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Investigation of Pedological Criterion on Rangeland Desertification (Case Study: South of Rude-Shoor Watershed)

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Abstract

Investigation of desertification trend needs understanding of phenomena creating changes singly or action and reaction together in the manner that these changes were ended up in land degradation. In investigation of pedological criterion on land degradation in Quaternary rock units, first, a part of the Rude-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 these maps. In this research three indices of erodibility, salinity and permeability of soil were considered that finally each of them was shown in the shape of classified map. Then by overlaying and cross of these three 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 for achieving to main result and were used functions of fuzzy algebraic sum, fuzzy algebraic product and fuzzy gamma after determining weight or value fuzzy gamma after determining weight or value of factors. Obtained results from a comparison of gained maps from different operators with an evidence map expresses this actual that the most appropriate of fuzzy function for zoning desertification intensity or potential in research area and similar area with that is function of 0.8 from fuzzy gamma model (gamma = 0.8). After classification of obtained map from function of 0.8 from fuzzy gamma model, by overlaying the desertification potential zonation map with land use map, kinds of soil zones were characterized on the base of their desertification effect. This research determined two classes of desertification qualitative potential (high 43.08% and moderate 56.92%).

Keywords: Desertification; Range Land; Fuzzy Logic; Pedological Criterion; Erodibility; Salinity; Permeability

1. Introduction

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

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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 salin 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 (evaporative marl) and their effects on water and soil degradation. Feiznia (1995) investigated erodibility of kinds of Rock units in different climate and has exhibited resistance coefficient to erosion. Bouwer (1976) showed the infiltration coefficient of kinds of rock units. Salehpour jam (2006) investigated 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. Material and Methods

2.1. Study area

Rude-Shoor watershed area is about 17000 square kilometers. 42 percents of total land of area is plain and remainder is in the shape of highland in height. This area has been located in geographic limit of 48º 30′ to 51º (East) and 35º 21′ to 36º 30′ (North) and between two geological systems and structures of relatively different of south Alborz and Central Iran.

The study area is range land located in south of Rude-Short watershed area. It has the area of 37545.6 ha^2 with different rock units of quaternary period.

2.2. Research methodology

In investigation of pedological criterion on land degradation in range lands, first, a part of Rude-hoor watershed area was selected. After distinguishing target area, maps of slop classes, land use and geology were created, and then map of units was founded by overlaying and crossing these maps.

At the first stage, for creating map of slop classes by using ILWIS 3.3 software, after georeferencing of topographic map and digitization of topographic lines, digital elevation model (DEM) was created, and then slop map was provided. At last it was showed in the shape of classified map with using class limits (Figure 1).

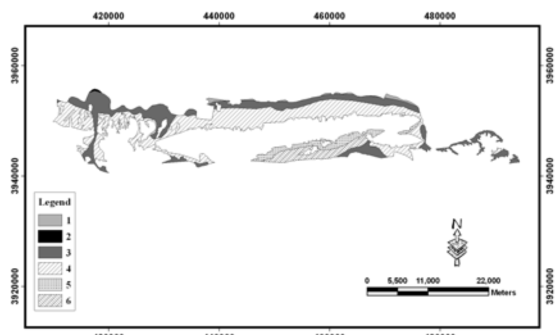

Fig. 1. Map of slope classes (classes of 1(0-1%), 2(1-2%), 3(2-4%), 4(4-8%), 5(8-15%) and 6(>15%))

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), map of land use (Figure 2) was created through optic analysis and in some cases digital.

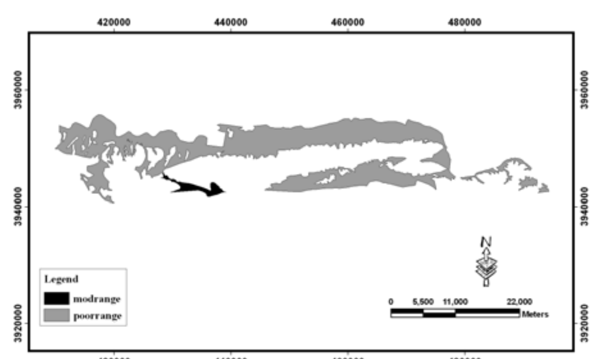

Fig. 2. Map of land use

At the 3rd stage, for creating geological map, first sheets of Eshtehard and karaj were merged by ILWIS 3.3 and 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 (Figure 3 and Table 1).

