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Study of Desertification Status using IMDPA Model with Emphasis on Water, Soil and Vegetation criteria (Case Study: Faryab-Kerman Province)

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ABSTRACT: Today, desertification regions of world, especially in arid, semi-arid and semi-humid areas are threatening by various causes, including natural and human factors. In these areas desertification not only degradation soils also creates some unstable condition for all of social and economical, especially on cultivation and irrigation. Land degradation can be more objective in soil and water on the leaves due to the importance of this issue; in this study have been studied three criteria: water, soil and vegetation. In order to evaluate desertification in Faryab region (south of Kerman province) were used of IMDPA model. For soil criteria four index: texture, depth, percent of gravel and electrical conductivity, for water criteria three index: electrical conductivity, chloride concentration and SAR, and for vegetation criteria three index: Vegetation condition, exploitation of vegetation and Renewal of vegetation were applied in this model. Results indicated that 14.53% of total study area classified as low class 33.69% is classified as moderate class and 51.78% of area classified as severe class of desertification.

Keywords: Desertification, IMDPA model, Water, soil vegetation and Faryab region

INTRODUCTION

Desertification is one of the major crises in the world nowadays. Currently, nearly one thousand and three hundred million people living in more than 110 countries (nearly three fifths of the world) suffer from adverse effects of desertification. Economic, social and political consequences of desertification undoubtedly affect residents of other parts of the world (Diallo, 2001). Desertification has affected nearly 3.100 million acres of pasture, 335 million hectares of irrigated lands, 40 million hectares of cultivated land and 3.475 million hectares or 70% of the total arid areas (Dregne, 1991). In addition, 33% of the earth with a population of 6.2 billion people is affected by desertification and land degradation (Adams and Eswaran, 2000). Desertification is defined as follows: land degradation in arid, semi-arid and sub-humid areas due to climatic factors and human activities (Danfeng *et al.*, 2006).

Nowadays, various models, indicators and criteria have been developed to assess the effective factors in desertification and land degradation, which are widely used in the world and our country. Each model has several advantages and disadvantages compared to each other. Certain factors and parameters are involved depending on the area where the models are used. These models should be calibrated according to local conditions. FAO-UNEP, GlASOD, LADA, ICD, MEDALUS, MICD, and Iranian Model of Desertification Potential Assessment (5IMDPA) can be noted as instances of these models. One of the above models is used to map desertification in most countries. Rafiei Emam (2003) examined desertification with an emphasis on soil and water issues using 6ESAS method in Varamin plain. He cited important desertification indices in the area under study as ground water, land use and soil quality.

Ghasemi (2006) assessed desertification indices and layers with an emphasis on soil and water indices in Zabul Province. They showed that soil index with an average weight of 1.68 was in the first effective factor in desertification in severe class. Abdi (2007) used IMDPA model for quantitative assessment of both severity and status of desertification in Abozeyd Abad region. Two water and soil indices were considered as key factors among nine criteria of IMDPA Model. Soil electrical conductivity (at first order) and water electrical conductivity (at second order) with respectively average weight of 3.67 and 2.8 had the greatest impact on desertification in the study area.

Moreover, they obtained desertification severity of the study areas as 1.62 based on geometric mean of the two criteria, which represents medium severity of desertification in this area. Dowlatshahi (2007) assessed the severity of desertification in southern Garmsar using IMDPA Iranian model with an emphasis on water, soil and vegetation indices. The results indicated that water electrical conductivity index had the greatest impact on desertification in this region and water index was the most effective factor on desertification among other criteria. The average quantitative value of potential desertification severity was obtained as 1.94 for the entire region in medium class. Nateghi (2007) assessed the severity of desertification in Segsi Plain using MDPA Model with an emphasis on water, land and vegetation issues. The map of desired parameters was prepared by combining layers of each index. Finally, map of desertification severity with severe and highly severe classes was obtained by combination of multiple criteria. Moreover, water index with an average weight of 3.97 was in highly severe class, land index with an average weight of 3.26 was in severe class and vegetation index with an average weight of 3.12 was in severe desertification class. Esfandiari and Hakim Zadeh Ardekani (2010) assessed the severity of soil degradation and desertification in agricultural land zones in Abadeh Tashak regions using IMDPA desertification models. The results showed that 48% (2212 ha) of total area was in low desertification severity class, 43% (2019 ha) of the total area was in medium desertification severity class and 10% (467 ha) of the area was in highly severe desertification class.

