Available online at www.elixirpublishers.com (Elixir International Journal)

Pollution

Elixir Pollution 46 (2012) 8067-8071

ISSN: 2229-712X

Assessment of desertification using MEDALUS model, with emphasis on wind and water indices: "case study Sistan province, Iran"

L. Fozooni[1], A. Fakhiri[2], M.R. Ekhtesasi[2], Y. Kazemi[3], H.Mohammadi[4] and H. Shafey[5]

[1]M.Sc. of desertification, Tabiaate Sarsabz Zagros Company.

[2]Natural Resources Faculty, University of Zabol, Iran.

[3]M.Sc. of Watershed Management, Natural Resources Faculty, University of Tehran, Iran.

[4]M.Sc. of range management, Tabiaate Sarsabz Zagros Company.

[5]M.Sc. of desertification, Natural Resources Faculty, University of Zabol, Iran.

ARTICLE INFO

Article history:

Received: 5 March 2012;

Received in revised form:

15 April 2012;

Accepted: 27 April 2012;

Keywords

Desertification,

MEDALUS,

GIS,

Wind erosion,

Water erosion.

ABSTRACT

Desertification is a phenomenon that happens in arid, semi arid and sub-humid areas. Iran is an arid and semi arid country and has two deserts: Lut desert and Kavir plain. Sistan plain is a part of Lut desert and has a very dry territory which impress by driest situation. In Sistan plain, desertification is considered as the main cause of soil lose and biomass decreasing and cause to a fragile environment. The MEDALUS[1] model is one of the most important projects that were provided by European commission for desertification assessment. One of the advantages of this model is its high precision. More over particular weighing of layers and usage of geographic information system (GIS) in overlying of indices maps are the other superiorities of this model that increase subtlety and speed of evaluation and preparation of desertification map as well as reducing expert's mistakes. In this research, the MEDALUS methodology was used to assess desertification rate in GHORGHORI region of Sistan plain. In first step, main indices and parameters in desertification process identified. Then, two main indices according to local conditions were selected: wind and water erosions. In second step, considering the main indicators in wind and water erosions, every indicator was quantified according to its quality and was given a weighting based on MEDALUS methodology. In next step, the quality maps of wind and water erosions were prepared using geometric mean of indicators using ArcGIS software. Ultimately, the final desertification map was developed by integration of wind and water erosion quality maps using GIS. Results shows that wind erosion index with average value of 2.84 and water erosion index with average of 1.86 take the high and medium class of desertification. Among main indicators of indices, land use with average of 3.25, percent of plant crown cover with 3.16, dusty days indicator with 2.98 and wind erosion intensity with 2.93 have the highest effects. Water erosion intensity with average of 1.01 has the lowest effect on desertification process. Desertification intensity for studied area was 2.3 that show the critical class (C_3).

Introduction

The United Nations Environmental Program (UNEP) estimated that 69% of the world's dry lands, excluding the hyper-arid deserts, were already moderately to severely degraded (Dregne1991). The definition of desertification has had a progressive evolution over time since it was first used by Aubreville (1949). UNEP continuously rewrote the concept of desertification over the past 20 years. In the early 1990s it was defined as land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNEP1992). Desertification sensitivity can be defined, in this context, as the response of the environment, or part of it, to a change in one or more external factors. Desertification is nothing new in IRAN. It is a natural process in most parts of this wide country. Dry land ecosystems cover more than 85% of country, of which desertified and desert lands account for 34 million ha (FRW 2004). Different models for evaluating of desertification process such as mathematical models, parametric equations, remote sensing, direct observation and measurement have been developed. Recently, several models of desertification and land degradation have been presented.

The aim of this study was assessment of desertification by modifying MEDALUS model in Sistan province.

MEDALUS model (Kosmas et al.1999) identifies regions which are environmentally sensitive area (ESAs). In this model, different types of ESAs to desertification can be analyzed in terms of various parameters such as landforms, soil, geology, vegetation, climate, and human activities. Each of these parameters is grouped into various uniform classes and a weighting factor is assigned to each class. After that, four layers evaluated: soil quality, climate quality, vegetation quality, and management quality. After determining indices for each layer, the ESAs to desertification are defined by combining the four quality layers. All of the data defining the four main layers are introduced in a regional Geographical Information System (GIS), and overlaid in accordance with developed algorithm

Tele:

E-mail addresses: youneskazemi1362@gmail.com

which takes the geometric mean to compile maps of ESAs to desertification.

