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Investigation of pedological criterion on land degradation in quaternary rock units (Case Study: Rude-Shoor watershed area)

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Abstract

To investigate pedological criterion on land degradation in Quaternary rock units, at first, a part of the shoor watershed area was selected. After distinguishing target area, slope classes, land use and geology maps were created, then map of units were founded by overlaying and crossing these maps. In this research three indices of erodibility, salinity and permeability of soils were considered that finally each of them was shown in the shape of classified map. Then by overlaying and crossing of these maps, a new map was created that is an expression of research area zonation from the viewpoint of indices that formerly, were explained. As determining and distinguishing of desertification intensity of potential of created units from crossing of indices was not possible with using of pure mathematical or statistical relations, so were exploited principles and concepts of fuzzy logic and statistics to achieve to main result. We used functions of fuzzy algebraic sum, fuzzy algebraic product and fuzzy gamma after determining weight or value of fuzzy gamma after determining weight or value of factors. Obtained results from a comparison of gained maps from different operators with an evidence map as control area including maximum of desertification intensity, were measured in research area, to prove fuzzy function usefulness for zoning of desertification intensity or potential in research area and similar area with function of 0.8 from fuzzy gamma model (gamma = 0.8). Finally by overlaying the desertification potential zonation map with geological map, kinds of soil zones were characterized on the base of their desertification effect. This research determined three classes of desertification qualitative potential (very high 23/08%, high 56/88% and moderate 20/04%).

KeyWords: Desertification; Fuzzy Logic; Pedological Criterion; Erodibility; Salinity; permeability

1. Introduction

The aim of this research is presenting indices for determining of pedological criterion effect on land degradation and zonation of desertification potential in research area.

Feiznia (2002 and 1997 a & b), kashki (1997), Rajabi aleni (2001), Gorji anari (1993), Sarabian (2002), Esenov et al (1999), Kaushalya (1992) and Metternicht et al (1996) showed the relation between saline Rock units and degradation of land and water.

Tahmasebi (1998) investigated the factors on salinization of water and soil and spread of desert in rude-shoor area of Eshtehard and distinguished point pollution source (salt dome) and diffuse (evaporate marl) and their effects on water and soil degradation. Feiznia (1995) investigated erodibility of kinds of Rock units in different climate and has showed resistance coefficient to erosion. Bouwer (1976) showed the infiltration coefficient of kinds of rock units.

Salehpour jam (2006) investigated

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desertification potential of kinds of rock units in rude-shoor watershed area with using of fuzzy logic, he introduced function of 0.8 from fuzzy logic model.

2. Materials and methods

2.1. Study area

Rude-Shoor watershed has about 17000 Km^2 areas. 42% of total land of area is plain and remainder is in the shape of highland. This area bounded between 48? 30′ to 51? (E) and 35? 21′ to 36? 30′ (N) it is between two geological systems and structures of relatively different of south Alborz and central Iran.

2.2. Research method

For investigation of pedological criterion on land degradation in quaternary rock units, at first, a part of shoor watershed area was selected. After distinguishing target area, maps of slope classes, land use and geology were created, and then map of units was founded by overlaying and crossing of slope, land use and geology maps.

At the first stage, for creating map of slope classes by using ILWIS 3.3 software, after georeferencing of topographic map and digitalization of topographic lines, digital elevation model (Dem) was created, then slope map was provided. At last it was showed as classified map with using class limits that was illustrated in figure 1 (Figure 1).

At the second stage, for creating land use map after monitoring and investigation of previous studies like face of watershed area plan (2003) and using satellite image of landsat 7 (ETM^+, 2004) and provided image from google earth site (2005,2006), land use map (Figure 2) was created through optical and digital analysis (id est. investigative method).

