Application of GIS and Remote Sensing in Assessment of Desertification

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Abstract

The increasing trend of natural resources degradation threatens human life dramatically. One kind of land degradation is desertification. It is a problem in global dimension, concerning not only special countries, but also all countries including developing countries and developed countries. Worldwide, one in five people live in affected area, which means that a total of 250 million people in 110 countries are directly affected by the various consequences of desertification processes, and another 750 million are severely threatened. The present study, attempts to assess quantitatively the desertification process in an area of 43000 ha located at Fars Province of Iran (Fidoye-Garmosht plain as a case study) using GIS and RS. In this study, the MEDALUS methodology has been modified and adopted to the study area. In this research, natural factors affecting on desertification were determined. GIS softwares then have been used to analyze data and prepare the required maps. Ultimately, maps have been combined and intensive desertification map has been developed. Results indicated that 86.3% of total study area classified as severe type, 11.2% is classified as high severe and, 2.5% as moderate type of desertification.

Keywords: *Desertification, MEDALUS, GIS, Remote Sensing*

Introduction

"According to the American Society of Photogrammetry remote sensing is the measurement of information of some proportions of an object or phenomena by a recording device, that is not in physical or intimate contact with the object or phenomena (Campo, 2003)." These systems, usually aircrafts or satellites are equipped with sensors that could record the incident radiation from the target or object of interest. Incident radiation is electromagnetic energy that encounters matter. Remote sensing has a lot of applications in various fields. In natural resource management, remote sensing is used for mapping and modeling resources.

Geographic Information Systems (GIS) is a computerized database consisting of data linked together by their geographic location. Proper software and hardware are needed to store and retrieve these data, and to analyze and display (by means of maps and graphs or charts) new information derived from the database. We can we use GIS in natural resource management. Based on these applications, different models can be created to represent the real world. Using the data in a GIS environment, these models may be employed to analyze trends, identify the factors that contribute to these trends, explore alternative solutions to the problems, and they may even show the possible outcomes to the system of the decisions made. For example the MEDALUS model is about identification of areas that are sensitive to desertification process in Mediterranean catchments using GIS and Remote Sensing (RS). According to this method, identify of parameters affecting on desertification process contain of natural factors and demographic factors, and then prepare map for each factors. Ultimately, integrate the prepared maps in GIS environment and create of desertification severity map.

According of United Nations Convention to Combat Desertification (UNCCD, 1992), Desertification is as "*land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities*". Arid, semi-arid and dry sub-humid areas are the territories, other than polar and sub-polar regions, in which the aridity index, that is the ratio of annual precipitation to potential evapotranspiration, falls within the range from 0.05 to 0.65.

Desertification is essentially a result of soil degradation. The direct effect of land degradation is either a decrease of land productivity. Severe soil degradation may ultimately result in complete desertification.

The following year, UNEP estimated that a total of 4.5 billion hectares around the world — 35 percent of the Earth's surface — were at different stages of desertification. Approximately 850 million people, living under the threat of losing their homes and livelihoods, inhabit these areas.
I. R. of Iran is one of countries that are affected by desertification with serious adverse impact. In this paper have been evaluated desertification severity using GIS and RS, according to the MEDALUS (Mediterranean Desertification and Land Use, 1999) methods and modified this model over study area conditions.

Study Area characteristics

The study area, located in the Larestan, Province of Fars, SW Iran (52º 37' - 52º 59' E and 27º 56'- 28º 08' N) (Figure1.1.).
Most precipitation there falls between January and March. The highest mean monthly rainfall is 81.6mm. The mean annual rainfall in a wet year is 300mm and 50mm in a dry year. The temperatures in the study area show an arid and semi-arid seasonal oscillation. There are great thermal differences between summer and winter, and so between years. In this desert environment, the hottest month is July and the coldest January, with a mean monthly maximum and minimum temperature of 46ºC and 4ºC respectively.

Materials and Methods

To aim of evaluated and assessment of desertification process that caused by natural factors and to modify the MEDALUS model for estimating of desertification severe, we have been followed below steps:
1) An area of 43000 ha has been selected in Larestan plain located in Fars Province of Iran as case study where affected by erosion and desertification.

