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Assessment of Tasoki-Rigchah critical area in wind erosion production in Sistan plain

Alireza Shahryary[*1]

[*1] *Faculty of Natural Resource, University of Zabol, Zabol, Iran*

Abstract

In order to determine the source and critical areas of wind Erosion, Sistan Plain, IRIFR-E.A method was applied. According to geomorphological investigations, the studied area consists of the following two main units namely: Pediment with 1 type and 8 geomorphological facies, and playa with 2 types of flatland and desert type that includes 9 geomorphological facies. On the basis of sediment, the facies in piedmont were divided into 3 groups so that, 2 facies (1-1-4, 1-1-3) have sediment delivery by 500-1500 tons/km²/y while, 4 facies (1-1-2, 1-1-8, 1-1-11) have 1500-6000 tons/km²/y sediment delivery, and 3 facies of covered pediment (1-1-5, 1-1-6, 1-1-7) have more than 6000 tons/km²/y sediment delivery. Therefore, the mean sediment delivery of piedmont (covered pediment type) is about 5500-39000 tons/km²/y. In playa unit, four facies (2-1-4, 2-1-5, 2-1-6 and 2-1-8) have 500-1500 tons/km²/y sediment load and three facies (1-1-2, 2-1-3, 2-1-7) carry 1500-6000 tons/km²/y, and two facies (2-1-2, 2-2-1) have more than 6000 tons/km²/y sediment load and total sediment load is 8000-30000 tons/km²/y. Morphoscopic study and investigation of the relationship between sediment grain diameter (D) and transport distance in 18 cases, it was shown that all samples except of one, transport distance is 5-20 km. Therefore the source of sediment is close to the sedimentation area. Dominant and erosive winds in the study area are from North and NW. Also due to drought, the erosive winds carry a considerable amount of sand especially during the summer and spring seasons and it has been intensified considering that, Hamoon and Hirman Rivers are dry.

Key words: Finding source areas, IRIFR-E.A method, Drought, Wind sediments, Morphoscopy, Facies

Introduction

Currently in Iran, about 13 million hectares of covered lands are as sand zones and dunes of which 5 million hectares are active and semi-active sand dunes (Ekhtesasi, 1996), and movement of these dunes and occurrence of dust storms cause drastic damages such as economic, social, industrial and environmental damages. Considering that, consolidating of flowing sand is an interim fight way and is not efficient for long-term. If the source area is not controlled, the issue of wind erosion and sand dune forming still remains, and since, erosion control in in transport and sedimentation areas is more difficult and costly than source areas (Ekhtesasi et al., 1996), the importance of determination of source area becomes clear. Sistan region as delta and alluvial plain of Hirmand River, is always faced with very difficult climatic conditions and numerous natural and unnatural problems such as low annual precipitation (59.6 mm), severe difference between cold and warm seasons temperature and even during a day, high evaporation (4820 mm), saline and alkaline lands, erodible soil and occurrence of winds with a speed greater than soil erosion threshold speed, which have faced the people life with risk. Drought occurrence in the recent years also has increased the severity of life limiting factors and has made the people and natural resources of Sistan region to be seriously considered.

Materials and methods

Characteristics of the study area

The study area is located in southeast of Sistan region and 90 km far from Zabol city. The region elevation above sea level is 474 m, and Shile River which has been generated from the end of Hamoon Lake and is thrown into Godzereh in Afghanistan, passes this region. General slope of the region is 5%. Critical area of Tasoki and Rigchah is in the southeast of Sistan with an area by 131660 ha at geographical position of 30^{0} 0′ 51″ of southern latitude and 30^{0} 37′ 36 ″ of northern latitude, and 60^{0} 54′ 42″ of western altitude and 61^{0} 12′ 47″ of eastern altitude (Fig. 1). In the studies about investigating critical areas of wind sediment Method of tracking the origin of sand dunes in Iran (Ekhtesasi- Ahmai I.R.RFR.E.A) was used. This method is an integrated and practical method in determination of source area of wind sediments and has been tested in various parts of Iran, and nowadays, it is known as an international method. This method is conducted within two stages:

1. Orientation of the source area including: 1) Collecting the region information through local questionnaire. 2) Investigation and comparison of aerial photos and satellite images. 3) Investigating morphology of the region sand dunes 4) Investigating the wind regime and identification of the region prevailing winds.

