DESERT

DESERT
Online at http://jdesert.ut.ac.ir

DESERT 16 (2011) 23-32

Evaluation of desertification intensity based on soil and water criteria in Jarghooyeh region

N. Shakerian[a*], Gh. R. Zehtabian[b], H. Azarnivand[c], H. Khosravi[d]

[a] *MSc. Graduate, Faculty of Natural Resources, University of Tehran, Karaj, Iran*
[b] *Professor, Faculty of Natural Resources, University of Tehran, Karaj, Iran*
[c] *Associate Professor, Faculty of Natural Resources, University of Tehran, Karaj, Iran*
[d] *PhD Candidate, Faculty of Natural Resources, University of Tehran, Karaj, Iran*

Received: 2 March 2011; Received in revised form: 24 May 2011; Accepted: 7 June 2011

Abstract

Desertification refers to land degradation phenomenon in arid, semi-arid and dry sub-humid areas, resulting from various factors including climate variation and human activities. For evaluation and mapping of desertification many research have been conducted leading to regional and local models. In this research, among different existing methods IMDPA was selected and desertification intensity was evaluated on the basis of 2 criteria and 8 indices including: soil (soil depth, Electrical Conductivity, texture and gravel percentage) and water (groundwater table decrease, EC, Cl concentration, Sodium Absorption Ratio). Each criterion was assessed based on the selected indices which result in qualitative mapping of each criterion cased on geometric average of the indices. Finally, sensitive map of region was extracted using geometric average of all criteria. Thematic databases, with a 1:50000 scale resolution, were integrated and elaborated in a GIS based on arc/info8, arc view3.2 and especially ILWIS. Analysis of desertification criteria in Jarghooyeh region showed that among study criteria, soil criterion is a major problem in the study area with a geometric average of 2.25 which shows medium class while water criterion with a weighted average of 1.14 stands in low class of desertification. Also, the results showed that that Electrical Conductivity index with quantitative value of 3.54 classified in very high class of degradation, and ground water recession with quantitative value of 0.05 classified in low class of desertification were the most and the least effective factor on land degradation among studied indices respectively.

Keywords: Land degradation; IMDPA Model; Index; Criteria; Isfahan

1. Introduction

Desertification process as a great problem effects most of the countries in the world especially developing countries. This process has high rate in arid and semi-arid countries as Iran. There are vast natural areas in Iran, which have susceptible and fragile ecosystem and desert condition. According to the new definition of desert, except a narrow strip in north of Iran, other parts of the country encounter desertification problem.

In order to challenging with desertification, it is necessary to do some scientific research and assessment in different parts of the world. The results may help to control and reduce the damages resulted from this phenomenon. In many regions of the world especially in arid and semi-arid ones, studies have been done to assess the land degradation rate, degradation status and mapping. In this regards, studies have been conducted which provided land degradation assessment methods such as UNEP-FAO

* Corresponding author. Tel.: +98 9131669877, Fax: +98 311 4415795.
E-mail address: no.shakerian@gmail.com

(FAO/UNEP, 1984; Grumblat, 1991; Harasheh, Tateishi,1998), TAXONOMY (Babaev, *et al*., 1993: Kharin, *et al*. 1985) ESAs[1] (Basso, *et al*. 1999; Giordano, *et al*. 2002; Ladisa, 2002; Rafiee 2003), MEDALUS (European Commission, 1999; Kosmas, *et al*. 1999; Khosravi, 2004, 2005; Nicholas, 2001, Zehtabian, *et al*. 2005, 2008; Khosravi, *et al*. 2005, 2008), ICD[2] (Ekhtesasi, Mohajer, 1994), MICD[3] (Ahmadi, *et al*. 2005), IMDPA[4](Ahmadi, 2004) and etc.

Soil degradation is one of the most important processes that it is used on the different desertification methods such as UNEP-FAO, ICD, and IMDPA as desertification criteria.

