THE EFFECT OF WIND EROSION ON THE DESERTIFICATION PROCESS IN THE ABSHERON PENINSULA

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Abstract

Climate change, land cover degradation, anthropogenic impacts, and the improper management of agricultural lands contribute to the intensification of wind erosion. This process is particularly dangerous for the Absheron Peninsula, which is located within the semi-arid dry steppe climate zone. Wind erosion leads to the loss of the fertile soil layer, degradation of vegetation cover, disruption of the water balance, and consequently, a decline in agricultural productivity, which in turn results in serious economic and ecological consequences. Therefore, the study of the causes, scale, and mitigation measures of wind erosion constitutes one of the main directions in combating desertification. For this purpose, the NDMI (Normalized Difference Moisture Index) map was generated using 2024 Landsat 8–9 OLI/TIRS C2 L2 multispectral imagery. Additionally, based on 2015 and 2023 Landsat 8–9 OLI/TIRS C2 L2 multispectral images**,** "Land Cover and Land Use" maps were created, along with a map of the average wind speed in the Absheron peninsula**.** As a result, the number of windy days, wind speed, soil granulometric composition, and soil moisture were determined; the areas with different land cover types were calculated; the regions with intense wind erosion were identified; and the development of the desertification process was assessed.

1. Introduction

The rapid increasing in temperature on the earth, including the increase in hurricanes, floods has drawn the attention of countries of the world to the investigation of the causes of global warming and the preparation and implementation of a plan of measures against it. It is noticeable that climate changes, especially the process of desertification, manifests itself sharply in the Absheron peninsula, characterized by a semi-desert dry-desert climate type, with hot-dry summers and mild winters, not bypassing the Republic of Azerbaijan. In this regard, it is no coincidence that the Conference of the Parties to the UN Framework Convention on Climate Change or Cop29 is held in Azerbaijan.

Determining the intensity of wind erosion, which is one of the most characteristic factors affecting the desertification process, for the Absheron Peninsula, as well as investigating the causes of wind erosion, is one of the objectives. The increase in wind erosion not only results in the blowing away of the upper fertile layer of the soil,but also causes the spread of soil contaminated with salt and radioactive substances to the surrounding areas.

2. Material and method

Maps were drawn using ArcGis 10.8 software using various base data taken from the National Atlas of Azerbaijan Republic, and factors such as average wind speed, soil cover and texture, soil moisture, and land cover that affect wind erosion were investigated. Using Landsat 8-9 OLI/TIRS C2 L2 multispectral images for the first 5 days of April 2024, the NDMI map of the area was drawn up based on the ratio of NIR and SWIR values and calculated using the following formula.

NDMI=(NİR-SWIR)/(NIR+SWIR) (1)

NDMI=(B05-B06)/(B05+B06) (2)

Based on Landsat 8-9 OLI/TIRS C2 L2 multispectral images for the first 10 days of April for 2015 and 2023, "Land cover and land use" maps were compiled. Areas of territories with different land cover were calculated by controlled decoding of space images from 2015 and 2023.

By comparing these data, the development of wind erosion, including the desertification process, was determined. In addition, the basic materials of the Global Wind Atlas were vectorized in ArcGis 10.8 software, and the "Average wind speed in the Caspian coastal plains" map was drawn up.

3. Analysis and discussion

Wind erosion is a chain of events that causes soil particles to be entrained, transported, and finally deposited as a result of the interaction of wind with the soil surface. Erosion is considered when the wind speed reaches 6 m/s at a height of 0.3 m above the ground surface and 8 m/s at a height of 9 m above the ground surface. Wind causes deflation in light soils at a speed of 10 m/s and more [5].

The hight wind speed in the area and the large number of windy days create conditions for the occurrence of wind erosion. The number of days with strong winds reaching 15 m/sec in the Absheron Peninsula area has reached 139, as well as the average monthly wind speed at meteorological stations is higher in the summer months, which leads to further drying of the soil surface that has lost moisture and acceleration of the deflation process. (Table 1).