2. Locating critical areas of sediment source including: 1) Study of geomorphology and facies identification. 2) Surface soil sampling from geomorphological facies. 3) Mineralogy of samples and evaluation of the genetic relation. 4) Morphoscopic evaluation of the samples.

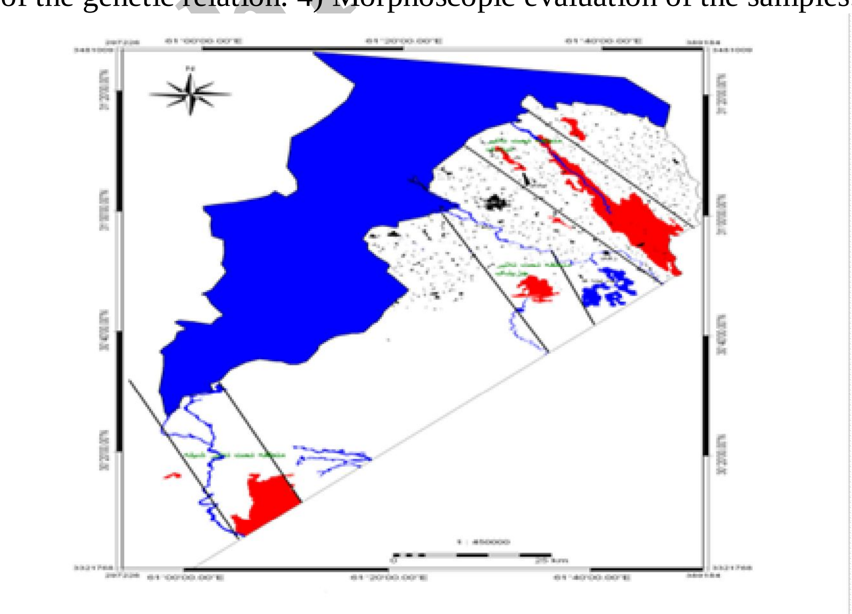

Fig. 1. Position of wind erosion critical areas of Sistan plain

Results

Orientation of source area

Determination of the main direction of critical points for sediment generation is the main purpose in this stage including the following stages:

Collecting local information through questionnaire

In order to use local information and their consistency with meteorological data about intensity and time of dominant and erosive winds and sand storms, a questionnaire was designed and filled there. The questionnaire was filled and analyzed in the study area which was attacked by flowing sands and it was concluded that:

The main winds have northern and northwestern directions and begin since May and last to September. Sand storms blow usually from the north and northwest and have occurred before drought period (1998-2004) during 120-day winds. But, winter winds with one week blowing time per year, have been along with dusts and sand. The storms color is brown but, if the wind is intense, its color is yellow to red. 68% of residents of Hamoon River dry bed, 21% of abandoned lands people, and 11% of the people have considered the drought and pastures degradation as the main reasons of sandstorm occurrence.

Evaluation and comparison of aerial photos and satellite images in different periods

For identification and determination of general direction of organ expansion and also, separation of geomorphological facies, aerial photos by 1:20000 of 1966 and Landsat 2005 satellite images (TM sensor) were used which showed general expansion of dunes by 330^0. Therefore, organ expansion of the region represents erosive winds in directions of north to northwest.

Evaluation of the region sand dune morphology

Conducted evaluations of satellite images and topography maps and field visits showed that, the sand dunes are among new and active sand dunes of Iran. The major morphology found in Tasoki and Rigchah, Seyf o Silak are transverse or linked Barchans. Therefore it can be said that, existence of Barchan and other forms of sand dunes represents a dominant and erosive wind in the region. These Barchans are currently active and all their formation conditions exist in the region which represent their mobility and existence of intense wind erosion. Sand dunes can be observed as incomplete and complete Barchans and also, transverse dunes. Morphology of small and big sand dunes represents north and northwest direction of dominant and erosive wind. Also, investigation of the region nebkha showed dominant and erosive win of the north to northwest because, sand expansion behind the shrubs, trees, bushes and all living and non-living barriers represent dominant wind of the north and northwest in the study area. Height of some sand dunes of the study sometimes reaches to 14 m.

