

Use of Anemometric Results and Threshold Velocities for Determination of Proper Regions Where Sand Storms are Generated (Case Study: Around the Synoptic Station of Yazd)

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Received: 19 August 2007; Received in revised form: 12 October 2009; Accepted: 27 October 2009

Abstract

In order to recognize the wind erosion situation of a region, the survey of its windiness is not sufficient and the physical characteristics of earth are of importance too. In fact, the outbreak of dust storms in a region is due to the sensitivity of earth and domination of wind in that region. In this investigation we have tried to find a way for determining the regions in which a dust storm is generated. In addition to wind rose that determines the windiness of a region, we have used another graph with the name of storm rose. With this new graph we have tried to find a relationship between the earth surface situations (threshold erosion velocity) and windiness of a region, so that we can reach a more suitable analysis for wind erosion. Studies made in the region show that where the threshold velocity less than 8 m/s (16 knots) is, the land is susceptible for erosion and thus has an important role in generation of dust storms. With the Storm roses drawn, it was also distinguished that most of the dust storms evolved in the region have the directions between west and northwest. So if we want to lessen the damages of flying dust and particles on Yazd city, we should stabilize the dust in the above-mentioned direction and bring them under control.

Keywords: Wind rose; Wind storm; Wind erosion; Threshold velocity; Facies; Dust storm; Yazd-Ardakan plain; Pediment

1. Introduction

One of the difficulties of deserts and brackish grounds (Kavir) are dust storms that cause visible and invisible damages in these areas. As an example, the inhabitable area of Yazd is between 7 to 8 thousand hectares and

every year 20 thousand cubic meter dust settles on its surface area, which causes damage to the inhabitants from various aspects. (Ekhtesasi, 2002)

Table 1 shows some of the damages caused by dust in the cities Yazd, Ashkezar, Zarach and Meibod.

Table 1. Damages caused by dust and dusty air in the cities Yazd, Ashkezar, Zarach and Meibod. (Alavi Panah et al., 2)

Type of damage	Amount (Billion Rials/yr)
Damages to office and residential buildings and transport vehicles	12
Damages to electronic instruments and weaving and electronic machineries	6.4
Respiratory and ophthalmic diseases of people and domestic animals due to dusty air	4.8

Recent studies done in Iran show that, more than 82 towns and 164 regions of Iran are under

the covering of erosive storms. 19.7 million hectares of Iran is confronting such a problem. 12.7 million hectares is where dust is picked up, 2 million hectares is where sand is transported, and 5 million hectares is where dust is precipitated and dust and sand hills and deserts are generated. 178 critical centers have been

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discovered in the country where wind erosion has caused economical and inhabitation damages. The surface area of these centers is 6.4 million hectares (Ahmadi, 1998).

In this article it has been tried that with the analysis of data's gathered from anemometric stations and with attention to threshold velocity in various faces, find a method to discover the regions that are susceptible to generation of flying dusts. It is worth mentioning that generation of dust in a region does not limit itself to places that are sensitive to erosion. Wind in its course, when reaches a place that is sensitive to erosion, picks up a considerable

amount of sand and dust and transfers them to another place in its route.

2. Data and Methods

2.1. Introduction of the region under study

The region under study has an area of 1563 square kilometres and covers Yazd city and its surroundings and the sand hills in the area. This region has the form of a rectangle and is between the longitudes of 54° 08' and 54° 39' and latitudes of 31° 45' and 32° 03'. Figure 1 shows the location of the region under study.

