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Soil erosion potential zoning of Arasbaran forest lands using MCDM and GIS (case study: Mardanaghom-chay Watershed)

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Key words: Soil erosion, Analytic Hierarchy Process, Multi criteria evaluation, Delphi questionnaire, Fuzzy logic.

Abstract

Potential Zoning and severity of erosion in management of areas, is a mechanism by which reduces conflict zones and provides the opportunity to take the required measures. The present study aimed at Potential Zoning areas prone to erosion Arasbaran forests, Mardanghom chay watershed, an area of 28,262 hectares, with the use of MCDM and fuzzy logic by using GIS. In this study, after visiting the region's forest after initial recognition and preparation of the digital maps to the Delphi questionnaire, and the AHP Layers were weighted and classified. In the next step is through using SPOT5 satellite images of the area, polygon of degraded lands and forests in vector format layers were prepared and then by using MCE, the final Soil Erosion Potential Zoning map were prepared. The rate of erosion in the study area based on environmental factors, vegetation and destructive was to the four classes of erosion, severe, moderate, low and very low classified. The results indicated that slope as one of the investigated parameters, according to the AHP, with 0.2 was assigned highest weight base on its significant relative to each of the other factors and aspect was assigned lowest weight. Parameters weights for each criteria after pair wise comparison matrix after slope, decrease respectively, Altitude, Climate, Population, Distance of river, Soil texture, Geology, Distance of road, Distance of village, Land use and Density. It can be said that, the most important factor in soil erosion was slope.

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Introduction

Soil erosion is one form of soil degradation along with soil compaction, low organic matter, and loss of soil structure, poor internal drainage, salinization, and soil acidity problems (Ngai and Chan, 2005). These other forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion (Nahuelhual, *et al.,* 2013). Soil erosion is a naturally occurring process on all land (Bou Kheir, *et al.,* 2008). The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year in Ontario (Ning, *et al.,* 2005). Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil (Demirel and Tüzün, 2011). The loss of soil from farmland may be reflected in reduced crop production potential (Ni, *et al.,* 2012), lower surface water quality and damaged drainage networks (Pourghasemi, 2009). Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion (Qafoku, *et al.,* 2008) (Nekhay, *et al.,* 2009).

Aims of the study

1) Determination of the priority factors of soil erosion in forest Arasbaran.
2) Determination of role of the analytic hierarchy process in the evaluation of the factors affecting the degradation of forest lands.
3) Determination of the usefulness and functionality of GIS in locating areas prone to erosion.
4) Finally, the final zoning maps of areas susceptible to erosion by the analysis of multi-criteria evaluation (MCE) in the study area can be a different program management, project development and reforestation and prevent the erosion and the choice of appropriate species and areas for reforestation and restoration of essential.... can be designed and implemented.

Materials and methods

The study area

Arasbaran forest that is located in the North West of Iran as a part of forest vegetation zones were Hyrcanian and Located, overlapping 3 layers of deferment's ecosystem appeared in the form of ecoton and are rich fauna and flora. Fortunately, after protection, valuable species such as *Taxus Baccata* have been developed in this area (Mohajer, 2010).The study was conducted in Mardanghom Chay watershed of which is a rather distributed forest, and that with interactions of villages and foresters can be seen in the area, that based on map is 28,262 ha and is located at between longitudes (◌38 40'- ◌38 52') and latitudes (′4627′-′4640′). According to the precipitation low rate, this forest can be included as a semi-arid forests. In the region, Annual precipitation varies from 400 to 600 mm. It is worth mentioning that in the area there are no signs of erosion that is result of natural factors, but erosion of which is resulted by clear cutting, intense grazing, soil compaction, erosion, surface and grooves, pasture and forest conversion to agriculture and the presence of invaders species, can be seen in all areas.

Methods of study

Field studies and forest tour: In order to identify natural features of the area, reviewing the situation and the type of soil erosion, tree and vegetation cover, photographed from the eroded areas and taken ground control points with GPS, the area was visited.

