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Wind erosion hazard assessment using GIS techniques El-Mesran Area, Djelfa Wilaya, Algeria

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ABSTRACT

Soil study is very important in geomorphological studies related to the study of earth's surface forms, as these qualities decide the soil's response to various geomorphological processes. The soil varies in Al-Mesrane as a result of the different environment and climatic conditions, where its types vary from north to south, otherwise this soil composition is very similar because it is a calcareous soil in general originated from the fragmentation of rocks, the nature of the soil and its distribution within the study area related to the earth's surface forms. Soils are directly affected by the climate factor, especially wind, the soil consisting of granules in diameter (0.1-0.15 mm) is the most vulnerable to wind erosion (Chepil and Woodruff) 1993, and soil resistance to wind erosion depends on some soil properties such as soil tissue and moisture in the soil, also to topography and roughness of the soil surface, these factors have overlapping relationships. From Davidson's point of view, (1989), the main causes of wind erosion are the removal of vegetation in addition to wind speed, by using suitable vegetation cover and increasing soil granules proportion on the surface can control wind erosion, and in this study we only care about wind erosion in its form. Potentially, where they can be reduced when applied to calculate soil loss or sand transportation on the surface, in the absence of vegetation on the soil and these processes are reduced to take into account only the soil erodibility and eolisivity wind sculpture, where it is known as the so-called Potential Wind Erosion (P.W.E), assuming that other factors are equal to one. Soil data and analysis collected to decide its texture, structure, proportion of organic matter, and salinity ratio within the geographic database using Arc-Map functions to extract results.

Key words : *Steppe, Wind erosion hazard, Desertification, Erodibility, WEQ.*

Introduction

The Steppe region of Algeria is the source of natural feed production for the animals in which it lives, and plays an active role in the environmental balance between the wet northern and the southern dry region, and any deterioration in this region leads to an imbalance between the two regions, thereby gradually eliminating Natural resources, which helps to creep sand and spread the phenomenon of sanding in this natural environment. The El-Mesrane region is an integral part of this environment, as it carries the characteristics ofthe steppe region.

The phenomenon of sanding is one of the most serious problems and challenges suffered by the steppe in general and the EL-Mesrane region in particular because of its negative impact and the effective role in soil degradation. This has been helped by the fact that the region is energized by natural factors and processes that accelerate the occurrence of the phenomenon, such as the quality of vegetation, surface forms or causative factors such as wind erosion. The latter activates and accelerates the phenomenon of sanding in the region as a second erosion factor, secondly transport factor and then sedimentation of sand, the soil is not protected from this type of wind erosion because of seasonal vegetation cover. Like natural factors, human activity also has a role in stimulating the phenomenon by draining resources such as overgrazing, and sand forms are creeping and invading the study area, which has become an area threatened by desertification.

Due to the wide range of sanding in the Al-Mesrane region, it is difficult to study this phenomenon in the traditional ways of ground surveys and field work, so it was necessary to rely on modern techniques in order to contain this phenomenon, such as GIS, which is an effective and modern means of dealing with data, it is characterized by a high ability to analyze data more accurately.

The location of the study area

The area in question represents an important part of the Wilaya of Djelfa, located 275 km south of Algiers, as an important part of the West Zahrez Basin on National Route 1 and on the north-west side of the city of Djelfa, between the arches of 02º 00’45’’ and 3º 15' 15" east of the Greenwich Line. The latitude 34º 20’50’’and 35º 15' 05" latitude north of the equator (Map 1, Picture 1).