According to the map "Average wind speed in the Caspian coastal plains (Absheron Peninsula)" in the mountains of Baku ears (383.8 m), Deghdovlar (234.7 m), Khanedan (209.3), Nishanga (243 m), Ulugaya (178.6 m),Bozdag volcano (309 m) and from there to the mountain of Deveboynu (271.8 m), Osman Bozdag volcano (392.1 m) and in the areas northwest of this volcano the average wind speed reaches 9-12 m/s. The average wind speed decreases from 8-9 m/s to 6-7 m/s as we go east and west from these areas.

Table 1

Average monthly wind speed, m/s [10]

Meteorological station	Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
Baku	1999	4,0	3,8	4,4	4,2	5,1	5,0	5,0	5,2	4,8	4,8	3,8	4,8	4,6
	2000	3,8	3,7	4,6	3,8	4,1	4,7	4,7	5,5	5.0	4,0	3,9	3,9	4,3
	2001	3,6	5,2	4,4	3,8	4,0	3,4	3,4	5,5	4,8	3,6	3,1	2,9	4,1
	2002	3,5	3,7	3,5	5,6	3,0	3,6	3,6	3,3	4,3	4,3	4,7	3,5	4,1
	2003	4,0	4,1	4,1	4,2	3,6	4,0	4,0	4,8	4,8	4,0	4,5	3,7	4,3
Sumgayit	1999	4,5	4,3	5,1	4,6	5,7	5,1	5,1	6,4	6,0	6,0	5,2	5,7	5,4
	2000	5,0	4,9	6,0	4,5	5,7	5,8	5,8	6,7	6,4	5,6	5,5	5,9	5,6
	2001	6,1	6,5	5,3	4,6	5,2	3,8	3,8	6,8	5,9	4,6	5,3	5,2	5,3
	2002	5,8	6,4	6,1	5,9	4,0	3,1	3,1	3,7	5,0	6,9	7,8	6,4	5,6
	2003	5,7	6,5	4,7	5,0	4,1	4,8	4,8	5,5	6,3	5,6	8,2	5,1	5,6
Mashtaga	1999	4,1	4,0	3,8	3,9	4,6	3,7	3,7	3,8	4,0	4,2	3,6	4,0	4,0
	2000	3,8	3,6	4,3	3,8	3,8	3,7	3,7	3,6	4,6	3,7	3,6	3,9	3,9
	2001	3,8	5,2	3,1	3,0	3,4	1,9	1,9	3,7	3,6	2,3	2,3	2,7	3,2
	2002	3,4	3,8	3,2	4,6	2,5	2,5	2,5	2,7	3,5	3,7	5,1	3,1	3,5
	2003	4,4	4,2	4,2	3,8	3,2	3,9	3,9	4,1	5,1	3,7	4,5	3,8	4,2

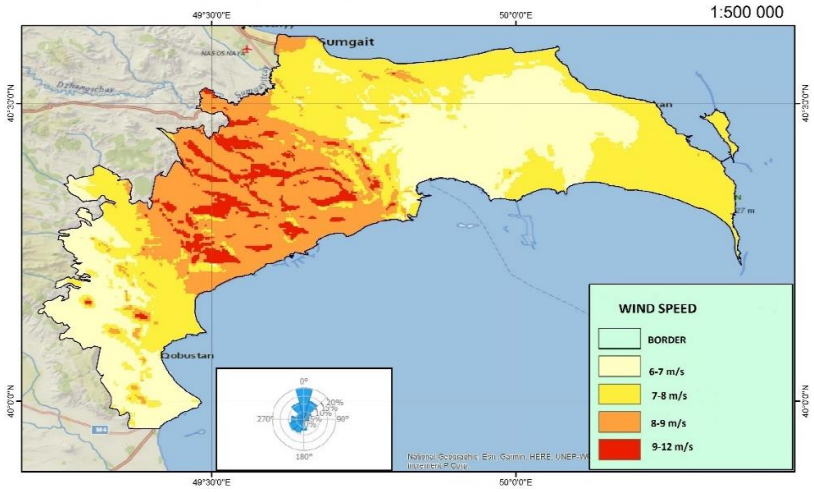

Figure 1. Wind speed in the Absheron peninsula [9]