Delphi questionnaire: Based on data gained by similar research and existing maps that affect erosion and the comments of the professors, Delphi questionnaire was developed for the analysis of hierarchical AHP analysis and were completed by 45 professional experts. According to the results of the Delphi questionnaire, by determining the relative value of the criteria specified in the table are weighted according to the criteria for the use of AHP was prepared.

Data and software: The data used in this study include: Topographic maps of 1: 25000 (Prepared by national planning organization), SPOT5 images (Pixel size 2.5m), Soil, Geology, Climate and population maps (Prepared by the Directorate General for Environmental Protection in East Azerbaijan province). To analyze the data and maps, Arc GIS 10.1 and IDRISI Selva software have been applied.

Preparation of base maps: The criteria affecting soil erosion were classified based on previous research and professional experts' opinion, and consequently the criteria 12 and 12 raster map with the same coordinate system and the pixel size of 5 x 5 as input, output. These maps include: Aspect, Altitude, Climate, Population, Distance of rive, Soil, Geology, Distance of road, Distance of village, Land use, Density and Slop. Land use and Density maps, were prepared based on Spot5 satellite images and observing the area. Most thematic maps such as soil, road, river, geology, village, climate, aspect, were extracted as topographic maps of 1: 25,000 by using Arc GIS software, and then by means of IDRISI Selva software, were converted to raster format. Altitude, slope and aspect maps were prepared by DEM map (DEM prepared by IDRISI software).

Then all the maps were, classified, and the weight of all the layers as shown in Table 2, were inserted and the weight of each factor was calculated as shown in Table 3. Class values of each criterion, were considered from 1 to 9, where 1 represents the lowest and 9 show the greatest effect is the impact on erosion. The value of each class is prepared based on the experts' ideas and reviewing the related literature and also based on the prepared questionnaire and were entered into the descriptive information table of that crimination that is shown in corresponding Fig. (Fig. 2-13).

Soil erosion potential zoning: The following table was prepared based on opinions of the experts and also through application of the AHP method. This table clearly shows the effects of each factor on soil erosion. The fuzzy map was prepared through overlaying the all maps (Fig. 14). Then by classification of this map, soil erosion potential zoning map was produced (Fig. 15).

The summary of this process is as follows: Creating paired comparison matrix, Standardization values of the matrix, Control of Consistency ratio, the weight of each factor is applied to the map, overlaying weighted maps, and finally classifying this map to 4classies, (High, medium, low and very low).

Results and discussion

For the 12 criteria, 12 maps were prepared (Fig. 2-13). Depending on the amount of influence of the criteria on erosion the values of classifications of each one is allocated in a manner of which to include the maximum effect and also the maximum value. Also the result of paired comparison of criteria resulted in achieving to the value of each criteria of which mentioned in Table 2.

In this stage Consistency ratio should be considered. Because if the coefficient of 0.1≥ is acceptable (Javidan, *et al.,* 2011). The result was as follows:
Consistency ratio: 0.01
Consistency is acceptable.

The results indicated that the factor of Slope with 0.2137 assigns the highest weight and Aspect with the weight of 0.0171 assigns the least weight. According to the Fuzzy map of soil erosion potential zoning (Fig. 14), the area was categorized into 4 classes (Table. 3).

Unlike the results of the (Abushnaaf *et al.,* 2013; Geology was the important factor),(Kazemi and Nohe gara, 2011; Land use was the important factor), (Zhang *et al.,* 2013; Soil was the important factor), (Mohammady, *et al.,* 2010; Soil was the important factor), the results of this study support the results of the studies of which were carried out by (Asgari *et al.,* 2009; Slop was the important factor), (Dehghani *et*

al., 2013; Slop was the important factor), (Lina *et al.,* 2008; Slop was the important factor).

Table 1. Criteria weighting based on the Delphi questionnaire for use in AHP.