At the third stage, for creating geological map, at first sheets of Eshtehard and karaj were merged by ILWIS 3.3, then they were georeferenced and geocordinated. Considering different means of rock units on Eshtehrd and Karaj, after merging, denomination of rock units to be done on the basis of Karaj sheet (Table 1 and Figure 3)

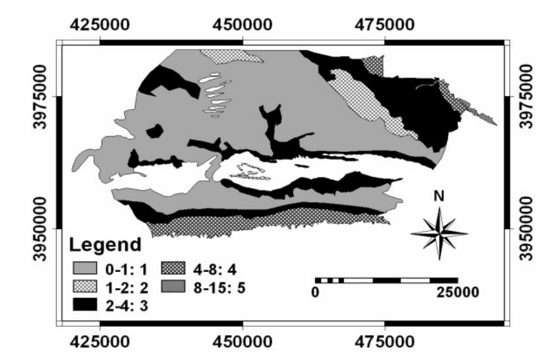

Fig. 1. Map of slope classes (class and slope percentage)

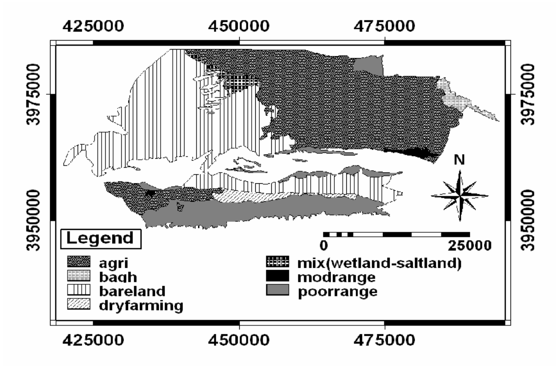

Fig. 2. Land use map

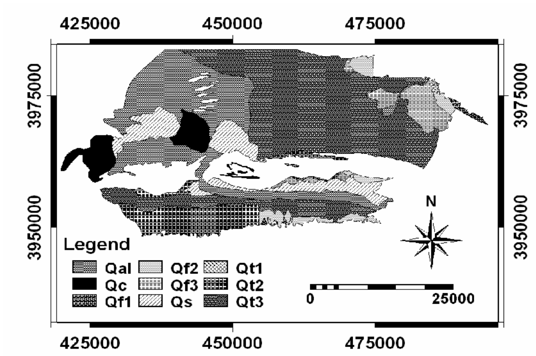

Fig. 3. Geological map

Table 1. Legend of geological map

Lithological characteristics of search area	Sign	Age		
		Epoch	Period	Era
Recent alluvium and flood plains	Q^{al}	-	Quaternary	Cenozoic
Clay flat	Q^{c}	-		
Salt flat	Q^{s}	-		
Youngest terraces	Q_3^t	-		
Youngest gravel fans	Q_3^f	-		
Young terraces	Q_2^t	-		
Young gravel fans	Q_2^f	-		
Old and high level terraces	Q_1^t	-		
Old gravel fans	Q_1^f	-		

At the fourth stage for creating map of study units, after providing three maps of rock unit, slope classes and land use by using ILWIS 3.3 software and with overlaying and crossing them, map of study units was created (Figure 4). After creating this map, zonation of research area from the viewpoint of three indices of erodibility, salinity and permeability of soil to be done.

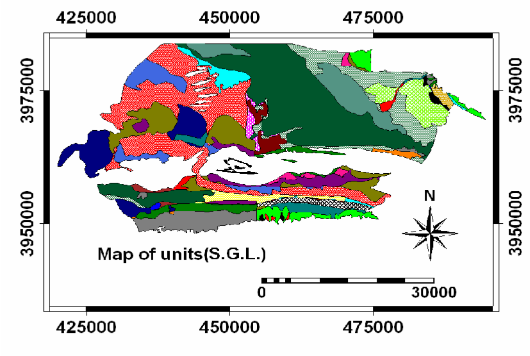

Fig. 4. Map of work units

Target area through soil erodibility to erosion on the basis of feiznia method (1995) is in the vulnerable class (with coefficient of resistance to erosion 3-4).

For Zoning of research area from viewpoint of salinity index, at we took samples and electrical conductivity of saturated mud of 261 samples were measured by EC-meter by $ds.m^{-1}$. finally classification of salinity with considering four classes of salinity (low (0≤ECe<2)), moderate (2≤ECe<4), high (4≤ECe<8) and very high (8≤ECe)) done according to USSL method (Daneshkar 2002), (Figure5).

