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Assessment of desertification hazard in Abu-Ghoveyr Plain, Dehloran, Ilam province

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Abstract: The present study aims to evaluate the desertification hazard and determine the effective criteria affecting desertification in Abu-Ghoveyr Plain in Ilam Province, using the 9 criteria Iranian Model of Desertification Potential Assessment To this end, first, work units maps (geomorphologic facies) were created using slope, geology, and land use maps. Using this method, work units were considered as the main unit of desertification and a map was generated for each index according to assigned weights, such that the qualitative map of the desired criteria were obtained using the geometric mean of indicators. Then, through integration and determining the geometric mean of layers obtained from criteria and finally classification of the obtained maps, map of the current status of desertification in the studied area was prepared. The obtained results indicated that 31.67% of the area was in the medium class of desertification (II) and 68.33% belonged to the intense class (III).

Keywords: Classification, model, criterion, vegetation cover, work units.

Ilam Eyaleti, Dehluran bölgesi Abu-Ghoveyr Ovası'nda çölleşme değerlendirmesi

Özet: Bu çalışmada 9 kriter içeren İran Çölleşme Potansiyel Değerlendirme Modeli kullanılarak, Ilam Eyaleti Abu-Ghoveyr Ovası'nda çölleşme zararının değerlendirilmesi ve belirlenmesi amaçlanmıştır. Bu amaçla, öncelikle eğim, jeoloji ve arazi kullanım haritalarını içeren çalışma birim haritaları oluşturulmuştur. Bu yöntem kullanılarak, çalışma birimleri çölleşme ana ünite olarak kabul edildi ve entegrasyon ve geometrik kriterler ile elde edilen tabakaların ortalaması alınarak çalışılan alandaki çölleşme mevcut durumunun haritası hazırlanmıştır. Elde edilen sonuçlar, alanın %31.67 sinin çölleşme orta (II) sınıfta ve % 68.33ünün ise şiddetli (III) sınıfta olduğunu göstermiştir.

Anahtar kelimeler: Sınıflandırma, model, ölçüt, bitki örtüsü, çalişma birimleri

1. INTRODUCTION

Desertification is a reduction of fertility in each ecosystem. This phenomenon is non-visible but dangerous and if that continuing, it leads to land degradation, especially in arid and semi-arid areas and hence, the social and economic losses attributed to it, is much greater than progressing of desert that occurs mainly in margin of desert areas (UNEP, 1997).

Desertification phenomenon can be assessed by quantitative indicators, in this way, the most important factors affecting desertification intensity and also critical points of a region will also been identified. Given that about 80 percent of Iran's area is located in arid and semiarid areas and one-third of those are susceptible to desertification (Farajzadeh and Nik Eghbal, 2007) the necessity of continuous assessment of this

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phenomenon is needed more than ever. One of the most discussed internal models to assess desertification is Iranian Model of Desertification Potential Assessment IMDPA model, a comprehensive desertification model, was presented by the faculty of natural resources, university of Tehran, as the result of a project entitled determination methodology of desertification criteria and indices in arid and semi-arid region of Iran. Nine criteria and 130 indices were introduced, the quantitative and weighted values which would determine the desertification intensity in each region (Khosravi et al., 2014). 9 criteria in this method are: soil, erosion (water and wind), climate, water, vegetation cover, agriculture, technology development and management criteria. To integrate data, , there is used the geometric mean (Ekhtesasi & Sepehr, 2011). Many studies have been conducted in relation to the assessment of desertification in different areas of Iran and the world, some of which as follows:

This model was confirmed by Abdy (2007) with an emphasis on water and soil criteria. Results of the IMDPA model showed that geology-geomorphology and wind erosion are the most important criteria for desertification in Abuzaydabad region. Arami (2014) assessed the desertification hazard using IMDPA model. In this study, 9 criteria and 26 indices were investigated. The results showed that 17.7 percent of region was in severe class and 51 percent in moderate class. Also, the vegetation cover and soil quality were the most effective factors influencing the desertification intensity. In general, the total intensity of desertification in the region was 2.03 and desertification class for the entire region was estimated as moderate. Mohammadi (2014) evaluated desertification trend of Mehran Plain using IMDPA model. In this study, the trend of desertification was analyzed during three periods of 2001-2004, 2005-2008 and 2009-2012. For generating desertification maps in each period in the studied region, according to conditions of region, three criteria of water, geology and climate were considered as key criteria of desertification. The results showed that weighted average of desertification intensity in the three periods was reached from 1.238 to 1.864 and it suggests that the trend of destruction is growing and the region goes toward desertification. In 2012, sensitivity map to desertification in Riberia Seca basin was prepared by Tavares. In this study, six indices have been used, including: climate, soil, vegetation, management, runoff and social indicator. The results showed that 45% of area is at high to very high risk of desertification, 29.3% at moderate risk and 25.7% at low to very low risk Lavazzo et al. (2013) studied the role of changing the climate and erosion in the trend of desertification in Ouagadougou and Burkina Faso. The study was based on MEDALUS project and to promote method, in addition to the indices of climate, soil, vegetation cover and land management, soil quality index was also added. The obtained results identified regions that had more efficient management.

Natural environmental conditions of Iran and its geographical location that falls in the arid belt in one hand, and overuse of non-renewable resources in the other hand, cause series of problems and conditions that brings the country into a rapid deterioration. So mapping of desertification condition is important and necessary matter. The results may help to control and reduce the damages resulted from this phenomenon. So, the aim of this study is to evaluate the current status ,assessing the most important factors affecting the desertification and also providing map of desertification intensity using IMDPA in the arid region of Abu Ghoveyr, Dehloran city.

