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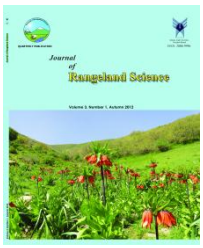

Full Length Article:

Desertification Evaluation Using IMDPA Model (Case Study: Taraz Nahid, Saveh, Iran)

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Abstract. Several studies have been performed to evaluate the desertification in Iran and other countries which led to present national and regional models. One of them is IMDPA model. This model was used as a case study in Taraz Nahid, Saveh, Iran. In this study, five factors including climate, soil, vegetation, irrigation, and socioeconomic ones were evaluated. According to the region conditions for each criterion, several indices were considered. Based on the selected indices for each criterion, the qualitative maps were developed from geometric mean of indices for each criterion and finally, the desertification intensity map was prepared from the geometric mean. The final desertification map shows the balanced (moderate) and intense (severe) classes of desertification process in the region. According to the performed evaluations, the soil texture index with the average value of 3.75 (very severe class) and vegetation conditions with the average value of 2.9 were more effective indices in the region desertification. Also, the desertification quantitative intensity value (DM=2.31) was calculated for the entire study region that showed the moderate class for this region.

Key words: Desertification, Evaluation, IMDPA model, Taraz Nahid.

Introduction

The United Nations Environmental Program (UNEP) estimated 69% of the world's dry lands excluding the hyper-arid deserts regarded as moderately to severely degraded in 1992 (Dregne, 1991). Desertification is defined as a process of sustained land (soil and vegetation) degradation in arid, semi-arid and sub-humid areas caused at least partly by human beings. It reduces both resilience and productive potentials to an extent which can be neither readily reversed by removing the causes nor easily reclaimed without substantial investments.

Dry land ecosystems cover more than 85% of Iran's land of which the decertified and desert lands account for 34 million ha (Forest, Range, and Watershed Management Organization), (FRW, 2004). Various studies had been done to evaluate the desertification which led to present lots of regional models. Using this models in other regions, we should restudy their criteria and indices and thus, evaluate and correct (modification) them according to the region situation (Zehtabian, 2007).

Different methods for evaluating the desertification process such as mathematical models, parametric equations, remote sensing, direct observation and measurement have been developed. Recently, several models of desertification and land degradation have been presented. The methods suggested by FAO/UNEP (1984) and Turkmenistan Academy of Science (Babaev, 1985) assess the main parameters affecting the desertification processes. Ekhtesasi and Mohajeri (1995) developed the ICD (Iranian Classification Deserts) model for the classification of Iranian deserts.

Generally, as each country has its own natural and human structures, the methods introduced in a country could not be reliable in other countries.

In other words, the evaluation of desertification in each country is different from the others. This research focuses on soil indicator with Iranian Model of Desertification Potential Assessment (IMDPA).

To this end, the criterion quantification and effective indices in the desertification of the country natural ecosystem plan were developed by Natural Resources College of Tehran University at the national level. Based on the results of this plan, 9 criteria and 35 desertification indices in Iran with qualitative and quantitative evaluation methodologies have been offered in IMDPA model (Ahmadi, 2006).

Using geographic information systems to combine the desired layers is another advantage for this model (Zehtabian *et al*., 2005).

This research aims to assess the most important factors affecting the desertification by modifying the IMDPA method in the study area of Taraz Nahid Saveh, Markazi province, Iran.

Materials and Methods

The study region is Taraz Nahid located in central part of Saveh, Markazi province, Iran.

According to the national divisions, its area is 32170 ha and it is located at 20 km of north eastern Saveh city. Considering geographic coordinates, this region is located between eastern longitude of 50°25' and 50°43'26'' and 34°57' and northern latitude of 35°57'32''. With respect to the hydrologic aspect, it is one of the Ghara Chai sub basins (Fig. 1).