According to local conditions two main indices were selected: wind and water erosions. A quantitative classification scheme with values ranging from 1 to 2 has been applied throughout the model for individual indices as well as the final classification of Desertification Sensitive Areas (DSAs). The value 1 was assigned to areas of least sensitivity, and the value 2 was assigned to areas with the most, Values between 1 and 2 reflect relative vulnerability. For more accuracy, it was taken into values ranging from 1 to 4. This values range classified and used according to Iranian Model Desertification Potential Assessment (IMDPA).

The first world map of desertification with scale of 1:25000000 are prepared for united nations conference in 1977, which is a picture of desert conditions. descriptive condition at the top, just rely on existing geographical information, but for better understanding of the problem, more detailed information of affected regions of developing deserts in world scale is needed. (Abrisham, 2004).

Sepehr (2007), evaluated the desertification in Fiduye field in Garmdasht, by emphasizing in Medalus model. In this study, at first, main and subordinate factors which were affective in creating desert of Fiduye region in Fars province, were considered which included soil, climate, erosion, vegetation cover, groundwater, management condition and degree of human destructive activities and each criteria was scored from some effective indices in its quality by MEDALUS model, and final map was obtained from geometrical mean of related criterion (Sepehr, 2007).

Wang et al. (2007) assessed the discrepancies of seven indices for 50 years. Results indicated that both human and environmental factors have an important role in desertification. (Nikeghbal, 2005).

Ladisa et al. (2002) considered six indices for assessing desertification in Bari region, Italy. The six indices include soil, climate, vegetation, land use, management, and the human pressure indices. Finally, by geometric mean the desertification map was obtained (Yuassogoalu, 1995).

Jiardao et al. (2002) used MEDALUS model to evaluate desertification in Sisil region of Italy. After modification and rebuilding of model, four indices were selected includes soil, climate, vegetation cover and land management. The results indicated that in more than 50% of the land surface, desertification is high to moderate (Yuassogoalu, 1995).

Farajzadeh (2007), evaluated the wind map of desertification hazard of Izadkhast by MEDALUS model and relied on climate index. In this research, map of creating desert hazard was drawn (Farajzadeh, 2007).

Karimi (2006), evaluated the creating desert situation of aquiferous pond of Hazarabad Yazd by using MEDALUS model and by relaying on water and wind erosion. She considered some indices according to region situation in order to draw creating desert map, include: Water erosion index, kind and compression of water erosion, drainage compression matrix, dominant kind of application of lands, percent of crown of vegetation cover in growing season.

Indices of wind erosion criteria include: emerge of erosion countenance, percent of litter on soil surface with vegetation cover percent, number of Stormy Days Index (DSI) (Karimi, 2006).

Ghasemi (2006), evaluated the creation of desert in Zabol region by using MEDALUS model and relied on water and soil (Ghasemi, 2006).

Azadnia (2006), evaluated water and wind criteria of desertification in Ein Khosh Dehloran region (abughuyr field) by using MEDALUS model (Azadnia, 2006).

Materials and Methods

Study Area

The study area, (Ghorghori-Sistan plain) with 281.7 km^2 area, is located in the Zabol, East of Iran (55 3052 - 55 43 30E and 31 22 30 - 31 12N), has a mean slop of 0.45(m/km).

It comprises one geomorphologic main unit: a plain unit with 14 facieses (Table. 5). Mean annual rainfall is 59.6 mm, mean annual evaporation is 4000 (mm), mean of land height is 450 (m), and mean temperature is 22°c. Blowing seasonal winds from the end of May with average rate of 30 (km/h) for 120 days.

Method

After evaluation of Food and Agriculture Organization of the United Nations Environmental Programme (FAO-UNEP), Modified Iranian Classification of Desertification (MICD), Iranian Classification of Desertification (ICD), MDALUS and quantitative models and evaluating with MEDALUS model, which is more accurate than other models (according to studies of researches who compared this model with other models), and according to using geometrical mean in combining indices and weighting, criteria and indices of evaluating error will decrease.