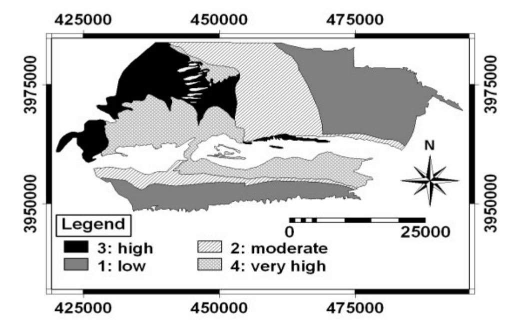

Fig. 5. Zonation map of salinity

For Zonation of research area from viewpoint of index of permeability coefficient, we took 284 samples by brazen rings and permeability coefficient of them was measured according to Darcy' s law by meters per day ($m.day^{-1}$). Finally classification of permeability with considering 4 classes of permeability coefficient (very low (<0.069 $cm.min^{-1}$), low (0.069-1.388 $cm.min^{-1}$), moderate (1.388-6.944 $cm.min^{-1}$) and high (>6.944 $cm.min^{-1}$) done according to bouwer classification (1978), (figure 6).

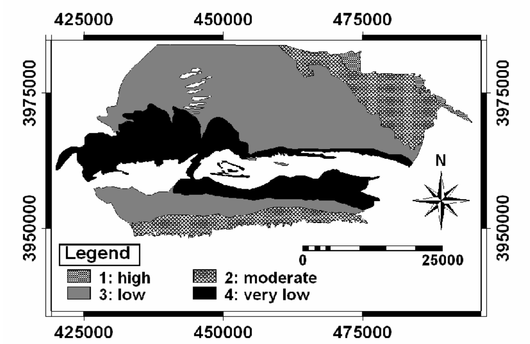

Fig. 6. Zonation map of permeability coefficient

Research area zonation from viewpoint of salinity, permeability and erodibility of soils through overlaying and crossing of these three maps to be done by ILWIS 3.3 software and using cross function (Figure 7). The created maps have nine units.

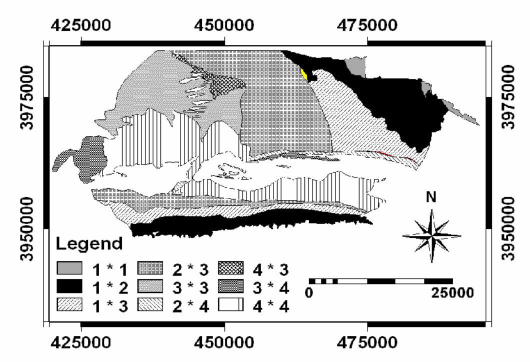

Fig. 7. Zonation map from viewpoint of three indices (erodibility, salinity and permeability of soils)

Calculation of quantitative amounts of indices in units:

In this stage calculation of quantitative amounts of indices to be done in each unit, weight average of each unit from zones determined and quantitative amounts of each index were calculated (table 2).

2.3. Combination of information layers

In view of determining and distinguish of quantitative amounts of three indices, as determining and distinguish of desertification intensity of potential of created units from crossing indices was not possible with using of pure mathematical or statistical relations, so were exploited principles and concepts of fuzzy logic and statistics for achieving to main result.

Table 2. characteristics of units

Resistance coefficient to erosion		Salinity		permeability		Unit name	Unit number
Quantitative amounts (without dimension)	Qualitative class	$dS.m^{-1}$	Qualitative class	$m.day^{-1}$	Qualitative class		
3.200	Vulnerable	0.926	Low	153.717	High	1-1-1	1
3.200	Vulnerable	1.048	Low	54.068	Moderate	1-1-2	2
3.200	Vulnerable	1.138	Low	10.430	Low	1-1-3	3
3.200	Vulnerable	5.020	High	5.532	Low	1-3-3	4
3.200	Vulnerable	2.800	Moderate	9.386	Low	1-2-3	5
3.200	Vulnerable	16.385	Very high	5.497	Low	1-4-3	6
3.200	Vulnerable	5.263	High	0.401	Very low	1-3-4	7
3.200	Vulnerable	22.198	Very high	0.580	Very low	1-4-4	8
3.200	Vulnerable	3.206	Moderate	0.524	Very low	1-2-4	9

