The Reapplication of MEDALUS Methodology in Kashan Desertified Region, Iran

Gholam Reza Zehtabian[1], Farshad Amiraslani[2], H. Khosravi[3]

1- Professor of Faculty of Natural Resources, University of Tehran, Iran, ghzehtab@ut.ac.ir
2-Reseracher of International Research Center for Living with Desert, University of Tehran
3- Former Graduated student of Natural Resources Faculty, University of Tehran

Resume

Desertification process as a great problem affects most of the countries in the world. This process has a high rate in arid and semi-arid countries such as Iran. The main objective of this research was to investigate land degradation status and desertification mapping of Kashan area. Different studies have been carried out in the world in order to assess desertification resulted in production of different regional models for their application in another region the indices should be re-investigated and adjusted to local conditions. So in this study, the newest method for assessment and mapping of desertification was used. The method was carried out by European Commission (EC) at the MEDALUS project and booked as ESAs in 1999. All indices of the model were revised before using, and regarding to the region condition these indices for land degradation were defined as key indices which were: hydrological index, wind erosion and climate index, human index and each index has some layers getting from their geometric mean. Method were parameterized and tested for Kashan area (91383 ha) with dry climate. Thematic databases were integrated and elaborated by using a GIS and its spatial modeling function. Finally by means of all the above mentioned information land degradation mapping was provided. The area was presented as a present situation map of desertification on area. Among the total studying area about 29867 ha is, under average class, 3600 ha is high class and 24021 ha is under very high class desertification.

KEY WORDS: Iran, Kashan, Desertification, Environmental Sensitive Area, MEDALUS

Introduction

Nowadays, desertification as a serious challenge, affects most of the countries and occurs in different climatic conditions. In many regions of the world, especially in arid ones, studies have been done to assess the land degradation rate, degradation status and mapping. In this regard, many studies have been done to introduce land degradation assessment methods e.g. FAO-UNEP, Turkministan model, GLASOD, MEDALUS, LADA, etc. The researchers believe that applicable key benchmarks are necessary to evaluate desertification process. It seems that MEDALUS model introduced by European Commission (EC) in 1999 has apparent advantages compared to the other ones. Due to the lack of comprehensive model for assessing desertification in Iran, MEDALUS model or ESAs, can be applied to evaluate desertification condition in Iran.

2-Materials and Methods

2-1- Desertification mapping based on MEDALUS model

In this stage, four benchmarks were considered for desertification mapping and each includes some indicators have a weighted value in desertification. Finally, desertification map of the region was prepared using individual benchmark and geometric mean as follows:

2-1-1- Soil benchmark role in desertification process is related to the available water and soil erodibility. The soil properties such as texture, etc. can be defined as soil indicators.
2-1-2- Vegetation benchmark is assessed based on the type and coverage percentage of vegetation, fire hazard, revegetation capability and resistance to erosion and drought. Vegetation Quality Indicator (VQI) is measured by a geometric mean of the mentioned vegetation features related to their sensitivity to desertification using the following algorithm:
Vegetation cover quality = (Fire hazard × soil conservation × drought resistance × coverage percentage of vegetation)$^{1/4}$
2-1-3- Climate benchmark is assessed based on factors affecting water availability for plants such as aridity, air temperature and precipitation.
- Annual precipitation indicator is categorized into three classes.
- Aridity index is measured by Goessen-Bagnolous index and classified into six classes.
- Aspect index is classified in two classes.

Finally, climate quality indicator is measured through merging mentioned factors and using the following formula and previous data.
Climate index = (Precipitation × aridity × aspect)$^{1/3}$
2-1-4- Management or human stress indicator

Based on land use types, the following groups are determined in the study areas:
1- Agricultural lands including croplands and range lands, 2- Natural resources including forests, shrub lands and bare land, 3- Mines, 4- Recreation sites including parks, tourism attractors, etc.
5- Infrastructure facilities such as roads, dams, etc.

Then, land use intensity and executive policies related to the environmental conservation are evaluated. *Executive policies* are classified based on measures implemented for conservation of environment. The related data are gathered the extent of implementation is assessed. In this case, three classes are defined. Management quality indicator is also measured using mean of land use intensity and implementation of policies.
Management = (Type and intensity of land use × policy implementation)$^{1/2}$

Synthesis of data

Final stage of the research was to synthesis the physical qualities of environment (soil, climate and vegetation cover qualities) as well as Management Quality Indicator to determine different levels of susceptibility to desertification using the following algorithm:
Desertification map = (Soil benchmark × climate benchmark × vegetation benchmark × management benchmark)$^{1/4}$
The range of ESAI for each ESAs includes three sub-classes and the range of each ESAs type is between 2 (high) and 1 (low). The map symbol of each ESAs type shows its class and sub-classes. Also, four abbreviations related to landuse quality (S for Soil, C for Climate, V for vegetation cover and M for management) and four numbers indicating the level of limitation in each quality were considered to determine susceptible areas to desertification. For example, formula of figure 2 illustrates that the study area has low level of susceptibility to desertification

(F_1). In this regard, climate limitation is medium (C_2), soil limitation is low (S), vegetation cover is medium (V_2) and finally management limitation is low (M_1).