The aims of this research are soil degradation mapping and study the effect of soil criteria on desertification intensity in Jarghooyeh region, Isfahan province.

It is expected to calibrate the desertification related models for mapping desertification intensity map in arid, semi-arid, and humid semi-arid regions of Iran which will ease decision making and recommendations for desertification control activities. It is also expected to share these expenses with other country for expand global knowledge about the phenomena.

2. Materials and methods

2.1. IMDPA Model

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. In this project, some international models of desertification such as FAO-UNEP (FAO/UNEP, 1984), GLASOD, LADA, AOOSD, MEDALUS (European Commission, 1999) as well as national models including ICD (Ekhtesasi, Mohajer, 1994) and MICD (Ahmadi, 2005) were reviewed in this research and 9 criteria were chosen based on previous experiences for desertification intensity mapping (Ahmadi, 2004).

All of the criteria as well as the selected indices for soil criteria are given here:

A score ranging from 1 to 4 is assigned to each index based on weight of each factor. Finally the value of each criterion was obtained as geometric average of scores of single indices according to the formula:

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

Where:
Index-X: A given criteria
Layer: Index of each criterion
N: number of indices for each criterion
Finally the desertification intensity will be a 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 values related to other criteria, which ultimately will result in desertification intensity, and class in each geomorphologic work unites of different land use (Agricultural, rangeland, forest, etc).
At the end, the risk of desertification (final map) is classified in 4 subtypes according to the Table1.

Table1. Classification of desertification intensity

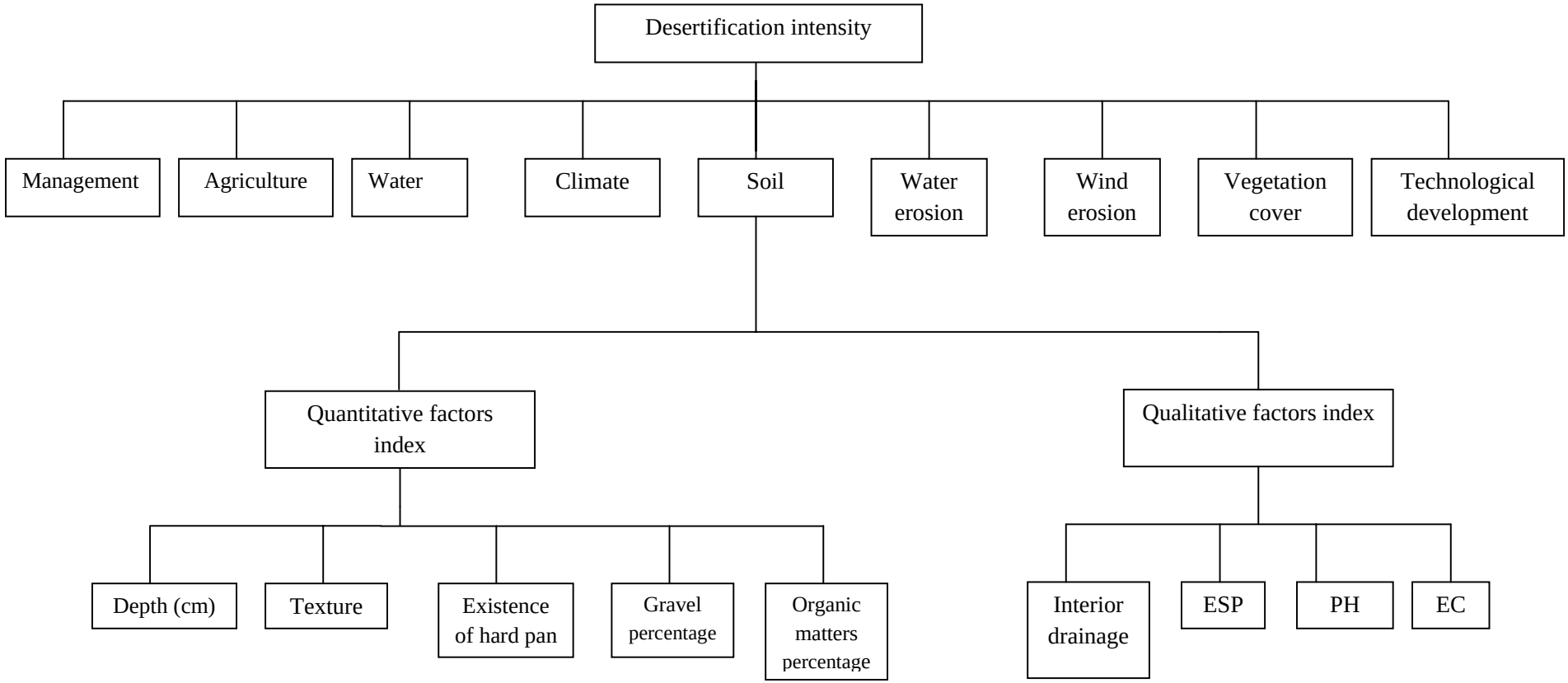
Order	Numerical value	Class
1	1-1.5	Low
2	1.6-2.5	Medium
3	2.6-3.5	High
4	3.6-4	Very High