2. MATERIALS AND METHODS

2.1 Study Area

The study area, Abu Ghoveyr plain with area of 583 square kilometers, is located in the southeastern of Ilam province, Dehloran city, and at the eastern margin of Doyrej River and geographical location between 47 31 29 to 47 55 01 E longitude, and 32 10 06 to 32 24 19 N latitude (Figure 1). The mean annual rainfall in the area is 195 mm, maximum and minimum temperature of the region happens in August and December that is 46.7 and 7.4°C, respectively.

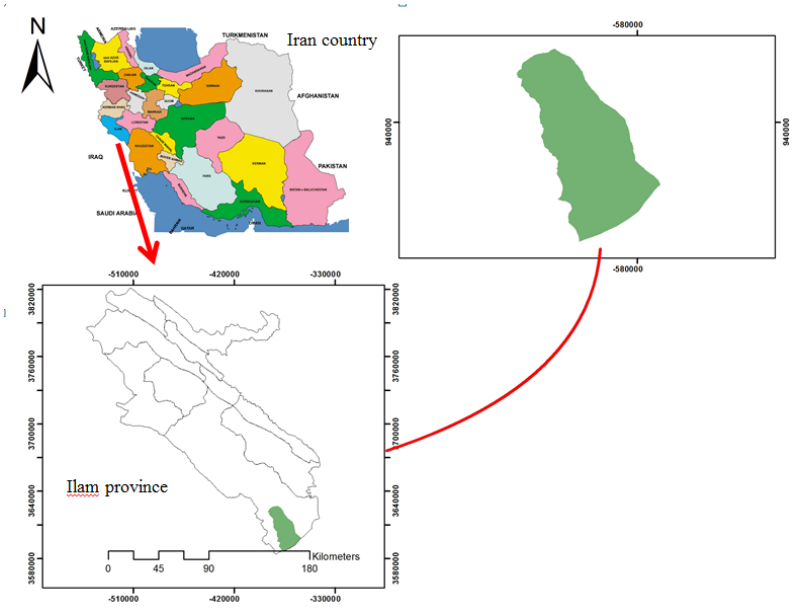

Figure 1. Location of the study area in the country and Ilam province
Şekil 1.Çalışma alanının konumu

2.2. Methodology

As it may be seen in Table 1, there are no dramatic differences in the altitudes of the stations. This prevents abnormalities based on differences of altitudes.

In this study, geomorphological facies were considered as the basic unit of study. For this reason, after field surveys and integration of land use, geology and slope maps, 1 unit, 2 types and 10 geomorphological facies (work units), respectively, was obtained (Table 1, Figure 2).

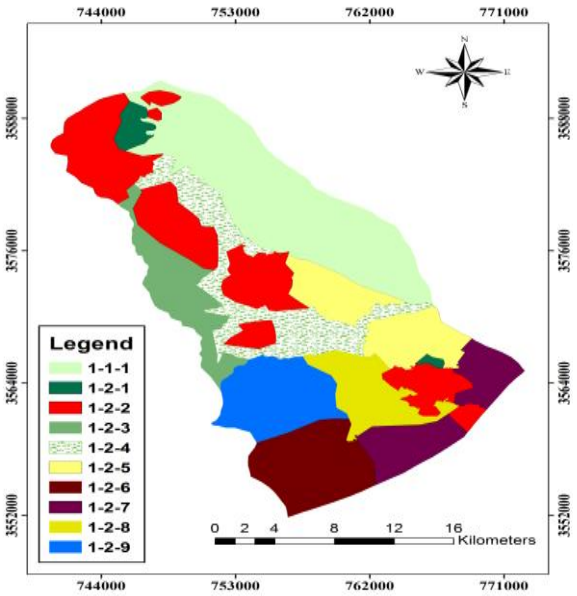

Figure 2. Work units map of Abu Ghoveyr (geomorphological facies)
Şekil 2. Abu Ghoveyr çalışma ünitesi

Table 1. Frequency distribution of geomorphological unit of Abu Ghoveyr plain
Tablo 1. Abu Ghoveyr pvasının frekans dağılımı ve jeomorfolojik birimleri

Unit	Type	Faceis	Code	Area(ha)
	Appendage Pediment	Detachment area	1-1-1	1386.21
		Plantation forest	1-2-1	895.22
		Agricultural lands	2-2-1	11185.23
		Water erosion	1-2-3	4489.69
		Detachment areas	1-2-4	7052.53
Pediment	Deposit pediment	Sand dunes including Barkhan and Bukelyh	1-2-5	5053.24
		Silt-sand land with scattered shrubs	1-2-6	4944.81
		Silt – sand land with wind deposits and plantation forest	1-2-7	3742.14
		Relatively flat upper plateaus and terraces with low slope and scattered coverage	1-2-8	3029.5
		Upper plateaus and terraces with medium height and medium general slope and low herbaceous	1-2-9	4052.42

2.2.1. IMDPA Model

In this study, there were used all of the criteria of IMDPA model to identify factors contributing to the trend of desertification. In this way, each of geomorphological facies was considered as work units. In the IMDPA model, a weight ranging from 1 to 4 was assigned to each layer based on its influence on desertification according to literature renews and researches performed by other researchers and condition of the region (Table 12). Indices of annual Precipitation, Aridity Index and Continuing Drought in climate criterion were used (Table 2). In the geology criterion three indices of slope, Stone sensitiveness to erosion and exploitation of land (land use) were used (Table 3). When the scores are assigned, the value of the quality index for each elementary unit within an index is obtained as the geometric average of scores for single indices.