MEDALUS method has some advantages such as calculating of geometric mean, collecting of data and information easily, using RS & GIS, defining of value and weight for any index.

This model was selected to evaluate and draw the map of present situation of creating desert in Sistan land (with emphasis on wind and water criteria).

Following stages for evaluating of creating desert situation was done in MEDALUS model:

1) Collecting necessary basic maps: geology information, topography and morphology, (by using satellite TM 2002, and inspection of earth).

All applicable maps with satellite pictures and software ARCGIS9, ARC VIEW3.2, Ilwis academic3.1 were prepared.

In field operation, at first stage, border displacement and corresponding with region situation, was done.

As vegetation cover has an effective role in soil protection across erosive factors, percent of vegetation index was involved in both water and wind criteria. To determine percent of surface cobblestone in work unites, in the land, transect method was used.

2) Determining dominant criteria of creating desert in studied region: after evaluation and study, appropriate criteria and indices with region situation were considered.

According to MIDPA model, Indices which considered for each of main criteria of water and wind erosion were:

Water erosion criteria index: kind and compression of water erosion, drainage matrix, dominant kind of using lands, percent of vegetation crown in growing season.

Wind erosion criteria index: presence of wind erosion faces, erosion intensity, percent of vegetation cover, number of dusty days.

3) Scoring indices of each studied criteria in work units (geomorphology faces, Table 1) and finally preparing creating desert situation maps according to criteria:

According to the effect of each of these indices on desertification, a weight of 1 to 4 designate to them based on modified MEDALUS model (Tables 2&3).

Weight 1, expressed the least effect on creating desert and weight 4 showed the most effect on creating desert.

Thus, by using geometrical mean of related weight on these indices, we can obtain the quantity map of each criteria and finally we can obtain final map that shows sensitive region in desertification in that area, which is obtained of geometrical mean of weight of evaluated criteria (water and wind erosion) and categorized according to final categorization in 4 classes of desertification.

Presented final categorization in Iranian model, was shown in Table 4 (fig. 1).

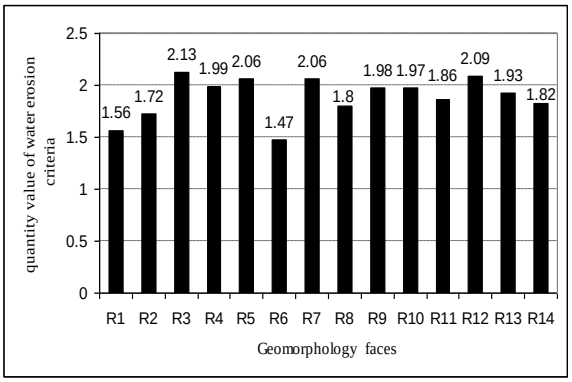

Fig.1: analysis and dissolving water erosion criteria in the geomorphology faces

Results

Results of this research by separating main criteria and evaluated indices were as follow:

1) Evaluation and analysis of criteria in work units.

A) Water erosion criterion

This criterion in studied region was effective in desertification. The most scores were related to the northern and southern regions, which included Coered and Appendage pediments.

Small compression of drainage and worthless of water erosion rate in the region, affect the dominant land uses and the percent of litter coverage and total water erosion.

Javadi (2004) argued that the main factors of land degradation in Mahan are water erosion, deterioration of water resources and wind erosion.

B) Wind erosion

The resulted map of evaluating wind erosion criteria included four class of desertification (low, moderate, high and very high). Units which are located in very high situation, are in north and south region of study area /and a part of covered pediment and clay plain.

Topography situation (with low height), lack of vegetation cover, blowing 120 days winds of Sistan and inappropriate tissue and soil structure are effective in increasing of the rate of this criteria.

Khosravi (2004) believed that wind erosion and degradation of water resources are the major factors of desertification in Kashan plain. Although Gerivani (2009) stated that wind erosion has minimum contribution to desertification of Northern Khorasan.

Farajzadeh (2007) investigated the reasons of desertification in Izadkhast region and concluded that climate, water erosion, mismanagement and destruction of vegetation cover are the reasons.

