Assiut Journal of Agricultural Sciences 54 (4) 2023 (286-303)
ISSN: 1110-0486 / EISSN: 2356-9840
Website: http://ajas.journals.ekb.eg/
E-mail: ajas@aun.edu.eg

(Original Article)

Using a Modified Medlaus Model to Assess the Environmental Sensitivity for Desertification in El-Gallaba Plain, New Aswan City, Aswan, Egypt

Salah H. Abd El-Aziz[1*] Ahmed Gh.M. lbrahim[2]; Esraa G.M. Okashaa[2] and Alaa H. Abd El-Azem[2]

[1]Department of Soils and Water, Faculty of Agriculture, Assiut University, Assiut, Egypt.
[2]Department of Lands and Natural Resources, Faculty of Agriculture and Natural Resources, Aswan University, Aswan, Egypt

* Correspondence: abdelazizsh@yahoo.com
DOI: 10.21608/AJAS.2023.220680.1276

Abstract

This study aims to use the Geographic Information System (GIS) of spatial analyses for environmental desertification sensitivity assessment in the El-Gallaba Plain region, New Aswan City, Aswan governorate, Egypt, using the soil characteristics and the modified MEDALUS methodology. Five indicators of desertification including soil factor, climate, soil erosion, vegetation, and land management to calculate the environmental sensitivity to desertification. The Desertification Sensitivity Model (DSSM) was designed to assess and map the sensitivity of land to desertification, depending on the weighted mean of some soil properties. The obtained data reveals that 5.03% (50.3 hectares, or 119.7 feddans) of the area is sensitive to desertification. While the area exposed to very severe sensitivity to desertification is about 94.97% (949.7 hectares, or 2260.3 feddans) of the studied area.

The results obtained showed that the area under study suffers from desertification sensitivity due to mismanagement, topographic conditions, scarcity of vegetation cover, lack of exploitation of the land, soil quality, and wind erosion, as well as climate condition. Whereas the majority of the studied region is susceptible to desertification, it could be concluded that assessing its sensitivity is crucial for sustainable development measures to prevent it as well as for enhancing the use of natural resources. Additionally, the region requires significant efforts from everyone, including the Egyptian government, to counteract desertification through efficient management of the greatest hazards to sustainable development in the arid, semi-arid, and sub-humid areas of many countries.

Keywords: *El-Gallaba Plain, GIS, Desertification, Modified MEDALUS approach.*

Introduction

Desertification is soil degeneration and ones. It is a world phenomenon caused by many factors, including natural processes and human activities. Natural processes include drought, rain scarcity, wind erosion, water erosion, and sand encroachment. Human activities include rapid urban sprawl, soil salinization, and

Received: 12 July 2023/ Accepted: 1 October 2023/ Published online: 5 October 2023

overgrazing. Therefore, Environmental and human characteristics are important indicators of land sensitivity to desertification (UNEP 1992; MALR 2018; Mostafa *et al*., 2020; Shokr *et al*., 2021; Fadl *et al*., 2022). On the other hand, according to Herrmann and Hutchinson (2005), the human factor is the most significant dynamic mechanism affecting the acceleration of desertification. Additionally, several interactions between diverse elements, such as climatic change and human activity, contribute to desertification (UNCCD 2008).

Wind erosion is one of the most effective factors for desertification in desert areas. The standard MEDALUS is used to assess the susceptibility to desertification, and it depends on a combination of five quality indicators, including soil, climate, erosion, vegetation, and management quality. In general, the equation for five quality metrics is calculated to estimate the desertification sensitivity index after weighting factors are added to each parameter (Mohamed, 2013).

In regions of scanty rainfall, climatic conditions, erodible soil, bare land, little vegetation cover, and low organic matter are considered the most important reasons for increasing the so-called environmentally sensitive areas (Zambon *et al*., 2017). As a result of wind activity in the western desert, its erosion risks vary from moderate to severe (DRC, 2005). Thus, the quantitative assessment of the loss of soils by wind action is essential when assessing desertification in these regions (Fadl, *et al*., 2022). Additionally, according to Borrelli *et al*. (2016), combining the original Mediterranean Desertification and Land Use (MEDLAUS) technique and the index of land susceptibility to wind erosion (ILSWE) into a spatial model can help with a more accurate evaluation of the risks associated with desertification. Additionally, the vegetation index has been expressed by the Normalized Differential Vegetation Index (NDVI) (Saleh *et al*., 2018).