Investigation of wind regime and identification of erosive dominant winds affecting wind erosion

Intensity, duration and speed of the region winds:

To investigate wind intensity, duration and speed, available data of Zabol synoptic station data since 1963 to 2002 were used. According to this data, maximum wind speed is in June by 21.2 m/s and its minimum is in December by 0.3 m/s. The maximum wind variation coefficient is in

February by 55.2% and its minimum is in July by 20.7%. Study of monthly wind speed regime showed that, speed trend is ascending since January to July and it becomes descending until December. Time series of mean annual wind speed indicate wind speed variations trend and gradual increase of wind speed in long-term. Also, the maximum mean annual wind speed is for 1984 and its minimum is in 1963. To determine return period of maximum annual wind speed, different statistical distribution was used and accordingly, it can be expected that, maximum wind speed with return period of 2 years is 19.22 m/s, 50 years is 37.33 m/s and 100 years is 41.4 m/s. Wind regime of the region was computed according to Table 1 and considering long-term statistical period to determine dominant winds.

Table 1. Weather wind regime, dominant direction and wind speed in synoptic station of Zabol (1972-2002)

Wind speed (km/h)		Wind speed (m/s)		Main dominant wind			Month
The most intense winds	Mean speed	The most intense winds	Mean speed	Blowing percentage	Direction	Calm weather percentage	
114.7	15.9	62	8.6	31.7	NW	37.3	October
96.2	9.3	52	5	21	N	58.6	November
83.3	6.7	45	3.6	17	N	95	December
90.7	8.2	49	4.4	20.2	N	58.8	January
144.3	10.4	78	5.6	24.1	N	50.2	February
125.8	11.9	68	6.4	25.5	N	43.3	March
94.3	13.3	51	7.2	26.5	N	39.3	April
107.3	20.38	58	11	39.2	N	25	May
144.3	29.2	78	15.8	43.2	NW	11	June
148	34.4	80	18.6	50	NW	4	July
107.3	33.7	58	18.2	50.2	NW	3.7	August
107.3	26.6	58	14.3	43.3	N	15.9	September
148	18.2	80	9.9	31.7	NW	34.3	Annual

Direction of dominant wind is northern during 8 months, and for the other 4 months it is northwestern. Dominant wind speed which blows in June, July, August and September is 26.6-34.4 km/h. Minimum wind speed is 6.7 km/h in December and the most intense wind is in July, 1979 by 148 km/h.

Investigation of geomorphology and identification of geomorphological facies with emphasizing on wind morphodynamic

In this regard, 1:50000 topography maps of year 2000 were prepared for the study area, and Tasoki-Rigchah region was determined on the maps, and the, it was transported on aerial photos of year 1345, and units, types and geomorphological facies were separated using stereoscope. At the next stage, slope and morphology maps of the region were extracted from topography map, and then, geomorphology map was produced by combining the provide maps and geology map, and ultimately, the separated areas were modified by field visits and GPS. The study area has two units, three types and 17 morphological facies. Pediment unit has a covered pediment type and playa unit has two geomorphological types including clay plain and desert. The study area consists of 17 geomorphological facies and includes source, transport and deposition areas that are different in terms of wind erosion quality and quantity and erodibility of facies. Erosion intensity and class, erosion quantity (annual sediment yield) were computed in each facies according to the presented method by Ekhtesasi and Ahmadi (IRIFR. E. A) and considering obtained scores.

Table 2. Determination of erosion class and estimation of land sediment yield relative to wind erosion by empirical method

Sediment yield (tons/km^2/year)	Total score	Erosion quality	Erosion class
<250	<25	Very low	I
250-500	25-50	low	II
500-1500	50-75	Moderate	III
1500-6000	75-100	high	IV
>6000	>100	Very high	V

In this study, critical areas and sand dunes activity are divided into three groups which have been shown in the map.