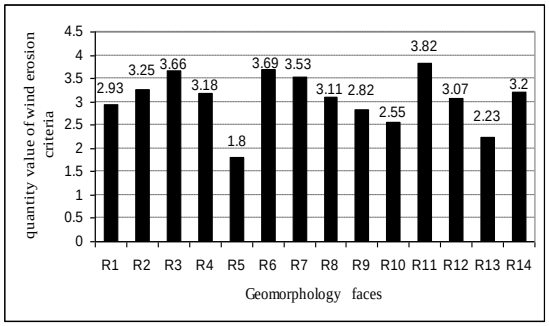

Fig. 2: Analysis and dissolving wind erosion criteria in the geomorphology faces

According to mentioned subject and fig. 2, it will be designated that in all work units, wind erosion has a more destructive effects than water erosion criteria that can relate it to region morphology and bare lands and 120 days winds blowing and dominating wind erosion in this region.

Hemati (2001) used FAO-UNEP model to determine the factors of desertification. He found that devastating vegetation cover following with water and wind erosion are the primary elements. Through investigating the factors of desertification in Khezrabad yazd, Karimi (2006) released that water erosion has the least and wind erosion has the biggest contribution to desertification. Fig.3 show the evaluation and categorization of present situation of creating desert in ESA model in Ghorghori region of Zabol.

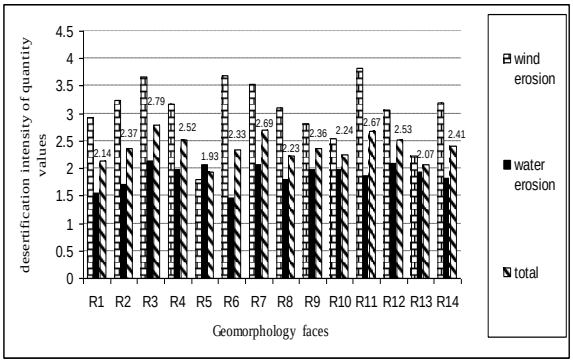

Fig. 3: Analysis and dissolving desertification intensity in the geomorphology faces

Indices of desertification

Implemented evaluation on mean weight of quantity values of creating desert factors of studied region, had shown that in Ghorghori region of Sistan land, index of dusty days by value of 3.42 is dominant and index of Land use with quantity value of 3.25 and index of percent of covered crown in growing season with quantity value of 3.16 are in high class of desertification and indices of water erosion rate and drainage compression by numbers of 1.02 and 1.18 are located in low class of desertification. Karimi (2006) believed that indices of DSI, canopy percentage in growth season and primary land use were classified as high and very high while water erosion and drainage network density were classified as low severity class.

Abrisham (2004) also assessed the desertification condition in Mehriz and introduced DSI as major parameter of desertification. Ghasemi (2006) represented land use index as main factor of desertification in Sistan plain.

Fig. 4 show the quantity values of evaluated indices in Ghorghori region of Zabol in modified MEDALUS model. Fig. 5 Show the potential situation of desertification and emphasized on two criteria of water and wind erosion in modified MEDALUS model and in Ghorghori region of Zabol.

Discussion and conclusion

Natural environment condition of Iran and its geographical location which located in the arid belt of the world in one hand, and overuse of non renewable resources in the other hand, cause to series of problems and conditions that brings the country into a rapid deterioration. So, mapping of desertification condition is an important and necessary matter. In this study, a modify MEDALUS method was used for mapping of desertification condition. Results showed that dusty days index, land use, and percent of covered crown in growing season were the most important indicators for describing desertification process in the study area, similar to results of Karimi(2006) and Abrisham(2004) studies.

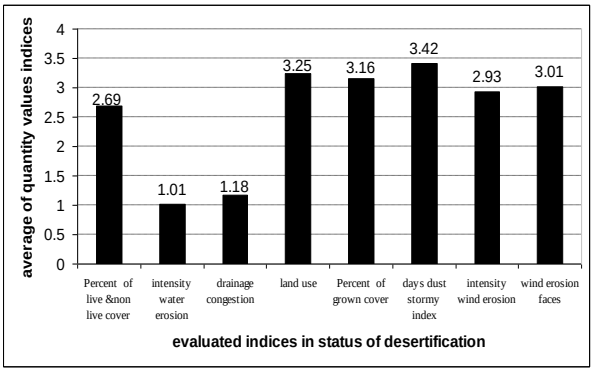

Fig.4: values of evaluated indices in Ghorghori region of Zabol in modified MEDALUS model.