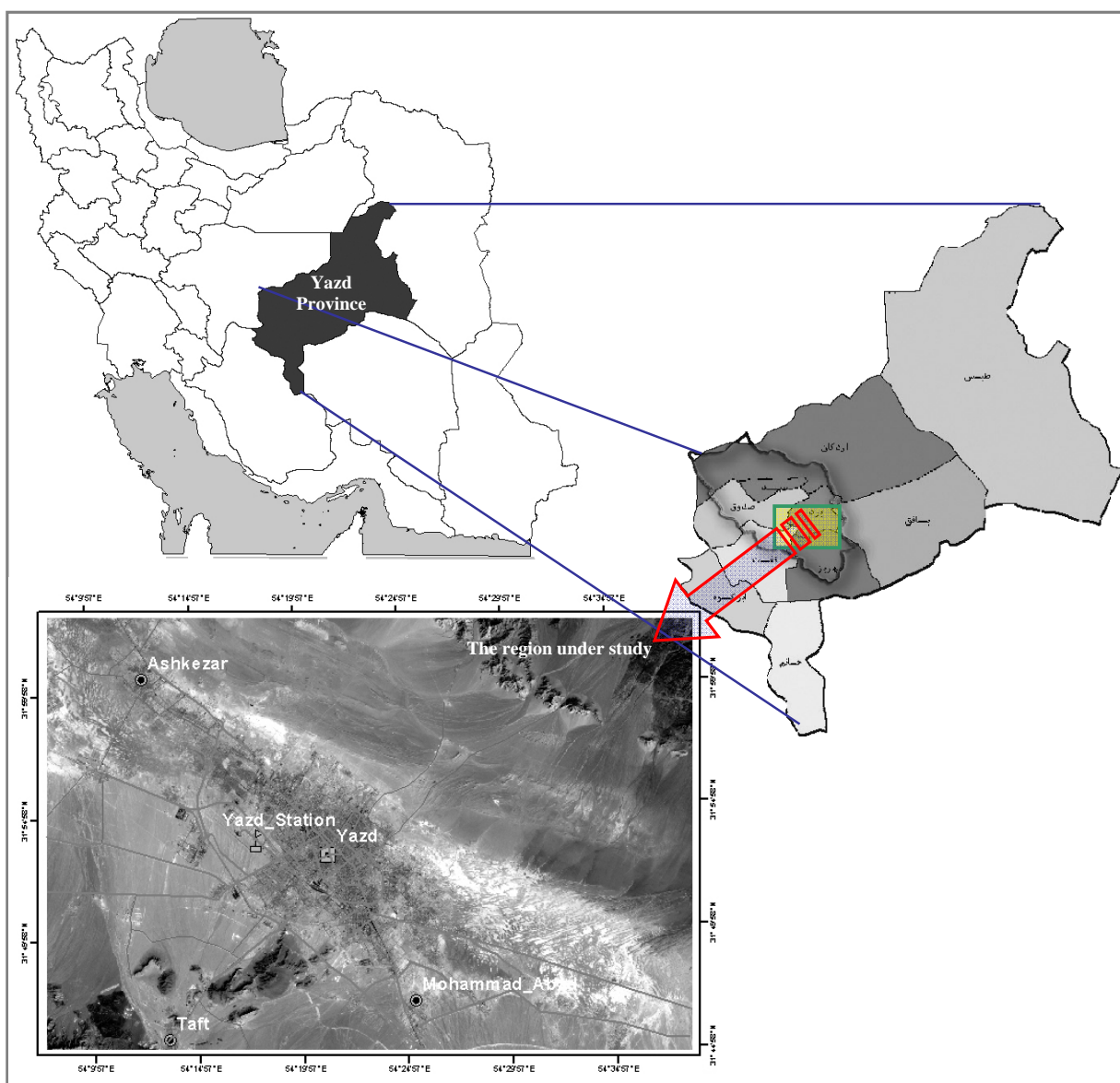


Fig. 1. The location of the region under study

2.2. The Methodology

Various steps for determination of places that are effective in generation of dust storms are presented in a flow chart in Figure 2. As shown in the rotating graph, for preparation of the drawing of the places susceptible to dust storm we need to have suitable anemometric data's in a suitable span of time, the drawing of various morphological faces, and the threshold velocity of each face. When we have gathered these

pieces of information we are able to draw the storm roses of every face, and by having the storm roses of every face we can prepare the plan of the places that generate dust storm.

For the analysis of anemometric data and wind blowing conditions, use has been made of the data's that have been prepared in the span of 20 years, that is from the year 1982 to the year 2005 and for the preparation of the map of the Geomorphological faces satellite images ETM+ of the year 2002 has been used.