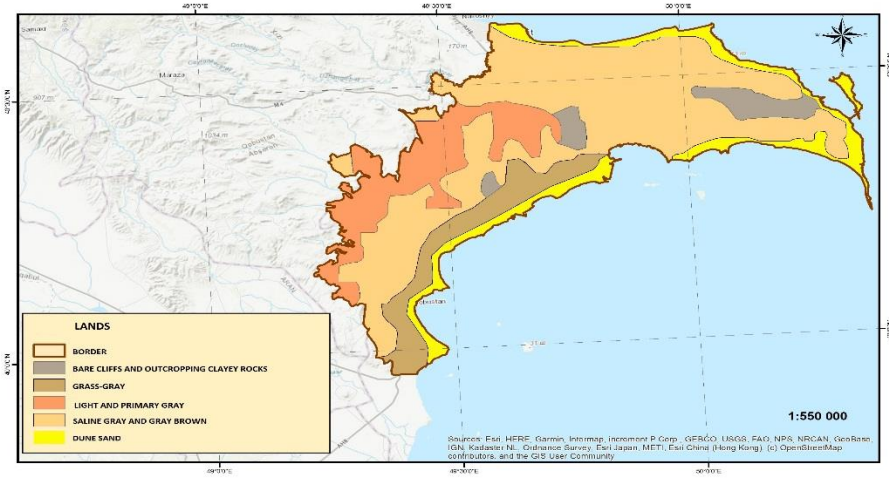

Figure 2. Lands of the Caspian coastal plains [7]

In the northwestern part of the Absheron peninsula, Haji Isa mountain (452 m) and around it, the wind speed from northwest to southeast reaches 9-12 m/s. At the same time, the wind speed reaches the highest level in Absheron in the direction of Bayanata (588 m),Sungurdag (673 m).

There are favorable conditions for the intensification of wind erosion in the areas listed above, where the wind speed reaches 9-12 m/s. The high wind speed not only results in the blowing away of the top fertile layer of the soil, but also causes the spread of soil contaminated with radioactive substances and heavy metals over large areas.

Soil surface conditions. Soil properties can change rapidly due to weather events, tillage and other management operations. This includes properties such as bulk density and dry aggregate size distribution. If the size of the soil aggregates is larger than 1mm, it is almost not subjected to deflation.

Soil texture is the most important soil property affecting the susceptibility of soil to wind erosion. In areas located in the eastern parts of Absheron, such as Kurdakhani, Buzovna, Corat and Mastaga the sand layer with a coarse texture and easier erodibility is 50 sm thick and is replaced by clayey soils in the lower layers[1].

In the area of Sumgayit and Haji Zeynalabdin settlements, sand-fish ear piles occupy a large area. In recent years, the retreat of the Caspian Sea has resulted in the expansion of the coastal sand dunes. The sand duneus running parallel to the coast from Corat to Gilazi are in some parts cut by piles of limestone that have come out from under the sea. Sand piles are in semi-solid and moving forms and are intensively exposed to wind erosion. Due to the lowering of the underground water level, these sand piles become dry and more erodible [8].

The gray and gray-brown soils that cover a large area in the Boghaz plain, including the western and eastern parts of Absheron, are light and medium gritty, characterized by an abundance of CaCO, and are subject to foaming when acid is applied to them. The abundance of lime in these soils facilitates erosion. Gray-brown saline soils are clayey according to their mechanical composition, the amount of physical clay in their content reaches 70-75% [8]. Although the mechanical composition of the soils spread over the area is clayey, it weakens the intensive course of the erosion process, but the abundance of CaCO in the soil creates conditions for the intensity of this process.

Soil moisture-sand-sized material with a gravimetric moisture content greater than 5% is resistant to erosion by most natural winds.

According to the NDMI map of the Caspian coastal plains along the shores of the Absheron Peninsula, the moisture supply index of the eastern parts of the area is -0.02-0.4, which is considered more satisfactory than the western parts.

In the western parts, this indicator varies between -0.5 and -0.06 and is characterized by a very low supply of moisture, and a sharp lack of moisture in these areas leads to the intensification of the erosion process due to the influence of the winds blowing in the summer months.

The roughness of the surface, rocks, plants on the surface, as well as microrelief are factors that cause wind erosion. The roughness created during plowing protects the soil surface from the impact of erosive particles by reducing the effect of the cross section of the wind [4].