The topography, geology, and geomorphology of the Western Desert, including the area under study, is basically, is a desert plateau with a wide flat expanse of rocky land or many enclosed depressions (Said 1961). According to Said (1962) and Abd El-Razik and Razavaliaev (1972), the El-Galaba area lies on the African platform with its Precambrian flooded basement; the tectonic framework is related to the Last African Orogenic Belt. Tawardros (2001), and Lansbery (2011) studied the sequence of Nubian sandstones in the Aswan region and classified them into three clusters of formations, Abu Aggag at the base located above the crystalline Precambrian rocks, and above it, there is the Timsah formation, which is topped by the Umm Barmil formation. The maximum thickness of the Nubian sandstone in the Aswan area is about 160 meters (Youssef, 2003). The morphological features of the area under study as part of the West Nile Valley are divided based on Farrag (1982) into surface units: the Nile River passes through the young alluvial plains. The ancient alluvial plains of the Nile consist of terraces located at different elevations on the eastern and western sides of the Nile Valley. The limestone plateau and its surrounding slopes. The plateau was underlain by limestone in the Eocene period and lies on both sides of the Nile Valley. Structural plains occupy the southern part of the region and lie under the hydrographic basins of the Nubian sandstone and including dry drainage lines channeled into the Nile basin and crossing the skeletal plains and the limestone plateau.

To estimate the extent of desertification in many nations around the world, including Egypt, many researchers have used geographic information system approaches including the modified MEDALUS method (Basso *et al*., 2000; Gad and Lotfy 2006. Ali and El Baroudy 2008; Lavado *et al*., 2009 Afifi *et al*., 2010; Gad and Shalaby 2010; Abdel Kawy and, Belal, 2011; Luca and, Sofia 2011; Mohamed, 2013; Salunkhe *et al*., 2018; Mostafa *et al*., 2020; Fadl *et al*., 2022; Okashaa, 2023). Because desertification is the final result of soil degradation (Hill 2005). Soil desertification refers to the reduction of the economic productivity of the soil in arid and semi-arid regions (Zonn *et al*. 2017).

The objective of this study is to evaluate and map the El-Gallaba Plain in New Aswan City's vulnerability to desertification using the modified MEDALUS approach, spatial analysis, and geographic information systems (GIS).

Materials and Methods

1. Study area

The study area is a part of the western desert (El-Gallaba Plain and a part of Wadi El-Kubbaniya), it is located in the new Aswan City, about 20 Km west of Aswan governorate. The study area lies between latitudes 24° 16' 18" and 24° 18' 44" N and longitudes 32° 46' 32" and 32° 45' 38” E. (Figure 1).

