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Original Article

Assessment of Land Degradation and Desertification with Use of IMDPA Model (Case Study; Chah-hashm Plain, Iran)

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ABSTRACT

Objective: More than 75 percent of Iran is located in arid and semi-arid then land degradation and desertification are one of the crises ecological. We require a proper understanding of causes and processes of desertification to control the huge phenomenon on the global and regional situation. Because southeast of Iran located in arid land then assessment of desertification is very importance for planning of project. **Methods:** In this study, using GIS techniques to assess desertification with IMDPA model in 27.020 Ha of Chah-hashm Plain. **Results:** Result show vegetation criteria (2.97) is more effective than climate criteria (2.68) and other hand aridity index (3.92) is most effective index and continuing drought (1.6) index is less effective index in this area. Result indicated intensity of desertification is in high class with 2.82 numerical value. In this area some limitations such as lack of rainfall, high temperatures, high evaporation, the instability and sensitivity to soil erosion is a natural limits of the area and cannot be control but with improved irrigation methods, education and extension service for the optimization use of agricultural land can be move to improve the situation and to assist in slowing desertification.

1.INTRODUCTION

Land degradation is a global process which ultimately leads to a reduction of soil fertility (Luca Salvati, 2013). In dry areas Land degradation coupled with extreme bio-physical and socio-economic phenomena, may turn into an irreversible process of environmental degradation that is desertification (Montanarella, 2007). In the Mediterranean basin, sensitivity to Land degradation has generally been associated to ecological conditions (e.g. climate aridity, soil characteristics and erosion, slope, vegetation cover) together with specific aspects of drought, human pressure (e.g. population density), and unsustainable land use management (Salvati, 2008; Rahdari, 2014).

Desertification was initially defined as the change of productive lands into desert, caused by human activity, as suggested by Aubreville in 1949 (Herrmann and Hutchinson, 2005); later as the development of barren mobile sand dunes as described by Le Houérou in 1968 for the northern edge of the Sahara (Dregne, 1977); and also as an aggravation or extension of deserts (Hare et al., 1977). The United Nations Environment Program in 1977 defined desertification as "the diminution or destruction of biological potential of land which can lead ultimately to desert-like conditions"; UN member

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countries have ratified the United Nations Convention to Combat Desertification (UNCCD) which provides international guidelines for responding to desertification. According to the definition in this Convention, desertification is "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities" (Dawelbait and Morari, 2012). The process of desertification and land degradation make in arid, semi-arid and sub-humid area due to multiple factors. It is widely recognized that desertification is a serious threat to arid and semiarid environments which cover 40% of the global land surface and are populated by approximately 1 billion humans. Given the potential relevance of this problem, it is surprising that there is no consensus on the proper way to assess the desertification status of a piece of land. During the last 70 years, conflicting definitions have produced both different assessment methodologies and divergent estimates (veron et al., 2006). Desertification is regarded as one of the most serious social–economic–environmental issues in arid, semi-arid and dry sub-humid areas (Sepehr and zucca, 2012).

As a result of the following factors, land degradation and desertification have accelerated in Iran during the recent decades: first, the population has doubled over the last 25 years (since 1979); second, increased agricultural and pastoral products have forced people to use land extensively or convert forest and rangelands to cultivated land; third, overuse of wood and plants as fuel for household cooking and heating, and use of natural regulations tend to denude the soil and intensify the desertification (Aminmansour, 2006; Azareh, 2014). Most of the factors affecting the desertification process in Iran are climatic such as fluctuations, drought, runoff, flood, water erosion and aridity, although mismanagement and land use alternations accelerate the desertification process and intensify the desertification. Finally, several studies have been conducted to assess desertification which many regional models are present. The most important offered models are UNEP-FAO (FAO/UNEP, 1984), TAXONOMY, Environment Sensitive Areas to Desertification (ESAs), MEDALUS (Zehtabian, Gh., et al. 2006), Iranian Classification Desertification (ICD) (Ekhtesasi, M., M. Mohajer, 1995), Modified Iranian Classification Desertification(MICD), Iranian Model of Desertification Potential Assessment (IMDPA) (Ahmadi, 2004). The geographical location of Iran shows that about 80% of the total area is located in an arid or semi-arid zone then assessment of sensitivity to desertification is an importance action in these areas. In this research is do sensitivity to desertification and land degradation in southeast area of iran because this region is very importance for agriculture, industrial and people Living. On the other hand, in this study to determine of land degradation and desertification used from IMDPA model for assessment of desertification base on climate and vegetation criteria.