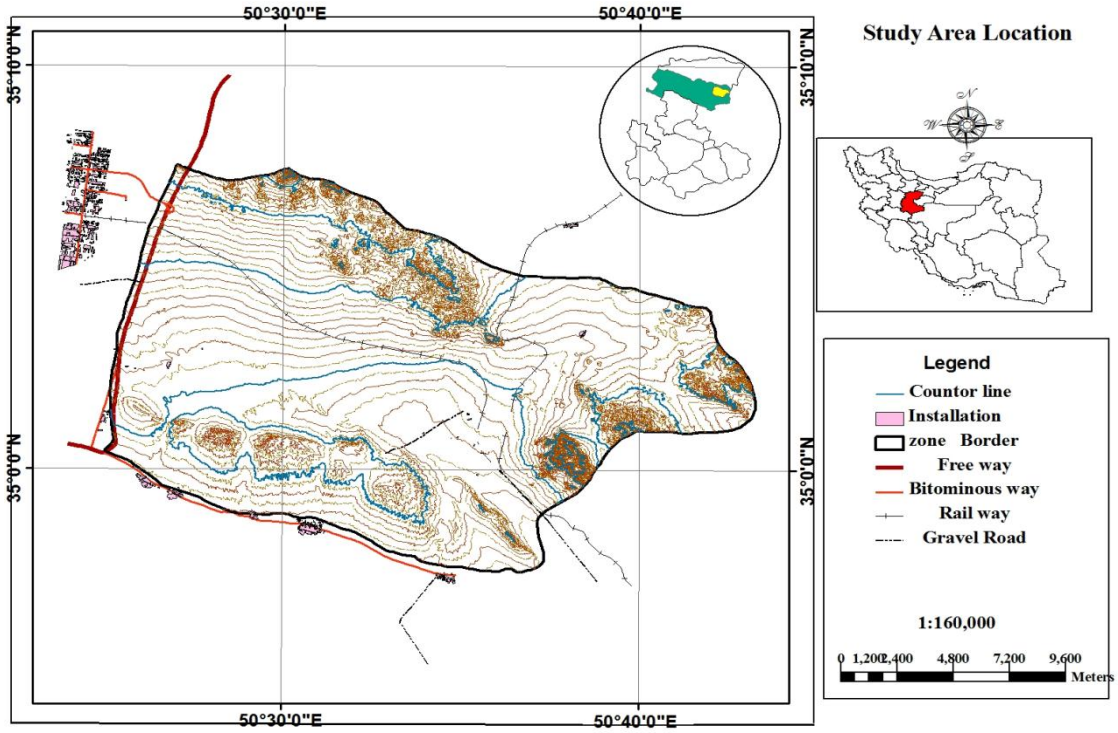

Fig. 1. Geographical location of study area in Markazi province, Iran

Using this model and drawing desertification map in the studied region according to the regional conditions, 5 criteria were considered as the main ones for the desertification including soil, irrigation water, vegetation, socioeconomic and climate (expert theory).

To achieve these criteria, it has been tried to do some relatively complete studies on the region's land uses, geology, geomorphology and vegetation. Accordingly, each parameter considered as the desertification criterion was separately evaluated and then, studied. According to the region conditions and available statistics, several indices were considered for each criterion. The criterion of the geometric mean of its index is calculated according to the formula:

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

Criterion X: the criteria

Layer: the indices of the criterion

n: the number of the criterion's indices

Finally, the desertification intensity was calculated as the result of geometric average of 9 criteria as follows:

Desertification intensity = (Water × Soil × Water erosion × Wind erosion × Climate × Vegetation cover × Agriculture × Technological development× Management) $^{1.9}$.

The geometric average of relevant indices determines the values related to other criteria which will ultimately result in the desertification intensity and definite classes for each geomorphologic unit of different land uses (agricultural, rangeland, forest, etc.).

At the end, the risk of desertification (final map) was classified into 4 subtypes according to (Table 1).

Table 1. Grasped weighs and classes for criterion conditions' evaluation

Row	Actual Desertification Condition	Desertification Class	Numeric Value Domain
1	Low	I	0.0- 1.5
2	Moderate	II	1.6- 2.5
3	Intense	III	2.6- 3.5
4	Very Intense	VI	3.6- 4.0

So, 5 maps came up and then, they were used to study the quality of each criterion and their effects on desertification and at last with the combination of these maps and based on the listed criterion geometric mean, the final map which showed desertification situation in the region was obtained with respect to the following formula:

$DM = [CQI \times VQI \times SQI \times WQI \times SoQI]^{1.5}$

DM: Desertification Mapping
CQI: Climate Quality Index
VQI: Vegetation Quality Index
SQI: Soil Quality Index
IQI: Water and irrigation Index
SoQI: Socioeconomic

Results

Climate criterion

Considering climate criterion indices in IMDPA model involving annual precipitation, UTI drought index and drought continuation, it has been proposed that among 5 evaluating criteria, climate criterion has the second place in intensifying the region desertification progress (Table 2 and Fig. 2). The UTI drought index is the most effective index in intensifying the desertification progress with the score of 3.35.

Table 2. Climate criterion numeric value and desertification class for drought, annual precipitation and soil pluralization

Indices	Desertification Class	Numeric Value	Area (ha)
Drought UTI	Intense	3.35	32170
Drought continuation	Moderate	2.22	32170
Annual precipitation	Moderate	2.36	32170
Climate pluralization score	Intense	2.63	32170