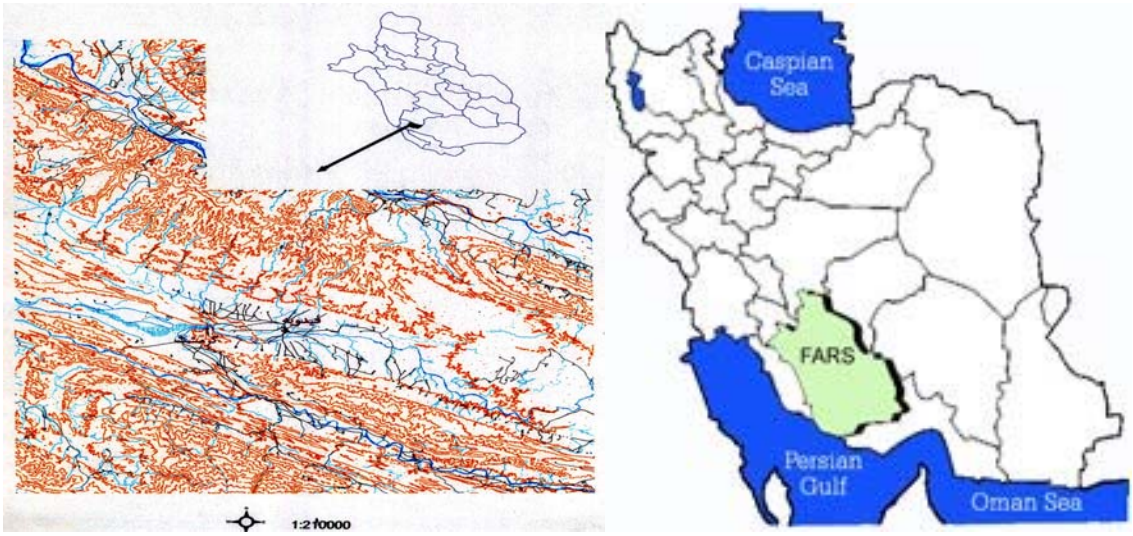

Fig. 1: The position of study area

2) Then, using topographic maps (1: 25000), aerial photographs (1: 55000), especially Landsat satellite images (ETM^+ with color composite of 4-3-2 for evaluation of plant cover and 5-4-3 for evaluation of geology) were identified slope regions, geology map and geomorphology facies.

3) We have been considered geomorphology facies as study unit that identified 27 facies in study area, contain two main unit that called of mountain unit and glacis unit.

4) Information on soil, climate, plant cover, erosion and other factors were collected according of study area. The goals were determination of desertification severity that caused by natural parameters in the study area.
5) Then, were selected of parameters affecting on desertification process (table 1) and have been assessed severe of each factors on desertification according facies and prepared maps (parameters have been considered as one index).

Index (Main Layers)
Climate Index (CI)
Soil Index (SI)
Vegetation Index (VI)
Erosion Index (EI)
Ground water Index (GWI)

Table 1: Selected factors affecting on desertification process in study area

6) We were applied MEDALUS method in the study area and modified it for study region and developed a regional model for assessment of desertification.
7) In this step, we were used GIS software for combination of index maps by Arc GIS (Arc Map) software. Then, geometric mean of five indexes has been was for calculated of Desertification Severity, according to the formula below:

$$\mathbf{DS = (CI * SI * EI * VI * GWI)^{1/5}}$$

Where:
• DS is Desertification Severity
• CI is the Climatic quality Index
• SI is the Soil quality Index
• EI is erosion quality Index
• VI is the Vegetation quality Index
• GWI is the groundwater quality Index
Then, were prepared desertification severe map (figure 1).