2.2. Case Study: Jarghooye Sofla Region (Isfahan Province)

The study area is located in 32º 09´ to 32º 27´ N and 52º 11´ to 52º 43´ E. and has an arid climate with annual average precipitation of 122.5 mm. This region is in Isfahan province and south of Tehran with mean annual temperature of 14.8°C.
The risk of desertification in study area was evaluated on the basis of water and soil criteria. Each criterion includes the following indices:
Soil: Depth, Electrical Conductivity (EC), Texture and Gravel Percentage.
Water: Ground Water Table Decrease, Electrical Conductivity (EC), Cl Concentration, Sodium Absorption Ratio (SAR)

According to the factorial scaling technique, score-ranging from 1 (good condition) to 4 (deteriorated condition) is assigned to each index. Value "Zero" is assigned to the areas where the measure is not appropriated and/or those, which are not classified.

[1]. Environment Sensitive Areas to Desertification
[2]. Modified Iranian Classification Desertification
[3]. Modified Iranian Classification Desertification
[4]. Iranian Model of Desertification Potential Assessment


Desertification intensity
Management
Agriculture
Water
Climate
Soil
Water erosion
Wind erosion
Vegetation cover
Technological development
Quantitative factors index
Qualitative factors index
Depth (cm)
Texture
Existence of hard pan
Gravel percentage
Organic matters percentage
Interior drainage
ESP
PH
EC

When the scores are assigned, the indices are grouped. The value of quality index for each elementary unit within an index is obtained as geometric average of scores for single indices.
Consequently 8 maps representing the condition of each index were produced to study the role and effect of each index in desertification. Then water and soil maps were generated as geometric average of the mentioned indices showing the desertification condition in four classes.
Consequently 2 maps representing the condition of each criterion was produced to study the role and effect of each index in desertification.

3. Results

To assess the proposed method in this study, with respect to all information mentioned in methodology and evaluation method, this method for up to 82329.46 ha of jarghooyeh region was used and obtained data were analyzed. In general, various steps of studying and evaluation effective indices to determine soil degradation intensity and to analyze obtained data are presented in the Figures1-8.

To study these criteria, data collected from analyses of soil and water samples and interpolating amongst data points were be used. Table 2 and 3 show indices used to evaluate recent desertification condition and chosen to study water and soil criteria in study area.

3.1. Analysis of indices

3.1.1. Indices of Water Resources Criterion

In order to determine the level of desertification of the region using the groundwater criterion, firstly regarding the information in table1 and field surveys, the indices considered in the unit map of the region have been graded. Figures 1 to 4 are presented maps of water resources indices.

3.1.1.1. Electrical Conductivity Index

Electrical Conductivity is one of major factors of water resources degradation in Iran that used in different regional desertification model. The Figure1 shows that the map of soil depth index has classified in two classes of desertification.