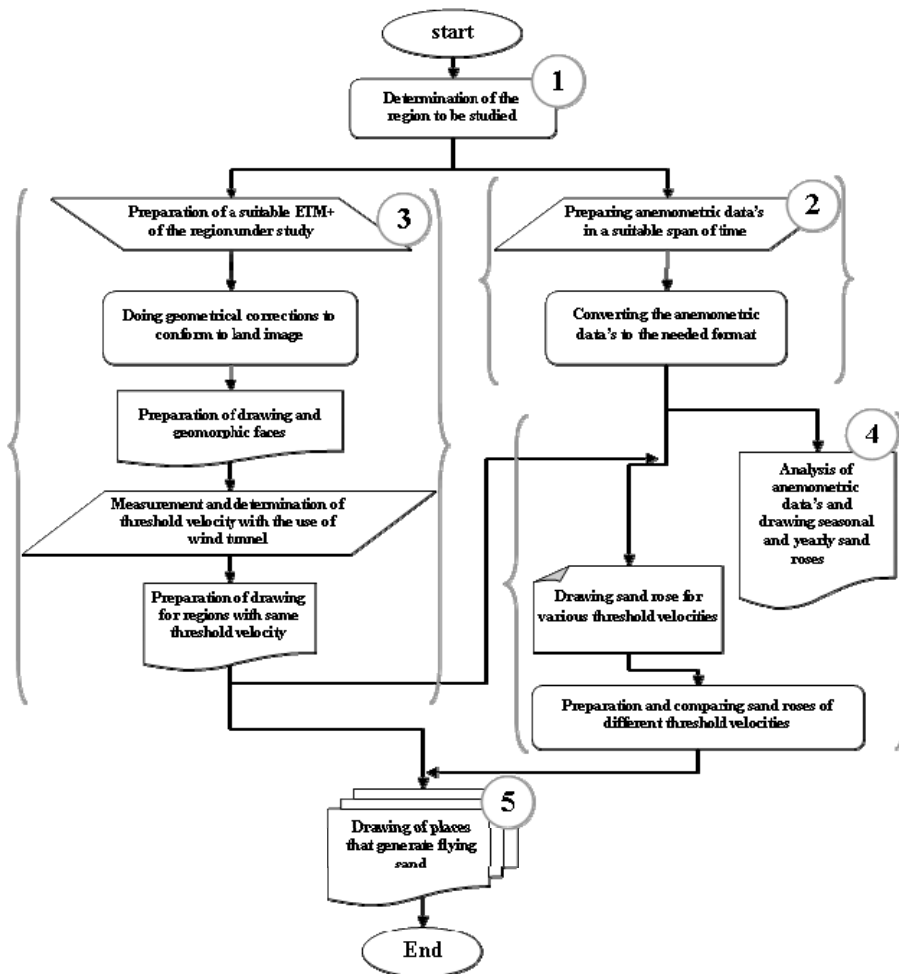


Fig. 2. Investigation method and various steps of study

3. Results

3.1. Analysis and Drawing of Seasonal and Yearly Wind Roses

Figure 3 shows the seasonal and yearly wind roses of the anemometric station of Yazd and shows the direction, velocity, and frequency of

the governing winds of the region under study. The yearly wind rose of the region shows that 36, 14% of the prevailing winds have a velocity of less than one knot. These winds are called gentle winds and in drawing of wind roses they have been ignored.

