BIABAN Journal Vol.10 No.1-1 (2005), PP.37-50

EVALUATION AND MAPPING OF DESERTIFICATION CONDITION IN FAKHRABAD- MEHRIZ REGION WITH THE ICD AND MICD MODELS

H.Ahmadi[1], E.Abrisham[2], M.R.Ekhtesasi[3], M.jafari[4], A.Golkarian[5]
1- Professor, Faculty of Natural Resources, University of Tehran. 2- M. Sc. In De -desertification. 3- Associate Professor, Faculty of Natural Resources, University Of Yazd. 4- Professor, Faculty of Natural Resources, University Of Tehran. 5- M. Sc. In Watershed management

Received : 26/12/2004

ABSTRACT

There are different models for mapping and evaluation of desertification condition, such as global FAO_UNEP model. There are also several models for evaluation of desertification in Iran. In this study, tow following methods was used:
1- ICD method, (Iranian Classification of Desertification).
2- MICD method, (Modified Iranian Classification of Desertification).
In this research, at first, these models were considered and indices and factors were improved. Then, working unit map in this region was made by geomorphologic method and land use of each working unit was determined. This map has 14 working unit. At last, evaluation of desertification condition was determined in this region by ICD and MICD methods. The results methods were:
- In ICD method, from an intensity of desertification point of view, Fakhrabad-Mhriz region is in low and medium classes. In this region the low class is about 82351 hectare (91.59%) and the medium class is about 7565 hectare (8.41%) of total area.
In MICD method, this region has four classes of calm, low, medium and high.
The calm class is about 33327 hectare (37.06%), low class is about 8346 hectare (9.28%), medium class is about 37245 hectare (41.42%) and high class is about 10998 hectare (12.23%).
According the results of this investigation and by comparing them with the condition which have been observed in the Fkhrabad-Mehriz region, the MICD is better method for evaluation of desertification condition in this region.

Keyword: *FAO-UNEP method, ICD method, Desertification, Desert region and Desertification index.*

Introduction

The study area is about 89916ha and located on 25 km southeast of Yazd city. It located on 31° 25′ 55″, 31° 42′ 46″ latitudes and 54° 03′ 02″, 54° 33′ 15″ longitudes. Fakhrabad-Mehriz basin is a part of great Yazd-Ardakan plain.

Iranian Classification of Desertification (ICD) and Modified Iranian Classification of Desertification (MICD) were selected to evaluate current condition of desertification (with emphasis on wind erosion processes) in the study area.

Although FAO-UNEP method is one of the most suitable models for assessing current condition of desertification, it has some disadvantages as follows (Jafari, 2001):

1. Lack of sufficient data in different countries for assessing desertification processes
2. Complexity of the method and indices for experts
3. Lack of acceptance of the model in different countries
4. Lack of coinciding the major and secondary processes of the model with the local and regional characteristics

5- Lack of ability to separate natural and anthropogenic factors of desertification

6- Lack of considering regional biomes of the Middle East countries including Iran

The objectives of current study are as follows:

1- Investigation of efficacy, advantages and weaknesses of ICD and MICD methods

2- Preparation of the current condition of desertification map with empasis on wind erosion in Fakhrabad-Mehriz basin

3- Determination of major and secondary factors of desertification in each region

4- Introduction of the benchmarks and indicators of desertification in the study area.

Materials and methods

Steps of desertification assessment based on ICD method:

1- Determination the types of deserts:

Several base maps of landuse and vegetation cover of the region were considered to determine natural desert landscapes and then, work unit map consists of geology, topography and geomorphology maps was prepared (Table 1).

