric and atmospheric corrections, images were classified using two neural network and object-orientedalgorithms. Moreover, to evaluate the accuracy and control the correctness of the obtained maps, typical parameters such as Kappa coefficient, the Confusion matrix, and stability of the classification were extracted for assessing the accuracy. The results show that most changes are related to increase in bare lands and decrease in poor and fair rangelands; therefore, approximately 18% of these areas has turned into desert. The results of evaluation of maps correctness show that these two methods are of high accuracy, but the object-oriented approach with Kappa coefficient (94%) and overall accuracy (96.26 %); in addition to being able to detect and categorize more classes, has a high accuracy compared to neural network method.

Keywords: Neural network classification, object-oriented classification, land use changes, Changouleh watershed**.**

Sinir ağı sınıflandırma ve obje tabanlı sınıflandırma teknikleri kullanarak çölleşme eğilim değerlendirilmesi

Özet: Çölleşme nedeniyle üretim ve ekolojik faaliyetlerde düşüş oluşur. Bu düşüş doğal ya da doğal olmayan (insan) faktörlere bağlı olarak ortaya çıkmaktadır. Bu durum kurak ve yarı kurak bölgelerde daha belirgindir. Bu çalışmanın amacı, 9949 hektarlık alan kaplayan ve İlam eyaletinin güneyinde yer alan Changouleh havzasında sinir ağı sınıflandırma ve nesne yönelimli teknikleri kullanarak çölleşme eğilim değerlendirmesini ortaya koymaktır. Bu çalışmada, 1984 ve 2013 yılı TM ve ETM + uydu görüntüleri kullanılmıştır. Geometrik ve atmosferik düzeltmeler yapıldıktan sonra, görüntüler iki sinir ağı ve nesne yönelimli algoritmalar kullanılarak sınıflandırılmıştır. Ayrıca, elde edilen haritaların doğruluğunu değerlendirmek ve kontrol etmek için, Kappa katsayısı, Karışıklık matris ve sınıflandırma istikrarı gibi tipik parametreler hariç tutulmuştur. Sonuçlar değişikliklerin çoğunun çıplak topraklardaki artış ve fakir mera alanlarındaki azalma ile ilişkili olduğunu göstermiştir; Bu nedenle, bu alanların yaklaşık% 18'i çöle dönüşmüştür. Harita doğruluk değerlendirme sonuçlarına göre, her iki yöntem (Kappa katsayısı (% 94)) ve (genel doğruluk (96,26%)) de yüksek doğruluk göstermektedir. Bunun yanı sıra nesne yönelimli yaklaşım ile; daha fazla sınıf kategorize etmek mümkündür ve sinir ağı yöntemine göre yüksek bir doğruluğa sahiptir.

Anahtar Kelimeler: Sinir ağı sınıflandırma, obje tabanlı sınıflandırma, arazi kullanım değişiklikleri, Changouleh havzası.

1.INTRODUCTION

Desertification is a process which causes fundamental modifications in an ecosystem and changes the condition from relatively non-desert state to desert state (Sen and Sharma, 1995). The phenomenon is

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created due to increasing human pressure on sensitive ecosystems which reduces production efficiency and also causes lack of reversibility. According to the estimates of the United Nations Conference on Desertification (UNCOD), in the future desertification will threaten more than 785 million arid regions' residents which make up 17.7 % of the total world population. A total of 60 to 100 million people will directly affect due to reduction of soil fertility and other desertification processes (Mashkuh, 1998). Desertification may happen in every climatic condition and it highly depends on the normal conditions of the region. In regions with warm and dry climates, the desertification process can lead to disaster more quickly. This process always includes degradation of soil, water resources, vegetation cover, and other resources and also causes natural and ecological tensions (Babaev, 1999).