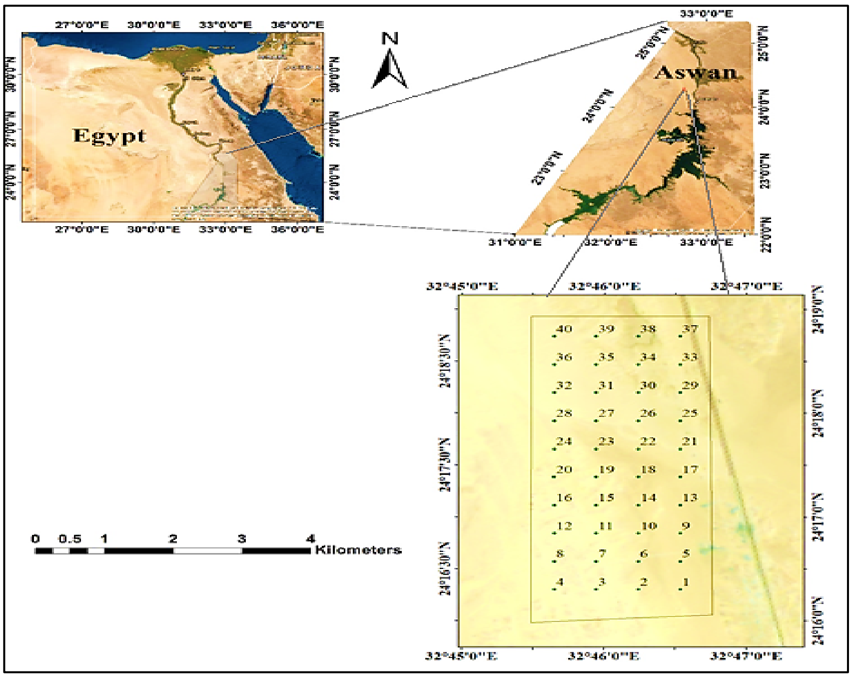


Figure 1. A map of Egypt shows the location of soil profiles.

2. Field description and soil sampling

Forty soil profiles were selected to represent the area under study according to the geology, topography, and recent aerial photographic maps of the studied area

(Figure 1). The morphological description of the soil was carried out according to the soil description standards (FAO, 2006; Soil Survey Staff, 2014). According to FAO (2006) and Schoenberger *et al*. (2012), these profiles were excavated to the appropriate depth (150 cm), and morphological properties and vertical morphological variations were recorded. Soil samples were taken from the various layers of all profiles. The samples were stored for various tests after being air-dried, crushed, and passed through a 2 mm screen.

3. Laboratory analysis

According to the Soil Survey Staff (2014), soil analyses were performed. According to USDA (2004), the gravel content was calculated based on volume. The particle size distribution was carried out using the traditional pipette approach as reported by Gavlak *et al*., 2005. According to Alvarenga *et al*. (2012), a glass electrode (pH meter model, Hanna Instruments HI 2211Ph/ORP) was used to evaluate the pH at 1:1 soil-to-water suspension, and Bashour and Sayegh (2007)'s methods were used to measure electrical conductivity (ECe) using a calibrated Hanna EC meter model (JENCO Vision Plus EC 3175N) at 25°C. The typical Walkley-Black approach was used to estimate the soil organic matter (OM). The ammonium acetate pH 7.0 technique was used to calculate the cation exchange capacity (CEC) and exchangeable sodium (Bashour and Sayegh, 2007). The gas evolution method of Scheibler's calcimeter (Eijkelkamp-model 08.53) was used to estimate total calcium carbonate ($CaCO_3$) gasmetrically (Nelson, 1982; Houba *et al*., 1995). The acetone precipitation method was used to calculate the gypsum content (Nelson, 1982; Hesse, 1998).

4. Climate of the Study Area

The study region has a hot environment; the lowest temperature is 16.91 OC and the maximum is 35.25 OC and the mean annual temperature is 25.91 OC. The total annual rainfall is 0.01 mm, and the average yearly rate of evapotranspiration (PET) is 7.2 mm/day. In comparison to the mean annual wind speed of 3.36 m/sec, the mean annual relative humidity average is 26.05% (Table 1).

Table 1. Meteorological- climatic data of the studied area (Station of Aswan)

Year	Temperature (°C)			Relative Humidity (%)	Evaporation (mm/day)	Wind velocity (m/sec.)	Rainfall (mm)
	Man.	Max.	Mean				
10-19	16.9	35.3	26.1	25.9	8.3	3.3	0.01
2020	21.3	33.9	29.8	27.3	7.2	4.3	0.01

The examined region frequently experiences arid climate conditions, according to meteorological information acquired from the Aswan station. Both the soil temperature and moisture are in hyperthermic and torric regimes. The area being investigated has relatively little native vegetation.

5. Soil Classification

The researched soil profiles were categorized down to the subgroups level by Soil Taxonomy based on the meteorological data, field observations, morphological, and analytical soil attributes (Soil Survey Staff, 2022).