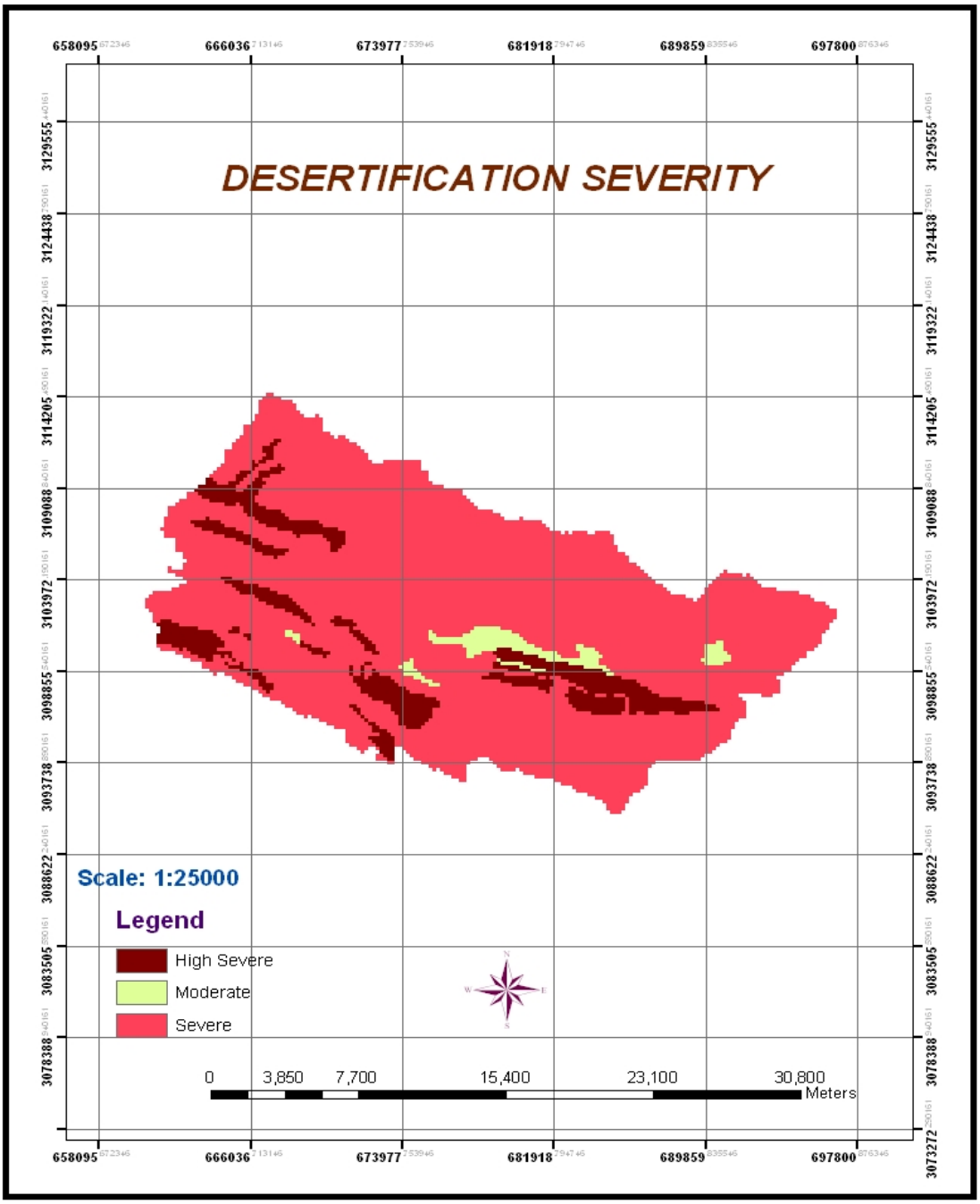

Fig. 1: Map of desertification severity in Fydoye-Garmosht basin, Fars Province, Iran.

10) According to this model, severe of desertification process has been classified in 4 classes involved high severe, severe, moderate and low class (table 3).

Type	Desertification Severe Classes			
Qualitative	High Severe	Severe	Moderate	Low severe
Quantitative	1.54 - 2	1.38 – 1.53	1.23 – 1.37	1 - 1.22

Table 3: Desertification Severity Classes

Results and Discussions

According to the developed model, 27 geomorphological facies were identified in the study area, and severe of desertification fitted within the study unit.

The results from this assessment indicated that study area (43093 ha) has desertification severity, as well as, 86.3% has severe desertification process, 11.2% has high severe and 2.5% is in moderate severe class. Also study area has not low severe class.

This model may be used to determine desertification process and can be useful to distinguish sensitive areas to desertification in the study region. It also may be generalized to other area with the same characteristics.

In short, GIS offers its users a more efficient way of performing tasks because less time is spent on each task. GIS benefits from being able to manage and analyze spatial data in digital form and being able to effectively communicate information visually, just as a paper map could. People are more inclined to understand pictures (maps and graphs) better than just plain text.

The advantage of using remote sensing is that information from the same area could be easily obtained at different times. This is important in change detection applications. Since remote sensing systems can cover a large area (depending on the sensor), the users are provided with an overall picture of the area-of-interest. Although satellite images are quite expensive, in the future it might prove to be more economical as compared to tradition techniques of data gathering over a large area such as ground survey and aerial photography.

It can be observed that RS and GIS applications in natural resources management go hand in hand. To maximize the information that can be derived from RS, additional information is needed, and can be provided by GIS. On the other hand, remote sensing can provide data at different times and scales appropriate for different GIS applications.

The applied method provides a satisfactory approach for the identification of prone areas, which need to be considered in the National Action Programme.

It should be noted that the final prepared map was based on the available data. It shows an overall picture of the study area, but there is scope for minor improvements whenever more recent data is available. Also, we just considered natural parameters affecting on desertification process. Therefore, the final map shows desertification severe according to the natural factors. Wherever, desertification cause by climate change and human activities, the potential of desertification severity is the sum of natural factors and demographic problems. Considering the above results, although in Moderate class the risk of desertification is low but the management in these lands is very necessary and important, because these lands are generally denoted to the rangeland and also agricultural activities and may be affected by mismanagement.

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