Table 1: Classifications and symbols of natural landscapes in ICD method

Row	(Land escapes)			Symbol
1	Lands covered with vegetation	Natural vegetation	Forest	P/F
			Range land	P/R
		Forest plantations	Forest	ap/f
			Range land	ap/R
2	(Bare lands)		mountain	m/B
			Salty	s/B
			clay	c/B
			Hamada	b
			bad land	b/B
			Active sand dune	s.d/B
3	(Agricaltural land)		Irrigation	I/A
			Dry-farming lands	Ni/ A
			habitat & building	A/b

The criteria used for assessment of desertification condition include environmental and anthropogenic factors as well as desertification indicators. Within this frame work, several factors and sub-factors were considered and modified as follows:

Environmental factors contributing in desertification:

A: Climate

This factor includes two sub-factors including climate and length of drought period. In ICD method, the length of drought period is assessed by qualitative factors while in the modified model, the factor is scored using number of dry years within a drought period.

B: Geomorphology

In the modified ICD method, geomorphology was replaced by topography consisting of slope factor. Because of the reverse effect of slope on water and wind erosion and since changes of vegetation cover have similar effect on both water & wind erosion, the slope factor was classified and scored based on its effects on soil and vegetation cover establishment to evaluate its role in desertification.

C: Geology

Rock susceptibility and resistance to erosion was considered in the modified ICD method. To reduce errors in scoring, standard tables introduced by the Iranian Geological Survey were used for evaluation of rock resistance.

D: Soil and water resources

In the ICD method, this factor has two sub-factors including quantitative and qualitative limitations. These sub-factors have been scored qualitatively. In the modified ICD approach, soil parameters are evaluated quantitatively. Because of the important role of soil on vegetation cover and desertification, some other parameters of soil were considered in the modified method. So, six sub-factors for soil and two sub-factors for hydrology were introduced. In order to reduce errors, scoring was done quantitatively (Table 3).

Anthropogenic factors contributing in desertification

A- **Management**

Degradation of vegetation cover is considered as an important factor in ICD model which includes sub-factors such as shrub and trees removal, livestock grazing, reforestation and inappropriate agricultural techniques. In the modified ICD, management factor consists of degradation of vegetation cover and land resources to evaluate and score each factor separately (Table 3).

Benchmarks affecting desertification

A- Soil erosion and degradation

ICD model includes four sub-factors such as water erosion, wind erosion, salinity increase and erosion intensity. To avoid repeated scoring of erosion intensity, this sub-factor was ignored in the modified ICD model and some other sub-factors were added to it (Table 3).

B- Combating desertification feasibility

This factor includes needed measures and implemented activities. In the modified ICD model, the former sub-factor was not changed but much consideration was focused on the negative impacts of combating desertification activities. Three points should be considered in this process:

1- If there are no features of each factors in the tables of modified ICD method, the score of a given factor will be considered "Zero" (Table 3).

2- High range of scoring (0-2, 2-4, 4-7, 7-10) in ICD method was a major source of error then it was replaced by a new range of scores (0-1, 1.1-2, 2.1-3, 3.1-4) in the modified ICD model.

3- In ICD method, for the areas in which the role of anthropogenic factor on natural vegetation cover is limit, scores are not allocated and the obtained scores of the environmental factors are multiplied by two. This logic is not coincided with the reality. So, in the modified ICD, zero was given to such areas in which human has no effect on desertification. In ICD, in order to assess desertification, each factor and benchmark was given a score and finally environmental and anthropogenic factors were summed to obtain a final score for each working unit. Then, according to the standard tables which categorize different classes of desertification in each working unit (Table 2), desertification status was identified. In each working unit, the major and sub-factors which obtain the highest score, are introduced as the most effective factors and sub-factors on desertification in each working unit.

Preparation method of desertification map

All working units having similar intensities of desertification are categorized

under homogenous groups. The class of desertification intensity, natural landscape, type of desertification (anthropogenic "A" or environmental "E") and sub-factors are as follows:

Class of desertification intensity	Natural landscape of each working unit
Type of desertification (anthropogenic "A" or environmental "E")	Major and secondary factors (sub-factors) of desertification

Table 2: The classification of desertification intensity in ICD model

Desertification intensity	Score	Symbol
Slow	0-19.2	I
Low	19.2-38.4	II
Medium	38.4-57.6	III
High	57.6-76.8	IV
Sever	76.8-96	V

The stages of desertification evaluation on the basis of the modified ICD method (MICD) for Iran (with emphasis on wind erosion)

MICD method is capable to evaluate both current (current potential) and natural condition of desertification (natural potential) in a certain region. In this research, current condition of desertification in Fakhrabad-Mehriz basin was evaluated based on wind erosion processes and the final map of desertification was prepared.