Table 2. Details of climate criteria in IMDPA model
Tablo 2. IMDPA modelinde iklim kriteri detayları

Indices	Low	Medium	Severe	Very severe
Annual Precipitation (mm)	≥600	150-280	75-150	<75
Aridity Index (P/ET)	≥0.65	0.2-0.45	0.05-0.2	<0.05
Continuing Drought (Year)	<3	5-6	6-7	>7

Table 3. Details of geology criteria in IMDPA model

Tablo 3. IMDPA modelinde jeoloji kriteri detayları

Indices	Low	Medium	Severe	Very severe
Slope	<5	5-15	15-30	>30
Stone sensitiveness to erosion	Forest	Rural Area	Agricultural Land, Fix Sand Dune	Active Sand Dune
Type of land use	Forest, Canopy cover 60-80%	Agricultural Land, slope 12-17%	Water erosion	Changing Rangeland to Agricultural Land

Exploitation, vegetation cover situation and the revival of vegetation were defined as vegetation indices (Table 4). In agricultural criterion indices of agriculture use or cropping patterns, crops yield compared with the appropriateness of cropping of the habitat conditions as well as inputs use and machinery were used (Table 5).

Table 4. Details of vegetation cover criteria in IMDPA model

Tablo 5. IMDPA modelindeki vejetasyon örtüsü kriteri detayları

Indices	Low	Medium	Severe	Very severe
Vegetation cover situation	Canopy cover 5>	Canopy cover 5-15%	Canopy cover 15-30%	Canopy cover 85-100%
Revival of vegetation	Revival of vegetation occurs naturally	Low biologic measure is possible	Revival of vegetation is possible with mechanical and biologic measures	Revival of vegetation is impossible
Exploitation	Stock rate /grazing capacity=1	Stock rate/ grazing capacity = 1-2	Stock rate/ grazing capacity = 2-3	Stock rate/ grazing capacity >3

Table 5. Details of agriculture criteria in IMDPA model

Tablo 5. IMDPA modelindeki ziraat kriteri detayları

Indices	Low	Medium	Severe	Very severe
Agriculture use or cropping patterns	Garden	Proper rain fed farming	Dry land farming	Improper Dry land farming
Crops yield	Proper agriculture perennial crops	Relatively Proper agriculture, perennial crops	Improper agriculture and fallow	Lack of agricultural measure, no fallow and intense plough
Machinery use	Traditional agriculture	Improper machinery and pesticide	Modern machinery and pesticide	Low efficient machinery and pesticide

Also, for socio-economic criterion the indices of People participation, kind of exploitation and yields and ownership have been used (Table 6). In erosion criterion and sub-criterion of water erosion indices of the type and density of water erosion, the type of land use and the canopy density of vegetation were used (Table 7). Appearance of erosive facies, the percentage of vegetation cover and the number of days with dust storm index were defined as sub-criterion of wind erosion indices (Table 8).

Table 6. Details of socio-economic criteria in IMDPA model
Tablo 6. IMDPA sosyo-ekonomik kriteri detayları

Indices	Low	Medium	Severe	Very severe
People participation	Good connection between people and experts	Lack of people attention to extension	Projects without people participation	Conflict between local people and technical staff
Exploitation	proper exploitation	Traditional exploitation	Improper exploitation	Overgrazing
Ownership	Individual	Public	State	Unknown

Table 7. Details of sub-criterion of water erosion in IMDPA model
Tablo 7. IMDPA modelindeki su erozyonunun alt kriter detayları

Indices	Low	Medium	Severe	Very severe
Type and density of water erosion	Sheet erosion	Gully erosion	Channel erosion	Dissolution Erosion
Canopy cover	>50%	30-50%	20-30%	<20%
Type of land use	Good rangeland	Fair rangeland	Poor rangeland	Very poor rangeland

Table 8. Details of sub-criterion of wind erosion in IMDPA model
Tablo 8. IMDPA modelindeki rüzgar erozyonunun alt kriter detayları

Indices	Low	Medium	Severe	Very severe
Appearance of erosive facies	Without wind erosion forms and disturbance during a year	Parabolical Surfaces surfaces Gravel appearance pavement desert	Ripple mark Yardang Callote Desert pavement with low congestion	Active sand dunes intensive callotak
Plant cover percentage (PC)	PC<40	20<PC<40	10<PC<20	PC<10
Dust storm Intensity (DSI)	DSI<10	10<DSI<30	30<DSI<60	DSI< 60

For criterion of urban development indices of conversion farming and agricultural land into residential around the cities, conversion of rangeland and forest land into urban and industrial or agricultural or inappropriate agricultural lands and road congestion and mining have been used (Table 9).

Table 9. Details of urban development criterion in IMDPA model
Tablo 9. IMDPA modelindeki kentsel gelişme kriteri detayları

Indices	Low	Medium	Severe	Very severe
Conversion farming and agricultural land into residential around the cities (km^2/year)	<1	1-2	2-5	>5
Conversion of rangeland and forest land into urban and industrial lands (km^2/year)	<0/1	0/1-0/2	0/2-0/5	>0/5
Road and mining congestion (km/km^2)	<10	10-20	20-40	>40

Groundwater table decrease, electrical conductivity of water, sodium absorption ratio, chlorine index and dissolved solids in water were defined as water indices (Table 10). for soil criterion indices of texture and electrical conductivity (EC) have been used (Table 11).