In fuzzy method for determining value of quantitative amounts of indices for classification of desertification potential, used from weighting system based on information theory that it has explained in equation 1 (Asghar pour, 1998).

$$W_{ig}=1-e^{-2I} \quad (1)$$

That:

I = bilateral acquaintance criterion

WI = weight value of quantitative amounts

Then fuzzy membership function was used according to equation 2 (Ghoddousi, 2003).

$$\mu(x) = \begin{cases} 0_{x-a/b} \\ 1 \end{cases} \quad (2)$$

That:

μ(x)= fuzzy membership function, x= amount of independent variable, a= distance of data classes and b= X_{max} – h that X_{max} = maximum amount of observed for each index and h obtains from Sturges rule according to equations 3 and 4.

$$h= R/K=X_{max}- X_{min}/k \quad (4)$$

$$K= 1+3.3 \log N \quad (5)$$

That:

N= number and R= distance between minimum and maximum of, measured or observed amounts.

According to these equations, calculations were done and results have been illustrated in table 3.

Table 3. Calculation of desertification potential values.

Desertification potential class	Value of each class	Weight value	Bilateral acquaintance criterion	Fuzzy membership function $\mu(x)$	Fuzzy membership function x	Quality of each class	Limits of quantitative changes	Index	Row number
I	0.78	0.22	0.13	0.13	3.200	Very low	3-3.215	Resistance coefficient to erosion	1
I	0.70	0.30	0.18	0.00	22.198	Very high	5.761-23.393	Salinity	2
				0.36	16.385				
II	0.15	0.85	0.97	0.96	5.263	High	3.247-5.761		
				0.98	5.020				
III	0.11	0.89	1.12	1.14	3.206	Moderate	1.145-3.247		
				1.11	2.800				
IV	0.09	0.91	1.20	1.20	1.138	Low	0.100-1.145		
				1.20	1.048				
				1.20	0.926				
III	0.14	0.86	0.99	3.68	153.717	High	57.810-156.663	Coefficient of permeability	3
II	0.16	0.84	0.91	1.20	54.068	Moderate	10.704-57.810		
I	0.90	0.10	0.05	0.15	10.430	Low	0.436-10.704		
				0.11	9.386				
				0.04	5.532				
				0.04	5.497				
				0.00	0.580				
				0.00	0.524				
				0.00	0.401				

In this research, we used limits of quantitative changes and conspectus of integrative results of desertification potential classification in research area, obtained from previous researches (salehpour jam, 2006), (Table 4).

To obtain quantitative amounts for Creating desertification potential map, we used functions of fuzzy algebraic sum, fuzzy algebraic product and fuzzy gamma pertaining to γ =0.2, γ = 0.5 and γ=0.8, distinguishing values (Bonham-carter, 1996).

Table 4. Conspectus of integrative results of desertification Potential classification in research area

Desertification qualitative potential	Desertification quantitative potential	Mean of values (s)	Limits of value changes	Class
Very high	75-100	0.81	0.72-0.91	I
high	50-75	0.55	0.38-0.72	II
moderate	25-50	0.26	0.14-0.38	III
low	0-25	0.11	0.09-0.14	IV

3. Results

After creating desertification zonation map by different operators, for distinguishing best zoning, evidence map was created. This map created with knowing maximum of desertification intensity that was measured in research area (Figure8).

This map has two classes. Class 0 has maximum desertification intensity (32485 ha) and class 2 is unclassified area (118034 ha).

Also for evaluation of models, area pertaining to each class of desertification potential from viewpoint of pedological criterion related to each operator was illustrated (Table 5).

Then overlaying and crossing each maps from different operators with an evidence map as control area by ILWIS 3.3 software, over lapped map was obtained (Table 6).