6. Desertification Sensitivity

Based on information gathered from the field surveys, DEM analysis (slope and aspect), Landsat image processing (LULC types and plant cover intensity%), the weighted mean of some soil properties, meteorological data, and the design of the desertification sensitivity model, ArcGIS (10.4) software was used to assess and map the land sensitivity to the desertification in the area under study. The equation of Mediterranean desertification and land use (MEDALS), uses five desertification indicators such as soil factor, soil erosion, climate, vegetation, and land management as the following equation:

$$DSI = (SQI * VQI * CQI * MQI * EQI)^{1/5}$$

Where: DSI is the desertification index, SQI stands for soil quality index, VQI stands for vegetation quality index, CQI stands for climate quality index, MQI stands for management quality index and EQI is for erosion quality index. Table (2) shows the five desertification indicators, and Table (3) provides the desertification index, classes, and scores.

To assess the desertification sensitivity in the study area using the modified MEDALUS, the following indices were calculated: the soil quality index (SQI), the climate quality index (CQI), the management quality index (MQI), the erosion quality index (EQI), and the vegetation quality index (VQI).

Soil Quality Index:

To assess the soil quality index, the following equation was used:

$$SQI = (I_t \times I_d \times I_s \times I_r \times I_e \times I_c \times I_g \times I_{dr})^{1/8}$$

Where: I_t is soil texture index, I_d is soil depth, I_s is slope gradient, I_r is rock fragment, I_e is Electrical conductivity (ECe), I_c is calcium carbonate content ($CaCO_3$), I_g is gypsum content ($CaSO_4.2H_2O$) and I_{dr} is drainage condition.

Climate Quality Index:

The climate quality index was calculated according to the following equation:

$$CQI = (I_r \times I_e \times I_a)^{1/3}$$

Where: I_r is rainfall, I_e is evaporation index and I_a is aridity index.

Management Quality Index:

The management quality index was calculated according to the next equation:

$$MQI = (I_l \times I_g \times I_p)^{1/3}$$

Where: I_l is land use/ land cover, I_g is soil grazing intensity and I_p is land policy.

Erosion Quality Index:

The erosion Quality Index was calculated according to the following equation:

$$\text{EQI} = (\text{Wind erosion} \times \text{Water erosion})^{1/2}$$

Vegetation Quality Index:

The vegetation quality index was calculated as follows:

$$\text{VQI} = (I_{ep} \times I_{dr} \times I_{nd})^{1/3}$$

Where: I_{ep} is soil erosion (soil erodibility), I_{dr} is drought resistance index and I_{nd} is the normalized difference vegetation index (NDVI).

Table 2. Classes and factors assigned weighting index affecting desertification process

Indicators	Indicators Characteristics	Classes	weigh	Index
1. Soil quality index	Soil depth	-Very deep	Depth >1 m	1.0
		-Moderately deep	Depth <1 to 0.5 m	1.33
		-Shallow	Depth <0.5 to 0.25	1.66
		-Very shallow	Depth <0.15 m	2.00
	Soil texture	-Loamy sand, Sandy loam	1	1.0
		-Loamy clay, clayey sand, sandy clay	2	1.2
		-Clayey, clay loam	3	1.6
		-Sandy to very sandy	4	2.0
	Slope gradient	-Gentle	<6 %	1.0
		-Not very gentle	6–18 %	1.33
		-Abrupt	19–35 %	1.66
		-Very abrupt	>35 %	2.0
	Calcium carbonate	-Non-calcareous	<5 %	1.0
		-Slightly calcareous	5–10 %	1.2
		-Moderately calcareous	10–20 %	1.5
		-Strongly calcareous	>20 %	2.0
	Gypsum	-Slightly gypsiric	<5 %	1.0
		-Moderately gypsiric	5–15 %	1.2
		-Strongly gypsiric	15–60 %	1.5
		-Extremely gypsiric	>60 %	2.0
	Electrical conductivity	-Very low	<4 dS/m	1.0
		-Low	4–8	1.2
		-Moderately	8–16	1.5
		-Moderately high	16–32	1.7
		-High	>32	2.0
	Rock fragments	-Very stony	>60 %	1.0
		-Stony	60–20 %	1.3
		-Bare to slightly stony	<20 %	2.0
	Drainage	-Well drained	1	1.0
		-Moderately drained	2	1.2
		-Poorly drained	3	2.0
2. Climate quality index	Rainfall (mm)	-High	>300 mm	1.0
		-Moderately	150–300 mm	1.33
		-Low	<150 mm	1.66
	Evapotranspiration (mm)	-Low	<1.500 mm	1.0
		- Moderately	1.500–2.000 mm	1.5
		- High	>2.00 mm	2.0
	Aridity index (P/ETp)	-Semi-arid	AI ≥1	1.0
		-Arid	AI 0.1-1	1.5
		-Hyper-arid	AI <0.1	2.0

Table 2. Cont.