Considering the role of natural resources in the human life, it is necessary to obtain accurate information about these resources and their changes. Some of the key factors of planning, decision-making and management tools for any organization are to monitor these changes and access the updated information and statistics (Zahtabian and TabaTabayi, 1999). Some of the world's most updated techniques for identifying potentials and also proper analysis of land-uses with regards to potential of each area are using satellite data, remote sensing techniques, and Geographical Information System (GIS) (Brouters, 1978) which received much attention in the recent two decades due to the high amounts of natural data. Satellite data, because of its characteristics such as wide surface coverage, repeatability, continuous updating, lower cost, and the ability to access impassable areas, plays an effective role in the studies related to land-use planning and determining changes in vegetation cover in developed and developing countries (Franklin, 2001; Terrill,1994). Some modern techniques have emerged to achieve better results in the classification of satellite data such as pixel-oriented, fuzzy, neural network, or object-oriented. In general, every method of plant classification is based on the relationship between the classifications of plant communities by ecologists, and classification of satellite images by remote sensing scientists. Although artificial neural network techniques for classification of satellite images might be used with high accuracy, a number of studies have shown that neural network techniques users experience some difficulties regarding selecting various parameters during the implementation of learning. Some problems with this method include selecting the network architecture, the sample size for training, learning algorithms and the number of iterations required for training (Vapnik, 1995). The present research aims to investigate the desertification in Changouleh area of Ilam province. Moreover, this research will compare neural network and object-oriented classification methods in the process of evaluation of desertification. The study area was selected due to its arid climate and sparse land cover that leads to accelerate the natural erosion process.

2. MATERIALS AND METHODS

2.1 The study area

The Changouleh drainage basin, having an area of 9948 hectares is located in the south of Ilam province, Mehran Township, and the geographical location between 46 16 33and 46 34 00eastern longitude, and 33 01 24 to 33 05 58 northern latitude (Figure / Şekil 1). The maximum elevation of the areas is 483 meters and the minimum elevation at the output of the basin is 199 meters above sea level. This area is located in the central and eastern parts of the Chalab and Changouleh villages and ends at Islamieh town. The mean annual rainfall in the area is 258 mm.

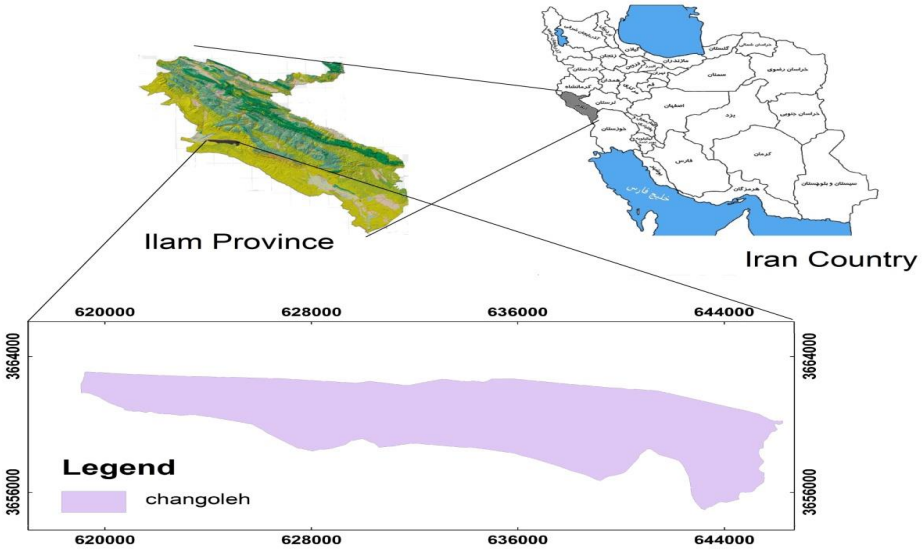

Figure 1. Location of the study area in the country and Ilam province.
Şekil 1. Çalışma alanı ve İlam bölgesi

2.2 The Data Used

Landsat 1984 satellite images (TM), Landsat 2013 (ETM+), 1:20000 aerial photographs, Google Earth satellite images, and also ENVI 4.8, Idrisi Taiga 16.03, ArcGIS 9.3 Software, have been used in this research.