Several studies have been conducted to assess desertification in Iran and abroad. As a result, numerous regional models specific to studied areas were provided. Indices and layers of this model should be evaluated, reviewed, modified and calibrated in other areas.

The present study aimed to evaluate the effects of water, soil and vegetation indices in desertification based on analysis of IMDPA Model and preparing potential desertification map based on the Iranian model.

MATERIALS AND METHODS

A. Location of the study area

The study area is located in 360 km southern part of Kerman City and 65 km northern part of Kahnuj City, which consists of two Chekckek and Gelashekard watersheds. Chekchek watershed with an area of 3879.2 hectares and Gelashgard watershed with an area of 7996.86 (both watersheds are expanded to 11876.06 hectares) cover Faryab City. This area is located between 28º 3´ to 28º 11´ northern latitudes and 56º 56´ to 57º 12´ eastern latitudes. The highest altitude is in the northwest part of Chekchek watershed with 2470 meters above sea level and the lowest altitude was 750 meters above sea at outlet of Chekchek watershed near Faryab City (Fig. 1).

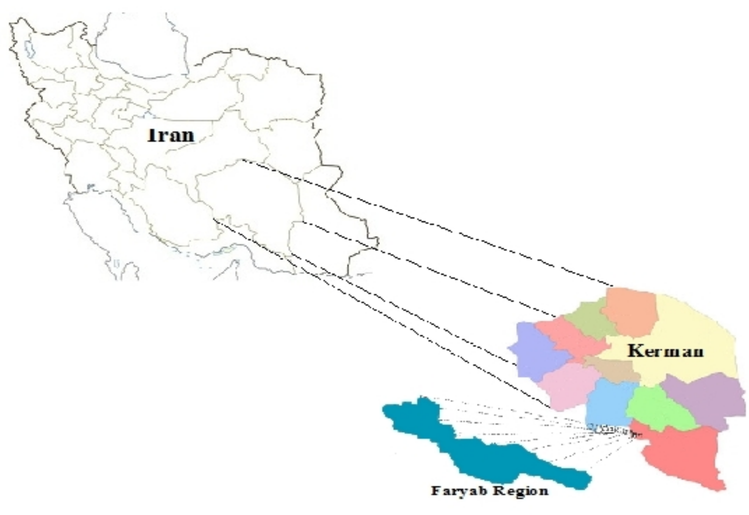

Fig. 1. Geographical location of the study area in the province and country.

B. Research Methodology

Arc GIS 9.3 software was used to prepare map of indices and layers as well as final map of potential desertification. Then, values of each index was determined in all areas and entered to the software.

The layers were weighted and value of each layer was determined according to the relevant index. The impact of each layer on desertification was investigated. Finally, desertification map was prepared.

Three indices of water, soil and vegetation (key factors in desertification) in the region were considered to use this model and plot desertification map in the region. Several detailed studies were conducted in terms of land use, soil and vegetation to obtain these criteria. Thus, each parameter was considered as desertification index and was studied separately. Then, several indices were considered for each index according status of the region and relevant statistics. Each index was obtained by calculating geometric mean of relevant indicators according to the following formula: Index-X = $[(LayER1). (Layer2)\ldots(Layerx)]^{1/n}$

where:

Index-X: the required index

Layer: indicators for each index

n: number of indicators for each index

Thus, four maps were prepared according to each index. These maps were used to study both quality and effect of each index on desertification. Finally, these maps were integrated to prepare the final map that shows status of desertification in the region by calculating geometric mean of all indices based on following formula:

$DM = [GWI * VQI * SQI]^{1/3}$

where:

GWI: ground water index

VQI: vegetation quality index

SQI: soil quality index

DM: current status of desertification in area

C. Scoring every one of the selected indices

(i) Water index. Data relevant to water index was collected by taking samples from two wells and three springs to determine certain layers in order to assess water index. Scores of sodium absorption ratio, electrical conductivity and the amount of chlorine were determined by tests on water samples in the laboratory. Table 1 shows how these indicators were scored. Finally, map of water quality index was prepared by calculating geometric mean of all indices according to the following formula:

Water index: (Electrical conductivity x sodium absorption ratio × the amount of chlorine)

Table 1: Layers of water index assessment, which are effective in desertification in IMDPA Model.