Indicators	Indicators Characteristics	Classes	weigh	Index
3. Management quality index	Land use	-Agricultural lands	1	1
		-Rangelands	2	1.3
		-Poor and degraded	3	1.6
		-Bare lands	4	2
	Grazing intensity	-Low	<1	1.0
		-Moderate	1–2.5	1.5
		-High	>2.5	2
	Policy and management	-Complete: >75 % of the area under protection	1	1.0
		- Partial: 25–75 % of the area under protection	2	1.5
		-Incomplete: <25 % of the area under protection	3	2.0
4. Erosion quality index	Wind erosion	-Very low	1	1
		-Low	2	1.2
		-Moderate	3	1.5
		-High	4	1.7
		-Very high	5	2
	Water erosion	-Very low	1	1
		-Low	2	1.2
		-Moderate	3	1.5
		-High	4	1.7
		-Very high	5	2
5. Vegetation quality index	Erosion protection	-High	1	1.0
		-Moderate	2	1.33
		-Low	3	1.66
		-Very low	4	2
	Drought resistance	-Gardens, orchards, rangelands	1	1.5
		-Permanent grassland, annual crops, and grasslands	2	2.0
		-Bare land	3	2.5
	Normalized different vegetation index	-High	NDVI >0.95	1.0
		-Moderate	NDVI 0.95–0.65	1.2
		-Low	NDVI 0.65–0.35	1.5
		-Very low	NDVI <0.35	2

Table 3. Desertification sensitivity index, classes, and scores

DSI class	Classes	Scores
Low sensitive	1	1.2-1.3
Moderately sensitive	2	1.3-1.4
Sensitive	3	1.4 – 1.6
Very sensitive	4	> 1.6

Results and Discussion

Topography or elevation is an important factor in soil formation and land capability for sustainable agriculture, especially in semi-arid and arid regions characterized by active physical weathering. The digital elevation model (DEM) of the study area (Figure 2) showed that the soil elevation varies from 110 to 168 meters above sea level (a.s.l). The topography of the study area is almost flat, most of the studied soil profiles are located in a semi-flat topography, and the upper surface is almost flat with very few undulating surfaces. The soil surface is covered with desert pavement with different levels of gravel.

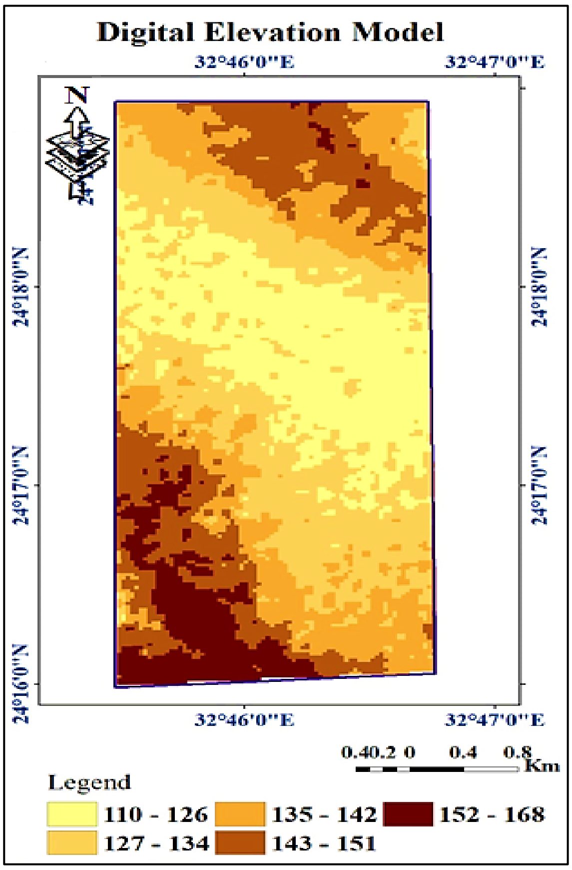


Figure 2. Digital elevation model (DEM) of the study area.