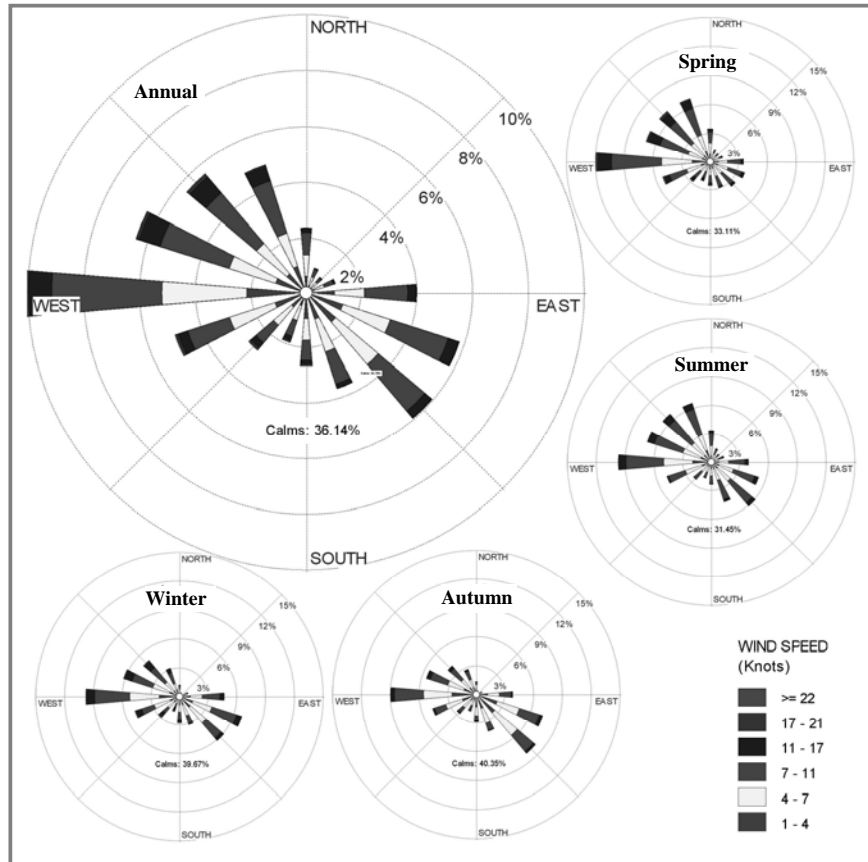


Fig. 3. Seasonal and Yearly Wind Roses of the Synoptic Station of Yazd

The seasonal wind roses of the region show that the most frequent winds in the four seasons of the year have west directions (Figure 3). With comparison of the wind roses of the spring and summer we see that in both seasons, the most frequent winds have west to north-west directions. The winds of winter and autumn are similar and the most frequent ones have west and then south-east directions.

Looking at the yearly wind roses we see that the most governing winds of the region have their direction from west to northwest. These winds have velocities of 4 to 11 knots and are the most frequent ones in all directions. 42% of all of the winds fall in two classes of 4-7 and 7-11 knots. Therefore the winds faster than 11 knots consist 6.2% of all of the winds. The frequency and intensity of the winds in the region is even less than this percentage (Table 2).

Table 2. Statistical wind velocities and directions of the synoptic station of Yazd

yearly	Autumn			summer			Spring			Winter		Statistical particulars	
	Dec.	Nov.	Oct.	Sep.	Aug.	Jul.	Jun.	May.	Apr.	Mar.	Feb.		Jan.
58440	14737			14734			14563			14457		Watching Time(hr)	
	4977	4817	4977	4816	4975	4977	4809	4972	4816	4977	4497	4977	
	W,SE, ESE			W,WNW,NW			W			W, ESE		Direction of wind	
W	W	W	W	W	W	W	W	W	W	W	W	W	
	SE	SE	SE	SE	NW						ESE	SE	
	3.74			4.92			5.18			4.46		Average velocity (knot)	
4.57	3.84	3.54	3.82	4.22	4.87	5.65	5.08	5.43	5.02	5.0	4.56	3.85	
36.14	40.35			31.45			33.1			39.7		% Calm	
	40.0	42.3	38.8	35.94	32.01	26.55	32.76	31.66	34.94	63.3	39.2	43.4	

According to Table 2, the most frequent winds of all of the months of the year that have been registered in Yazd Station have west directions. These are local winds that blow from

the direction of the local mountain to desert, better to say, they are blowing from the heights of Shirkuh toward Yazd plain. There is a channel of wind in the west that channelizes the

winds that come from Isfahan toward this region and is called Isfahan winds. In addition to west winds, we witness also winds that blow between the months September to February in south-east direction too. These winds are called Kerman winds.