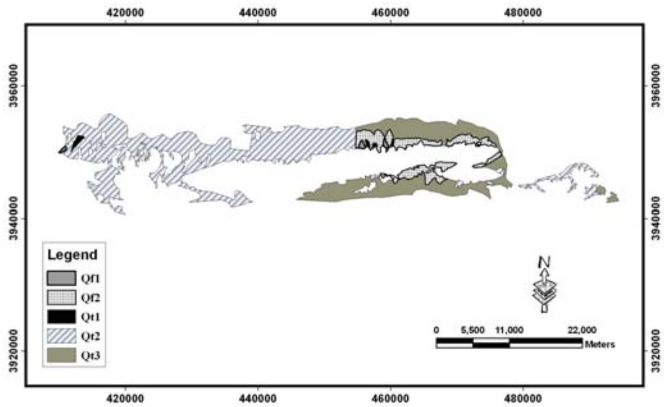

Fig. 3. Geological units map of the study regions

Table 1. Legend of geological map

Lithological characteristics of study area	Sign	Age		
		Epoch	Period	Era
Youngest terraces	Q_3^t	-		
Young terraces	Q_2^t	-		
Young gravel fans	Q_2^f	-	Quaternary	Cenozoic
Old and high level terraces	Q_1^t	-		
Old gravel fans	Q_1^f	-		

At the 4th 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 was done.

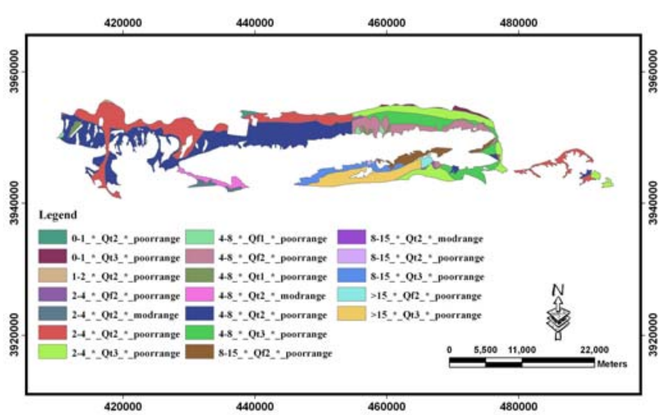

Fig. 4. Map of work units

Target area from viewpoint of soil erodibility to erosion on the basis of Feiznia method (1995) is in the vulnerable and rather vulnerable class (respectively with coefficient of resistance to erosion 3.2 & 4.2), (Figure 5).

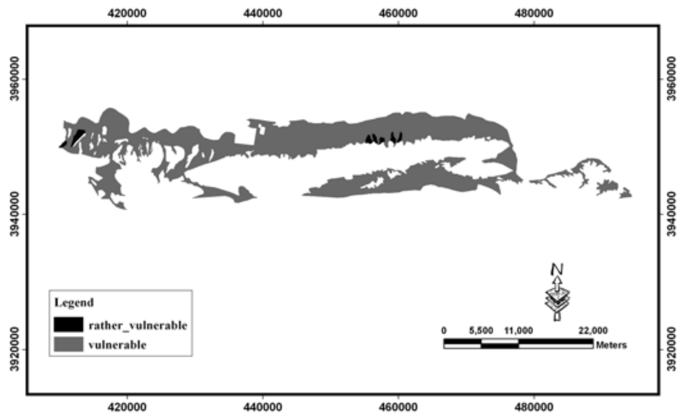

Fig. 5. Zonation map of erodibility

For Zoning of research area from viewpoint of salinity index, first sampling to be done and electrical conductivity of saturated mud of 114 samples were measured by EC-meter by ds.m^{-1} and finally classification of salinity with considering 4 classes of salinity (low (0≤ ECe <2), moderate (2 ≤ECe <4), high (4≤ ECe <8) and very high (8≤ ECe)) to be done according to USSL method (Daneshkar 2002), (Figure 6).