	Aspect	Altitude	Climate	Pupulation	Distance of river	Geology	Distance of road	Distance of village	Soil	Landuse	Density	Slop
Aspect	1											
Altitude	1.125	1										
Climate	1.125	1	1									
Pupulation	2.25	1.125	1.125	1								
Distance of river	3.375	2.25	2.25	1.125	1							
Soil	3.375	2.25	2.25	1.125	1	1						
Geology	4.5	3.375	3.375	2.25	1.125	1.125	1					
Distance of road	5.625	4.5	4.5	3.375	2.25	2.25	1.125	1				
Distance of village	6.75	5.625	5.625	4.5	3.375	3.375	2.25	1.125	1			
Landuse	7.875	6.75	6.75	5.625	4.5	4.5	3.375	2.25	2.25	1		
Density	7.875	6.75	6.75	5.625	4.5	4.5	3.375	2.25	1.125	1	1	
Slop	9	7.875	7.875	6.75	5.625	5.625	4.5	3.375	2.25	1.125	1.125	1

Table 2. The weight of each factor according to results WEIGHT function.

Weight of each factor	Factor name
0.0171	Aspect
0.0216	Altitude
0.0216	Climate
0.0299	Population
0.0423	Distance of river
0.0423	Soil
0.0595	Geology
0.0869	Distance of road
0.1192	Distance of village
0.1786	Land use
0.1675	Density
0.2137	Slop

Table 3. Specifications of erosion classes in the study area.

The area of each class (%)	Classification of the severity of erosion	Class of Erosion
4	High	Class1
44	Moderate	Class2
51	Low	Class3
1	Very low	Class4

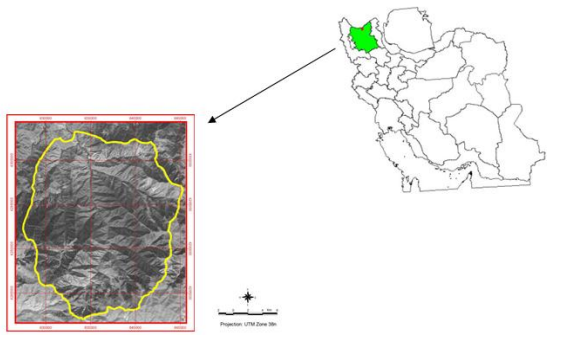

Fig. 1. Location of the study watershed.

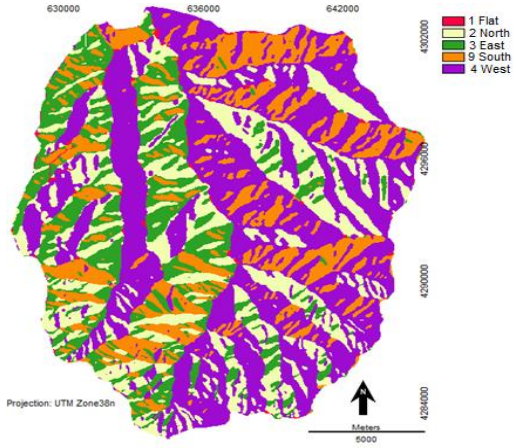

Fig. 2. Classified Map of Aspect.

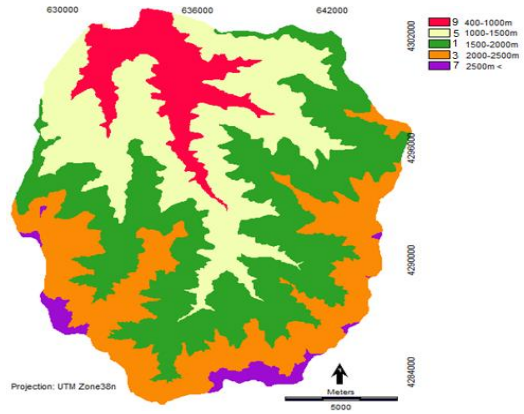

Fig. 3. Classified Map of Altitude.

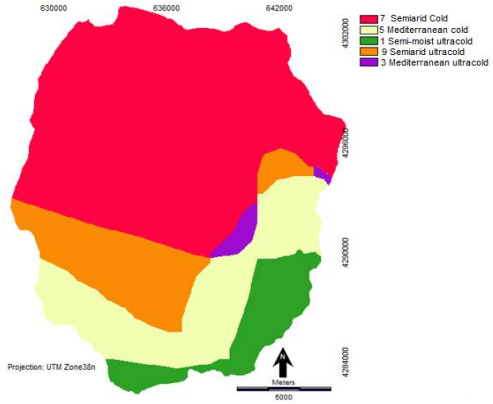

Fig. 4. Classified Map of Climate.