Table 2. Water resources degradation indices

Index	Class	Low	Medium	High	Very high
	Value	1-1.5	1.5-2.5	2.6-3.5	3.6-4
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

Table 3. Soil resourced degradation indices

Index	Class	Low	Medium	High	Very high
	Value	1.00-1.50	1.50-2.50	2.60-3.50	3.6-4
Depth (cm)		>80	50-80	20-50	<20
EC (µmhos/cm)		<4	4-8	8-16	>16
Texture		Sandy Clay, Silty Clay	Loam, Sandy Clay Loam, Silty Clay Loam, Silty Loam	Loam Sandy, Sandy Loam	Sandy, Clay<60%
Gravel percentage		<15	15-35	35-65	>65

3.1.1.2. Sodium Absorption Ratio Index

Figure 2 shows that the map of soil depth index has classified in one classes of desertification.

3.1.1.3. Groundwater Table Decrease Index

The map groundwater table decrease index just classified in low class of desertification. On the other hand, this index has no effect on desertification in Jarghooyeh region.

3.1.1.4. Cl Concentration Index

The figure4 shows that Cl concentration index classified in low class of desertification.

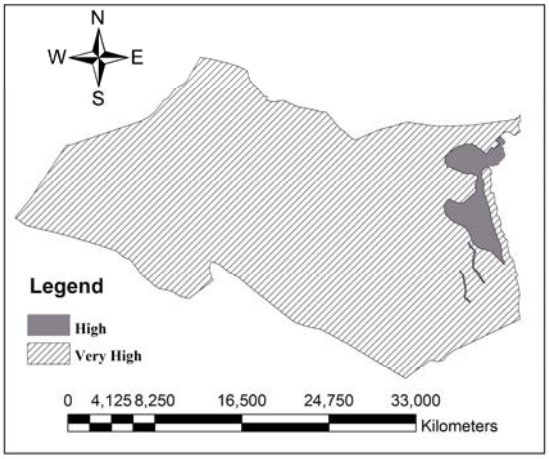


Fig. 1. Map of EC Index

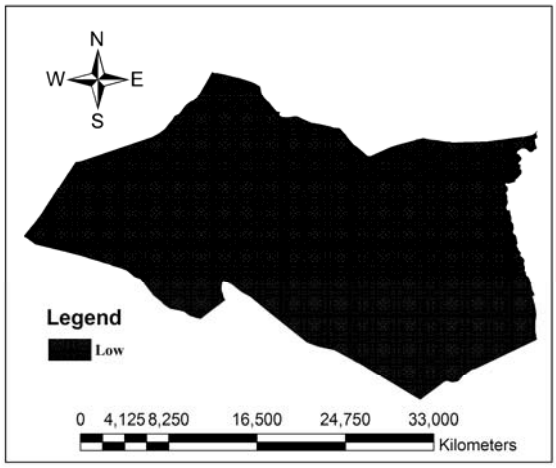


Fig.2. Map of SAR Index

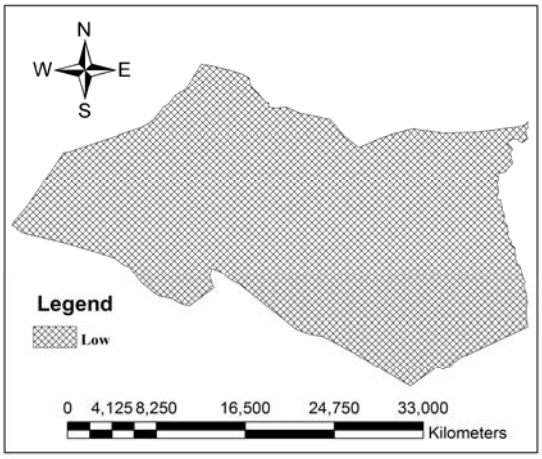


Fig. 3. Map of Groundwater Table Decrease Index

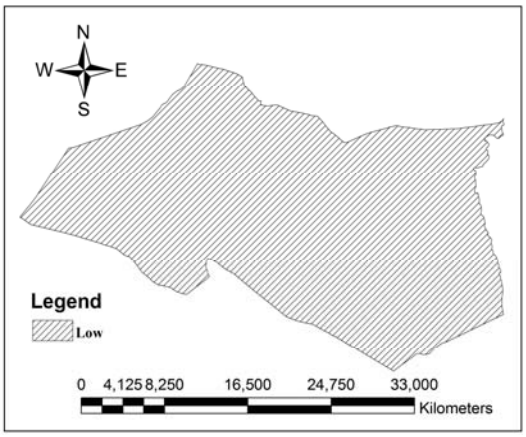


Fig. 4. Map of Cl Concentration Index

After studying mean value of factors involved in water resources deterioration, it's indicated that Electrical Conductivity index with a geometric average of 3.62 which shows very high class is the most effective factor in increasing groundwater degradation intensity of studied region. In general, we can introduce the following table for all indices influencing water resources deterioration.