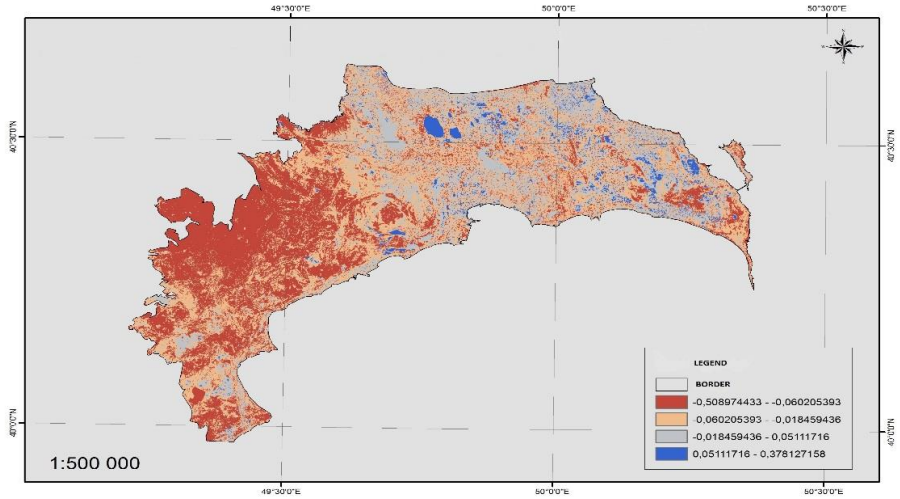

Figure 3. The NDMI map

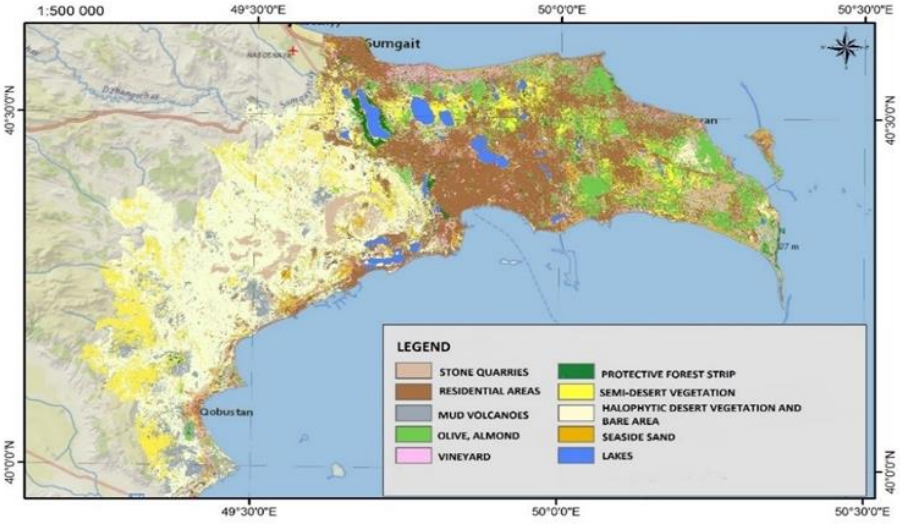

Figure 4. Land cover and land use map of the Caspian coastal plains-2015

Based on the maps prepared with reference to Landsat 8 images of April 2023 and Landsat 8 images of April 2015, it can be determined that there is a decrease in the area of naturally distributed vegetation in the coastal plains of the Absheron Peninsula of the Caspian Sea.

As a result of the analusis of these maps, it was determined that the area of desert vegetation with halophytes and bare areas decreased from 889.86 km² to 855.18 km² and the area of semi-desert vegetation with wormwood decreased from 294.37 km² to 258.91 km². The observed decrease in the area of halophytic desert vegetation and barren areas is due to the increase in the area of semi-desert vegetation with wormwood in the western part of the coastal plains of the Absheron Peninsula and stone quarries. The area of stone quarries has increased from 161.9 km² to 170 km² in the corresponding years, which naturally results in the bareness of the area. The largest deposits of stone quarries on the territory are located in Zigh, Zira, Nardaran, Mashtaga, Garadag, Guzdek areas, which make up 37% of stone quarries in the country. The main deposits of construction sand are located in the Kirmaki valley near the villages of Duvanni and Balakhani. After the use of stone and sand quarries in the Caspian coastal areas, the pits created in those areas are flooded, resulting in the creation of lake-marsh hydromorphic landscapes [3].