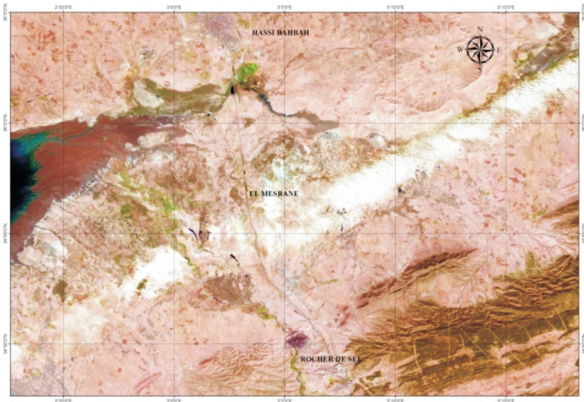
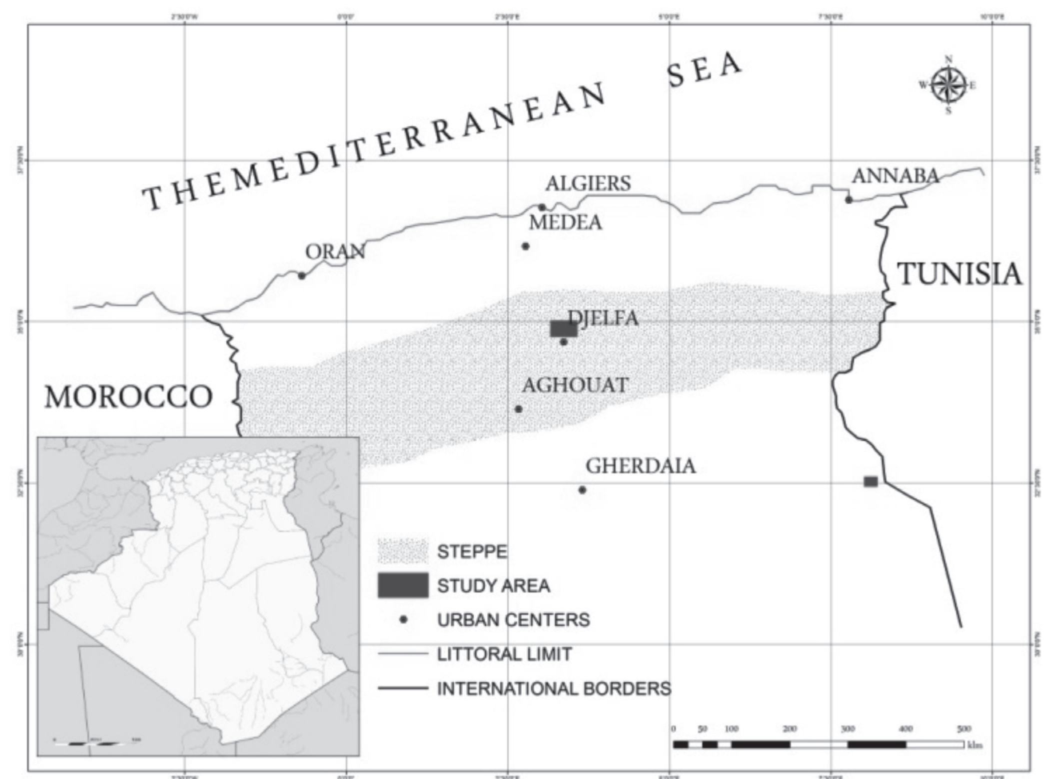


Photo 1. Landsat 8 OLI satellite image dated 03 October 2018 covering the study area

The objectives of the study

This study aims primarily to cover the following research aspects:



Map 1 : The boundaries of the Steppe region and the location of the study area

- To identify and analyze the reality of the region and monitor the phenomenon of sanding as an important manifestation of desertification, to develop appropriate plans for the development of the region and to develop appropriate solutions to address it and reduce its seriousness.
- Interpreting some of the geomorphic processes associated with the phenomenon and trying to quantify it.
- To know the magnitude of the risk posed by the phenomenon of sanding in the study area.
- GIS contributes to answering the questions and its role in creating an integrated database of the region.

Methodology and methods of study

In the study, we will rely on the combination of descriptive and quantitative approaches with the use of the comprehensive descriptive quantitative method of different data for the region, all supported by different maps and charts.

The effect of wind erosion in the Al-Mesrane area

The impact of wind erosion on agricultural land and agricultural production through the work of erosion, such as wind erosion and its including dust storms, dust and rising dust, some of which comes from the land of the study area, and the other part comes from the deserted lands surrounding the area The study, this effect is represented by the serious deterioration of these lands, as we are a manifestation of desertification capable of causing natural changes in the upper part of the soil, whose vulnerability is related by wind to the ease of removing single or collected granules from the soil and also the size of these Granules.

In order to estimate the amount of soil loss in the study area by wind, the wind erosion equation (W.E.E.E.) was used. Woodruff and Siddoway, 1965.