2.3 Radiometric and Geometric Corrections

Darkness reduction of Phenomenon is one of the radiometric correction techniques which is widely used in many cases (Chavez, 1996). In this research, Darkness Reduction of Phenomenon has been conducted using ENVI4.8 Software. Moreover, and since the 1984 satellite images TM have been georeferenced using image-to-image method on ETM+ 2007 images, some corrections have been made on the images. Corrected image coordinates have been converted to the uncorrected image using first degree function. Also the re-sampling of uncorrected image pixels values has been conducted using Nearest Neighbor method and finally images with RMSE error equal to 0.57 were selected as the georeferenced.

2.4 Classification Algorithms Used

2.4.1 Neural Network Classification

Since 1988, by developments in research techniques, the use of Artificial Neural Networks has been expanded for classification of satellite images. The main advantage of Artificial Neural Networks compared to statistical methods is that the statistical methods are based on a certain statistical distribution, whereas neural approaches are more successful in combining data from different sources (Atkinson, 1997). The present research utilizes neural network technique for assessing the process of desertification.

2.4.2 Object-Oriented Classification

Object-Oriented Classification is a type of classification which considers a set of pixels instead of a pixel as visual phenomena and through this method the process of segmentation can be achieved. In the next stage, classification is performed based on training samples and fuzzy logic. The most important stage in Object-Oriented Classification is image segmentation. Image segmentation is the process of integrating pixels according to the homogeneity of visual phenomena which is controlled by the following three factors:

color/shape, compactness/smoothness, and scale (Baatz and Schape, 1999). Segments must be homogeneous within their selves and only represent one level, not a combination of several levels. At the same time, there must be some heterogeneity and difference between adjacent phenomena in the whole image (Definiens Imaging, 2006). Using scale factor, it is possible to create a hierarchical segmentation network which can make different levels of segments. In this hierarchy, smaller segments are always surrounded by larger segments. Figure / Şekil 2 shows an overview of the different segmentation scales.

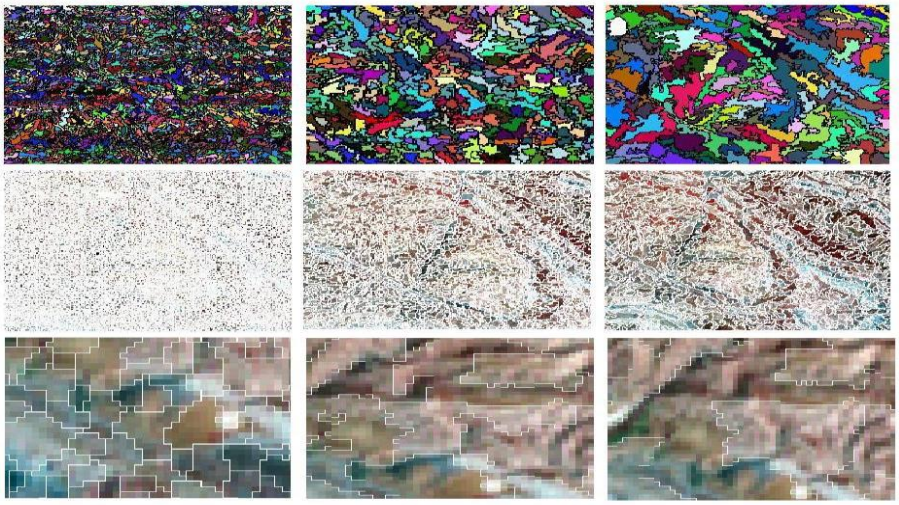

Figure 2. Image segmentation results, using different scales
Şekil 2. Farklı ölçekler kullanılarak görüntü bölümlemesi sonuçları

2.5 Assessment of Classification Accuracy

To validate the classification results, the classification accuracy is evaluated (Anderson et al, 1976). Accurate estimation is necessary to understand the obtained results and apply these results to decision making strategies. The most common accurately estimation parameters are: Overall accuracy, producer`s accuracy, user`s accuracy, confusion matrix, and Kappa coefficient (Lu et al, 2004). Overall accuracy and Kappa coefficient parameters were used to assess the accuracy of classification.