In general, the reason for the decrease in the area of semi-desert vegetation here is due to the increase in the area of olive and almond gardens in the eastern parts of Absheron. This change in the distribution area of the natural vegetation of the area means that there are favorable conditions for wind erosion to go intensively in the western and central parts of Absheron region. At the same time, the area of the lakes in the area decreased from 68.83 km² to 67.66 km², which in turn is one of the indicators of the desertification process.

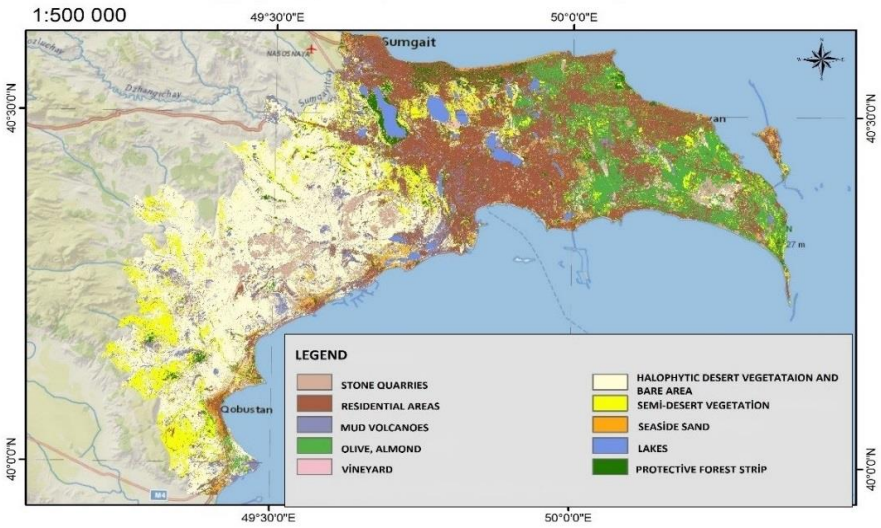

Figure 5. Land cover and land use map of the Caspian coastal plains-2023

Table 2

Land cover and land use

Land cover		Area (km²)	
		2015	2023
1	Stone quarries	161,89	169,98
2	Residental areas	644,44	693,56
3	Mud volcanoes	139,59	133,45
4	Olive, almond	244,35	300,45
5	Vineyard	83,83	27,35
6	Halophytic desert vegetation and bare areas	889,86	855,18
7	Semi-desert vegetation with wormwood	294,37	258,91
8	Seaside sand dunes	74,83	60
9	Lakes	68,83	67,66
10	Protective forest strips	33,26	71,79

Strong winds characteristic of the area weaken their activity in the parts of the soil surface densely covered with vegetation, but in sparsely vegetated areas, pomegranate particles of the soil, including large pieces of sand, are blown away and carried to other surrounding areas. In areas with intensive wind erosion, the humus-rich upperwell-structured layer of the soil destroyed, so the amount of nutrients in the soil decreases and its fertility decreases [6].

Mud volcanoes are one of the natural factors that have a negative impact on the degree of vegetation cover in the Absheron region. As a result of periodic eruptions of mud vulcanoes in the area, volcanic breccia takes a fan-shaped shape and spreads over several kilometers, and the thickness of volcanic breccia usually reaches 10-12 m. The high volume of solid volcanic material discharged by volcanoes to the surface is confirmed by the following indicators: Ayrantoken-2.4 billion.m³, Otmanbozdag-1.2 billion.m³, Kenizdag-735 million m³ [2].

The presence of salt in mud volcano materials result in soil salinization. B. A. Klopotovsky (1940) shows that the mud of old volcanoes is formed late in the deep layers due to the leaching process of salts.

According to V. V. Akimtsev (1957) , rotting-sulphate soils are formed on such piles. From H. A. Aliyev's (1948) studies, it is known that mud volcano materials contain 2-10% water-soluble salt [8].

According to the “Land Cover and Land Use” maps of 2015 and 2023, when comparing the areas covered by mud volcano products, it can be observed that the area of these areas has decreased from 139.59 km² to 133.45 km². This is due to the replacement of those areas with bare ground cover and halopytic desert vegetation. In general, the eruption of mud volcanoes in the western parts of Absheron affects the devegetation, bareness of the

area, including salinization, and as a result, it affects the wind speed and the increase of wind erosion.