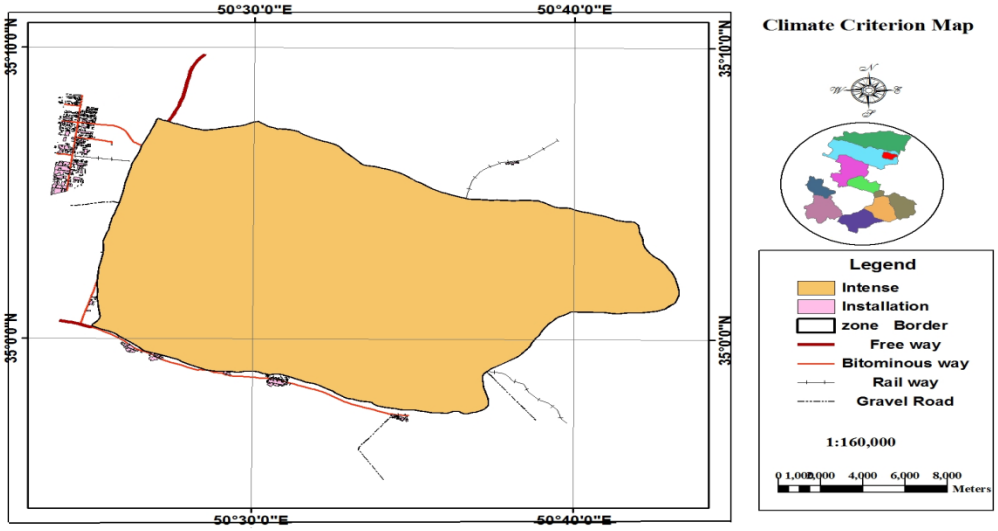

Fig. 2. Studying region climate criterion map

Soil criterion

According to the achieved results from analyzing soil criterion indices including soil depth, soil texture, grit and stone percentage and EC, soil texture was the most effective index for intensifying the region desertification progress with the score of 3.75. The EC and soil depth indices showed the least effects on this progress (Table 3 and Fig. 3).

Table 3. Soil criterion numeric value and desertification class values

Soil Criterion Indices	Desertification Class	Numeric Value	Area (ha)
Soil texture	Very intense	3.75	32170
EC	Low	0.80	32170
Grit and stone percentage	Moderate	2.00	52.2
	Intense	2.95	26968
Soil depth	Low	1.05	4957
	Intense	2.77	27213
Soil pluralization score	Moderate	1.96	1270
	Intense	2.84	30900

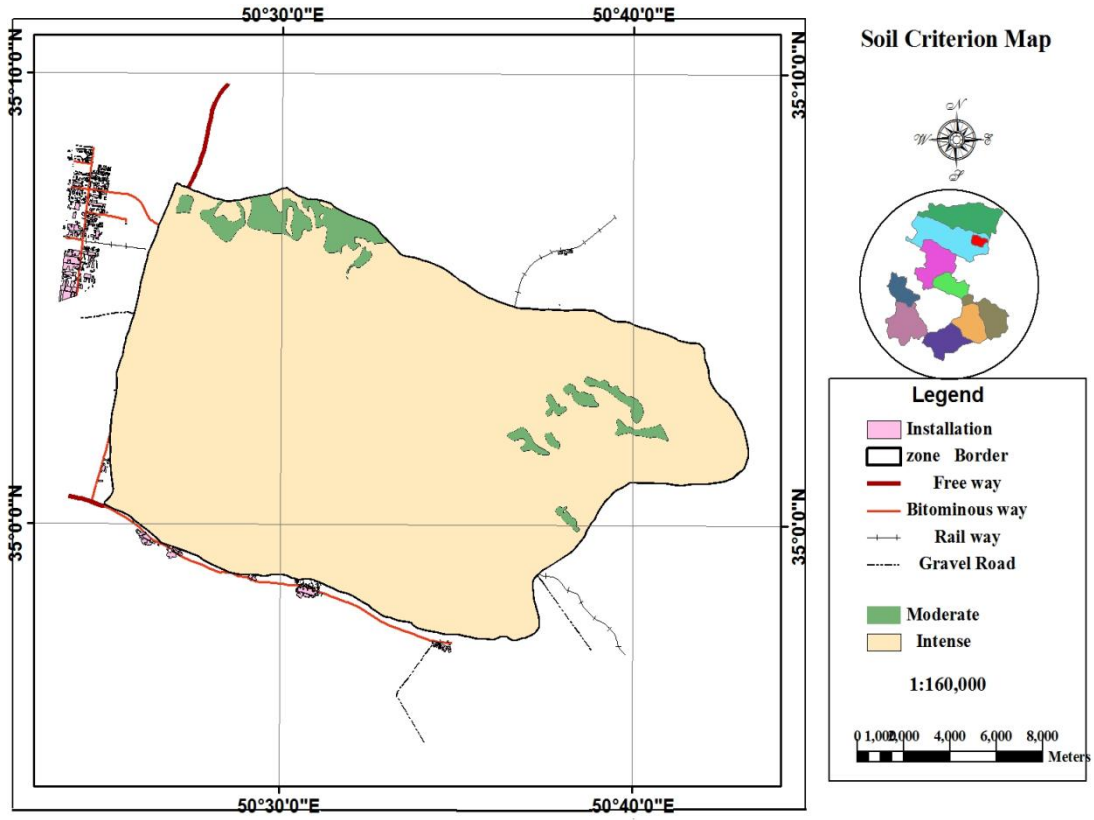

Fig. 3. Studying region soil criterion map

Vegetation criterion

Achieved results from analyzing effective indices suggest that this criterion has the first level among 5 analyzed criteria with the score of 2.9. It was the most effective index in the desertification progress (Table 4 and Fig. 4).