Use the general equation of wind erosion (U.W.E.E.E)

To estimate the loss of this soil-producing layer, the 1965 wind erosion equation of soil proposed by Siddoway and Woodruff was used to modify the Chepil and Woodruff in 1963, a result of several factors as shown in :

$$E = f\,(I, K, C, L, V) \quad t/km^2/year$$

E: is the potential annual soil loss (in t ha^{-1} yr^{-1})

I: is the soil erodibility, expressed as potential annual soil loss in (t/ha^{-1} yr^{-1}) from a wide, unsheltered isolated field with bare, smooth, level, loose and non-crusted surface where the climatic factor C is 100 such as Garden City, Kansas.

C: is an index of climatic erosivity, specifically wind-speed and surface soil moisture. The factor for any given location is based on long-term climatic data and is expressed as a percentage of the C factor for Garden City, Kansas.

K: is the surface roughness factor which is a measure of the effect of ridges made by tillage and planting implements, or other means of creating systematically spaced ridges. Ridges absorb and deflect wind energy and trap moving soil particles.

L: is the unsheltered, weighted travel distance (in m) along the prevailing wind direction,

V: Equivalent to vegetative vegetation (ton. ha^{-1}).

Soil Erodibility

The ability of the soil to wind erosion is linked to the ease of removal of single or collected granules from the soil and also the size of these granules, smaller granules are easier to move by wind, and the size of the granules affects the ease of transport in sandy land, granules with a diameter greater than 1 mm are more likely For wind erosion, while grains less than 1 mm are the most cohesive, and therefore more resistant to wind erosion.

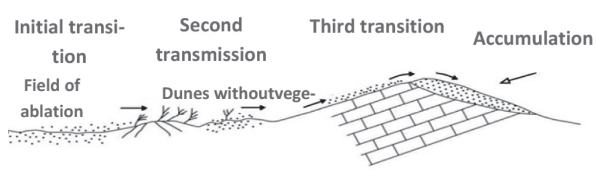


Fig. 1. Sanding stages

The equation for calculating soil susceptibility to wind erosion (I) is many, and in this study we suggest using the "I" method of wind erosion using the equation (Shiyatyi, 1965) which depends on the calculation of non-sculptable soil granules as well as some harvest coverage, which is of the form:

$$I = 10^{4.03691-0.0384\,S-0.00406\,N}$$

Where:

I: is the soil erodibility, expressed as potential annual soil loss in (t ha^{-1} yr^{-1}) from a wide, unsheltered isolated field with bare, smooth, level, loose and non-crusted surface where the climatic factor C is 100 such as Garden City, Kansas.

S: Percentage of dry soil granules with a diameter of more than 1 mm

N: Number of stems of existing plants (per square meter only with a length exceeding 20 cm)

Assuming that there is no vegetation cover (N = 0), the above equation is reduced to the figure:

$$I = 10^{4.03691-0.0384\,S}$$

What Woodruff and Siddoway referred to in 1965 corresponds to the soil's exposure, which is the potential annual soil loss rate from a broad, unprotected, isolated field.

The climatic factor of wind erosion (wind sculpture) (C)

The climatic factor or climate susceptibility to wind erosion is a measure of the ability of climatic elements towards the formation of wind-erosion conditions, these elements are the intensity of the wind and the impact of rainfall and evaporation, which is reflected in the state of earth's humidity, as the Earth is less susceptible to Wind erosion when wet, when moisture in the soil decreases, the wind effect begins to affect soil granules, and their ability to extract these granules increases and they move them away.

$$C = 386 \left[\frac{v^3}{(PE)}\right]$$

C: Climatic factor or climate susceptibility to wind erosion (climate agent)

V: Average rate or average wind speed for erosion (0.5 or 1.5) meters from soil surface b (m/seconde)

386: Garden City Local Conditions Worker, Kansas USA.

PE: Effective fall for Thorntwhite

equation to find the value of PE:

$$P/_E = 0.316\left(\frac{P}{1.8T + 22}\right)^{10/9}$$

Where:

P: Average monthly rainfall (mL)

E: Monthly evaporation (mL)

T: Temperature in celsius

Monthly values are then collected for an annual value, multiplied at 10 to give pe guide.