3.2. Preparation of Map of Faces and Determination of Threshold Velocity of each Face

To determine the erosion threshold velocity use has been made of wind tunnel. The reason of using such a method, in comparison with other experimental procedures, is its low cost

and rapidity of performance and its moderate preciseness in predicting the threshold velocity Ekhtesasi, 1994).

As shown in Figure 2, for determination of threshold velocity the drawing of geomorphic faces of the region should be in our access. To get this, use was made of satellite image ETM+ that has a place segregation (focusing) power of 30 meters. The images used have been taken in the year 2002. After geometrical correction and after conforming of the image to the location, and site visit and visual evaluations (Hybrid Method), the drawing of the geomorphologic faces of the region was prepared (Figure 4).

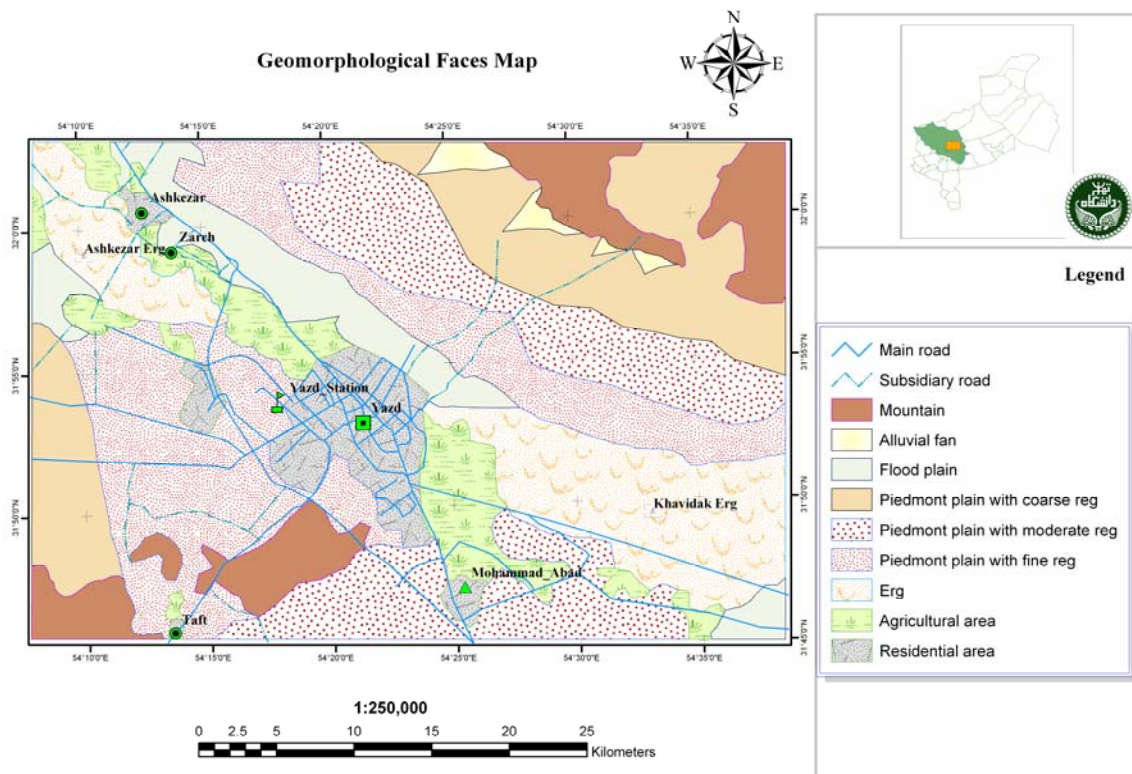


Fig. 4. The map of geomorphologic faces of the region under study

After systematic preparation of the map of geomorphic faces, we began accidentally to measure the threshold velocity of the region. Random places were selected and their threshold velocities were measured with the aid of wind tunnel.