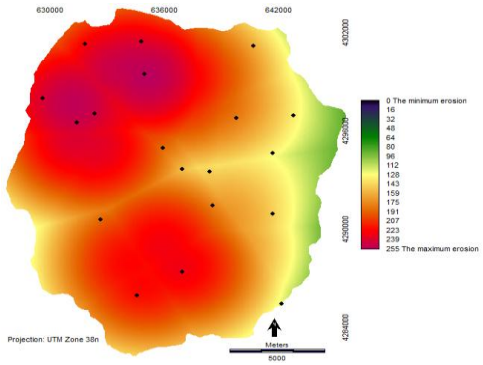

Fig. 5. Classified Map of population.

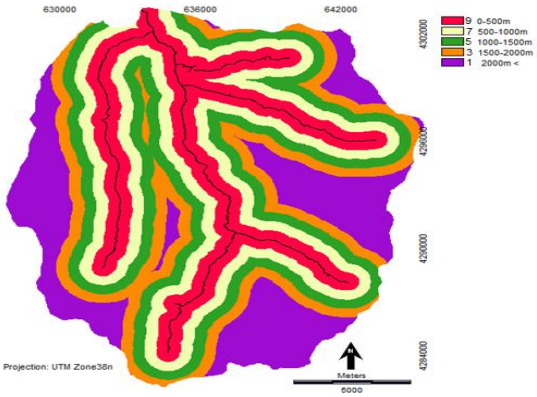

Fig. 6. Classified Map of Distance of River.

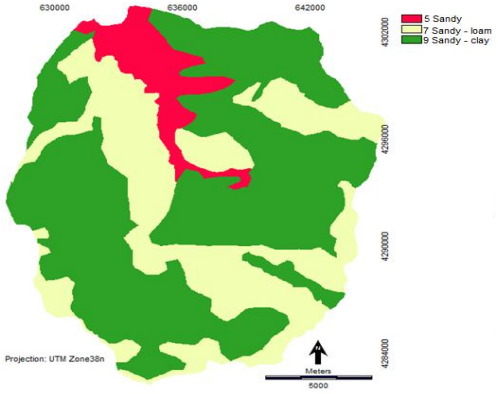

Fig7. Classified Map of Soil.

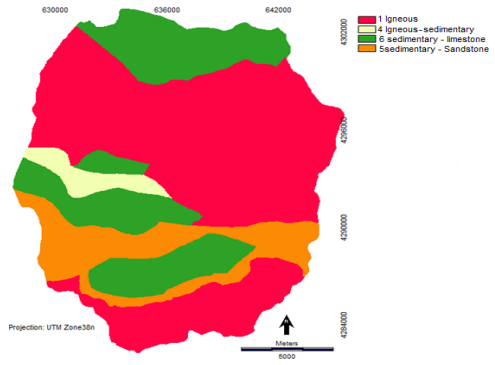

Fig. 8. Classified Map of Geology.

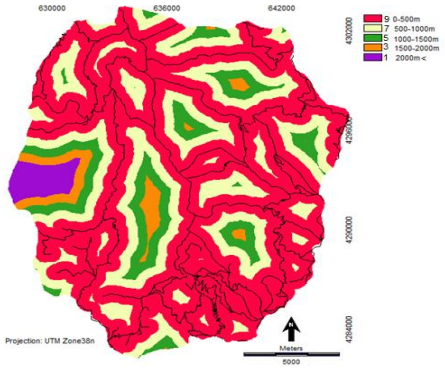

Fig. 9. Classified Map of Distance of Road.

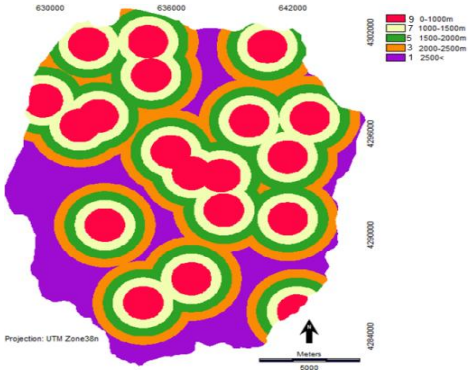

Fig. 10. Classified Map of Distance of the village.