	Desertification class			
Indices	Low and negligible (0-1.5)	Medium (1.6-2.5)	Severe (2.6-3.5)	Highly severe (3.6-4)
Chlorine	<250	250-500	500-1500	>1500
Sodium absorption ratio	<18	18-26	26-32	>32
Electrical conductivity Micromhos per centimeter	<750	750-2250	2250-5000	>5000

(ii) Soil index. Soil samples were analyzed to evaluate this index in the area. Soil profile was excavated in each land unit in the area under study in order to obtain information on soil. Thus, 18 soil samples were collected. Depth of each soil profile was measured to determine in numerical value. In the next step, soil parameters such as electrical conductivity, stone and gravel percentages and soil texture were measured in soil science laboratory. Value of each parameter was calculated separately with respect to land units. Table 2 shows how these parameters were scored. Finally, map of soil quality index was obtained by calculating geometric means of relevant indices according to the following formula: (Soil texture × soil depth × stone and gravel percentages × electrical conductivity) = soil index

Table 2 : Indices for assessment of soil index, which affects desertification severity in IMDPA Model.

	Desertification class			
Indices	Low and negligible (0-1.5)	Medium (1.6-2.5)	Severe (2.6-3.5)	Highly severe (3.6-4)
Soil depth	>80	50-80	20-50	<20
Soil texture	Heavy to very heavy	Medium	Light	Coarse to very coarse
Stone and gravel percentages	<15	15-35	35-65	>65
Electrical conductivity (decisimens per meter)	<4	4-8	8-16	>16

(iii) Vegetation index. The required data was collected in order to assess status of vegetation in the study area. Then, vegetation indices were scored based on collected data. Table 3 shows the indices selected to assess vegetation in the study area. Finally, map of vegetation quality was prepared by calculating relevant indices: (Restoring vegetation × exploitation of vegetation) = vegetation index

Table 3: Indices for assessment of vegetation index, which affects desertification in IMDPA Model.

IMDPA				
Desertification class				
Indices	Low and negligible (0-1.5)	Medium (1.6-2.5	Severe (2.6-3.5	Highly severe (3.6-4)
Vegetation status	Permanent canopy cover% more than 30%	Permanent canopy cover% between 15% and 30%	Permanent canopy cover% between 5% and 15%	Permanent canopy cover% less than 5%
Exploitation of vegetation	moderate grazing or less than seasonal capacity	Surplus livestock up to 25% more than grazing capacity	Surplus livestock between 25% and 50% more than grazing capacity	Surplus livestock up to 50% more than grazing capacity
Restoring vegetation	No modification is required	Vegetation restoration was effective so far	Implemented changes were relatively successful so far	changes and vegetation restoration were not successful so far

RESULTS

The map shows status of water index in the study area (Fig. 2) in which 37.01% of the area was classified as low desertification severity class, which covers northern and southern areas, 62.99% of total area constitutes the central areas, which were not classified since no piezo metric wells and springs were found there. In addition, evaluating geometric and weighted means of quantitative values of water parameters showed that electrical conductivity was the most effective parameter in increasing desertification severity (numerical value = 1.32).

Map of soil index (Fig. 3) shows that 52.64% of this area is located in the medium desertification severity class, which mostly covers southern regions and 47.36% of total area mostly covers northern areas in severe desertification class. The geometric and weighted means of quantitative values of soil parameters showed that percentages of stones and gravels (numerical value = 3.45) is the most effective factor in increasing severity of desertification in the study area. These results are consistent with those obtained by Parvane *et al.* (2008) and Esfandyari and Hakim Zade Ardekani (2010).

Map of status of vegetation (Fig. 4) shows that 14.52% of total area is in low desertification severity class, 73.14% of total area is in desertification severe class and 12.34% of total area is in highly severe desertification class. The geometric and weighted means of quantitative values of vegetation parameters showed that restoration (numerical value = 3.82) was the most effective factor in increasing severity of desertification in the study area. Finally, it is found out that 14.53% (1725.59 ha) of total area is in low or negligible desertification severity class and 33.69% (4001.4 acres) of total area is in medium desertification severity class and 51.78% (6149.42 ha) of total area in severe desertification classes (Fig. 6) with regard to map of potential status of desertification in the study area (Fig. 5).

Table 4 Geometric mean values and desertification class of studied indices.