$$P/_E = 0.316\sum_{i=1}^{12}\left(\frac{P}{1.8T + 22}\right)^{10/9}$$

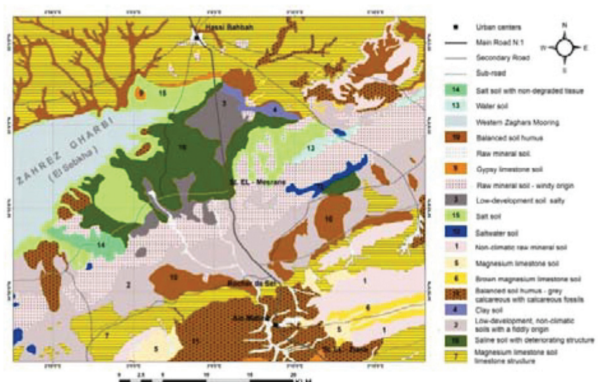
Table 1. Degree of wind erosion

Climate factor for wind erosion (C)	Degree of erosion
Less than 17	Veryweak
18 – 35	weak
36 – 71	Medium
72 – 150	High
More than 150	Very high

The results obtained are compared to Table 1 in order to determine the degree of wind erosion in the study area.

Results

Where the climatic factor for wind erosion (C) 99.21, compared to Table 1 (Chepil *et al.*, 1962) the study region was classified within the degree of high erosion, on the other hand soil analysis showed that the study area is characterized by soil with sandy loam fabric by 55% of the total area of the d A highly vulnerable head of wind erosion (Map 2), where the soil through its fabric provided the conditions to help to easily undress.



Map 2. Types of soil in the study area

To determine the Erodibilityof the soil to erosion, the equation proposed by Shiyatyi, 1965 was used, showing that factor I varies between 14.24 tons/ha/year for soil where the grains of soft sand are reduced to 104.16 tonnes/ha/year for the most Erodibilitysoils (Map 3).

In an area with no vegetation such as the study area, Soil Erodibilityto wind erosion (I) and wind exposure (C) together translate into so-called potential wind erosion of soil (P.W.E),which reflects the potential risk of wind erosion on the soil for the site in the absence of protection (Lall, 1995, p. 149),

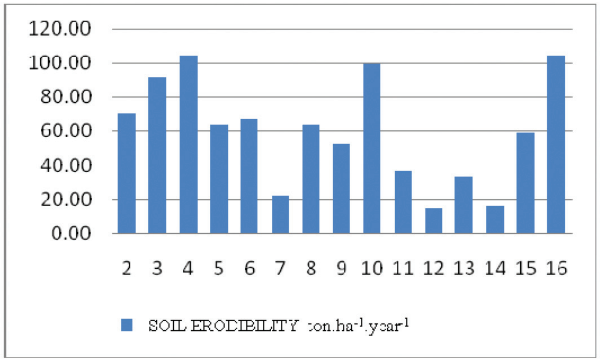


Fig 2. Soil erodibilityin the study area

Mathematically, it is based mainly on the global mathematical model of soil loss by wind which is:

Ep = I. C

Where:

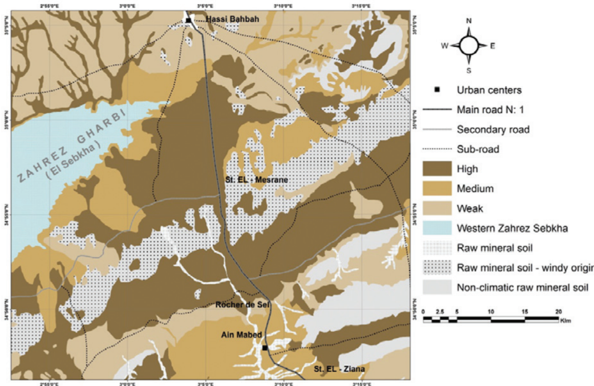
Ep: Potential risk of wind erosion (ton/ha/year).

I: Soil Erodibility

C: The climatic factor of wind erosion or wind ability to erosion.

According to this perspective, the results of the calculation of the potential wind erosion factor or the so-called standard erosion of all soil units in the western zahrez basin, whether for erosion-resistant soils or soils with minimal resistance to erosion, are equal to the values represented in the Table 3.