Table 4. Vegetation criterion numeric value and desertification class

Vegetation Indices	Desertification Class	Numeric Value	Area(ha)
Vegetation condition	Moderate	1.96	725
	Intense	3.34	18410
	Very intense	3.71	13020
	Residential		15
Vegetation utilization	Moderate	1.81	17625
	Intense	3.02	14530
	Residential		15
Vegetation revival	Moderate	2.10	15890
	Intense	2.95	16265
	Residential		15
Vegetation pluralization score	Moderate	2.48	725
	Intense	2.70	24535
	Very intense	3.64	6895
	Residential		15

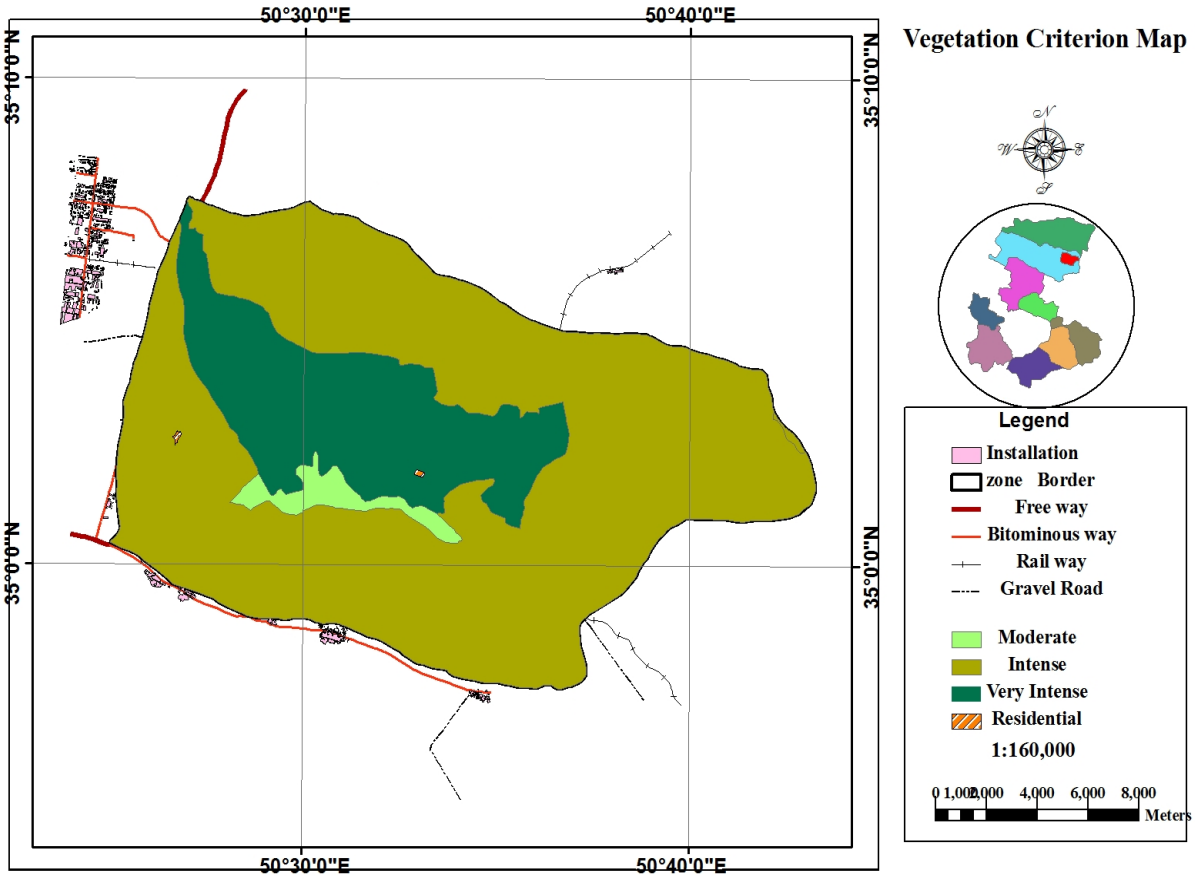

Fig. 4. Studying the region vegetation criterion map

Water and irrigation criteria

Achieved results from analyzing effective indices suggest that for this criterion, the obtained score was 1.96 for intensifying the studying region's desertification progress. Among effective fourfold indices, irrigation system type is the most effective index in intensifying the region desertification (Table 5 and Fig. 5).