2. MATERIALS AND METHODS

2.1. Case study

Chahhashm plain is a desert area that located in the Southeast of Iran and in Political subdivisions is in the Sistan and Balochestan province as well as this region is located in 30 km southeast Jazmurian wetland. These basins located between 26°53′ to 27°05′north latitude and 59°2′ to 59°15′ east longitude with 27.020 hectare. Most of the rainfall in autumn and winter, and the long-term average rainfall are 111.2 mm and the average temperature estimate to 29/6 ° C. The average relative humidity was 42% and the mean wind speed is 6.2 knots. In terms of geologically the study area is part of the Makoran region and also follows from the nature of the zone (Aslinejad, 2013).

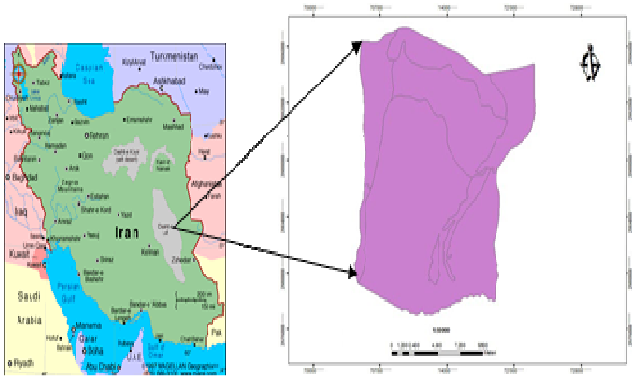

Fig 1. Location map of study area

2.2. Methodology

The first step towards a regional model to assess the current status of desertification in the region is determining of Land Use of area. Then the study area determined on topographic maps, geology map, geomorphology map, and then these area did control with a field visit. The next step we used from IMDPA model to evaluate the extent of desertification during the period. Based on its effect on desertification with regard to region condition, field survey, and expert opinion, a weigh between 1 to 4 was gave to each index; so that value 1 and 4 are the best and worst, respectively (Tab 1). Based on the performed weighing a map was prepared for each index. Then, to determine desertification intensity for each criterion, geometric average of indices of the same criterion and relation (1) were used, and finally based on performed weighing a map was prepared for each criterion.

Index-X= [(Layer-1).(Layer-2)...(Layer-n)]1/n
Relation (1)

Where, Index-X is the related criterion; Layer is the indices of each criterion; and n is number of indices in each criterion. We mapping region about climate criteria (Tab 2) and vegetation criteria then eventually we have analysis about change trend with it in case study.

Tab 1.
Frequency distribution of intensity classes of present desertification conditions

Unconsidered	Low	Medium	High	Very High
0.01-1	1 - 1.50	1.51 - 2.5	2.51 - 3.50	3.51 - 4

Tab 2.
details of climate criteria in IMDPA model

Evaluation indicator	Very high	High	Medium	Low	Unconsidered
Annual Precipitation (mm)	<75	75-150	150-280	280-600	≥600
Aridity Index (P/ET)	<0.05	0.05-0.2	0.2-0.45	0.45-0.65	≥0.65
Continuing Drought (year)	<3	3-4	5-6	6-7	>7

In each of land use after scoring of every indicator with climate and vegetation criteria make one layer for each in Arc Gis9.3 software. Indicators that determine for each criteria classify in four class low, moderate, high and very high in order to assessment of the current situation. Then used from relation (2) and relation (3) for assessment of desertification in this region.

Vegetation criteria= (Coverage Status × Coverage Exploitation ×Recovery of Coverage) $^{1/3}$ Relation (2)

Climate criteria= (Annual Precipitation × Aridity Index × Continuing Drought) $^{1/3}$ Relation (3)