By applying the equation of wind-induced soil carving, it appears that annual potential loss of soil surface is the highest on soil types of 4 and 16, at a rate of 10,334.76 tons/ha/year, while the lowest annual potential loss of soil surface recorded in soil types: 12 and 14, with a loss of 1412.89 And 1543.86 tons /ha/year, and the areas of potential risk of



Map 3. Soil Erodibility to wind erosion (I) in the study area

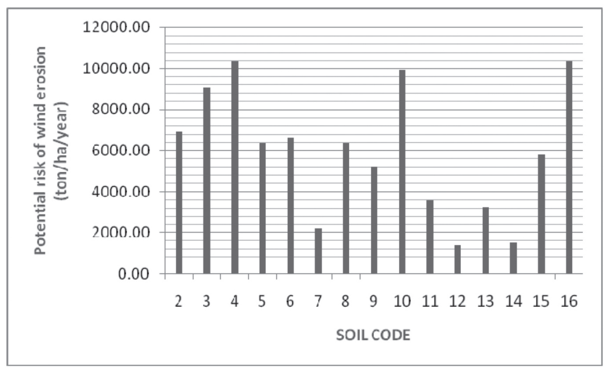


Fig. 3. E potential wind erosion of soil in the study area.

Table 2. Results of the calculation of the Soil Erodibility factor in the study area

Soil code	S: Percentage of dry soil granules with a diameter of more than 1 mm	I : g.m-1	I : ton.ha-1
69.96	6996.97	5	2
91.22	9122.42	2	3
104.16	10416.22	0.5	4
64.04	6404.87	6	5
66.94	6694.37	5.5	6
22.16	2216.72	18	7
64.05	6404.87	6	8
52.72	5272.66	8.2	9
99.65	9965.75	1	10
36.05	3605.04	12.5	11
14.24	1424.66	23	12
32.99	3299.97	13.5	13
15.56	1556.36	22	14
58.62	5862.87	7	15
104.16	10416.22	0.5	16

wind erosion in the EL-Mesrane region vary between them in terms of area and severity of erosion, where the area was divided into four regions (Table 4, Map 4).

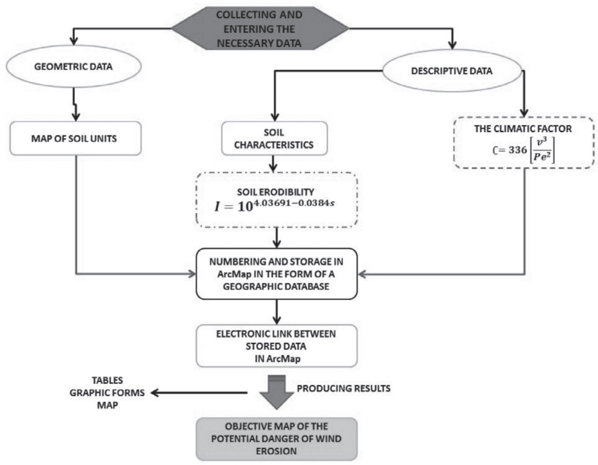
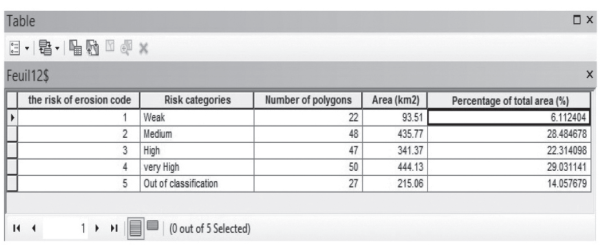


Fig. 4. A general plan to complete an objective map of the potential wind erosion of soil in the EL-Mesrane area.

Table 4. Area and degrees of wind erosion in the study area.



Table

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the risk of erosion code	Risk categories	Number of polygons	Area (km2)	Percentage of total area (%)
1	Weak	22	93.51	6.112404
2	Medium	48	435.77	28.484678
3	High	47	341.37	22.314098
4	very High	50	444.13	29.031141
5	Out of classification	27	215.06	14.057679

(0 out of 5 Selected)

Discussion and Conclusion

It can be said that the difference in the degrees of potential risk of wind erosion in the study area is mainly due to the difference recorded in the values of Soil Erodibility to wind erosion (Fig. 5), as the risk decreases with the increase in the proportion of coarse sand (in other words, the higher the percentage of soil granules greater than 1Mm. The end result of wind erosion is the continuous deterioration of the soil and the increase in the problem of desertification, in addition, the movement and accumulation of grains of sand threatenmany human activities, and the consequences of this process will be serious in terms of the depletion of the surface layer produced from the soil or agricultural land. And pastoral quality, which is difficult to compensate for by reclamation.