Table 5. Water and irrigation numeric values and desertification classification

Water and Irrigation Indices	Desertification Class	Numeric Value	Area(ha)
Irrigation system type	Intense	3.11	32170
Ground water drop	Moderate	1.78	32170
SAR (Sodium Adsorption Ratio) level	Low	0.90	32170
EC (ds/m)	Intense	2.98	32170
Water and irrigation pluralization	Moderate	1.96	32170

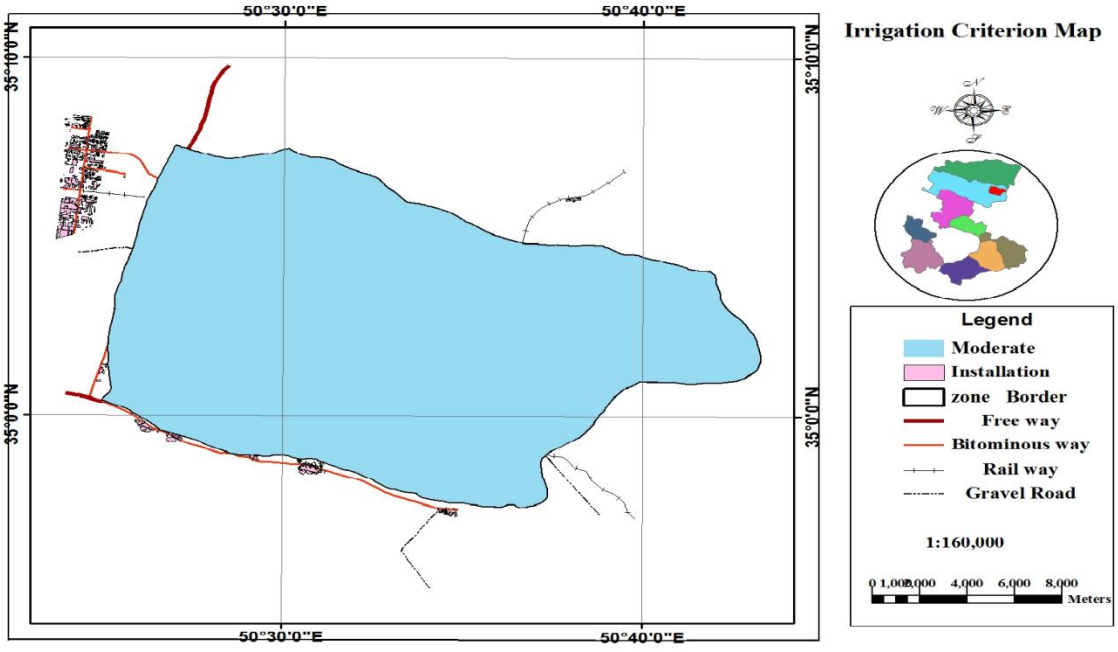

Fig. 5. Studying the region water and irrigation criterion map

Socioeconomic criterion

According to the achieved results from analyzing socioeconomic criterion indices involving population, poverty, economy, institution, juridical and legal factors, organization and participation, it has been shown that poverty, economy and population were the most effective indices in intensifying the region desertification with the ordered scores of 3.04 and 2.96 (Table 6 and Fig. 6).

Table 6. Socioeconomic criterion numeric value and desertification class average

Socioeconomic Indices	Desertification Class	Numeric Value	Area(ha)
Population	Intense	2.96	15
Economy and poverty	Intense	3.04	15
Institution factors, juridical and legal	Moderate	1.76	15
Organization and participation	Moderate	1.97	15
Socioeconomic pluralization scores	Intense	2.55	15