The overall accuracy (overall correctness), is the ratio of pixels correctly classified by the total number of pixels classified (Rasouli, 2008) which can be calculated using equation 1 (AlaviPanah, 2003):

$$OA= \frac{1}{N} \sum P_{ii} \quad (1)$$

Where: OA is the overall accuracy, N is the total number of training pixels, and $\sum P_{ii}$ is the sum of main diagonal elements of the confusion matrix. Due to the drawbacks of the mentioned method, the Kappa index is used in operational tasks in which the comparison of the classification accuracy is important, because the Kappa index considers the incorrectly classified pixels and is calculated using equation 2 (Bonyad& Haji Ghaderi, 2007):

$$\text{Kappa} = \frac{Pi-P_c}{1-P_c} \times 100 \quad (2)$$

Where: P_i is the correctness of the observation and Pc is the expected agreement. The value for ideal state for Kappa coefficient is 1.

3. RESULTS AND DISCUSSION

After applying atmospheric and geometric correction on the image, using neural network and object-oriented classification methods, the mentioned imaged were classified into 4 classes based on field data and

training samples (Figures / Şekil 3, 4, 5 and 6). To assess the accuracy of classification methods, these methods were evaluated based on the mentioned parameters. To accomplish this, 5 training samples for each class were randomly collected from surface of the study area and to investigate the accuracy of both methods. After implementation of training samples on the image, the two classification methods, neural network and object-oriented, were evaluated and results showed that the object-oriented method is more appropriate and has a higher precision (Table / Tablo 1). This is because object-oriented method uses image segments. .Finally, the total area related to each land-use was compared according to the classification method per hectare (Figures / Şekil 7 and 8).

Also, results indicated that the land-uses of agricultural and barren areas have increased whereas poor and fair rangelands have reduced such that barren areas (desert) have increased from1253 hectares to 3119 hectares.

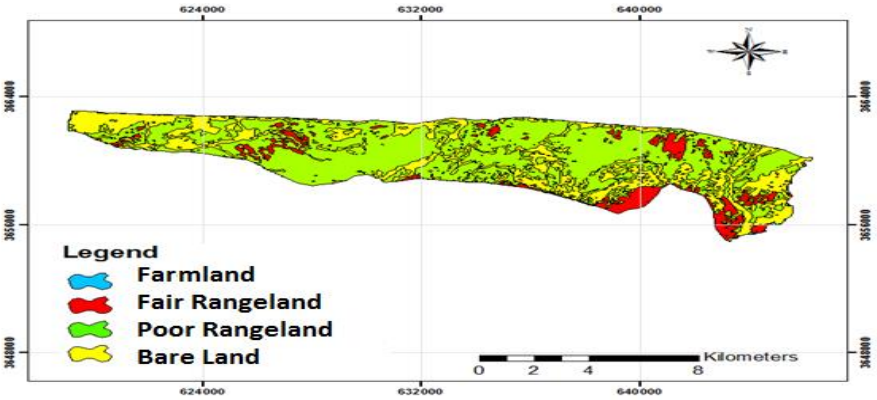

Figure 3. The obtained map using neural network method, 1984.
Şekil 3. 1984 yılı verilerine göre sinir ağı yöntemi kullanılarak elde edilen harita.