Based on the desertification map, about 22.37% of study area was located in the very high class and 76.21% was located in high class of desertification that Ghasemi(2006) also was observed this result with study water and land use indicators in this area. According to the results of this investigation and comparing them with the condition which have been observed in the study area, the MEDALUS method is determined as the best method for evaluation of desertification condition in the dry and hyper dry land. sepehr(2007), Ladisa et al(2002), Jiardao et al(2002), Ghasmei(2006) and Nikeghbal(2005) were observed the same results in other area.

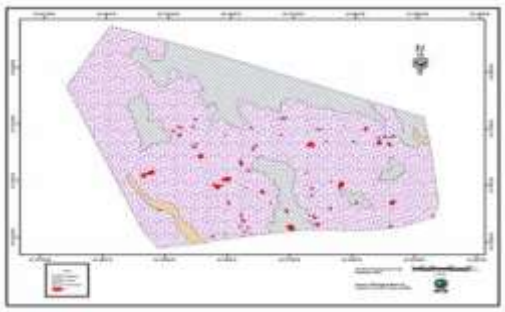

Fig.5: final map of desertification status with severity classes in study area

References

1) Abrisham, A. 2004. Assessment and Preparing of desertification map with analyses models FAO-UNEP, ICD, MICD in the Fakher Abad (Yazd). Journal of desert. 10(1). Iran. Tehran.

2) Aubreville, A. 1949.climates, forest et desertification del Afrique tropical. Paris: Societe d Editions Geographiques, Maritimes et Coloniales.

3) Azadnia, F.2006.Study of soil and water indicators in desertification Eynkhosh (Dehloran). M.Sc. thesis. University of Tehran.

4) Chaman Pira, GH.2003. Assessment of potential desertification in south of Lorestan. M.Sc. thesis. University of Tehran.

5) Dregne, H. E.1991.Human activities and soil degradation. New York: Marcel Decker.

6) Farajzadeh. 2007. Assessement of desertification based on climate indicator in the Ezadkhast plain. Pakistan Journal of Scientific Information.

7) FRW (Forest, Range, and Watershed Management Organization). 2004. National action program for combating desertification and mitigation of drought impacts. Iran: Tehran.

8) Ghasemi, S. 2006. Assessment of desertification in Sistan plain considering the soil and water indicators. M.Sc. thesis. University of Tehran.

9) Giordano L., F. Giordano., S. Grauso, M. Lannetta, M. Scicortino, G. Bonnati, F. Borfecchia.2002. Desertification Vulnerability in Sicily. Proc. Of the 2nd Int. Conf on New Trend in Water and Environmental Engineering for Safety and Life: Eco-Compatible Solution for Aquatic Environments.

10) Hemati, N. 2001. Determination the factors of desertification by FAO-UNEP model. Journal of desert, vol. 8 number 2:276-291.

11) Gerivani, G. 2009. Assessement of desertification of Northern Khorasan. Journal of Rang and Desert Research, vol. number 35:172-190.

12) Javadi, M. 2004. Assessment of main factors of land degradation in Mahan. M.Sc. thesis. University of Tehran.

13) Karimi, V. 2006. present status using MEDALUS model considering the water and wind erosion indicators in the Yazd plain. M.Sc. thesis. University of Tehran.

14) Khosravi, H. 2004. Application of MEDALUS model in desertification In Kashan area. M.Sc. thesis. University of Tehran.

15) Kosmas, C., Poesen, J., & Briassouli, H. 1999. Key indicators of desertification at the Environmentally Sensitive Areas(ESAs) scale. In C. Kosmas, M. Kirkby and N. Geeson(Eds), The MEDALUS Project: Mediterranean Desertification and Land Use. Manual on Key Indicators of Desertification and Mapping Environmentally Sensitive Areas to Desertification. Project report. European Commission.