Table 4. Geometric average of the quantitative values of water resources degradation criterion

Order	Index	Value	Class
1	Groundwater table decrease	0.05	Low
2	EC (µmhos/cm)	3.62	Very high
3	CL (Mgr/liter)	0.24	Low
4	SAR	0.66	Low

3.1.2. Indices of Soil Criterion

3.1.2.1. Soil Depth Index

Soil depth is very important factor for determining the susceptibility to desertification. The deeper the soil, the less sensitivity to desertification, and vice versa. The soil depth is divided to four classes according to its depth as (i.e. Very deep, Not deep, moderately deep and Very thin soil). The very thin soil is the most susceptible to desertification, and takes a score of 4.0 on the desertification sensitivity index (Table3). Figure5 shows that the map of soil depth index has classified in three classes.

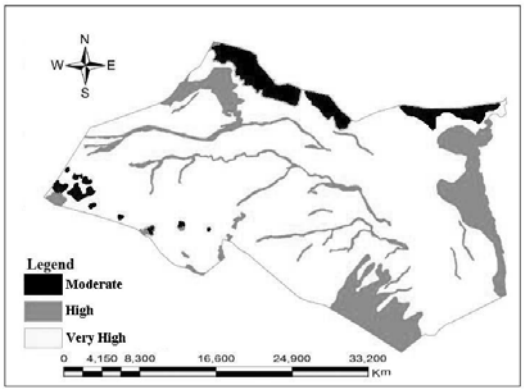


Fig.5. Map of Depth Index

3.1.2.2. EC Index

Electrical Conductivity is one of major factors of soil degradation in Iran that used in different desertification model as soil-criteria index. The Figure6 shows that the map of soil depth index has classified in two classes of desertification.

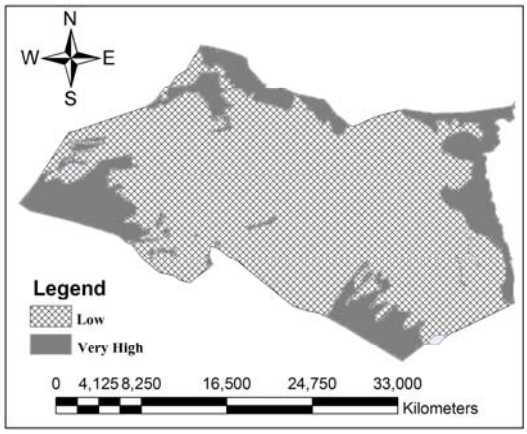


Fig. 6. Map of EC Index

3.1.2.3. Soil Texture Index

Soil texture is very important factor for determining the susceptibility to desertification. The soil texture is divided to four classes according to its texture, based on IMDPA methodology (table3). The soils characterized as "Not very light to average" are the least susceptible to desertification. The fine to average textured soils is moderately susceptible to desertification. The coarse textured soils are the most susceptible to desertification. Figure7 presents that soil texture of study area is divided in four desertification intensity classes.