1. Soil Properties

The physicochemical properties of study soil profiles and their weighted means are present in Table (4). The descriptive statistics of the soil analysis indicated that the standard deviation (SD) values ranged from 0. 0.22 to 19. 42 among the studied characteristics. A low standard deviation indicates that the results tend to be close to the mean of the properties excluding the gravel content. The coefficient of variation (CV%) varies from one property to another and ranges from 2.62 % to 115.06 % among all the soil properties. The data reveal that the very high variability (CV %) was in organic matter (OM), calcium carbonate ($CaCO3$), gypsum content, soil salinity (ECe), cation exchange capacity (CEC), exchangeable sodium percentage (ESP), sodium adsorption ratio (SARe), gravel content, silt fraction, and clay fraction. On the other hand, the coefficient of variation (CV%) was low for the soil pH and sand fraction.

The results indicate that the slope ranges from 1.93 to 8.67, and a CV value of 90.12%, which was flat to gently sloping, soil depth refers to very deep soils (150 cm). The organic matter content of the studied soil profile weighted mean ranges from 0.07 to 1.72 g/kg and the CV value of 79.54%. The soils were slight to moderately calcareous and calcium carbonate contents ranged between 0.75 and 11.67 %, with a CV value of 63.23%. The tested soil samples also showed that the gypsum content varies from 0.31 to 8.71% and the soil was slightly gypsiric with a CV value was 85.38%. Soil reaction is mild to moderately alkaline, as indicated by pH values, which range between 7.84 and 8.83. The soil pH was characterized by very low variability (CV= 2.62 %). The soil was fairly non-saline with profile-weighted mean ECe values ranging between 0.69 and 13.86 dSm-1 (CV = 106.09%). The CEC of the studied soil profile weighted mean varies between 4.86 and 32.19 cmol (+)/kg (CV= 106.09%). The data also, showed that the sodium adsorption ratio (SARe) ranged from 1.66 and 13.82 (CV=53.06%), while the exchangeable sodium percentage (ESP) ranged between 1.8 and 16.66%, (CV=40.38%).

The results showed that the percentage of sand prevailed in most of the studied soil samples, especially in the surface layer. The profile weighted mean of sand varies from 55.17 % to 99.20% and CV of 10.68%, followed by silt varies between 0.40% and 23.09% (CV=115.06%), while the clay percentage ranges from 0.40% to 33.55% (CV=84.88 %). The texture of the soil was coarse-textured and consisted mainly of sand, loamy sand, and sandy loam texture. The soils contained little gravel, ranging from 0.26% to 59.83% (CV= 103.89%).

Table 4. Soil profile weighted means of some physiochemical properties of the study area

Property	Min.	Max.	Mean.	SD.	CV (%)
Slope	1.59	11.82	4.84	4.36	90.12
OM (g/kg)	0.07	1.72	0.45	0.36	79.54
$CaCO_3$ (%)	0.75	11.67	3.26	2.06	63.23
Gypsum (%)	0.31	8.71	2.08	1.78	85.38
pH (1:1)	7.84	8.83	8.318	0.22	2.62
EC_e dS/m	0.69	13.86	3.582	3.801	106.09
CEC (cmole$^{(+)}$/kg)	4.86	32.19	11.35	6.018	53.028
SAR_e	1.66	13.82	3.90	2.07	53.06
ESP (%)	1.8	16.66	6.75	2.73	40.38
Gravel	0.26	59.83	18.69	19.42	103.89
Sand (%)	55.17	99.2	89.03	9.51	10.68
Silt (%)	0.4	23.09	4.26	4.89	115.06
Clay (%)	0.4	33.55	6.72	5.70	84.88

SD, standard deviation; CV, coefficient of variation; EC, electrical conductivity; OM, organic matter; CEC, cation exchange capacity; SARe, sodium adsorption ratio, and ESP, exchangeable sodium percentage.