According to this method, landuse classes were determined as:

1. Forest and rangeland,
2. Agricultural lands and
3. Areas with no land use.

Then, scores of each index within the working units were selected (Tables 4-6) to determine current condition as well as class of desertification. Because of difference in scales of indicators, it was not possible to use a unique classification. In this case, indicators were rescaled. Soil texture indicator (Table 5) was added while vegetation cover density and surface gravels (>2mm) for forest and rangelands were classified in a similar level.

Total score of each working unit was obtained based on the summation of scores related to each indicator which classifies and determines desertification intensity for each working unit (Table 7).

Results

The working unit map of the region was prepared using geomorphology method which includes 14 units. The results of scoring and evaluation of ICD method (level of desertification intensity, natural landscape of each working unit, type of desertification (anthropogenic "A" or environmental "E" and effective factors) are summarized in table 8 and MICD in tables 9-11.

Table 3: The modified table of ICD for natural factors of desertification

Major factors		Secondary factors		Low (0-1)	Medium (1.1-2)	Severe (2.1-3)	Very severe (3.1-4)
Climate (c)		Aridity index (i)		Semi humid (0.5-0.65)	Semi arid (0.02-0.5)	Arid (0.05-0.2)	Hyper arid <0.05
		Duration of arid years (dr)		0-1	2-3	4-5	≥ 6
Topography (T)		Forest	Slope (%) (s)	30-55	55-65	65-75	≥75
		Rangeland or no land use		15-30	30-45	45-55	≥ 55
		Farm land		5-8	8-15	15-30	≥ 30
Geology (G)		Rock resistance to erosion (Se)		High resistance (0-30)	Medium resistance (30-60)	Low resistance (60-90)	Very low resistance (>90)
Soil (S)		Texture (T)		Medium: loamy, silty, clay loamy, sandy, clay sandy	Coarse: sandy, sandy loam, loamy, sand	Fine: silty, silty clay, silty clay, loamy	Very fine: clay, sandy clay, silty clay
		Soil stability in dry condition (Co)		Stable (Vh, eh)	Medium stability (h)	Low stability (Sh, So)	Instable (Lo)
		Soil depth (cm) (d)		≤10	10-50	51-100	≥100
		Soil maturity		Soils with A, Bt and C horizons	Old soils with A1, A2, Bt, C horizons	Young soils with A and C horizons	Parent materials and C horizon
		Organic matter (%) (o)		OM ≥3	2 ≤ OM < 3	0.5 ≤ OM 2<	OM <0.5
		Salinity ECe (ds/m)		$EC_e \leq 4$	$4 < EC_e \leq 8$	$8 < EC_e \leq 16$	$16 < EC_e$
Quality of surface and irrigation water	Hydrologic factors (w)	Salinity ECe (µmoh/cm)		$EC_e \leq 250$	$250 < EC_e \leq 750$	$750 < EC_e \leq 2250$	$2250 < EC_e$
Depth of ground water table		Depth of ground water table (m) (d)		> 3	1.3-2	0.75-1.3	<0.75

Table 3: Cont.