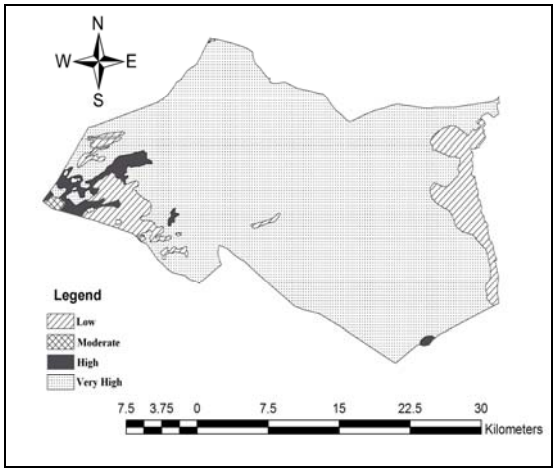


Fig. 7. Map of Texture Index

3.1.2.4. Surface Gravel Sand Index

Gravel sand percentage present in the soil surface is classified in four classes according to their capacity to conserve soil water and protect soil from erosion as Table3. The resulting map of gravel sand index shows that more than 80% of Jarghooyeh region falls within the high class of desertification-risk sensitivity.

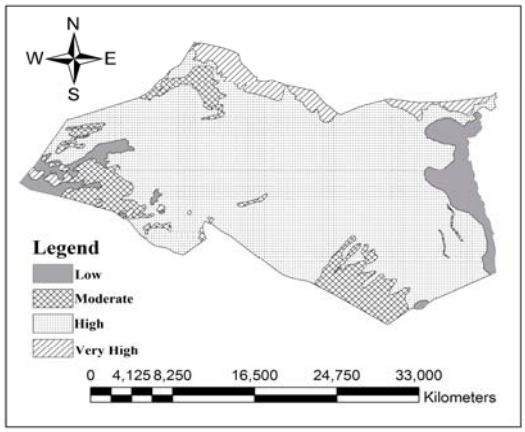


Fig. 8. Map of Gravel Soil Index

Analyzing the mean value of four effective indices on soil degradation presents that soil EC index is the most effective factor in increasing soil degradation intensity by the geometric.

Table-3 Geometric average of the quantitative values studied indices

Order	Index	Value	Class
1	depth	3.42	high
2	EC (µmhos/cm)	3.54	Very high
3	texture	3.41	high
4	Gravel percentage	2.79	high

3.2. Analysis of criteria

Analysis of studied criteria in Jarghooyeh region showed that soil criterion with a geometric average of 2.25 shows medium class while water resources criterion with a weighted average of 1.14 stands in second order of desertification factors.

4. Discussion and conclusion

As a process of desertification in arid ecosystem, desertification is widespread in the arid region of world. In Iran where more than 85 percent of its 164.8 million ha are occupied by arid, semi-arid and hyper-arid regions with 34 million ha of desert, the major part of the country is susceptible to desertification. Although the government has gone into many projects to combat desertification in recent year, it seems that they are not adequate due to country extensive arid region. The problem needs more attention in addition to effective cooperation in the national as well as the international scene over the long term.
We used a regional model by modifying IMDPA model whereby desertification parameters were collected in the study area, using GIS. The 2 composite criteria, each consisting of several indices, were analyzed. Based on the results, the soil criterion (average weight = 2.25) has average role in desertification process. The water resources criterion (average weight = 1.14) has low rate on desertification (Figure9). Analysis of soil and water criteria indicates the rate of desertification in Jarghooyeh region is not intensive.