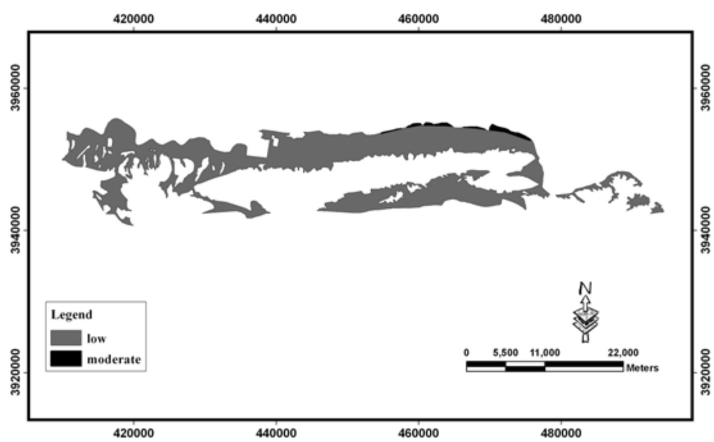

Fig. 6. Zonation map of salinity

For zonation of the area from viewpoint of index of permeability coefficient, sampling of 105 samples by brazen rings to be done and permeability coefficient of them was measured according to Darcy' s law by meters per day (m.day^{-1}) and 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}) to be done according to Bouwer classification (1976), (Figure7).

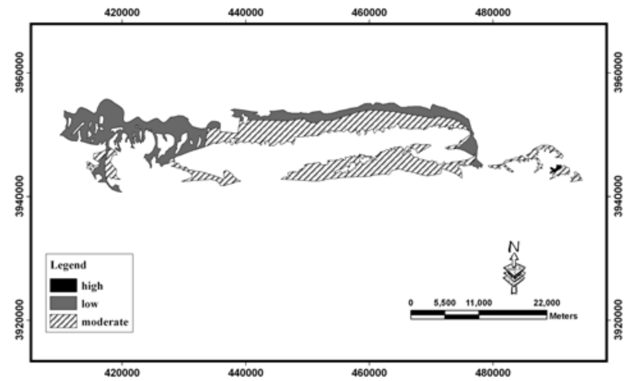

Fig. 7. Zonation map of permeability coefficient

Research area zonation from viewpoint of salinity, permeability and erodibility of soils through overlaying and cross of these three maps to be done by ILWIS 3.3 software and using cross function (Figure 8). The created maps have six units.

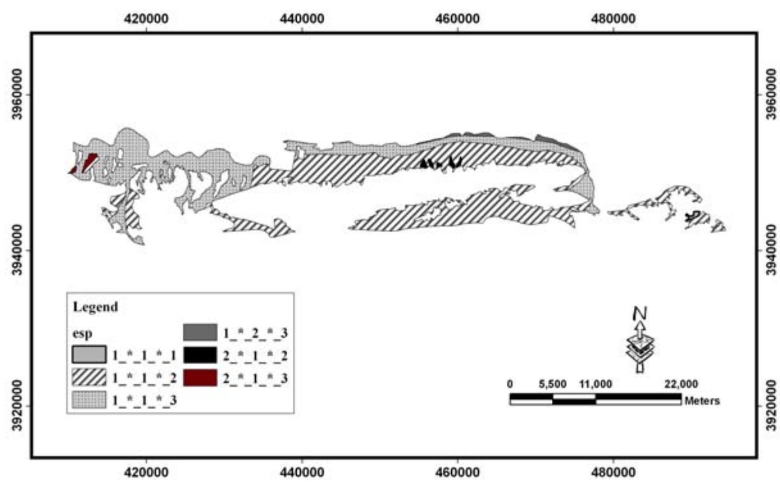

Fig. 8. Zonation map from viewpoint of three indices (erodibility, salinity and permeability of soils)

2.2.1. Calculation of quantitative amounts of indices in each unit

In this stage calculation of quantitative amounts of indices to be done in each unit, in the manner that by weight average to be done in each unit from zones that is inside it, quantitative amounts of each index were calculated (Table 2).