Major factors	Secondary factors)	Low (0-1)	Medium (1.1-2)	Severe (2.1-3)	Very severe (3.1-4)
Management (M)	Overazing (gr) forest, rangeland and no landuse	Current livestock/grazing capacity < 1.5	Current livestock/grazing capacity 1.5-2	Current livestock/grazing capacity 2-3	Current livestock/grazing capacity >3
	Plough and fallow (Pl)	Plough and fallow are respected	Plough and fallow are relatively respected	Plough and fallow are inappropriate and duration is less than 6 months	Inappropriate plough and no fallow
	Lack of wind break and mulch (sh)	- Inappropriate windbreaks - Agricultural mulch with density 50% and height 30 cm	- Inappropriate windbreaks - Agricultural mulch with density 50% and height 30 cm	- Inappropriate windbreaks - Agricultural mulch with density 20-40% and height 5-20 cm	No wind breaks, agricultural mulches are harvested or grazed
	Preserve of preventive factors on soil surface (r)	- Vegetation cover (>50%) - high gravel - high crust	- Vegetation cover (25-50%) - medium gravel Medium crust	- Vegetation cover (10-25%) - low gravel - low crust	- Vegetation cover (<10%) - lack of the mentioned criteria
	Landuse charge (ch)	- landuse change of forest and rangeland into farmland, appropriate management	- low or medium landuse change - low bare lands	- high landuse change - relatively high bare lands	- very high landuse change - very high bare lands
	Shrub cutting	Annual shrub cutting (<10)	Annual shrub cutting (10-25%)	Annual shrub cutting (25-50%)	Annual shrub cutting (>50%)
	Inappropriate application of agricultural machinary	- inappropriate agricultural machinery - contour furrow	- relatively inappropriate application of agricultural machinery - contour furrow	- inappropriate application of agricultural machinery - inappropriate furrow	- very inappropriate application of agricultural machinery - inappropriate furrow

Table 3: Cont.

Major factors	Secondary factors)	Low (0-1)	Medium (1.1-2)	Severe (2.1-3)	Very severe (3.1-4)
Erosion and soil degradation (S.e)	Wind erosion (Wi)	- No sand dunes - sand deposition near shrubs (5-20 cm) - wind erosion facies on rocks and plants are not apparent	- Low active and inactive sand dunes - Sand deposition near shrubs - Nebka (20-100cm) - Relatively wind erosion facies on rocks and plants	- Active and inactive sand dunes - Nebka (1-2m) - Severely wind erosion facies and Klutak	- Active sand dunes - Large sand seas - Nebka (3-5m) - Yardang & Kalutak
	Wind speed 6 m/s (V)	<10 day per year	10-20 day per year	20-60 day per year	>60 days per year
	Water erosion (Wa)	Mechanical degradation, solution, surface and rill erosion (5-15%)	Surface and rill erosion (15-30%)	Surface, rill and stream bank erosion (30-50%)	Stream bank erosion, bad land, gully and mass movement (>50%)
	Rainfull intensity (maximum daily, 2 years return period) (P)	<10 mm	10-15 mm	15-30 mm	> 30 mm
Erosion and soil degradation (S.e)	Salinity increase and ponding (Sa)	No apparent salinity & alkalinity or ponding	Medium ponding, salinity & alkalinity	High ponding, salinity & alkalinity	Very high ponding, salinity & alkalinity
	Trampling and micro terraces	No apparent trampling and micro terraces	Medium trampling and micro terraces	High trampling and micro terraces	Very high trampling and micro terraces
Combating desertification feasibility (a.a)	Needed actions (a1)	Combating desertification is naturally possible with appropriate management	Combating desertification is possible with low cost natural measures	High cost mechanical or biologic measures are needed	De-desertification is not economic or ecologically accepted
	Conducted activities (a2)	Successfully conducted activities and no need for other activities	Relatively successful managerial activities	Managerial measures are needed but no negative effects are apparent	Negative effects of measures has accelerated desertification