As the soil is an essential factor in evaluating the environmental sensitivity of an ecosystem, especially in the arid and semi-arid zones. The soil Criteria was evaluated, based upon soil texture class, soil depth (cm), Electrical Conductivity and the surface gravel sand (%). Figure10 represents the class, description and areas of soil criteria of Jarghooyeh territory. The areas of very high soil quality (value 3.5-4) represent the soil coverage majority. The very high class of soil degradation dominates the areas characterized by sandy texture, shallow depth and salinity.

One of the disadvantageous of the proposed procedure is difficulty of measuring all effective factors because of limiting parameters such as costs, intensive filed works, deficiency of necessary data and information. Meanwhile all of the indices play major role in desertification process since the number of indices in the current study has been reduced consequently the

efficiency of the model has decreased which needs more studies to find solutions for overcoming this problem.

It can be concluded that the assessment of desertification sensitivity is rather important to plane sustainable development in highly potential desert areas as Jarghooye region. Achieved information is essential to improve the employment of natural resources. The merely quantitative aspect of desertification sensitivity demonstrates a clearer image of the risk state, thus, reliable priority actions can be planned. Remote sensing, in addition to thematic maps, may supply valuable information concerning the soil quality at the general scale. However, for more detailed scales, conventional field observation would be essential.

It can be recommended that mathematical modeling should be developed for the operational monitoring of different elements contributing in desertification sensitivity. Multi scale mapping of IMDPA are needed to point out the risk magnitude and causes of degradation in problematic areas.

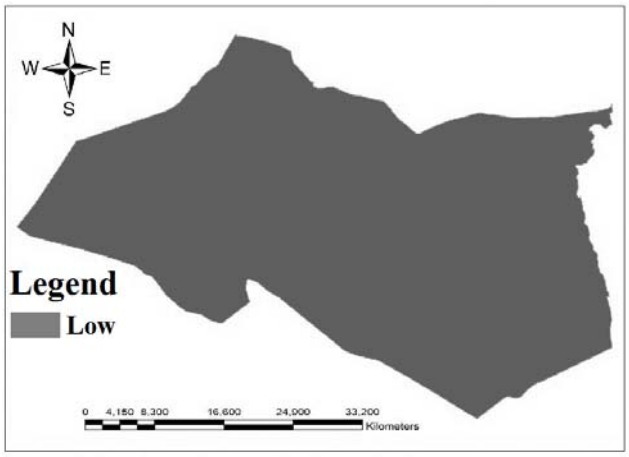


Fig. 9. Map of Desertification Condition Based on Water Resources Criterion

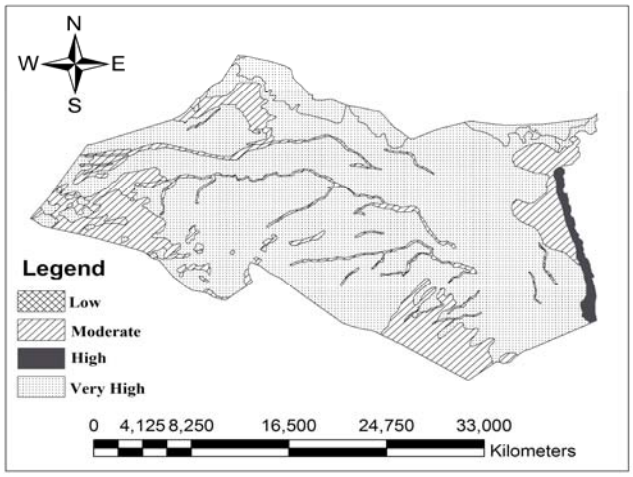


Fig. 10. Map of Desertification Condition Based on Soil Criterion

References

Ahmadi, H. *et al*., 2004, Iranian Model of Desertification Potential Assessment, Faculty of Natural Resources, University of Tehran.

Ahmadi, H., Abrisham, E., Ekhtesasi, M.R., 2005. Evaluation and mapping of desertification condition in Fakhr Abad region with the ICD and MICD models, Biaban Journal. Vol. 10, No 1-1, 37.

