Hazard Assessment of Groundwater Degradation Using IMDPA Model (Case Study: Isfahan Province, Iran)

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Abstract

Today water resources degradation is one of the most important desertification factor in arid and semi-arid regions which is caused by mismanagement and improper practices of human, especially in the agriculture sector. The aim of this study is investigation of groundwater criterion in desertification condition of Jargooye region, Iran and finally preparing groundwater degradation map. At the first, among different existing methods, IMDPA model was selected and the intensity of ground water quality was evaluated on the basis of 4 indices including: groundwater table decrease, Electrical Conductivity (EC), Cl concentration, Sodium Absorption Ratio (SAR). The numerical value of indices was considered as a degradation intensity class of water resources. A score ranging from 1 to 4 is assigned to each index based on weight of each factor. Finally the value number of ground water criterion was obtained as geometric average of scores of single indices according to the formula: Ground water quality: (groundwater table decrease x CL concentration x EC x SAR)1/4. Thematic databases, with a 1:50000 scale resolution, were integrated and elaborated in a GIS based on GIS. Analysis of ground water degradation indices in Jarghooye Sofla region, Isfahan province showed that Electrical Conductivity index with a geometric average of 3.62 classified in very high class of degradation is the most effective factor in water degradation among these four indices. Studying the mean weight of numerical value, it is distinguished that the intensity of water resources degradation for the total area is 1.14 which is classified under low class of degradation.

Keywords- Ground Water; Land Degradation; IMDPA Model; Index, Isfahan Province

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 [12, 16].

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 FAO-UNEP [5, 7 8, 17], GLASOD [4], MEDALUS [3, 5, 8], LADA, IMDPA [1], ICD [2], MICD [2] and etc.

Ground waters depletion because of increased exploitation and salt/fresh waters imbalance has decreased waters quality for different uses. These factors in addition to misuse of resources have increased soil degradation while decreased production and biomass [13, 18].

In this study, extreme use of ground water in arid region and its effect on land degradation has been investigated.

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.

MATERIALS AND METHODS

Some international models of desertification such as FAO-UNEP [8, 10], GLASOD [1, 4], TAXONOMY [4], LADA [1], AOOSD [1], MEDALUS [9,14, 15] as well as national models including ICD (Iranian Classification of Desertification) and MICD(Modified Iranian Classification of Desertification) were reviewed in this research and 9 criteria were chosen based on previous experiences for desertification intensity mapping.

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 [1, 11, 17]:

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

Where:

Index-X: A given criteria

Layer: Index of each criterion

N: number of indices for each criterion

The role of water resources criteria in desertification is given by the following formula:

Quantitative factors index= (Increase of water table × pumping rate × water utilization systems × Negative balance of water × Decrease of water table × Well/Qanat development ratio) 1/6

Qualitative factors index= (CL- × SAR × EC) 1/3

Water criteria= (Quantitative factors index × Qualitative factors index) 1/2

The relevant indices determine the values of other criteria like the mentioned example for water criteria. 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 landuse (Agricultural, rangeland, forest, etc) [1, 17].

Table1. Classification of desertification intensity

Low	Medium	High	Very High
1-1.5	1.6-25	2.6-3.5	3.6-4

CASE STUDY: ISFAHAN PROVINCE (JARGHOOYE SOFLA REGION)

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 water resources degradation in study area was evaluated on the basis of 4 regional indices including: Climate, water resources, water erosion, wind erosion, groundwater, soil, vegetation cover and management. Each criterion includes the following indices: groundwater table decrease, Cl concentration, EC and SAR.

According to the factorial scaling technique, score-ranging form 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.

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 4maps representing the condition of each indices were produced to study the role and effect of each index in desertification. Finally water resources map was generated as geometric average of the mentioned indices showing the desertification condition in 4 classes.

RESULTS

Table2 shows indices used to evaluate recent desertification condition and chosen to study ground water resources in study area.

Table2. Water resourced 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

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 2, 3, 4, and 5 are presented maps of groundwater indices.