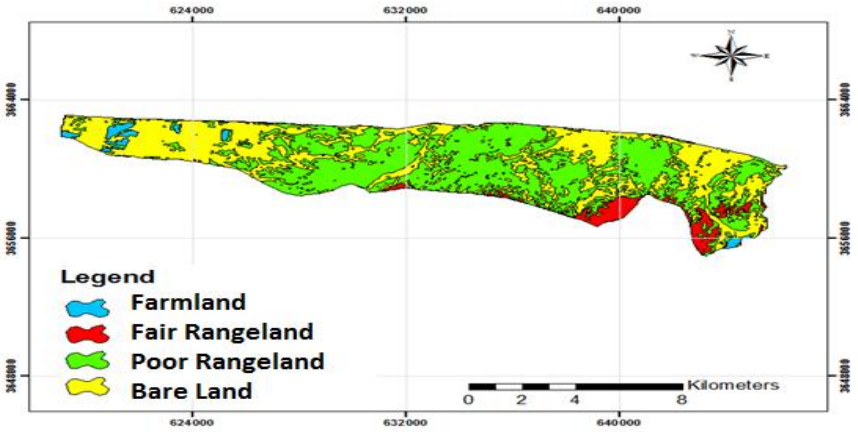

Figure 4. The obtained map using neural network method, 2013.
Şekil 4. 2013 yılı verilerine göre sinir ağı yöntemi kullanılarak elde edilen harita.

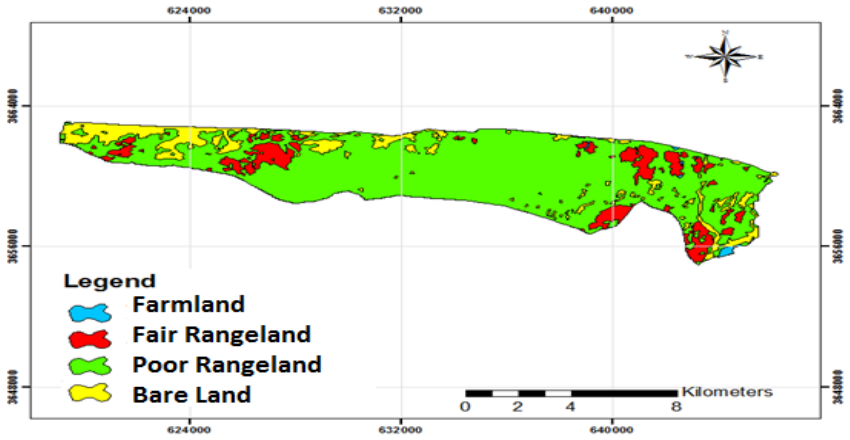

Figure 5. The obtained map using object-oriented method, 1984.
Şekil 5. 1984 yılı verilerine göre obje tabanlı sınıflandırma yöntemi kullanılarak elde edilen harita

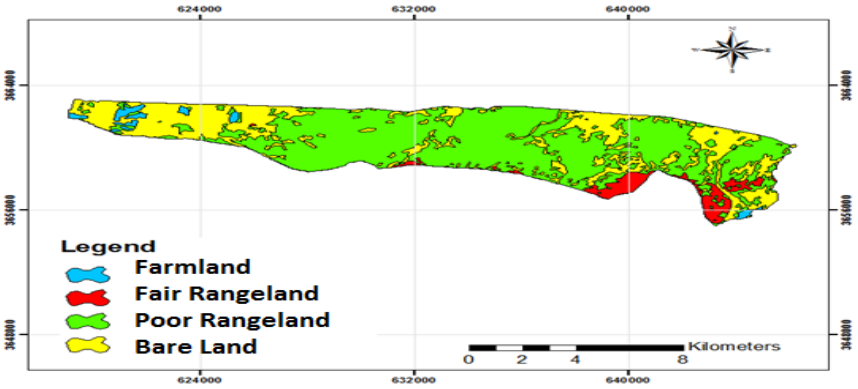

Figure 6. The obtained map using object-oriented method, 2013.
Şekil 6. 2013 yılı verilerine göre obje tabanlı sınıflandırma yöntemi kullanılarak elde edilen harita

Table 1. The statistical profile of accuracy of producer and user for classification of neural network.
Tablo 1. Sinir ağı sınıflandırılması için üretici ve kullanıcı doğruluğu istatistiksel profili

Classification Method	Classification Year	Kappa coefficient	Overall Correctness (Percent)
Neural Network	1984	0.89	90.76
	2013	0.91	91.97
Object-Oriented	1984	0.93	95.56
	2013	0.94	96.26