Table 10. Details of water criterion in IMDPA model
Tablo 10. IMDPA modelindeki su tkriteri detayları

Indices	Low	Medium	Severe	Very severe
Groundwater table decrease (cm/year)	0-10	10-20	20-30	30-50
EC (µmhos/cm)	<250	250-750	750-2250	2250-5000
CL (Mgr/liter)	<250	250-500	500-1500	1500-3000
SAR	<10	10-26	26-32	>32
TDS (µmhos/cm)	0-250	250-500	500-1500	>1500

Table 11. Details of soil criterion in IMDPA model
Tablo 11. IMDPA modelindeki toprak kriteri detayları

Indices	Low	Medium	Severe	Very severe
Soil texture	Sandy Clay, Silty Clay	Loam, Sandy Clay Loam, Silty Clay Loam, Silty Loam	Loam Sandy, Sandy Loam	Sandy, Clay<60%
Electrical conductivity (EC) (µmhos/cm)	<4	4-8	8-16	>16

The final map of each criterion is obtained through geometric mean of its indices as follows:

$$Index - X = \left[(Layer - 1)(layer - 2)...(Layer - n)\right]^{1/n}$$ Equation.1:

Where:
Index- x: given criterion
Layer: indices for each criterion
n: The number of indices for each criterion

For example, the numerical value of climate index can be obtained as follows:

Equation 2: climate criterion= (amount of annual rainfall × Drought Index ×the continuing of drought)$^{1/3}$

Finally, the map of the final status of desertification of region was obtained through the geometric mean of mentioned indices as follow:

Equation 3: $DM = (Q_C \,.\, Q_W \,.\, Q_S \,.\, Q_G \,.\, Q_A \,.\, Q_T \,.\, Q_E \,.\, Q_{(S\text{-}E)} \,.\, Q_V)^{\wedge(1/n)}$

After calculating each criterion, the prepared map classified on the basis of Table 12.

Table 12. Classification of desertification according to the IMDPA model
Tablo 12. Classification of desertification according to the IMDPA model

Class	Value rang	Sign
Low	0-1.5	I
Medium	1.6-2.5	II
Severe	2.6-3.5	III
Very severe	3.6-4	IV

As it can be seen, obtained maps can be categorized in four classes.

3. RESULTS

Final map of desertification of Abu Ghoveyr Plain showed that 31.68 percent of total area is in the middle desertification class, 68.33 % of the total area is in severe desertification class (Figure 3, Table 13).

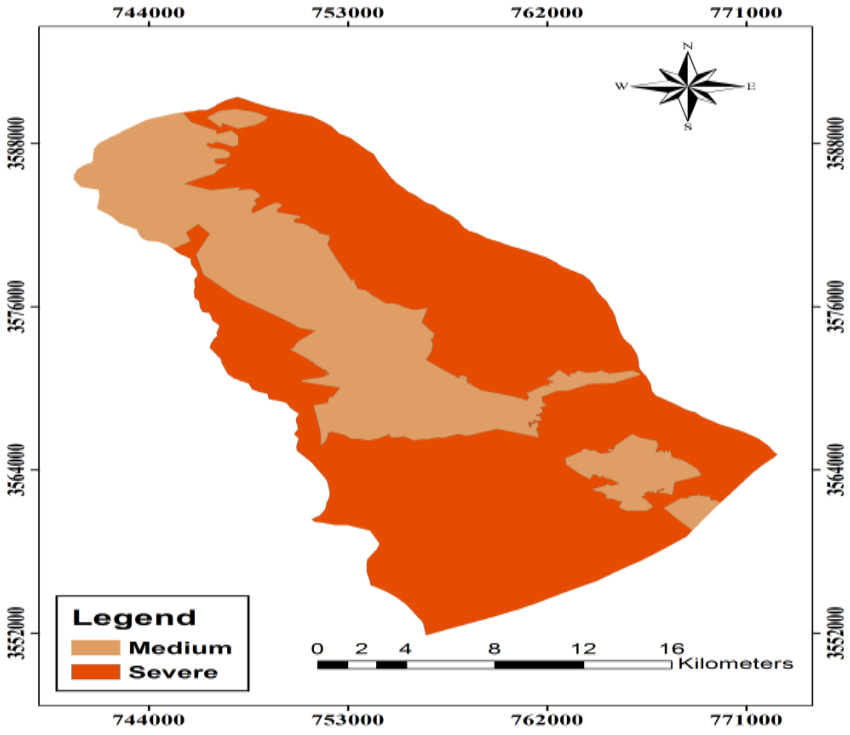

Figure 3. Desertification hazard map based on IMDPA model in Abu Ghoveyr Plain
Şekil 3. Abu Ghoveyr ovasında IMDPA modeit tabanlı çölleşme haritası

Table 13. Frequency distribution of hazard classes
Tablo 13. Frequency distribution of hazard classes

Class code	Hazard class	Value rang	Area (ha)	Percentage
II	medium	1.6-2.5	8471.79	31.68
III	severe	2.6-3.5	39841.34	68.33

Also the reviewing of weighted average of quantitative values of desertification indices showed that in this region, between 32 indicators studied, six indicators, i.e. the number of days with dust storm index (DSI), soil texture, electrical conductivity of groundwater, vegetation cover, kind of exploitation and yields and the amount of dissolved solids in the water, with numerical value of 3.77, 3.18, 3.14, 3.1, 3.01 and 3, respectively, had greatest impact and slope index with numerical value of 0.26 had lowest impact on desertification intensity (Table 14).