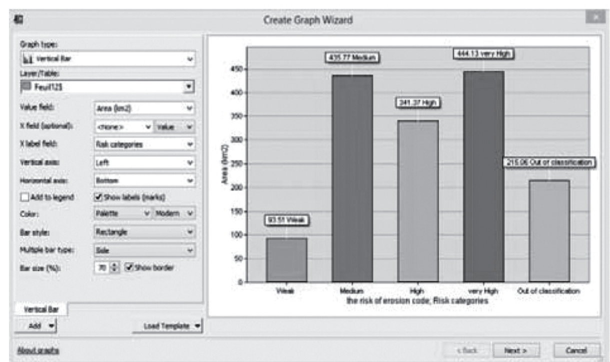
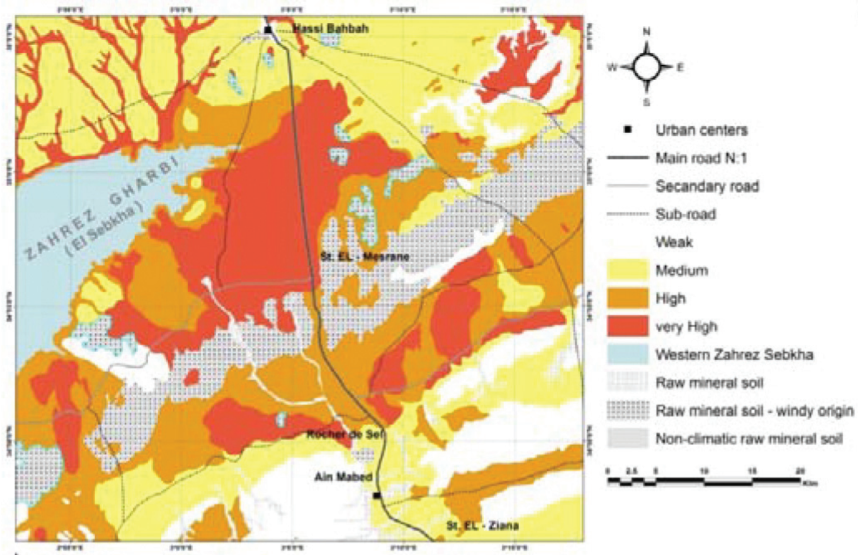


Fig. 5. Charting the risk of wind erosion in the EL-Mesrane region using ArcMap 10.3.

Table 3. Results of the calculation of the **E** potential wind erosion of soil in the study area.

Soil code	I : Soil Erodibility	C : Climate factor for wind erosion	E : Potential wind erosion of soil
2	69.96	99.22	6941.43
3	91.22	99.22	9050.85
4	104.16	99.22	10334.76
5	64.04	99.22	6354.05
6	66.94	99.22	6641.79
7	22.16	99.22	2198.72
8	64.05	99.22	6355.04
9	52.72	99.22	5230.88
10	99.65	99.22	9887.27
11	36.05	99.22	3576.88
12	14.24	99.22	1412.89
13	32.99	99.22	3273.27
14	15.56	99.22	1543.86
15	58.62	99.22	5816.28
16	104.16	99.22	10334.76



Map 4. Potential risk of wind erosion in the study area.

Wind erosion has a negative effect on soil characteristics through the transfer of small, light soil granules, organic matter and nutrients necessary for plant growth, causing soil level to decline, thus reducing arable and grazing areas.

Recommendations

Attention to vegetation cover and conservation from overgrazing, because it has a large and influential role in reducing wind speed near the surface of the soil, and carrying out full maintenance of soil and water in the area.

-Soil should not be left exposed between harvest and agriculture, by leaving the residue (residues) of the crop to cover the soil, as this is important in building the surface layer and protecting the surface from erosion.

-Open the door for researchers and those interested in soil science by encouraging them to conduct further studies in this area and in other locations.

-Taking advantage of modern techniques such as GIS to prioritize work on projects, where they will contribute to determining the direction of the wind during the establishment of a particular project, and preparing objective maps on erosion to develop programmes and appropriate methods for soil maintenance.

-Planning (by establishing a comprehensive land reclamation scheme based on the physical and chemical characteristics of the soil), increasing scientific research and increasing scientific stations, and the need to integrate disciplines through the conduct of geographical, geological, hydrological, agricultural and other studies of basins Surface water, in order to know the most important wealth and potential available in the region.

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