Index	Numerical value	Class
Water	0.49	1
Soil	1.52	11
Vegetation	3.11	111

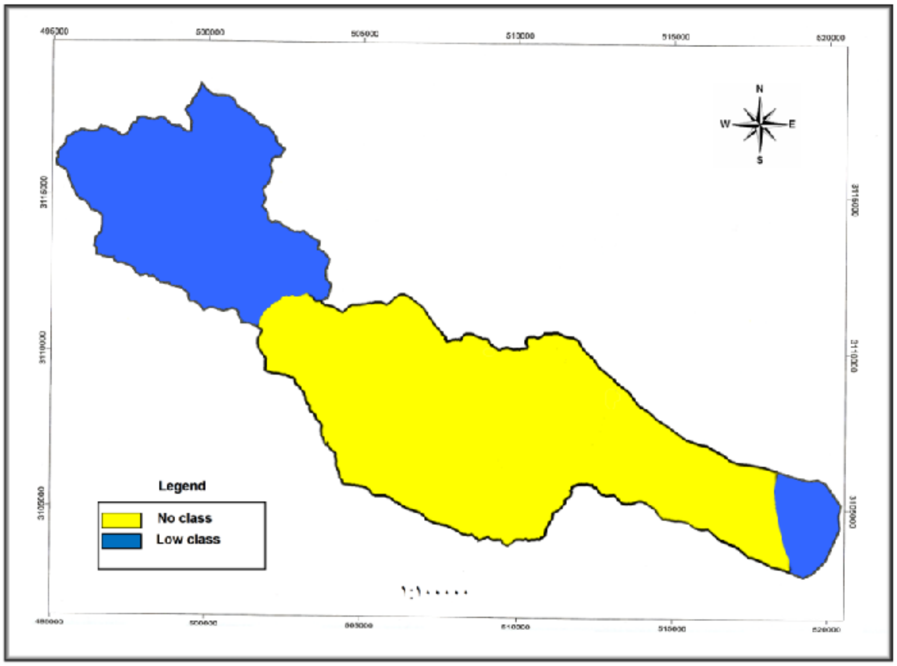

Fig. 2. Map of potential status of desertification with water index in the study area.

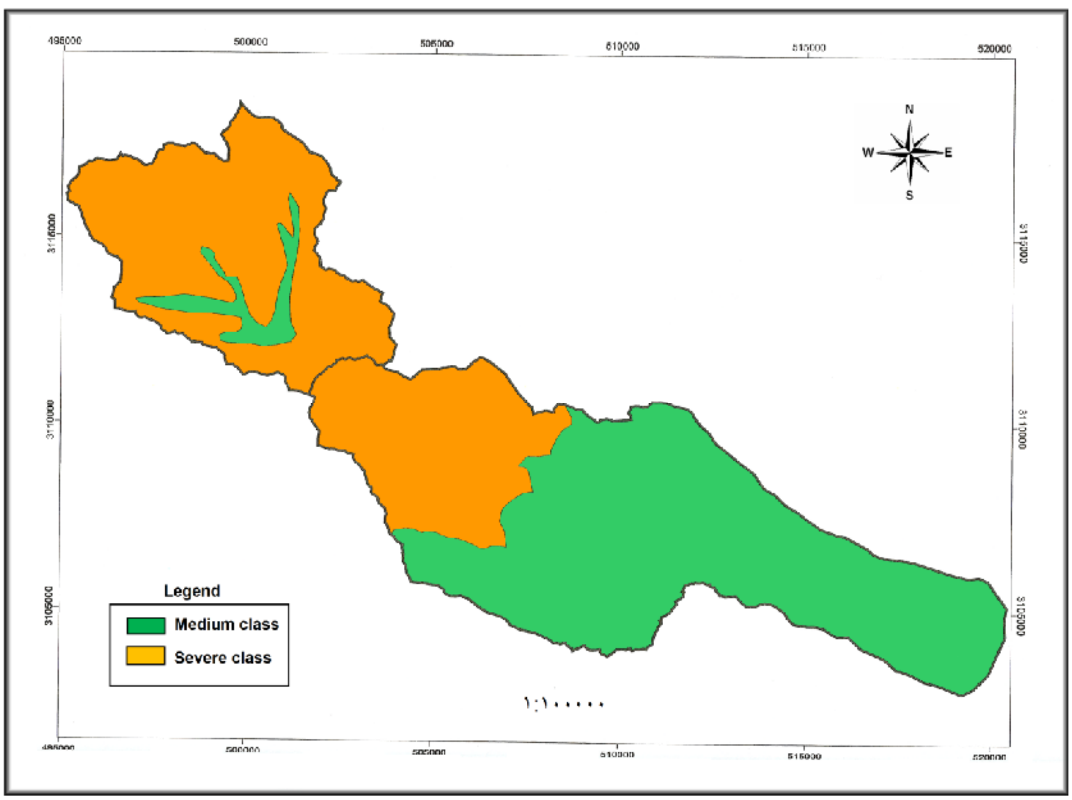

Fig. 3. Map of potential status of desertification with soil index in the study area.