Discussion

According to Table 2 it is found that, amount of produced sediment in 11 taken samples inside geomorphological facies is more than 200 tons/ha/year. Therefore, it is concluded that, all lands of the study area have particles smaller than 0.84 mm or 840 microns. The main part of these regions is located inside Hamoon of Southern Hirmand, Shileh River and its branches and bare land and salt-bloated land without vegetative cover. On the other hand, according to Table 3, mean particles diameter of all taken samples shows a transport distance by 5-20 km. Only one sample (No. 9) with mean particles diameter by 242 microns shows a transport distance by 20-50 km. Dominant and erosive winds of the region with direction of north toward the northwest and with 340-360 ^{0} are the main and most damaging winds in the region. In current conditions and drought, these winds displace sand particles during the year but, sands movement reaches its peak in spring and summer that causes sand storms in the region and damages the biological and economic resources. Conducted investigations show that, there is a very close genetic relationship between sediments of source area and sand dunes sediments. Evaluation and comparison of genetic relation of the sediments in source areas and sedimentation (deposition) of taken samples indicated that, the samples include Quartz, calcite, clay, biotite, gypsum, obsidian, muscovite, orthoclase, chlorite respectively. Fine sediments of Hamoon river bed have been deposited during time. Nowadays, Hamoo Hirmand Lake bed is one of the most important source areas in the region since, it has become dry, and at the next stage, bare lands without vegetative cover and saline lands Shileh River bed are considered as the source areas. On the other hand, diameter of carried particles represents local source area and the maximum transport distance is estimated by 5-50 km (Table 3).

Computation of sediment yield and erosion intensity in the source area:
As it is seen in Table 4, the range of sediment yield varies from at least 500 to more than 6000 tons/km/year. Also, soil loss intensity has been placed in three ranges of moderate, high and very high (Q1, Q2, Q3) (Map 3).

Computation of sediment yield and erosion intensity in sedimentation area:
As it is presented in the results of investigations, the range of sediment yield varies from at least 500 to more than 6000 tons/km/year, and sedimentation activity is as active and semi-active (S1, S2).

Table 3. Relationship of soil erodibility and frequency of particles smaller than 0.84 mm based on wind with speed by 20-25 m/s at a height of 1m

Percentage of particles smaller than 0.84 mm	20>	20-50	50-70	70-80	80<
Erodibility (tons/ha/year)	4<	4-84	84-166	166-200	200<
Tons/ha/h	.5	.5-1.5	1.5-5	5-15	15

Score of the factors affecting wind erosion by IRIFER method (Non-agricultural lands)										Facies code
Total scores of facies	Land use and management -5-15	Type and distribution of wind depositions 0-10	Soil surface moisture 0-10	Effects of soil surface erosion 0-10	Vegetation cover intensity -5-15	Soil and surface cover -5-15	Wind speed and situation 0-20	Landform and topography 0-10	Lithology 0-10	
78	10	4	7	11	13	5	15	6	7	1.2.3
81	12	4	4	15	8	7	16	7	8	2.3.2
50	10	4	4	3	3	2	15	8	5	3.3.2

74	12	4	5	10	6	6	17	8	6	4.3.2
110	13	10	8	18	12	14	18	9	8	5.3.2
121	14	10	8	20	15	15	20	10	9	6.3.2
106	14	9	7	18	14	11	18	8	7	7.3.2
86	11	8	7	15	5	11	16	7	6	8.3.2
77	11	6	7	17	10	13	15	7	6	1.1.3
102	13	7	8	13	13	13	17	9	9	2.1.3
97	10	8	8	17	11	11	17	7	8	3.1.3
74	9	4	6	10	13	7	10	8	7	4.1.3
43	7	2	4	2	4	5	7	7	5	5.1.3
64	7	4	4	5	11	7	10	9	7	6.1.3
87	11	2	7	15	11	11	15	9	6	7.1.3
57	8	6	3	5	6	5	13	6	5	8.1.3
108	14	7	6	16	15	13	18	10	9	1.2.3