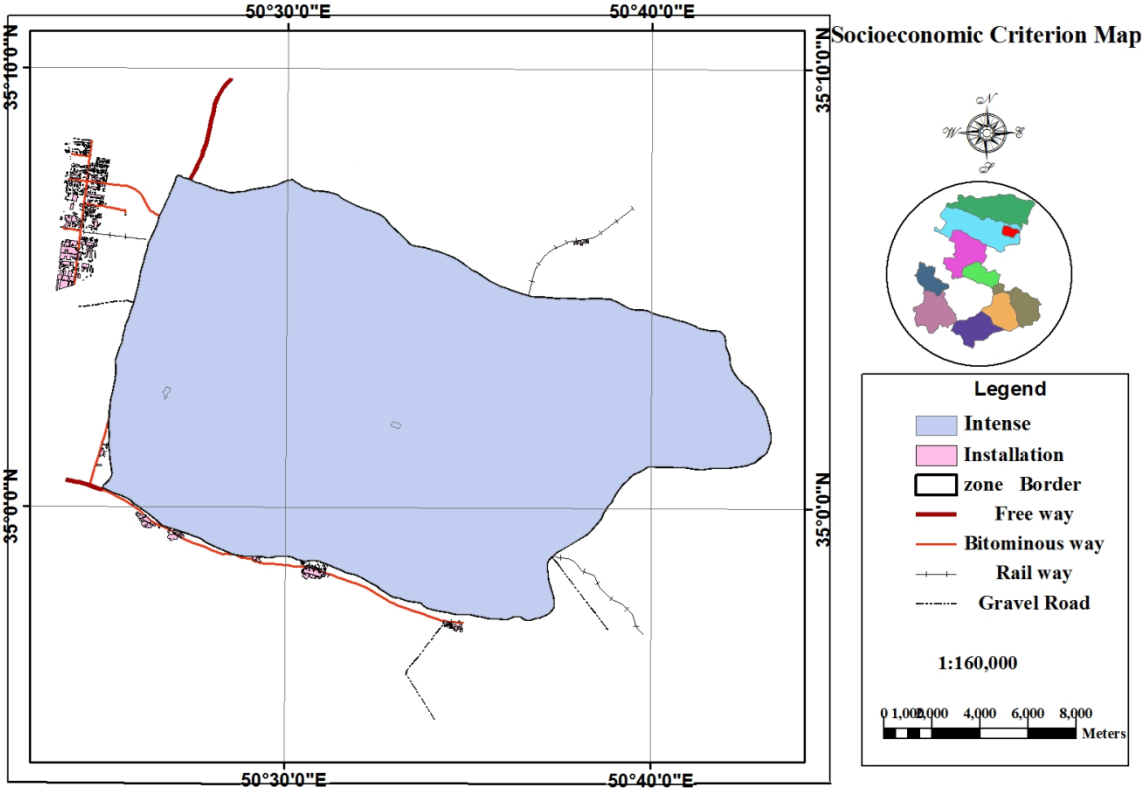

Fig. 6. Studying the region socioeconomic criterion map

Summary of IMDPA model criterion evaluation

According to the analysis conducted in this model and its recorded scores, vegetation criterion and socioeconomic criterion had the highest and the lowest impacts on the intensifying of region desertification (Table 8). Altogether, 24620 and 7550 ha of the region were located in the middle class and intense class desertification of the studied region, respectively (Table 8 and Fig. 8).

Table 7. Desertification classes in different units

Work Unit (Fig. 7)	Desertification Class	Area (ha)	Percentage
1-1, 1-2, 1-3, 1-4, 1-5, 1-6, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 2-9, 3-4, 4-1, 4-2, 4-3, 5-1, 5-2, 5-3, 6-1	Moderate	24620	76.5
3-1, 3-2, 3-3, U	Intense	7550	23.5

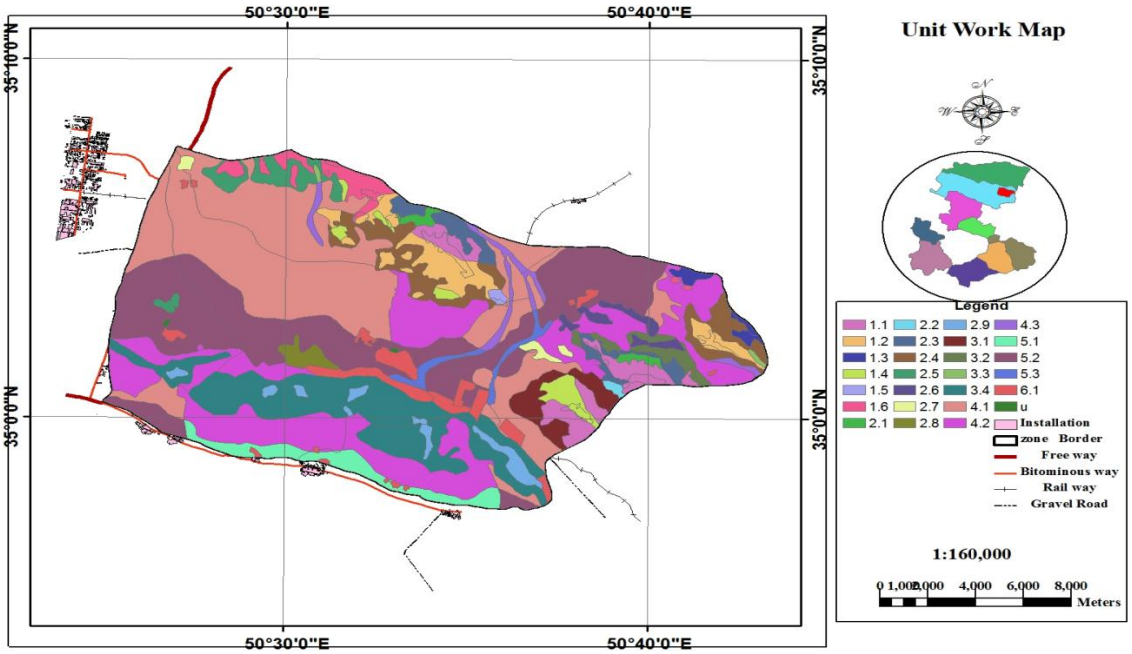

Fig. 7. Unit work map of the study area

Table 8. Effective criteria in the region desertification intensity

Row	Criteria	Numeric Value
1	Vegetation	2.9
2	Climate	2.63
3	Socioeconomic	2.55
4	Soil	2.35
5	Water and irrigation	1.96
	Total numeric value	2.31