Investigation of the value of the threshold velocities of each face showed that if we had correctly selected the faces, the difference in the velocities in one face was ignorable and the value could be extended to the whole face, and

with this in mind the whole region was divided into faces and various threshold velocities of different faces were determined.

3.3. Drawing of Storm Roses and Analysis of Erosive Winds

Recent studies show that in analysis of anemometric data's for investigation of wind erosion we can not only suffice to the direction and velocity of wind, that is, its wind rose, but

we should also bring the physical specifications of soil such as the erosion threshold velocity into consideration too, because this is of importance too. In order to enter the threshold velocity of erosion in analysis of anemometric data's another graph with the name storm rose is taken into consideration and defined. In this graph the winds that have a velocity of less than threshold velocity are considered as gentle winds. We thus investigate the winds that have a

velocity of more than threshold velocity and determine their direction, their velocity, and their frequency. Thus storm rose is a type of wind rose that has its place in the air and is touching the ground on which it is blowing, thus with interference of threshold velocity we see the difference between the effective winds that shape dust storms with other sorts of winds. Figure 5 shows samples of graphs of Storm Roses of the region under study.

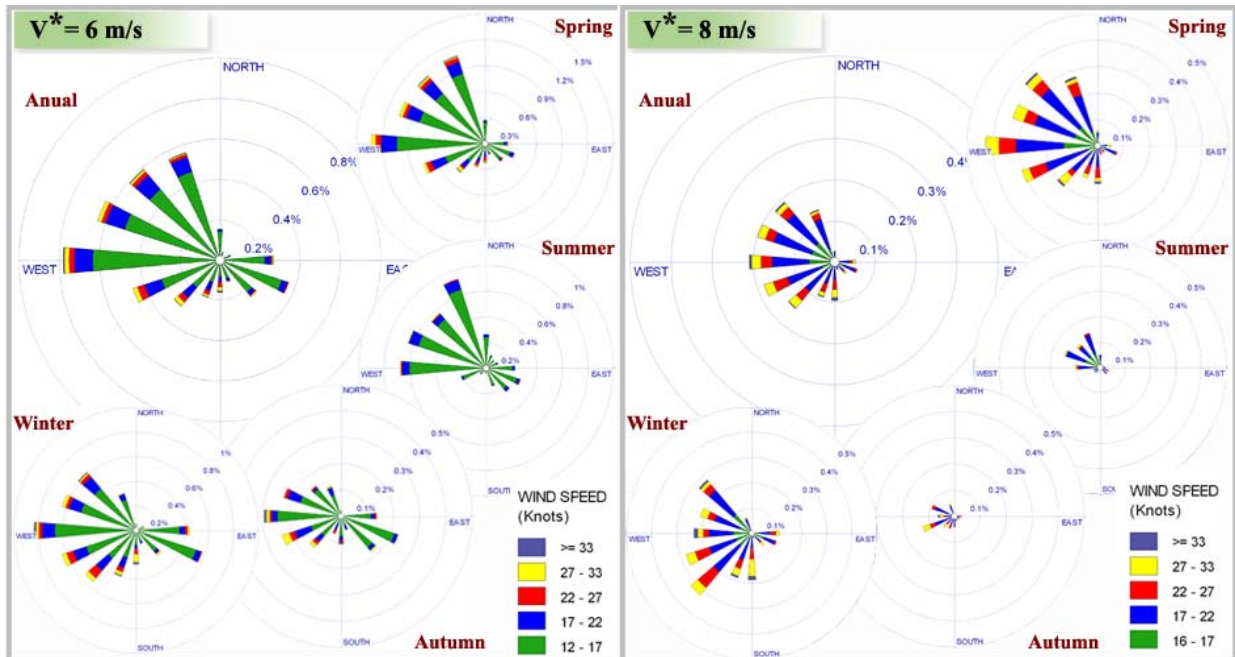


Fig. 5. Seasonal and yearly storm roses of various threshold velocities of Yazd plain

4. Conclusion

As the erosion threshold wind velocities of different faces are different, therefore it has been tried that with drawing and analysis of storm roses of various threshold velocities in the region, the particulars of all of faces that generate dust be investigated.