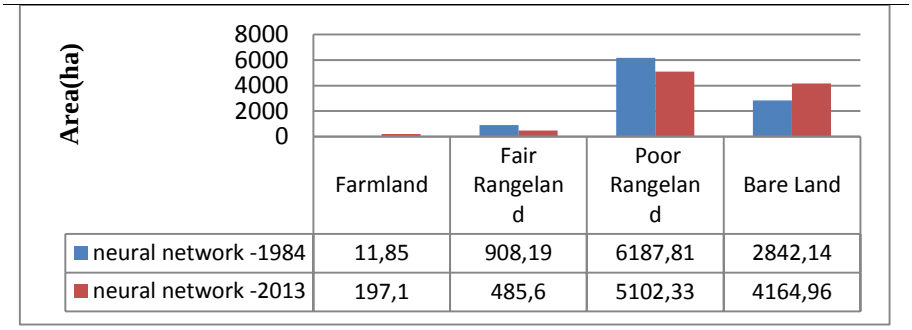

Figure 7. Changes in land-use, using neural network classification method
Şekil 7. Sinir ağı sınıflandırma yöntemi kullanılarak arazi kullanımı değişiklikleri

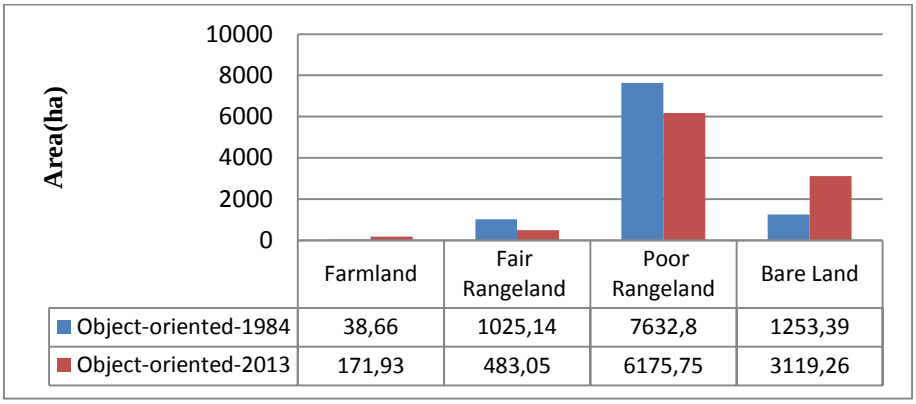

Figure 8. Changes in land-use, using object-oriented classification method
Şekil 8. Obje tabanlı sınıflandırma kullanılarak arazi kullanımı değişiklikleri

4. DISCUSSION AND CONCLUSIONS

This research aimed to investigate changes in land-use in one period using neural network and object-oriented classification methods. Most of the studied area was covered by rangeland. The obtained results from these two methods showed that poor and fair rangelands areas have reduced due to the fact that since mid-December month rangelands of this area host nomadic livestock from Kermanshah, Hamadan, and other neighboring provinces and also livestock of native villagers and nomads. This has been an ongoing issue during 50 past years and has severely degraded rangelands, because livestock arrival and departure time and rangeland preparation time has not been considered. Also, in the recent years the drought and dust phenomenon have severely affected area and increased the degradation of rangeland.

Bare Lands has severely increased, which can be seen as a result of degradation of rangelands especially poor areas, because these areas do not have the potential to become agricultural land and will be abandoned due to water shortages (low precipitation). The land-use of agricultural areas has slightly increased. Given the fact that most of the cultivation in this area is rain-fed, rangelands which have more fertile soils (poor rangelands) will go under rain-fed cultivation after degradation, but after a few years are abandoned due to food shortages and lack of dependable and enough rainfall in these areas. These areas do not have the ability to convert back and therefore are left without vegetation cover and will gradually turn into barren which can increase soil erosion and pose other serious problems.

The obtained results show that the object-oriented classification method is more accurate than the neural network method. But the overall accuracy and reliability of both methods are high. These results are in line with the work of Rezayi Moghadam et al. (2008), Mohamadi et al. (2009), which all indicated that the object-oriented method is more accurate.

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