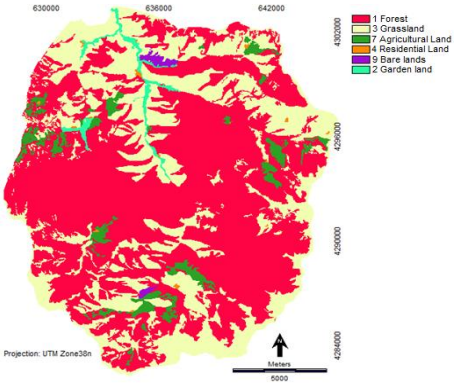

Fig. 11. Classified Map of Land use.

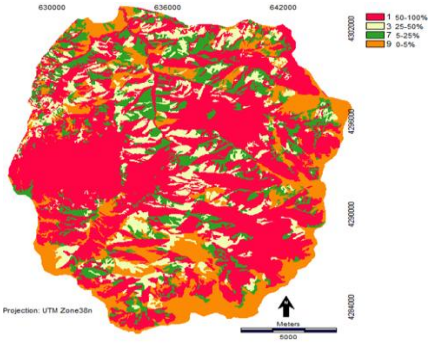

Fig. 12. Classified Map of Density.

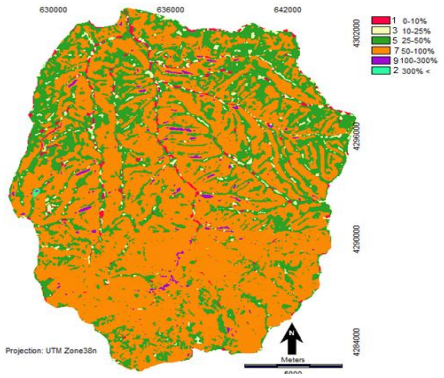

Fig. 13. Classified Map of Slop.

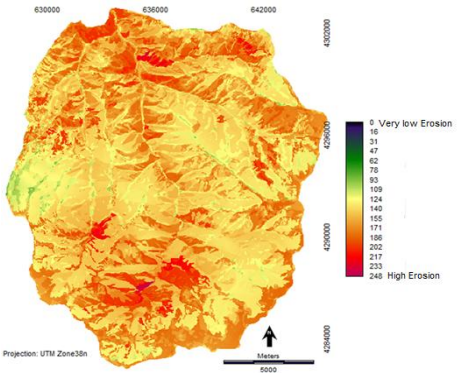

Fig. 14. Fuzzy map of soil erosion potential zoning.

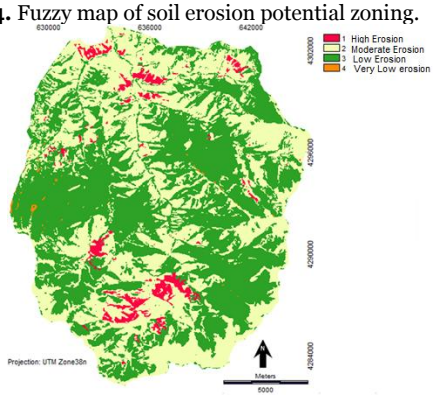

Fig. 15. Classified Map of soil erosion potential zoning.

Conclusion

With improvements in technology and industry, people are forced to exploit the environment and nature for continues to provide food and supplies or by their intervention in agricultural activities and disrupted the balance of ecosystems (Nekhay, *et al.,* 2009), So that substantial levels of land destroyed and the environment is heavily polluted (Ngai and Chan, 2005). Change of use of natural areas has increased the soil degradation and erosion (Ni, *et al.,* 2012). Understanding the wrong ways of exploiting of

the land helped the planners to design appropriate programs and by applying the appropriate methods to change or (correct) the current situation (Mohammady, *et al.,* 2010).