Table 14. Geometric Average of the Quantitative Values of indices
Tablo 14. İndislerin kantitatif değerlerin geometrik ortalaması

Row	Assessment criterion	Average numerical value	Desertification class
1	Annual Precipitation	2.24	Medium
2	Aridity Index	1.96	Medium
3	Continuing Drought	1.65	Medium
4	Slope	0.26	Low
5	Stone sensitiveness to erosion	2.32	Medium
6	Type of land use	2.7	Severe
7	Climate	1.92	Medium
8	Vegetation cover situation	3.1	Severe
9	Revival of vegetation	2.82	Severe
10	Exploitation	2.87	Severe
11	Agriculture use or cropping patterns	2.3	Medium
12	Crops yield	2.1	Medium
13	Machinery use	2.6	Severe
14	People participation	2.46	Medium
15	Exploitation	3.01	Severe
16	Ownership	2.4	Medium
17	Type and density of water erosion	1.65	Medium
18	Canopy cover	2.68	Severe
19	Type of land use	2.64	Severe
20	Appearance of erosive facies	2.89	Severe
21	Plant cover percentage (PC)	2.76	Severe
22	Dust storm Intensity (DSI)	3.77	Very Severe
23	Conversion farming and agricultural land into residential around the cities	1.5	Low
24	Conversion of rangeland and forest land into urban and industrial lands	2.5	Medium
25	Road and mining congestion	1.32	Low
26	Groundwater table decrease	2.04	Medium
27	EC	3.14	Severe
28	CL	1.86	Medium
29	SAR	1.1	Low
30	TDS	3	Severe
31	Soil texture	3.18	Severe
32	Electrical conductivity	1.51	Medium

Numerical value of desertification intensity at Abu_Ghoveyr Plain was also 2.56 and in severe class. Evaluation results of criteria showed that effective criteria in desertification in term of importance include: vegetation cover (2.93), erosion (2.78), socio-economic (2.57), agriculture (2.32), soil (2.17), water (2.08), climate (1.92), urban development (1.69) and geology (1.09) (Table 15).

Table 15. Geometric Average of the Quantitative Values of criteria
Tablo 15. Kantitatif değerlerin geometrik ortalaması

Row	Assessment criterion	Average numerical value	Desertification class
1	Vegetation cover	2.5	Severe
2	Erosion	2.78	Severe
3	Economic social	2.57	Severe
4	Agricultural	2.32	Medium
5	Soil	2.17	Medium
6	Groundwater	2.08	Medium
7	Climate	1.92	Medium
8	Urban development	1.69	Medium
9	Geology	1.09	Low

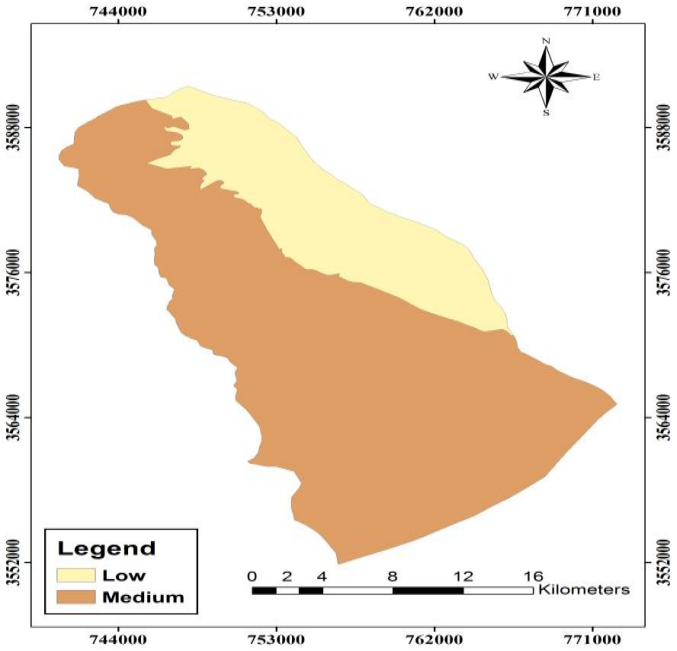

Figure 4. The map of desertification intensity based on climate criterion
Şekil 4. İklim tabanlı çölleşme yoğunluğu haritası

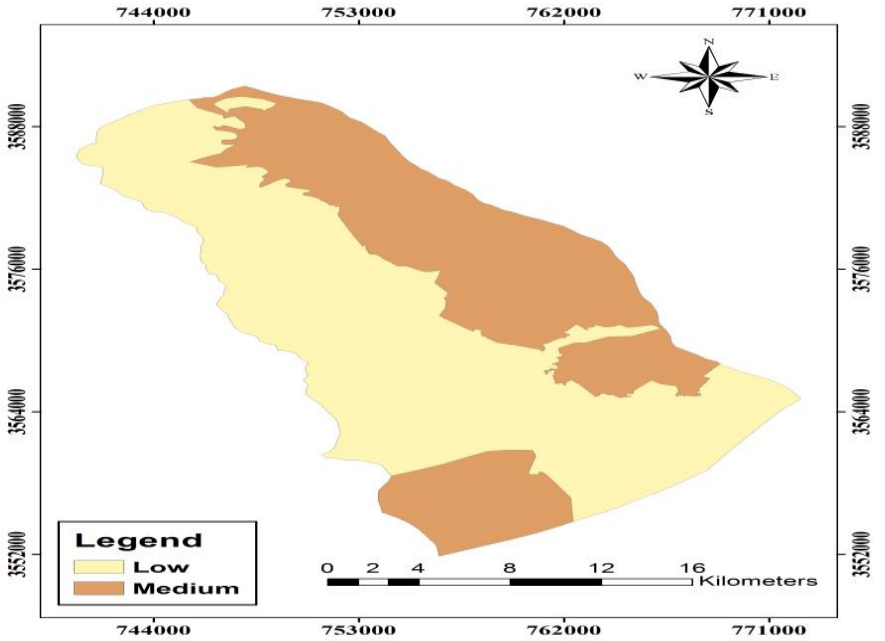

Figure 5. The map of desertification intensity based on geological criterion
Şekil 5. Jeolojik kritelere bağlı çölleşme yoğunluğu haritası