In arid and semi-arid regions, insufficient and irregular rainfall, excessive evaporation due to high temperatures, and low humidity due to strong winds. On the Absheron Peninsula, the summer is hot and dry, and the soil is not supplied with sufficient moisture. High temperature evaporates the moisture and results in drying of the soil from the top. High temperature evaporates the moisture and results in drying of the soil from the top. The top part of the fragile, exposed soil, devoid of vegetation, is dispersed by the action of strong winds and transported to other areas.

4.Conclusion

1. In the mountains of Baku ears (383.8 m), Degdovlar (234.7 m), Khanedan (209.3 m), Nishanga (243 m), Ulugaya (178.6 m), Bozdag volcano (309), where the average wind speed reaches 9-12 m/s and from there towards the mountain of Devaboynu (271.8 m), Osman Bozdag volcano (392.1 m) and the areas northwest of this volcano have favorable conditions for strong wind erosion. At the same time, the number of days with strong winds reaching 15 m/sec on the peninsula indicates the intensity of this process.
2. The soils of the Caspian coastal plains (along the Absheron Peninsula) have a sandy and clayey texture, and while sandy soils are easily eroded, this process is accelerated by the presence of CaCO in the clayey soils.
3. As a result of the NDMI analysis, it is determined that the moisture supply of the eastern parts of the peninsula is more satisfactory than the western coastal plains. Indicators of moisture supply are -0.02-0.4, respectively it varies from -0.5 to -0.06.

Based on the "Land Cover and Land Use" maps compiled for 2023 and 2015, it can be determined that the area of naturally distributed vegetation is observed in the coastal plains of the Absheron Peninsula of the Caspian Sea. Thus, the area of halophyte desert vegetation and barren areas is from 889.86 km² to 855.18 km², and the area of semi-desert vegetation with wormwood is from 294.37 km² to 258.91 km², the area of lakes is 68.83 km² to 67.66 km², while the area of mud volcanoes it decreased from 139.59 km² to 133.45 km² and the area of stone quarries increased from 161.9 km² to 170 km². As a result of the analysis of these indicators, it is determined that the process of wind erosion and desertification is intensive in the area.

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ABŞERON YARIMADASINDA KÜLƏK EROZİYASININ SƏHRALAŞMA PROSESİNƏ TƏSİRİ

G.Ə. Həsənova

Xülasə. İqlim dəyişikliyi, torpaq örtüyünün deqradasiyası, antropogen təsirlər və əkinçilik sahələrinin düzgün idarə olunmaması külək eroziyasının güclənməsinə səbəb olur. Yarımsəhra quru çöl iqlim tipində yerləşən Abşeron yarımadası üçün xüsusilə təhlükəli olan bu proses torpağın münbit qatının itirilməsi, bitki örtüyünün zədələnməsi, su balansının pozulması və nəticədə kənd təsərrüfatı məhsuldarlığının azalması ilə nəticələnir ki, bu da həm iqtisadi, həm də ekoloji baxımdan ciddi nəticələr doğurur. Ona görə də külək eroziyasının səbəblərinin, miqyasının və qarşısının alınma yollarının araşdırılması səhralaşmaya qarşı mübarizənin əsas istiqamətlərindən biridir. Bu məqsədlə 2024- aid Landsat 8-9 OLİ/TİRS C2 L2 multispektral görüntülərdən istifadə edərək NDMI xəritəsi, 2015 və 2023-cü illər üzrə Landsat8-9 OLİ/TİRS C2 L2 multispektral görüntülərinə əsasən "Torpaq Örtüyü və Torpaq Örtüyündən İstifadə" xəritələri və "Abşeron yarımadasında küləyin orta sürəti" xəritəsi tərtib edilmişdir. Nəticədə ərazidə olan küləkli günlərin sayı, küləyin sürəti, torpağın qranulometrik tərkibi, torpağın nəmliyi müəyyənləşdirilmiş,müxtəlif səth örtüklərinə malik ərazilərin sahələri hesablanmış, külək eroziyasının intensiv getdiyi ərazilər aşkar olunmuş və səhralaşma prosesinin inkişafı müəyyənləşdirilmişdir.

Açar sözlər: külək eroziyası, səhralaşma prosesi, küləkli günlər, NDMI analizi, səth örtüyündən istifadə.