Basso F, Belloti A, Faretta S, Ferara A, Manino G, Pisante M, Quaranta G, Tabemer M,1999,The Agri Basin In: MEDALUS Project_ Mediterranean Desertification and

Land Use. Manual on Key indicators of desertification and mapping Environmentally Sensitive areas to desertification.

Babaev, A.G. Kharin, N. G, Orlovsky, 1993, Assessment and Mapping of Desertification Processes, A Mythological Guide. Ashghabad.

European Commission (1999) Mediterranean Desertification and LandUse MEDALUS). MEDALUS Office. Lodon

Ekhtesasi, M. M. Mohajer, 1994, the Method of Iranian Classification Desertification.

FAO/UNEP, Land Degradation Assessment in Dryland (LAND), 2001, United Nations Environment Program, FAO/UNEP, 1984, Provisional Methodology for Assessment and Mapping of Desertification, Rome.

FAO-UNEP/ UNESCO/ WMO, 1977, Word Map of Desertification at a Scale of 1:25000000

Giordano L., F. Giordano., S. Grauso, M. Lannetta, M. Scicortino, G. Bonnati, F. Borfecchia, 2002, Desertification vulnerability in Sicily. Proc. Of the 2nd Int. Conf. On New Trend in Water and Environmental Engineering for Safety and Life: Eco-Compatible Solution for Aquatic Environments.

Grumblat, J., 1991, Kenya Pilot Study to Evaluate FAO/UNEP Provisional Methodology for Assessment and Mapping of Desertification (Gok, DRSRS).

Harahsheh, H., R. Tateishi, 1998. Desertification Mapping of West Asia_a GIS and Remote Sensing Application. Center for Environment Remote Sensing, Chiba University, Japan.

Kharin N, G. *et al*. 1985. A Methodological principles of desertification processes assessment and mapping. Arid lands of Turkmenistan taken as example, Ashkhabad.

Khosravi H., 2004, The Strategies for Prevention of Desert Regions Degradation Using Desertification Models in Kashan, the forth international Iran and Russia conference "Agriculture and Natural Resources" Shahrekord, Iran.

Khosravi. H, 2005, Application of MEDALUS model in desertification of Kashan, M.Sc thesis, university of Tehran, 160p.

Khosravi. H, Gh. Zehtabian, M. Ghodsi, 2008, the study of water erosion effect on desertification intensity in Kashan region, The First European Conference of Iranian Scientists in Agriculture and Natural Resources, 8-9 October, Paris, France.

Kosmas C, Kirkby M, Geeson N, 1999, European Commission the MEDALUS Project Mediterranean Desertification and Land Use.

Kosmas C, Gerontidis St, Detsis V, Zafiriou Th, Marathianou M.,1999,Application of the MEDALUS methodology for defining ESAs in the Lesvos island, European Commission. Capri, Italy, June 24-28, 2002.

Ladisa G, Todorovic M, Trisorio_liuzzi G., 2002, Characterization of Area Sensitive to Desertification in Southern Italy, Proc. Of the 2nd Int. Conf. On New Trend in Water and Environmental Engineering for Safety and Life: Eco-compatible solutions for Aquatic Environmental, Capri, Italy.

Nicholas, J., Yassoglou, C.Kosmas, 2001, Desertification in the Mediterranean Europe, a Case in Greece. No 200 MEDALUS report.

Rafiei Emam A., 2003, Desertification vulnerability in Varamin plain. Proc. Of the 6th Int. Conf. on Map India 2003, New Delhi, India.

Zehtabian. Gh., H. Ahmadi, H. Khosravi, A. Rafiei Emam., 2005, The Approach of Desertification Mapping Using MEDALUS Methodology in Iran. BIABAN Journal, Vol. 10, No.1-1.

Zehtabian, Gh., H. Ahmadi, M. R. Ekhtesasi, H. Khosravi, 2008, Calibration of MEDALUS Model to Present Regional Model For Desertification Intensity(case study: Kashan, Iran). Vol. 60, No. 4.