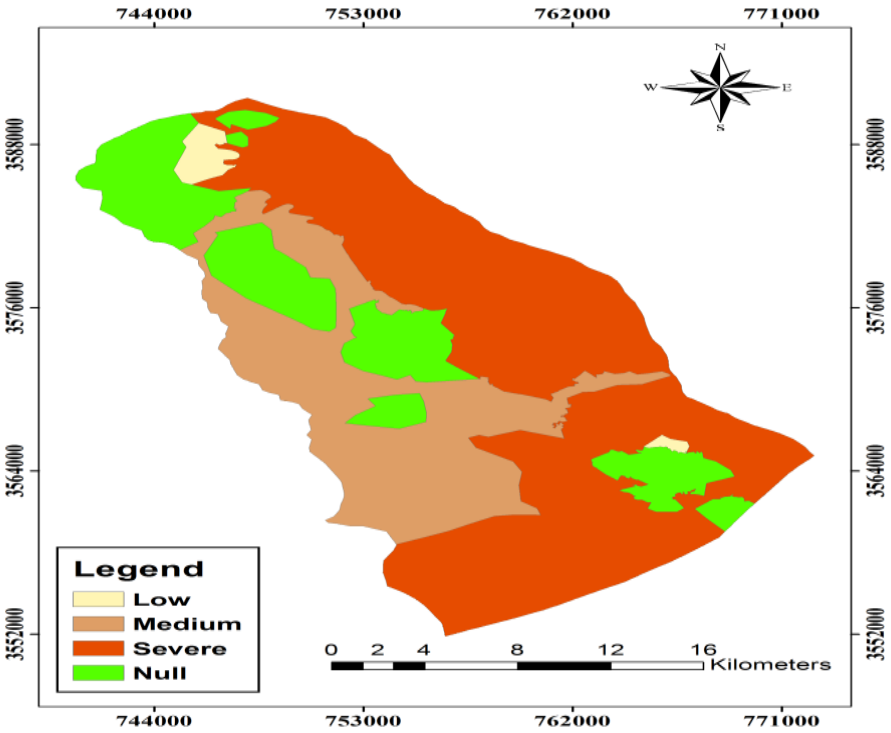

Figure 6. The map of desertification intensity based on vegetation cover criterion
Şekil 6. Vejetasyon örtüsü tabanlı çölleşme yoğunluğu haritası

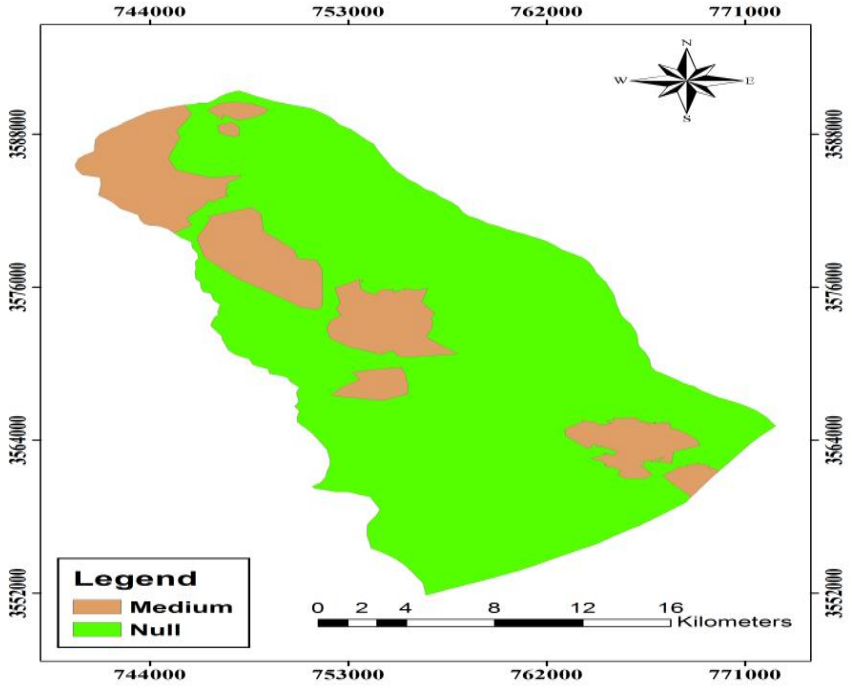

Figure 7. The map of desertification intensity based on agricultural criterion
Şekil 7. Zirai kritelere bağlı çölleşme yoğunluğu haritası