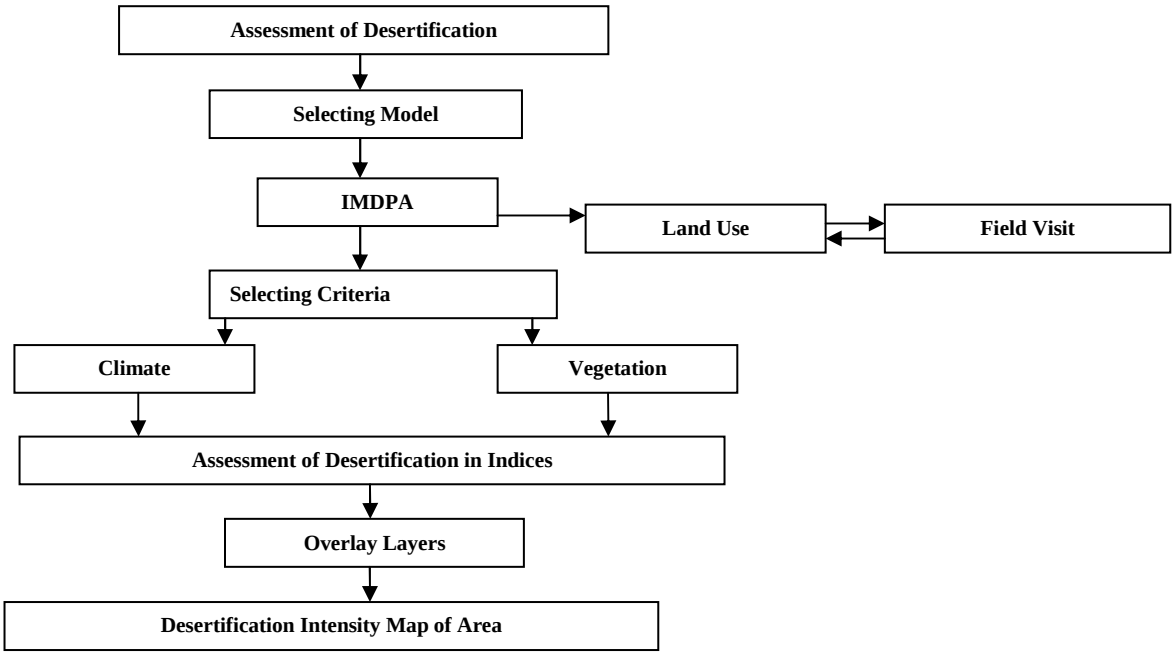

Fig 2. Flowchart of Research

3. RESULTS

Land use map of this area is show in Fig 3 and to the ultimate control of the map is checked with the field visits. Because precipitation and other climate indicators were the same in this region respectively are same the scoring of climate criteria for this region. The analysis conducted on the climate criteria is mentioned in Tab 3. Base on this analysis annual precipitation is in moderate class, aridity index is in very high class and continuing drought is in moderate class. On the other hand, aridity index is the most effective indicator and continuing drought is the least effective in this region.

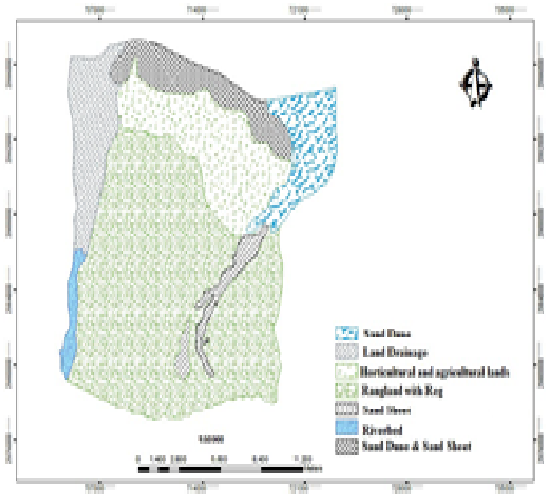

Fig 3. Land Use map of this area

Tab 3.
Scoring of climate criteria

Indicators	The Average Values	Actual Status of Desertification	Class
Annual Precipitation (mm)	3.1	high	III
Aridity Index (P/ET)	3.92	Very high	IV
Continuing Drought (year)	1.6	moderate	II

Climate criteria= $(3.1 \times 3.92 \times 1.6)^{1/3}$= 2.68

Scoring of climate criteria (Fig 4) is making with used of above formula and show that expresses the degree of desertification is in high class. The analysis conducted on the vegetation criteria is mentioned in Tab 4.