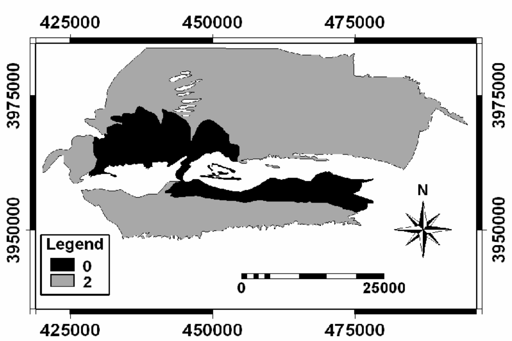

Fig. 8. Evidence map

Table5. Amount of overlapping between obtained maps from different operators with evidence map

Overlap area of obtained map from operator of γ = 0.8 with evidence map (ha)	Overlap area of obtained map from operator of γ = 0.5 with evidence map (ha)	Overlap area of obtained map from operator of γ = 0.2 with evidence map (ha)	Unit name
32421	32421	-	0.I

Table 6. Areas of different classes of desertification potential in obtained map from different operator

Area of class in obtained map = 0.8 (ha) γ from operator of	Area of class in obtained map = 0.5 (ha) γ from operator of	Area of class in obtained map = 0.2 (ha) γ from operator of	Class name
34818	34818	0	I
85670	0	34818	II
30047	85670	63918	III
0	30047	51800	IV

Because of created map from gamma = 0.2, have not area of maximum desertification intensity, is not true, but due to the area zone of maximum desertification intensity in evidence map is equal with obtained maps from γ = 0.2 and γ = 0.8 and on the other hand, research area have not minimum desertification intensity, therefore obtained map from γ = 0.8 was selected as best map for desertification potential zonation from viewpoint of pedological criterion in target area (Figure 9).

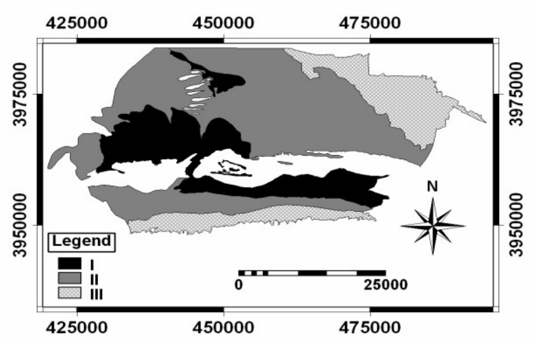

Fig. 9. Zonation map of desertification potential from viewpoint of pedological criterion from operator of γ = 0.8

Also, overlaying and crossing of desertification potential zonation map from the viewpoint of the pedological criterion in research area, was obtained from operator of γ = 0.8, with geological map of research area, determined potential of soils in each unit of quaternary rock units from the viewpoint of the desertification potential of research area (Table 7).

4. Conclusion

Results from comparison of gained maps from different operators with an evidence map as control area including of maximum of desertification intensity, were measured in research area, show suitability of fuzzy function for zoning desertification potential in research area and similar area with that is function of 0.8 from fuzzy gamma model (gamma= 0.8).

Our results are similar to results of Salehpour Jam (2006) and Ghoddousi (2003) research.

Salehpour Jam (2006) introduced function of 0.8 from fuzzy logic model for desertification potential of kinds of rock units. Also Ghoddousi (2003) introduced γ=0/8 from fuzzy logic model for zonation of Gully erosion risk.

Overlaying and crossing of desertification potential zonation map from the viewpoint of the pedological criterion in research area, was obtained from operator of γ=0/8, with geological map of research area, determined three classes of desertification qualitative potential (very high 23/08%, high 56/88% and moderate 20/04%).

Table7. Potential of soils in each unit of quaternary rock units

Class area (%)	Class area (ha)	Rock unit area (%)	Rock unit area (ha)	Name of rock unit	Desertification qualitative potential	Class
23.08	34772	9.79	14750	Q^{al}	Very high	I
		2.60	3922	Q^{c}		
		9.51	14326	Q^{s}		
		0.53	795	Q_3^{f}		
		0.19	281	Q_2^{t}		
		0.46	698	Q_2^{f}		
56.88	85652	13.17	19828	Q^{al}	High	II
		2.81	4233	Q^{c}		
		36.30	54665	Q_3^{t}		
		4.55	6853	Q_2^{t}		
		0.05	73	Q_2^{f}		
20.04	30173	0.38	573	Q^{al}	Moderate	III
		7.57	11407	Q_3^{t}		
		4.37	6587	Q_3^{f}		
		3.94	5936	Q_2^{t}		
		3.07	4630	Q_2^{f}		
		0.20	295	Q_1^{t}		
		0.49	745	Q_1^{f}		

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