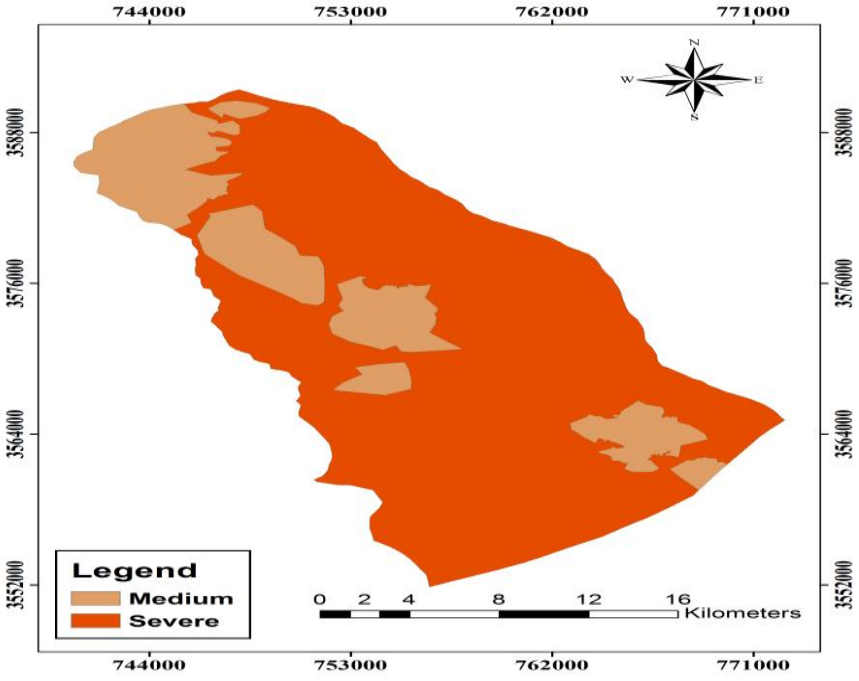

Figure 8. The map of desertification intensity based on socio-economic criterion
Şekil 8. Sosyo-ekonomik kriterlere bağlı çölleşme yoğunluğu haritası

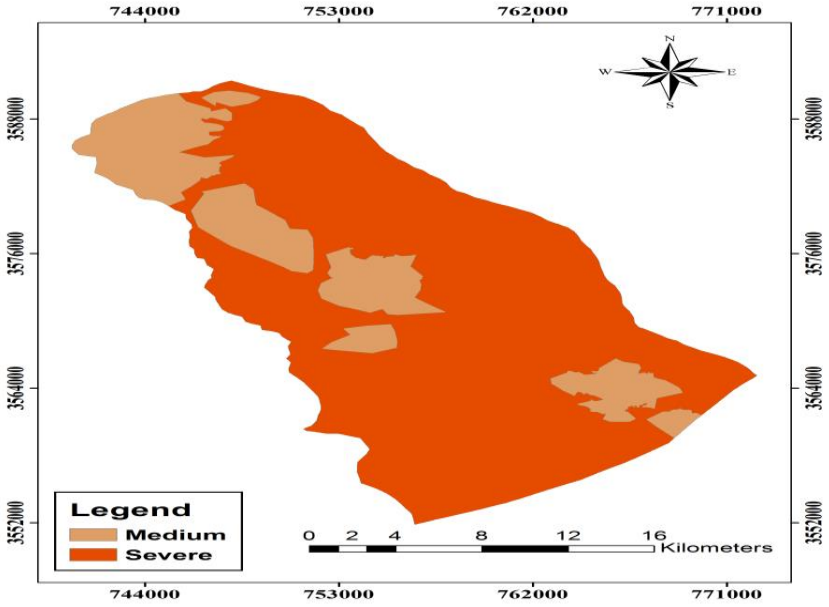

Figure 9. The map of desertification intensity based on erosion criterion
Şekil 9. Erozyon kriterine bağlı çölleşme yoğunluğu haritası

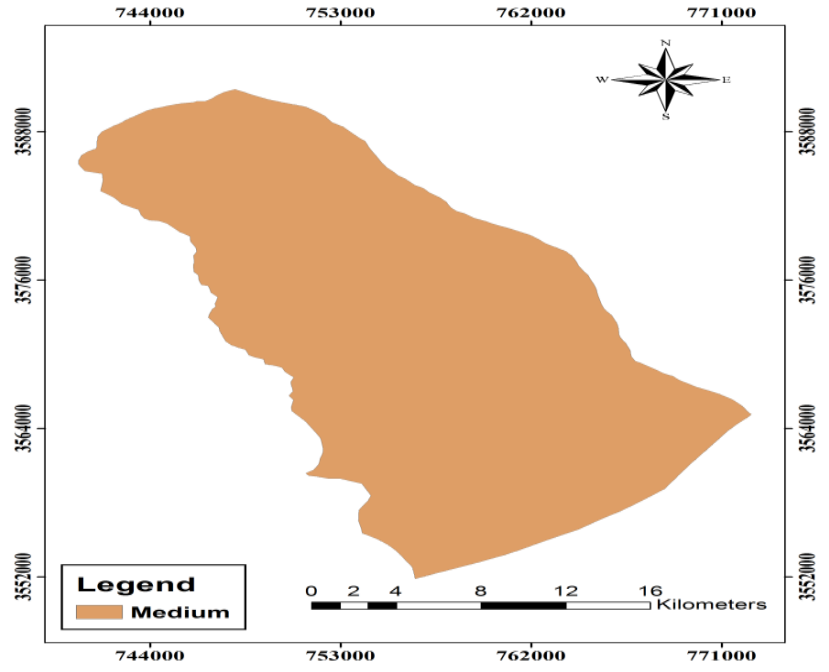

Figure 10. The map of desertification intensity based on the criterion of urban development
Şekil 10. Kentsel gelişim bağlı çölleşme yoğunluğu haritası