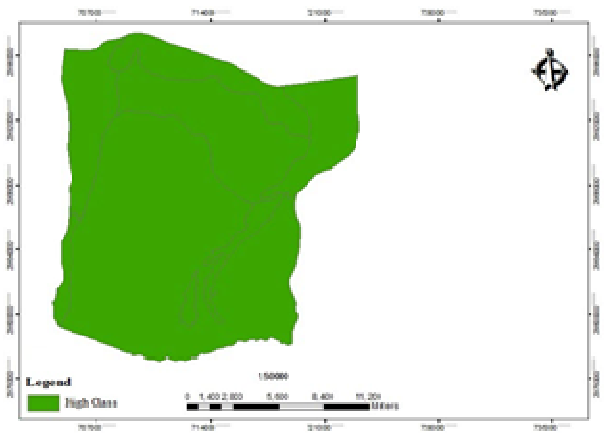

Fig 4. Climate layer in the region

Tab 4.
Scoring of vegetation criteria

Indicators	The Average Values	Actual Status of Desertification	Class
Coverage Status	2.93	high	III
Coverage Exploitation	3.15	high	III
Recovery of Coverage	2.84	high	III

Results about vegetation criteria show that coverage exploitation is the most effective indicator and Recovery of Coverage is the least effective in this region. In Fig 5 show the vegetation layer and all indicators of this are in high class.

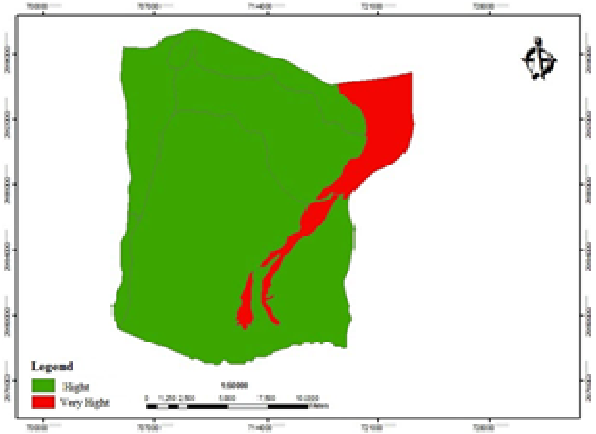

Fig 5. Vegetation layer in the region

Vegetation Criteria= $(2.93 \times 3.15 \times 2.84)^{1/3}$= 2.97

After evaluation of desertification in the each land use for these criteria make final layer (Fig 6) of the desertification potential for this area and show that is located in high class.

DM = $(2.68 \times 2.97)^{1/2}$ = 2.82

Fig 6. Desertification status map of the study area

4. DISCUSSION AND CONCLUSION

Vegetation criteria with 2.97 numerical value are more effective in land degradation and desertification in this region than climate criteria with 2.68 numerical value. Results indicated that the drought index is more effective in land degradation of this area with 3.92 numerical value and continuing drought index with 1.6 numerical value is less effective in this study. Some limitations such as lack of rainfall, high temperatures, high evaporation, the instability and sensitivity to soil erosion is a natural limits of the area and cannot be control. Therefore, the main focus of the activity on the vegetation is very importance in increasing of desertification. In the rangeland since utilization rate of area is a importance factor in desertification and since the fuel needed for domestic consumption in the region is mainly supplied by vegetation then Continuation of current trends could lead to the destruction of vegetation catastrophic, therefore the fuel supply to meet the needs of local people seem necessary. Also, animal control and prevent access by livestock and livestock farmers can help to maintain soil structure and management programs such as the balance between livestock and pasture, close rangeland can be help to vegetation.

In discussing the renewal of vegetation with respect to the corrective actions in the field (mulching, closing, etc.) in the past and has been quite successful in reducing the severity of desertification in the region. In general mechanical operations, reform and recovery to improve the quality and quantity of vegetation including seedling plantation and windbreak built around sand dunes can be useful. Review of native knowledge of local residents in the study area showed that Cultivation of crops and it remains buried beneath the soil as green manure are one of the most common measures for soil conservation in the region. This act also supply organic matter in soil and can activate the biological life in the soil, increase soil fertility, strength and stability of the soil particles. In agriculture, the use of alternative modern culture, improved irrigation methods, education and extension service for the optimization use of agricultural land can be move to improve the situation and to assist in slowing desertification.

The results of this study have a near relationship with Raesi (2013) and in final must be mention that this method must be test in other area that same with this area and for make better result must be do with other criteria in this region. Result show that used of vegetation and climate criteria with use of GIS can be show mapping of desertification with high accuracy.

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