Table 4: Indices used for evaluation of wind erosion in areas having no species

Type of index	Sub-indices and range of score			
	Low (0-1)	Medium (1-2)	High (2-3)	Very high (3-4)
Surface soil condition	Completely rock pavement, clay or salty crust	Relatively rock pavement (40-70%), relatively hard clay or salty crust	Relatively susceptible soil and rock, soil gravel (<40%)	Highly susceptible soil and rock soil surface gravel (<20%)
Soil disturbance because of trampling and machinery	Very low	Low	High	Very high
Duration of wind blowing (>6 m/s)	<10 days per year	10-20 days per year	20-60 days per year	>60 days per year
Wind erosion features, prismatic, klut and yardang facies	Very low - not seen	Low (<2%)	High (2-10%)	Very high (>10%)
Soil resistance on pressure in dry condition	>2 kg/cm^2	1-2 kg/cm^2	0.5-1 kg/cm^2	<0.5 kg/cm^2
Soil deposition	No sediment deposition	Sediment deposition (<2%)	Sediment deposition (2-10%)	Nebka, Rebdo and Zibar (>10%)
Soil texture	Gravely or clay	Sandy clay	Loamy sand - sandy loam	Sandy - loamy

Table 5: Indices used for evaluation of wind erosion in rangeland and forest (current condition of desertification)

Type of index	Sub-indices and range of score			
	Low (0-1)	Medium (1-2)	High (2-3)	Very high (3-4)
- Density of effective vegetation cover - Density of gravel (>2mm)	> 50% >70%	25-50 40-70	10-25 20-40	<10% <20
- Duration of plant appearance on soil surface	Yearly	> 9 months	< 6 months	< 3 months
Disturbance of soil due to livestock trampling and machinery	Very low	Low	High	Very high
Duration of wind speed higher than threshold (>6 m/s)	< 10 days per year	10-20	20-60	> 60
Wind erosion features, Klut and Yardang	Very low	Low (<2%)	High (2-10%)	Very high (> 10%)
Soil resistance on pressure in dry condition	>2 kg/cm^2	1-2 kg/cm^2	0.5-1 kg/cm^2	< 0.5 kg/cm^2
Soil deposition features	No sediment deposition	< 2%	2-10	>10%

Table 6: Indices used for evaluation of wind erosion in agricultural lands (current condition of desertification)

Type of index	Sub-indices and range of score			
	Low (0-1)	Medium (1-2)	High (2-3)	Very high (3-4)
Cultivation pattern	Orchards, permanent species without fallow	20% of the area cultivated	> 50% of area as dry forming and irrigated lands	> 80% dry forming and irrigated and orchards
Location of wind break	Tree species as wind breaks (>5%)	Some parts of the farm are not protected	> 50% has no wind break protection	> 80% has no wind brenk protection
Soil and land management	Countor furrow	Inappropriate plough low aggregation	Soil aggregation is low	Power texture and limited aggregation
Soil texture	Gravely or clay	Sandy - clay	Sandy loam - loamy sand	Loamy - silty
Management of plant residual	Plant residuals (>50%)	20-40	5-20	All residuals are collected or grazed
Soil moisture and irrigation period	Soil is always wet in field capacity level	Soil moisture is higher than wilting point	Soil moisture is lower than wilting point	Surface soil is dry and moisture is lower than wilting point
Duration of wind with speed > 6 m/s	< 10 days per year	10-20	20-60	> 60

Table 7: Classes of desertification intensity

Desertification intensity	Score	Symbol
Slow	0-5.6	I
Low	5.6-11.2	II
Medium	11.2-16.8	III
High	16.8-22.4	IV
Very high	22.4-28	V

Table 8: Analysis of processes, factors and intensity of desertification in ICD method