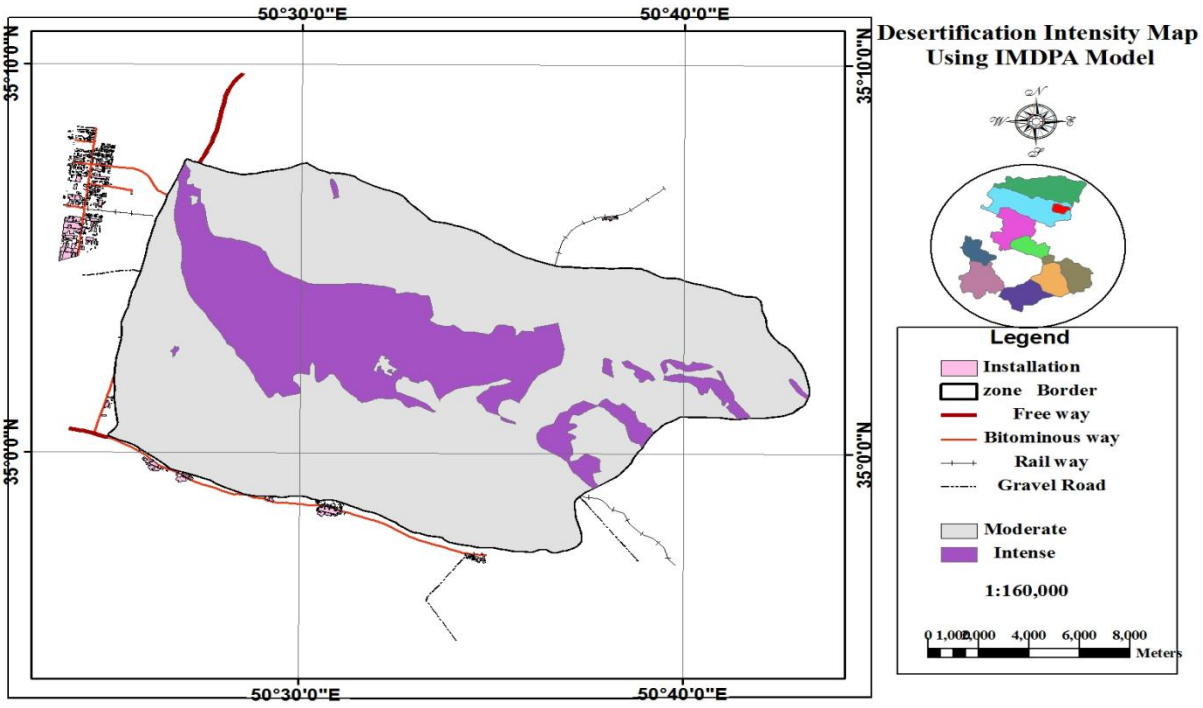

Fig. 8. Desertification intensity using IMDPA model

Comparing the effective indices in the region desertification, it has been found that soil texture and water SAR and soil EC have the highest and the least influences on the region desertification increasing, respectively. Effective indices in the desired region are shown in (Fig. 9).