16) Ladisa G, Todorovic M, Trisorio- liuzzi G, 2002.Characterization of Area Sensitive to Desertification in southern Italy, proc. Of the 2nd Int. conf. on New Trend in Water and Environmental Engineering for Safety and Life: Eco-compatible solution for Aquatic Environmental , Capri ,Italy.

17) Nikeghbal, M. 2005. Assessement of desertification considering climate indicator in the Ezadkhast plain. M.Sc. thesis. Tarbit Modares university.

18) Report of compose to indicators & sun-dials desertification in Iran. wind erosion indicators

19) Sepher, A. 2007. Quantitative assessment of desertification in south of Iran using MEDALUS model. Environmental monitoring and Assessment, vol. 134 number 1-3:243-254

20) Wang, T and S. Liu., 2007. Aeolian desertification from the mid-1970s to 2005 in Otindag Sandy Land, Northern China, *Environmental Geology*, vol. 51, no. 6, pp. 1057–1064,.

21) Yuassogoalu, N., 1995. land and desertification, and fanrchi, r, peter, d. balabanis. p. and rubio, jleds. desertification in the European context. Physical and socio-economic aspects Europeans commission eunp.

Table 1: Geomorphology faces in Ghorghori area

R7	R6	R5	R4	R3	R2	R1	sign
Released agriculture lands	Released lands& puffed inclined to Nebka	Bed rivers	Forested Dunes and sandy areas	Dunes and areas sandy	Hard clay lands inclined to Tamarix	Moist areas	Geomorphology faces

R14	R13	R12	R11	R10	R9	R8	sign
Released agriculture lands in the drought	Dry and hard crust inclined to Pheragmites commonis & Tamarix	Dry and hard crust inclined to Pheragmites commonis	salty lands & puffed inclined to less cover	sandy areas inclined to less cover	Urban areas and installations	Salty Released agriculture land	Geomorphology faces

Table 2: Evaluation indices for water erosion criteria

index	class			
	Low(1-1.74)	Moderate(1.75-2.49)	High (2.5-3.24)	Very high (≥3.25)
Kind and compression of water erosion	Surface erosion accompanied by groove erosion by compression lower than 60% in each work unit	Ditch erosion accompanied by scattered drainage with compression less than 50%	Drainage erosion accompanied by ditch erosion, surface and mass erosion by compression less than 40%	Dissolution erosion accompanied by mass erosion by high ditch erosion and badland with compression less than20%
Drainage matrix compression	Less than 10 km/km^2	10-20 km/km^2	20-30 km/km^2	more than 30 km/km^2
Percent of plant covered crown in growing season	>50%	30-50%	20-30%	<20%
Land use	Grassland and good land of water farming based on farming origin and using surface water in the rate of 70, accompanied by fallow at most 10% of earth ,barren earth, uncultivated and low output lands	Grassland suitable for water farming with slop of more than 20%and using surface water 70% dry farming with fallow of less than 30% lands with slop of at most 30% dry- lands uncultivated and free lands	Grassland with weak situation farming with water and using underground water 70%, dry-farming with fallow of 30-50%in farming lands with slope of 50-70%dry-lands barren earth and free and low output	Very poor grassland-water farming non-basic water farming by using under ground water 70% dry-farming with fallow of more than 50%of lands non- basic farming in lands with slope of more than 20% bare and free earth

Table 3: Evaluation indices of wind erosion criteria

index	classes			
	Low (1-1.74)	Mean (1.75-2.49)	High (2.5-3.24)	Very high (≥3.25)
Appearance of erosion faces(different faces of wind erosion)	Without effects and problem in wind erosion and soil agitation during the year	Having the effects of moving with wind limited in soil surface, divergence scattered surfaces and forming desert cobblestone	Sand land, scattered sod, divergence compression and forming compression cobblestone	Active sand hills, compression sod hill and next to each other
Intensity wind erosion	IRIFR<25	25<IRIFR<50	50 < IRIFR<80	IRIFR>80
Percent of live and none live cover	MC>80	40<MC<80	20<MC<40	MC<20
Days stormy index	DSI<10	10<DSI<30	30<DSI<60	DSI>60

Table 4: Desertification severity classes

No	Quantitative	Qualitative	class
1	1-1.65	Low	I
2	1.66 -2/1	moderate	II
3	2.11- 2.6	high	III
4	2.61- 4	Very High	IV