Table 4. Score of the factors affecting wind erosion by IRIFER method

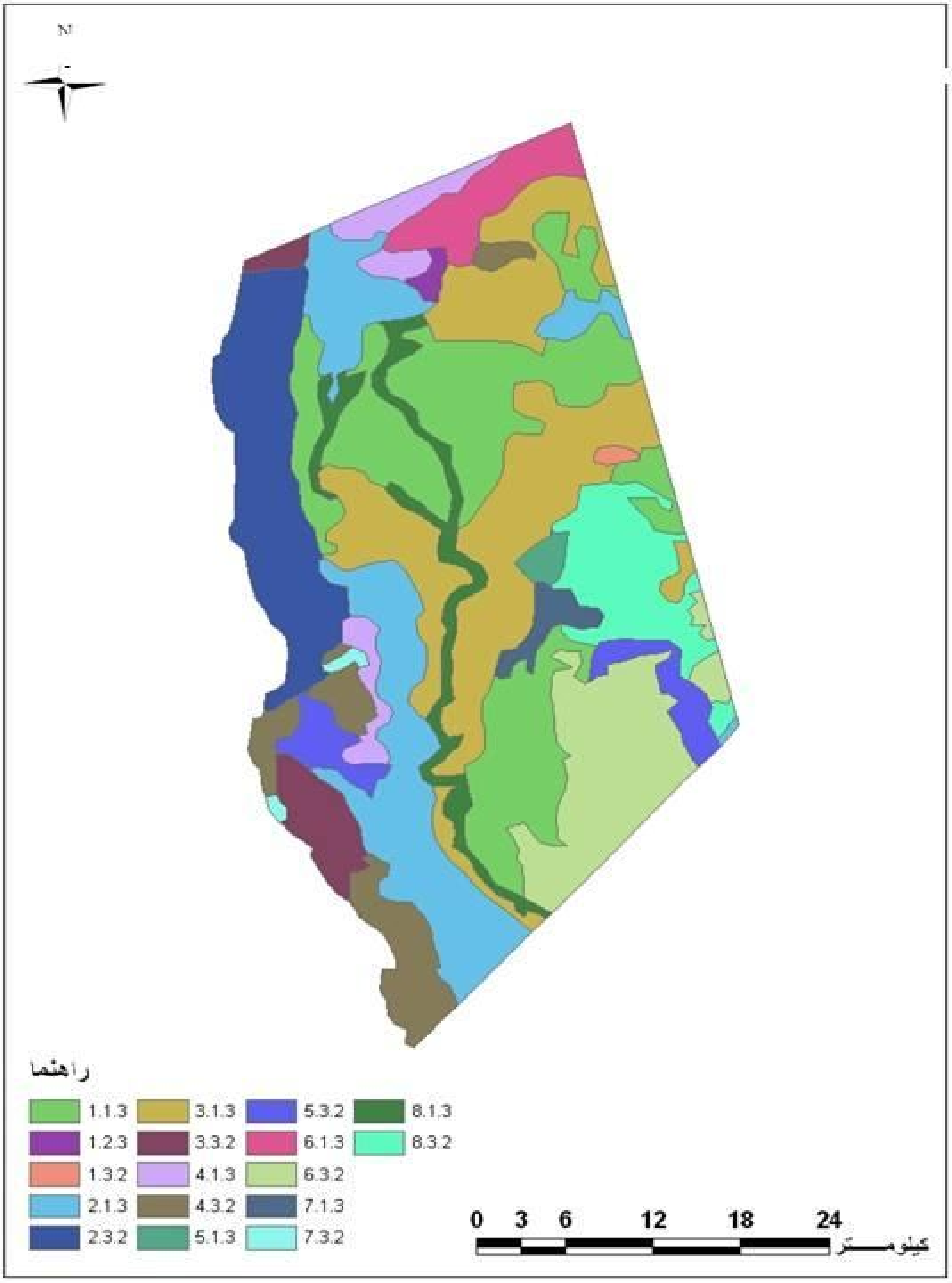

Fig. 2. Geomorphological facies in the study area