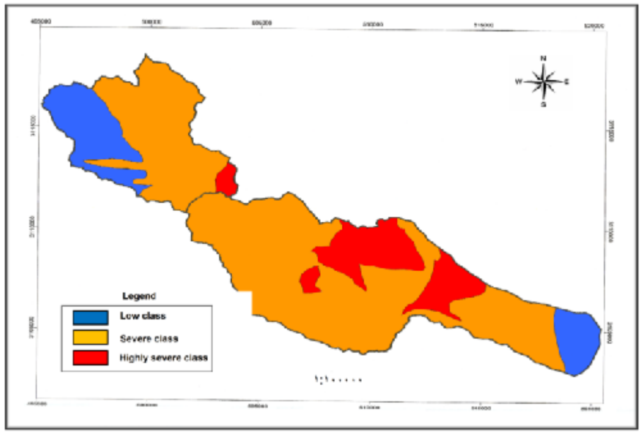

Fig. 4. Map of potential status of desertification with vegetation index in the study area.

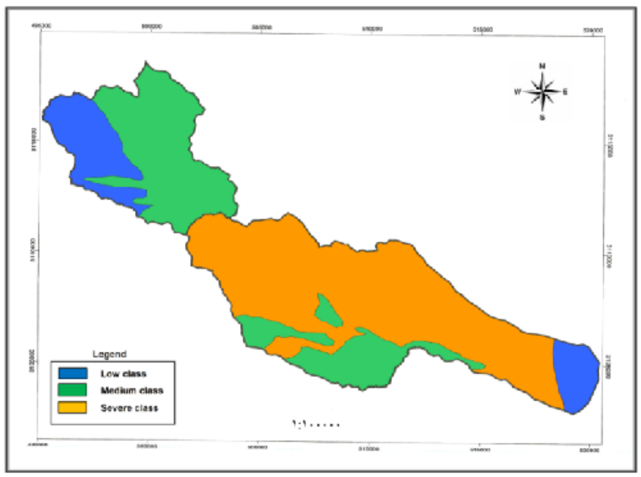

Fig. 5. Map of potential status of desertification with water index in the study area.

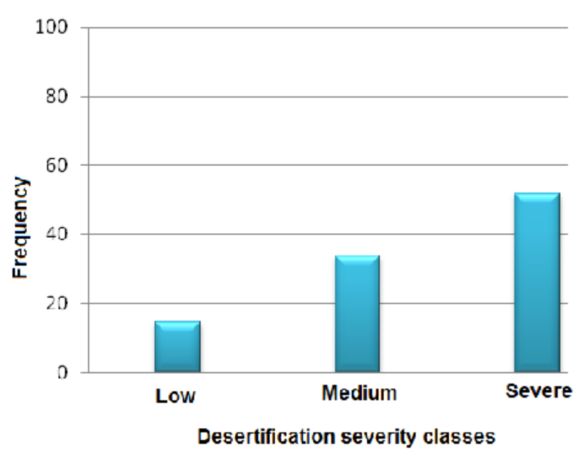

Fig. 6. Chart of frequency of desertification severity classes with water, soil and vegetation indices.

DISCUSSION AND CONCLUSION

According to discussion on water, soil and vegetation indices, index of vegetation restoration was most the effective factor among vegetation indices (numerical value = 3.82), sodium absorption ratio (SAR) (numerical value = 1.59) was the most effective index among water indices in desertification in the study area. In addition, the effective indices in vegetation were rated as follows: vegetation index (numerical value = 3.11) was the first effective index in desertification in severe class, soil index (numerical value = 1.52) was the second effective index in desertification in medium severity class and water index was the third effective index in desertification in low and negligible severity class (Table 4). These results were inconsistent with those obtained by Dolatshahi (2007).

The results also showed that vegetation is effective in desertification. It is recommended that a comprehensive research be performed in order to determine the appropriate method to modify and restore rangeland by Department of Natural Resources as soon as possible. In case this issue was neglected, about 50% (medium and low grade desert regions) will be the subject of intense destruction, which can damage other components of the ecosystem such as wildlife. This study aimed to restore the area to prevent overgrazing by applying intermittent grazing, seeding pasture plants and observing range management practices and not digging plants and not destructing the vegetation by residents for fuel supply.

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