In this study "Soil Erosion Potential Zoning of Arasbaran Forest Lands has been investigated through Using AHP & GIS (Case Study: Mardanghom -Chay watershed)". Thus, 12 parameters have been studied. The results indicated that the most important factor on soil erosion was slop. Aspect has little impact on soil erosion. According to the final map, the area in terms of erosion was categorized into 4 classes (Table 3).

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References

Abushnaaf FF, Spence KJ, Rotherham ID. 2013. Developing a Land Evaluation Model for the Benghazi Region in Northeast Libya using a Geographic Information System and Multi-criteria Analysis. Journal of APCBEE Procedia Science Direct **5**: 69-75.

Asgari Sh, Servati M, Jafari M. 2009. Estimation of soil erosion and sediment yield Ilam dam basin using MPSIAC. Geographical research **64**, 29-35.

Bou Kheir R, Abdallah C, Khawlie M. 2008. Assessing soil erosion in Mediterranean karst landscapes of Lebanon using remote sensing and GIS, Journal of Engineering Geology. ScienceDirect **99**, 239-254.

Dehghani M, Ghasemi H, Malekian A. 2013. Prioritize areas to reduce flood and erosion control using fuzzy logic (case study watershed Forg). Journal of pasture and Watershed Management Journal of Natural Resources **1**, 73-88.

Demirel T, Tüzün S. 2011. Multi Criteria Evaluation of the Methods for Preventing Soil Erosion Using Fuzzy ANP: The Case of Turkey. Journal of Proceedings of the World Congress on Engineering **2**, 1-5.

Javadian M, Shamskooshki H, Momeni M. 2011. Application of sustainable urban development in environmental suitability analysis of educational land use by using AHP and GIS in Tehran. Journal of Procedia Engineering ScienceDirect **21**: 72-80.

Kazemi M, Nohegara A. 2011. Evaluate the spatial variability of water erosion hazard zonation using CORINE. Study of environmental degradation **2**, 11-12.

Lina WT, Tsalib JS, Linc CY, Huangd PH. 2008. Assessing reforestation placement and benefit for erosion control: A case study on the Chi-Jia-Wan Stream, Taiwan. Journal of Ecological Modelling **2**, 444-452.

Mohajer M. 2010. Silviculture. University of Tehran Press, 3rd Edition, pp:418.

Mohammady M, Morady HR, Feiznia S, Pourghasemi HR. 2010. Prioritization of Landslide Effective Factors and its Hazard Mapping using Information Value and AHP Models. Journal of Geosciences Scientific Quarterly Journal 7**4**, 27-35.

Nahuelhual L, Carmona A, Lozada P, Jaramillo A, Aguayo, M. 2013. Mapping recreation and ecotourism as a cultural ecosystem service: An application at the local level in Southern Chile. Journal of Applied Geography SciVerse ScienceDirect **40**, 71-82.

Nekhay O, Arriaza M, Boerboom L. 2009. Evaluation of soil erosion risk using Analytic Network Process and GIS: A case study from Spanish mountain olive plantations. Journal of Environmental Management ScienceDirect **90**, 3091-3104.

Ngai EWT, Chan EWC. 2005. Evaluation of knowledge management tools using AHP. Expert Systems with Applications, **29**, 889–899.

Ni, JR, Li XX, Borthwick AGL. 2012. Soil erosion assessment based on minimum polygons in the Yellow River basin, China. Journal of Geomorphology ScienceDirect **93**, 233-252.

Ning SK, Chang NB, Jeng KY, Tseng YH. 2005. Soil erosion and non-point source pollution impacts assessment with the aid of multi-temporal remote sensing images. Journal of Environmental Management **79**, 88-101.

Pourghasemi HR. 2009. Lanslide Hazard Assessment using Fuzzy Logic. (Case Study: A part of Haraz Watershed), Master Thesis.

Qafoku NP, Van ranst E, Noble A, Baert G. 2008. Mineralogy and chemistry frariable charge soils. Journal of Encyclopedia of soil scieuce, Marcel dekker, New York., Tarbiat Modares University **12**, 45-63.