Table 2. Characteristics of units

resistance coefficient to erosion		salinity		permeability			
Quantitative amounts (without dimension)	Qualitative class	$dS.m^{-1}$	Qualitative class	$m.day^{-1}$	Qualitative class	Unit name	Unit number
3.20	Vulnerable	0.82	Low	149.81	High	1-1-1	1
3.20	Vulnerable	1.12	Low	57.78	Moderate	1-1-2	2
3.20	Vulnerable	1.13	Low	10.64	Low	1-1-3	3
3.20	Vulnerable	2.44	Moderate	9.47	Low	1-2-3	4
4.20	Rather Vulnerable	0.80	Low	57.80	Moderate	2-1-2	5
4.20	Rather Vulnerable	1.09	Low	10.15	low	2-1-3	6

2.2.2. Combination of information layers

In view of determination and distinguish of quantitative amounts of three indices, as determining and distinguish 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 for achieving to main result.

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 and WI= weight value of quantitative amounts

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

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

That:

$\mu(x)$ = 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 4 and 5.

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

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

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. Results of 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	0.77	0.23	0.13	0.13	3.20	Low	3-3.20	Resistance coefficient to erosion	1
II	0.61	0.39	0.25	0.25	4.20	Moderate	3.20-5.60		
III	0.11	0.89	1.10	1.10	2.44	Moderate	1.15-3.25	Salinity	2
IV	0.08	0.92	1.25	1.21	1.13	Low	0.10-1.15		
				1.21	1.12				
				1.22	1.09				
				1.30	0.82				
				1.30	0.80				
III	0.14	0.86	0.97	0.97	149.81	High	57.81-156.66	Coefficient of permeability	3
II	0.17	0.83	0.87	0.87	57.80	Moderate	10.70-57.81		
				0.87	57.78				
I	0.71	0.29	0.17	0.18	10.64	Low	0.44-10.70		
				0.17	10.15				
				0.17	9.47				

In this research used from 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).

Obtained results from a comparison of gained maps from different operators with an evidence map expresses this actual that the most appropriate of fuzzy function for zoning desertification intensity or potential in research area and similar area with that is function of 0.8 from fuzzy gamma model (gamma=0.8), (Salehpour Jam 2006).

With achieving to quantitative amounts for creating desertification potential map, functions of fuzzy algebraic sum, fuzzy algebraic product and fuzzy gamma pertaining to γ =0.8, distinguishing values, were used (Bonham-Carter, 1996).

3. Results and Discussion

After classification of obtained map from function of 0.8 from fuzzy gamma model (Figure

9), by overlaying the desertification potential zonation map with land use map, kinds of soil zones were characterized on the base of their desertification effect (Table 5).

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

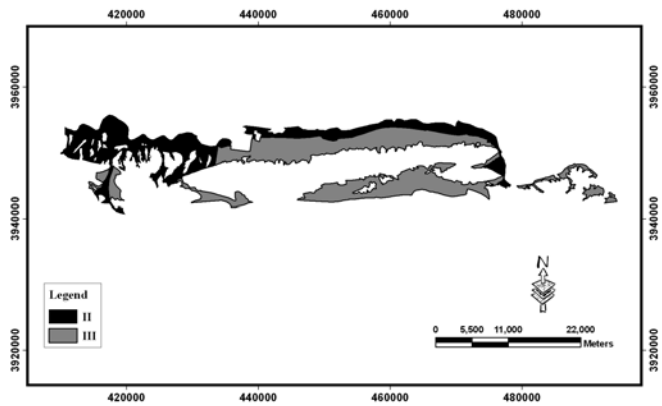

Fig. 9. Zonation map of desertification potential from viewpoint of pedological criterion from operator of γ =0.8

Table 5. Potential of soils on each unit of quaternary rock units

Class area (%)	Class area (ha)	Land use area (%)	Land use	Desertification qualitative potential	Class
43.08	16174.80	16174.80	Poor range	High	II
56.92	21370.80	1086.00	modrange	Moderate	III
		20284.80	Poor range		

4. Conclusion

This research had similar results with research of Salehpour Jam (2006) and Ghoddousi (2003).

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 cross of desertification potential zonation map from the viewpoint of the pedological criterion in study area, was obtained from operator of γ=0/8, with land use map, determined two classes of desertification qualitative potential (high 43/08% and moderate 56/92%).

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