No. of facies	Name of facies	Type of presentation for current condition of desertification	Quantitative value of major process	Quantitative value of desertification intensity	Quantitative value of desertification index	Quantitative value of environmental factors	Quantitative value of anthropogenic factors
1	Reg and aeolian deposits (Q)	III - (b) / E - (p,co,d)	4	42.7	16.1	21.6	5
2	Reg (Ev)	II – P/R / E - S(o)	4	30.05	7.1	19.2	3.75
3	Rock exposure and stream	II – P/R / E - S(p,d)	4	33.25	7.1	22.4	3.75
4	Reg (Q)	II – P/R / E - S(p,d)	4	30.55	8.1	20.7	1.75
5	Talus and water erosion (Kt)	II – P/R / E - S(co)	4	34.33	11	19.6	3.73
6	Alluvial fan (Q)	II – P/R / E - S(o)	4	33.1	10.2	20.4	2.5
7	Rock exposure and stream (Kt)	II – P/R / E - S(o)	3	35.3	10	19.3	6
8	Reg and stream (Q)	II – P/R / E - S(o)	4	31.6	7.2	18.7	5.7
9	Rock mass (gsh)	II – B/m / E - (o,p,d)	4	34.6	9	25.6	0
10	Rock mass (Kt, pgk)	II – B/m / E - (o,p,d)	4	34.6	9	25.6	0
11	Residential areas (gsh)	II – A/b / E - S(o,co)	3	33.3	10	19.3	4
12	Residential area (Kt)	II – A/b / E - (p,d,co)	4	41.7	14.1	21.6	6
13	Residential area (Q) (Harafteh, saryazd)	III - A/b / E - (p,co,d)	4	42.7	16.1	21.6	5
14	Residential area (Q) (Mehriz)	II – A/b / E - S(o)	4	31.6	7.2	18.7	5.7

Table 9: Evaluation of current condition of desertification caused by wind erosion in forest and rangeland

8 R+A/Q	7 B+A/Kt	6 Ma/Q	5 V+A/Kt	4 R/Q	3 B+A/Ev	2 R/Ev	1 R+N/Q	No. of facies index
2	1.5	2	2	2	2	2	2	1- Length of plant resistance on soil surface
2.5	1.7	1.2	3	0.5	0.5	1	0.5	2- Soil surface gravel
1	1	1	1	1	1	1	1	3- Soil disturbance due to livestock trampling and machinery
3	4	4	4	4	4	4	4	4- Duration of wind blow higher than threshold velocity
2	1.5	2	2	2	2	2	4	5- Wind erosion effects on soil and other Aeolian features
0.5	1	1	1	1	1	0.5	1.5	6- Soil resistance on pressure in dry condition
2	2	2	2	2	2	2	4	7- Features of sand accumulation
13	12.7	13.2	15	12.5	12.5	12.5	17	Total scores
Medium	Medium	Medium	Medium	Medium	Medium	Medium	high	Desertification intensity

Table 10: Evaluation of current status of desertification caused by wind erosion in lands lacking land uses

Index	Facies number	
	9 (T/gsh)	10 (T/Kt)
1- Soil Surface status	0.5	0.5
2- The evidences caused by livestock trampling and machineries	0.5	0.5
3- The contionus speed wind flow (10 meters above the ground)	3	3
4- The effect of wind erosivity and appearance of different geological	0	0
5- The soil resistance in aridity situation	0	0
6- The evidence of soil accumulation	0	0
7- Soil texture	1	1
Total score	5	5
Intensity of desertification	Slow	Slow

Table 11: Evaluation of current desertification status caused by wind erosion

Benchmarks	Facies number			
	11 (M/gsh)	12 (M/KT)	13 (M/Q)	14 (M/Q)
1- Cultivation patterns around arable lands	1	1	2	2
2- The status of windbreck around farms	1	1	3	3
3- Land and soil management	1	1	1	1
4- Soil texture	1	1	2.5	2.5
5- Crop residue management	1	1	4	4
6- Soil moisture and irrigation frequency	1	1	2	2
7- Continiousness of wind flow with high speed	4	4	4	4
Total score	10	10	18.5	17.5
Intensity of desertification	Low	Low	High	High

The figure 1 and 2 show the maps of desertification condition using ICD and MICD methods, respectively in Fakhrabad-Mehriz region.