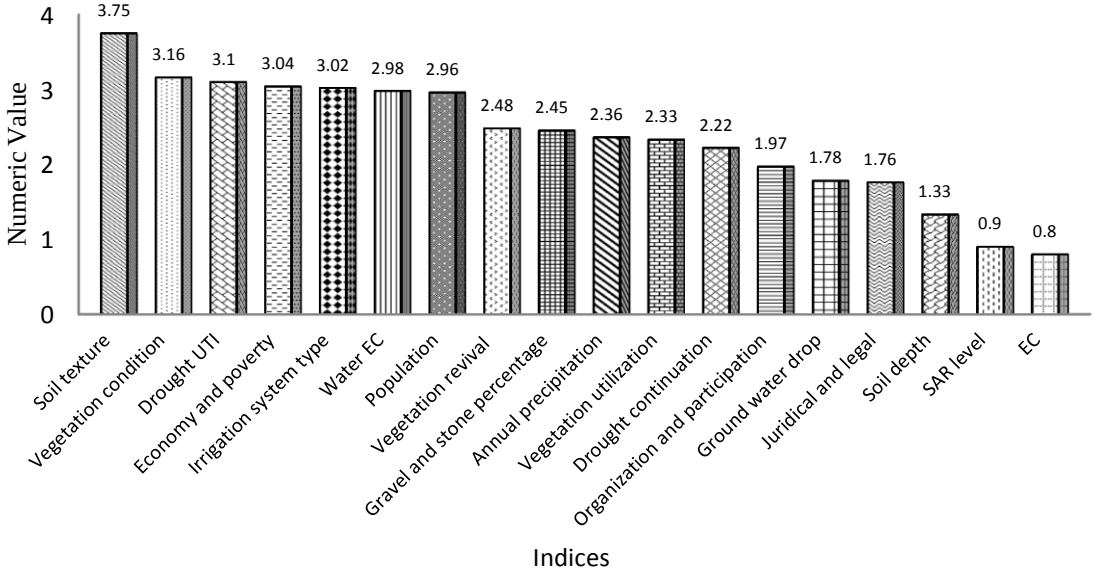

Fig. 9. Effective indices in region desertification display

Discussion and Conclusion

Unlike other models in which desertification intensity will be determined according to main criterion, the intensity of all of studying criterions will be engaged in this method and according to whole criteria, the status of the region desertification intensity will be clarified (Nateghi *et al.*, 2009). Variety and multiplicity of studying criteria and indices in this model lead to a more accurate evaluation for the environmental, physical and human factors. Sectional result which was achieved from studying the effective criteria and indices of desertification shows that the environmental and human factors had serious effects on desert conditions in this region (Khosravi, 2004).

The result of this influence (efficacy) is the destruction of water resources, soil and vegetation. For example, the main effective factors in the desertification intensity are vegetation destruction and economic poverty criterion.

According to the comparison of desertification criterions in the studied region (Taraz Nahid), the vegetation criterion is predominant and can be classified with the average weight of 2.9 as the intense class of desertification.

Studies of desertification indices' average weight showed that soil texture and vegetation conditions with the average values of 3.71 and 3.75 had the highest effects on the desertification in Taraz Nahid region, respectively.

Vegetation criterion has the highest intensity in the most parts of the region. It is because of the vegetation irregular usage. According to region conditions, management plans such as livestock grazing, livestock and pasture balance and biological operations in the form of such projects as shrub planting and precipitation storage as well as organizing some educational and promulgation classes under the titles of graze management and livestock and pasture balance in the region.

A region ranged as the intense class of desertification is a flat pasture and its main plant type is *Artemisia- pteropyrum*, it shows that vegetation has an extreme effect on the region desertification because of overgrazing, traditional animal husbandry and living based on natural resources. Also, the desired regions' prioritizing could be done on the basis of agenda to prevent from the desertification according to the final map (Fathi *et al*., 2011).

Using ICD model also showed that the human factor (including water and plant resources' destruction) is the main effective criterion in the desertification.

According to this research and other studies, we can conclude that IMDPA model is suitable (being of a good ability) for minor scales (with less accuracy and more extent).

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ارزیابی شدت بیابانزایی با استفاده از مدل IMDPA (مطالعه موردی: منطقه طراز ناهید ساوه)

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چکیده

تحقیقات مختلفی در ایران و کشورهای دیگر برای ارزیابی بیابان‌زایی صورت گرفته که منجر به ارائه مدل‌های ملی و منطقه‌ای شده است، که از آن جمله می توان به مدل IMDPA اشاره کرد. این مدل برای یک مطالعهٔ موردی در منطقهٔ طراز ناهید ساوه استفاده شده است. در این بررسی پنج فاکتور اقلیم، خاک، پوشش گیاهی، آبیاری و اقتصادی و اجتماعی مورد بررسی قرار گرفت و با توجه به شرایط منطقه برای هر معیار چندین شاخص در نظر گرفته شد. بر پایه شاخص‌های گزینش شده برای هر معیار، از میانگین هندسی شاخص‌ها در هرمعیار، نقشه کیفی معیار مورد نظر بدست آمد و در پایان از میانگین هندسی معیارها، نقشه شدت بیابانزایی تهیه شد. نقشه نهایی بیابانزایی بدست آمده نشان دهنده کلاس متوسط و شدید روند بیابانزایی در منطقه می‌باشد. با توجه به ارزیابی‌های صورت گرفته مشخص شد که شاخص بافت خاک با ارزش عددی ۳/۷۵ (کلاس خیلی شدید) و وضعیت پوشش گیاهی با ارزش عددی ۲/۹ تاثیر بیشتری را در بیانزایی منطقه دارد. همچنین ارزش کمی شدت بیابان‌زایی برای کل منطقه مورد مطالعه DS=۲/۳۱ محاسبه شد که نشان از کلاس متوسط برای کل منطقه می‌باشد.

کلمات کلیدی: بیابان‌زایی، ارزیابی بیابان، مدل IMDPA، طراز ناهید