2-2-The data used for desertification mapping (case study: Kashan region)

For this purpose, benchmarks and indicators of the original model were calibrated based on conditions and so, seven benchmark including ground waters, vegetation cover, soil, climate, water erosion, wind erosion and management were considered as key factors on desertification.

1- Ground water resources degradation benchmark consists of some indicators as groundwater tables, Cl^-, EC, groundwater table depletion, water crisis etc.
2- Water erosion benchmark including indicators as damages caused by flooding etc.
3- Wind erosion benchmark includes some indicators such as stormy days etc.
4- Vegetation benchmark: these are some indicators such as the amount of production etc.
5- Soil quality benchmark including indicators as SAR, EC, type of geologic formations etc.
6- Climate benchmark including indicators as Transo aridity index etc.
7- Management benchmark includes indicators as executive management and policy etc.

To obtain mentioned benchmarks, several comprehensive studies on hydrology, landuse, soil, geomorphology, erosion and vegetation cover of the region were conducted. Each of that parameters were studied individually. Then, a value was assigned to each layer based on its effect on desertification as 1 and 2. The 1 indicates the best while 2 the worst value.

Some landuses such as pools and residential areas were assigned value "Zero". Consequently, a map was prepared based on the given values. Each benchmark is measured using the following formula for their indicators: $\text{Index-X}=[(\text{Layer-1}).(\text{Layer-2})\ldots(\text{Layer-n})]^{1/n}$

Where:
Index-α= The given benchmark
Layer= Indicator of each benchmark
n: Number of indicators for each benchmark.

Therefore, seven maps were obtained showing the status of benchmark. These maps can be used for studying the quality and effect of each indicator on desertification. The final map showing desertification condition of the region was prepared using geometric mean of all indicators.

3- Results

Analysis of desertification indicators in calibrated MEDALUS used for Kashan showed that water resources degradation is the main factor with value of 1.74 as very severe factor and climate having value of 1.55 is in the second order.

The results for other benchmarks are shown in Table 1. The conducted research showed that precipitation, water deficiency index and groundwater depletion having values 1.85, 1.83 and 1.79, respectively have the lowest effect on desertification. The researches showed that in all Kashan area, desertification is occurred in different levels as shown in Table 2.

Table 1: Mean weight of quantitative value

Row	Benchmark	Quantitative value	Desertification class
1	Degradation of water resources	1.74	Very severe
2	Climate	1.557	Very severe
3	Management	1.409	Severe

4	Vegetation	1.369	Severe
5	Wind erosion	1.33	Severe
6	Soil	1.247	Moderate
7	Water erosion	1.097	low

Table 2: Frequency of desertification status classes

Qualitative classification	sign	Value rate	area	Studied area Total area (%)
Water pools & urban sites	U	0	8.91	0.97
Low	I	1-1.22	0	0
moderate	I I	1.23-1.32	298.67	32.68
Severe	I I I	1.33-1.41	366.04	40.07
Very severe	I V	1.42-2	240.21	26.28

4- Discussion and Conclusions

Based on the results of current research, calibrated MEDALUS model has high efficiency for desertification mapping in Kashan. This method has been used in other European and Middle Eastern countries and showed positive results.

The important issue for using MEDALUS model, declared by European Commission staff, is to adjust its benchmarks and indicators for desertification assessment based on the regional condition.

The method of value giving to each layer, using GIS as well as geometric mean instead of arithmetic as one are same of advantages of the model. Since different factors and their interaction play major role in desertification, it is necessary to consider all effective ones. The preliminary results of conducted research showed that both environmental and human factors affect desertification in Iran which leads to degradation land, water and vegetation resources. In Kashan, environmental and human factors all together causes desertification and degradation of resources.

The case study in Kashan also showed that water resources degradation has the highest effect on desertification while climate benchmark stands in the second order.

Meanwhile, it is necessary to conduct numerous regional researches in different climates of Iran to calibrate benchmarks and indicators and obtain more accurate results. One of the problems of presented models is lack of ability to measure all effective indicators due to the extent of lands, expenditures, lack of data, etc.

In the current research, 45 indicators were considered but it is important to continuously update the data in order to obtain actual results on intensity and trend of desertification and introduce the most effective combating desertification measures.

References

1- European Commission, 1999. Mediterranean Desertification and Land Use. (MEDALUS). MEDALUS Office. London.

2- Khosravi, Hassan, 2004. Application of MEDALUS model for desertification study in Kashan, MSc. Thesis, Tehran University.

3- 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.

4- Rafiei Emam, Amar, 2003. Desertification studies in Varamin plain with emphasis on soil and water problems, MSc. Thesis, Tehran University.

5- Rafiei Emam, Amar, Zehtabian Gh., 2005. The method of map preparation for susceptible regions to desertification, Forest & Rangeland Journal. No. 66: 6-13.
6- Zehtabian, Gh., Rafiei Emam, Amar, 2003. "ESAs", a new method for evaluation and preparation of susceptible regions to desertification, Biaban, Vol. 8, No. 1; 120-126.