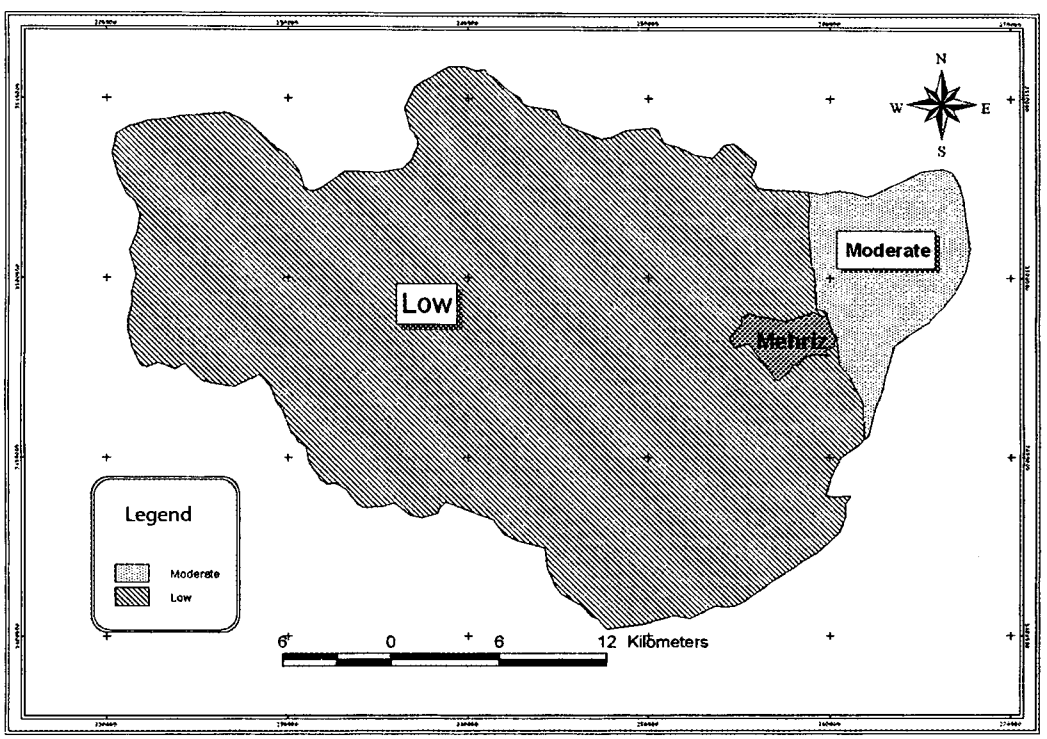

Figure 1: The current desertification status map prepared by ICD method (Fakhrabad-Mehriz basin)