With transferring the yearly storm roses of various threshold velocities on a map of regions that have the same threshold velocities we can distinguish the places that have more role in generation of dust. With transferring of the Storm Roses to the map of the regions that have the same velocity, regions that produce dust storms are discovered.

Figure 6 shows the situation of the places that generate dust storm in the region under study. As shown in this figure places that have erosion threshold velocities of less than 20 knots

(10 meter/second) have a role in generation of dust and thus the governing winds in this region are able to erode the soil.

With comparison of the map of geomorphologic faces and the map of locations that are effective in evolving dust storms, we see that, the plains that are covered with a layer of shingle and gravel are resistant to erosion and if their surfaces are not damaged, have no role in generation of dust and as a result do not need physical and biological control.

The storm roses of this region prove this matter too, and show that the dust storms of this region have their direction in west to northwest. So if we want to reduce the damages of dust to Yazd city and its surroundings stabilization of soil and control of areas in west to northwest of Yazd should be in priority.

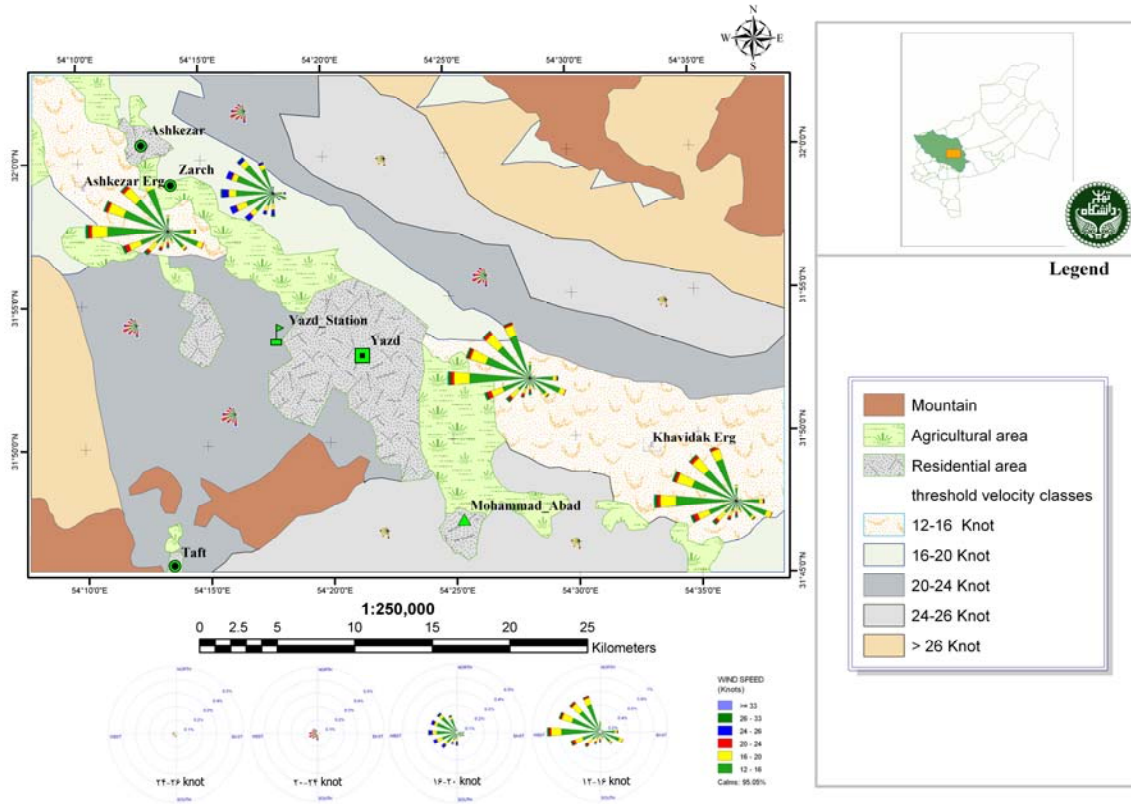


Fig. 6. Determination of effective places in generation of dust with erosive winds

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