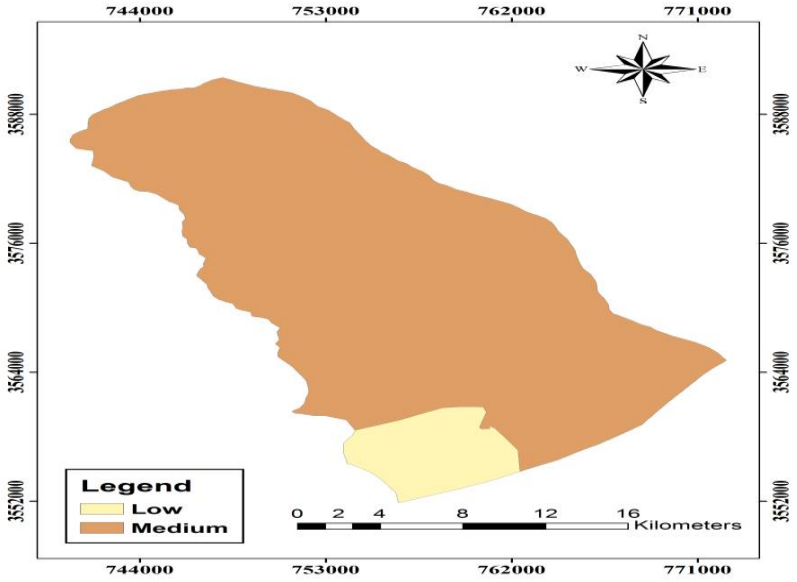

Figure 11. The map of desertification intensity based on the criterion of groundwater
Şekil 11. Tabansuyu kriterine bağlı çölleşme yoğunluğu haritası

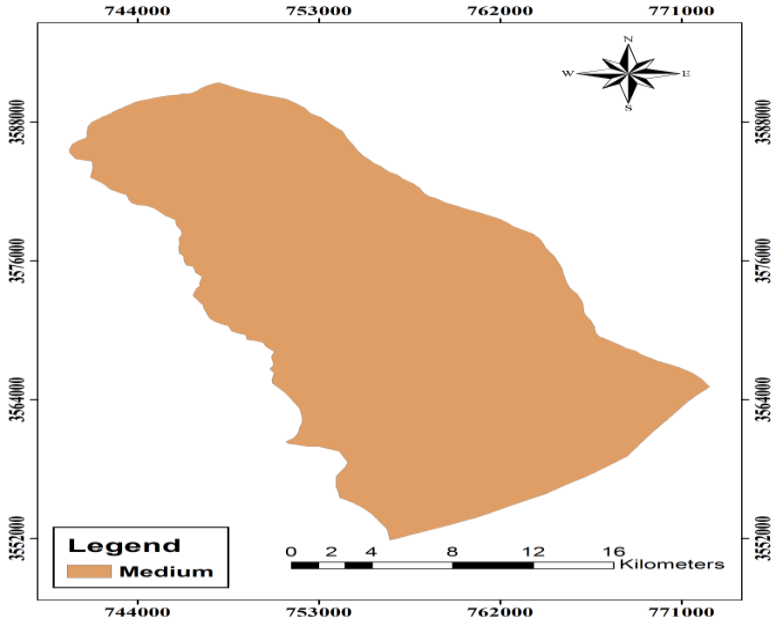

Figure 12. The map of desertification intensity based on soil criterion
Şekil 12. Toprak kriterine bağlı çölleşme yoğunluğu haritası

4. DISCUSSION AND CONCLUSION

In this study 9 criteria and 31 indicators of IMDPA model were used to assess the current status of desertification in Abu Ghoveyr plain. According to the results obtained among desertification criteria, two criteria of vegetation cover and erosion with weighted averages of 2.92 and 2.78, respectively, had the greatest impact on desertification of the region that is in agreement with the results of Rahimi (2011) and Jafaryzadeh (2010) who introduce vegetation cover as the most effective factor and is also consistent with research of Zolfaghari et al. (2011) who consider wind erosion as the most effective factor.

In present study, socio-economic criterion with weighted average of 2.57 is in third rank of importance among the criteria and in severe class of desertification due to the poverty and deprivation of that region. The study of desertification indices showed that the dust index in the region is the most important indicator influencing the region. It is consistent with results of Zolfaghari et al (2010), that they consider the number of days of dust as the effective factor in wind erosion. The most common causes of the creating of dust in the area are its proximity to Iraq and existing of sand dunes in the region. After the dust index, soil texture index is in third rank of importance, which is in agreement with results of Esfandiari et al. (2010).

Electrical conductivity (EC) index of groundwater is in the next category of importance and in severe class of desertification. According to the results of Khosravi et al (2011) in the region of Kashan, desertification status of EC index of water was very severe, and also according to results of Dolatshahi (2007), desertification of EC index of water was evaluated as severe.

According to 9 criteria, quantitative value of the desertification intensity (current status of desertification) in the entire area was determined 2.54 and was in severe class. The results are consistent with the results of Zakerinejad et al (2012) in Zarrindasht and Mombeny plain (2013) who evaluated severity of desertification as severe.

In total, 31.67 % of region is in meduim class and 68.33 % of the region is located in the severe class of desertification that represents the intensity of the activity of this phenomenon. Sand dunes are active in the region and are expanding day by day. Poverty and deprivation and loss of vegetation cover are of other factors exacerbating this phenomenon which, if not restrained, current situation of the area gets more critical.

From the present study, can be concluded that the entire study area is affected by desertification. It can be recommended that mathematical modeling should be developed for the operational monitoring of different elements contributing to desertification sensitivity. In this way the recognization of more important affected factors from analysis of the model is possible. Identification of effective factors can be used to present suitable policies in order to mitigate the desertification effects on the areas.

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