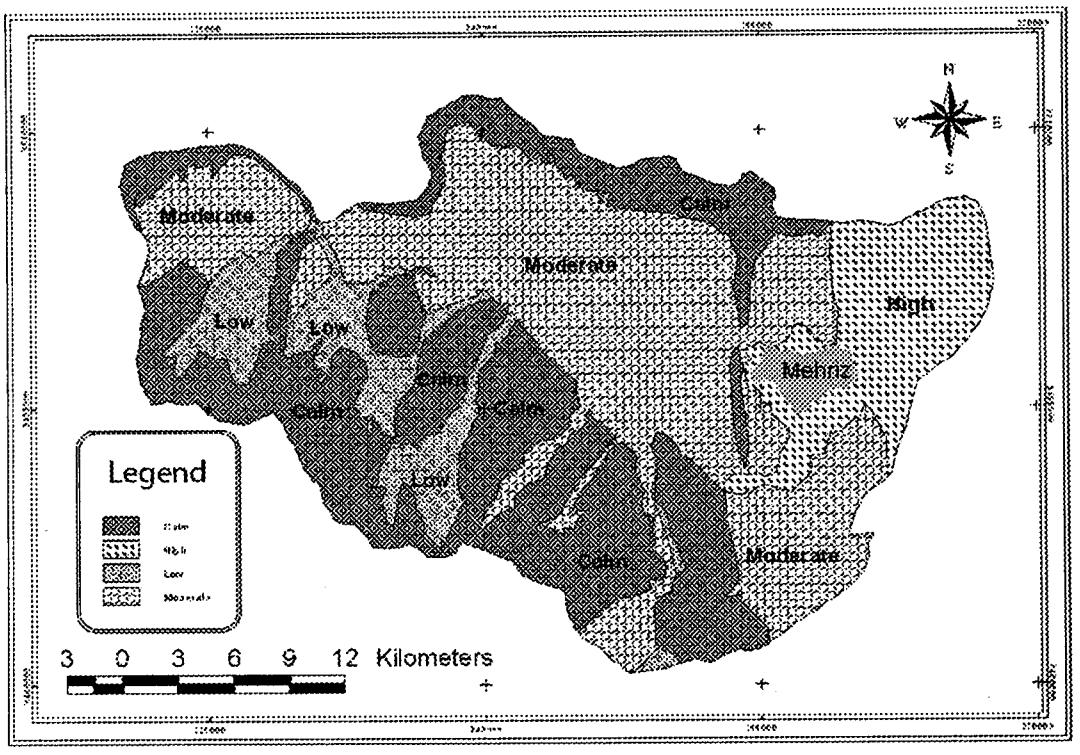

Figure 2: The current desertification status map prepared by MICD method (Fakhrabad-Mehriz basin)

Discussion and conclusion

Based on the results of current study, ICD has the following advantages:

1- It is in accordance with Iran conditions

2- It easily determines the type of factors including anthropogenic and environmental ones contributing in desertification for future planning

The method has also limitations as follows:

1- Qualitative - based scoring of some indicators decreases the accuracy of the model

2- High range of scores of different classes causes differences in opinions among experts

3- A variety of factors and their interactions decrease effectiveness of the model

4- Some factors of ICD model are scored repetitively

5- The natural factors in areas having no vegetation cover are scored twice.

This study attempts to solve the mentioned limitations. Based on the results, the study area was classified in low and medium categories. About 82351 ha (91.59%) of the area has low class of desertification while 7565 ha (8.41%) is in medium class.

MICD has the following advantages:

1- Selection of indicators for desertification is based on type of land use.

2- In the modified method, desertification intensity is assessed separately with emphasis on processes. Only, the factors are evaluated which are effective. To avoid interactions of different factors, other ones are not assessed.

3- The number of indicators used for different landuses are not the same. To resolve this problem, all indicators were balanced.

Based on the results of MICD method (with emphasis on wind erosion processes), the study area covers following conditions:

1- Slow; 33327 ha (37.06%)

2- Low; 8346 ha (9.28%)

3- Medium; 37245 ha (41.42%)

4- High; 10998 ha (12.23%)

The comparison of the results showed considerable differences between two methods. ICD method categorized the area in two classes while MICD showed four classes. The reason is due to interaction among different factors in ICD method which underestimates desertification intensity. In water erosion model, it is possible to compare the predicted values with the recorded data but in assessment of desertification, the results of the model must be compared with the current condition of the area. Therefore, the results showed that MICD model is more appropriate for evaluation of desertification in this region.

References

1- Ahmadi, Hassan, 1998. Applied Geomorphology. Vol.2: Desert wind erosion, Tehran University press.

2- Babaev, A.G.Orlovsky (1993). Assessment and Mapping of Desertification Processes, a Methodological Guide Ashkhabad.

3- Ekhtesasi, Mohammad reza, Mohajeri, Saeed, 1995. Method of classification for type and intensity of desertification in Iran.

4- FAO-UNEP (1984). Provisional Methodology for Assessment and Mapping Of Desertification, Rome.

5- Jafari, Reza, 2001. Evaluation and preparation of desertification using ICD and FAO-UNEP methods in Kashan (wind erosion - water resources degradation. MSc thesis, Tehran University.

6- Jafari, Mohammad, Sarmadian, Fereydoun, 2003. Foundamentals of soil science and classification, Tehran University press.

7- Jazirei, Mohammad Hossein, 2000. Forestation in arid ecosystems, Tehran University press.

8- Meshkat, Mohammad Ali, 1998. A temporal method for evaluation and mapping desertification (translated, forest & rangelands Research institute, Iran.

9- Zehtabian, Gholam Reza, 2000. Desertification and it's controlling methods (class notes), Tehran University.