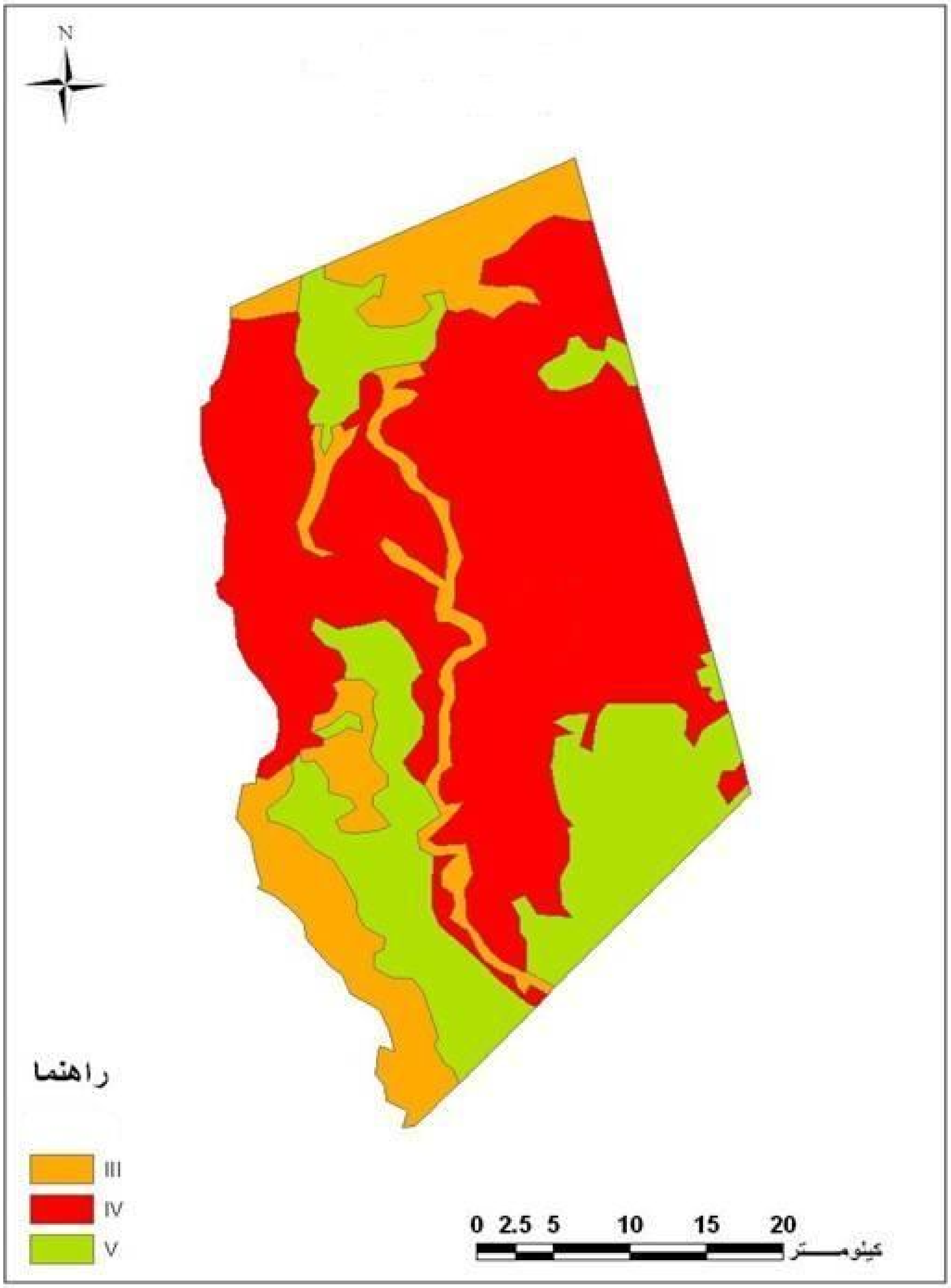

Fig. 3. Study area considering the facies sensitivity to wind erosion

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