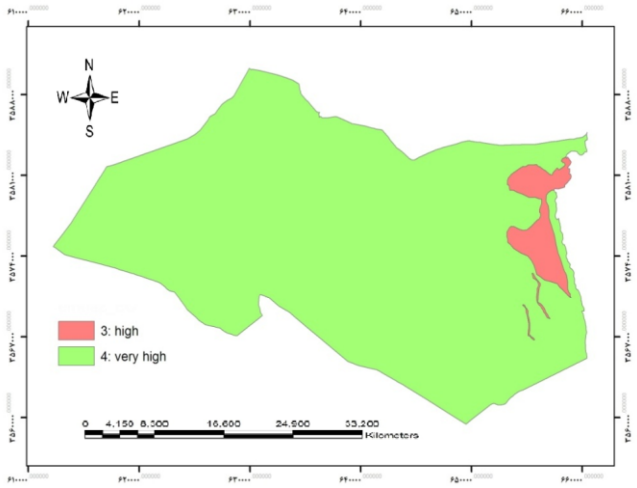

Figure2. Map of EC Index

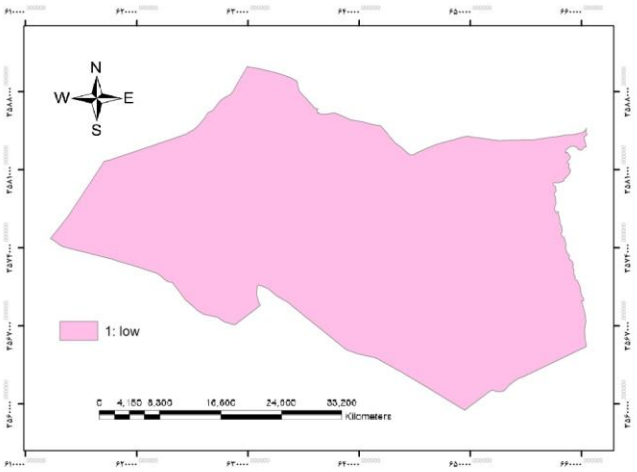

Figure3. Map of SAR Index

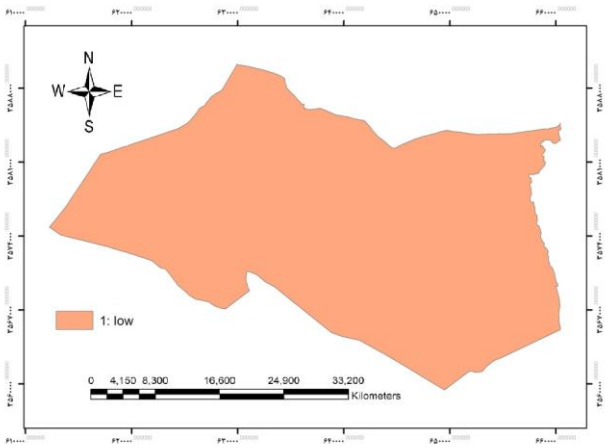

Figure4. Map of Groundwater Table Decrease Index

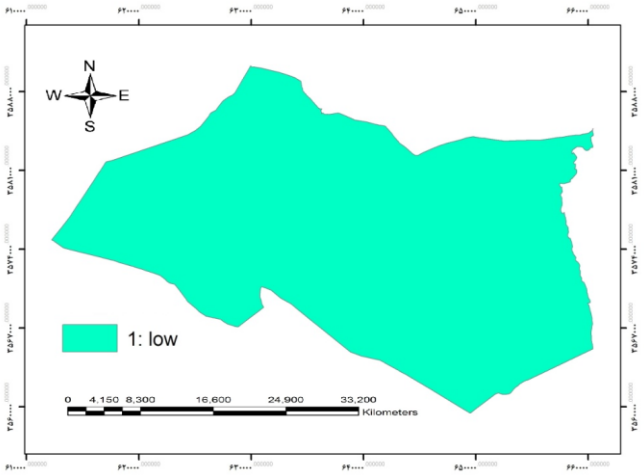

Figure5. Map of Cl Concentration Index

CONCLUSION AND DISCUSSION

After studying mean value of factors involved in water resources deterioration, it's indicated that electrical conductivity index with a geometric average of 1.74 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.

Table3. 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

Fig.6 shows the sensitivity of the study area to desertification according to the mentioned algorithm.

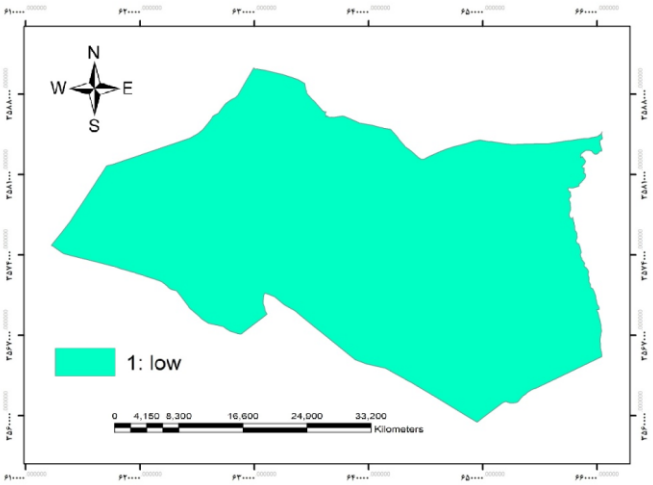

Fig.ure6-Map of Desertification Condition Based on Water Resources Criterion

Studying the mean weight of numerical value, it is distinguished that the intensity of ground water degradation for the total area is 1.14 which is classified under low class of degradation.

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