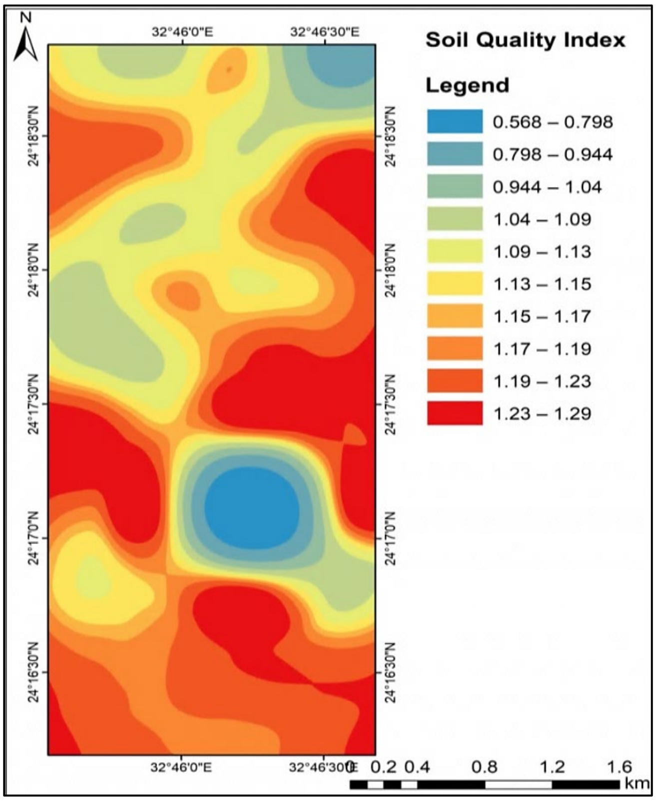
2. Classification of the Studied Soils

Soils in the study area were classified according to field observation, description of morphological characteristics, results of physical and chemical properties, as well as climatic data. The moisture regime of the study area is torric and the temperature regime is hyperthermic. Accordingly, the studied soils were classified down to the subgroup level. In general, soils are classified as Entisols. Two suborders are recognized, under this order namely, Psamments and Orthents. The recognized subgroups are Typic Torripsamments, Typic Quartzipsamments, and Typic Torriorthents.

3. Quantifying the Original Indices

Soil quality index (SQI)

The results in Figure (3) and Table (5) illustrate that the soil quality index (SQI) ranges from 0.598 to 1.29. High-quality soils occupied 40% (400 hectares or 952 feddans) of the study area, while moderate-quality soils covered only 60% (600 hectares or 1428 feddans).



Climate Quality Index (CQI)

The climatic conditions of the area under study are similar to other desert areas in Egypt, which are characterized by hot rainless summers and mild winters with scanty rainfall. The air temperature of the study area depends on the solar energy that comes from the sun, which is based on actual sunshine hours Generally, rainfalls in the western desert of Egypt are considered very rare and occur mainly in the form of winter storms that occur from time to time. The climatological data showed that dryness prevailed most of the year and there were no wet periods.

Consequently, it can be concluded that the climate of this area is extremely arid. As a result, the climate quality index (CQI) indicates low climate quality (100%), due to scarcity of rain, severe drought, and high rates of evaporation (Table 5).

Management Quality Index (MQI)

The management quality index includes land use, grazing methods and intensity, and land cultivation, all of which are important factors influencing the desertification process. The data obtained indicated that about 80% (800 hectares or 1904 acres) of the total area suffers from mismanagement of land resources, overgrazing, and improper use of the soil. Medium-quality index area represents about 10% (100 hectares or 238 feddans) of the total area, while 10% (100 hectares or 238 feddans) of the total area was characterized by a high-quality index as shown in Table (5).

Erosion Quality Index (EQI)

Erosion plays an important role in the susceptibility of the study area to desertification. In the absence of vegetation cover, high-speed winds, and a loose soil surface, erosion has a great impact on the soil surface. Due to the influence of morphology, topography, wind speed, soil characteristics, properties, and vegetation cover, the area has a moderate erosion quality index. The results showed in Table (5) and Figure (4) that areas with high and very high erosion quality indices account for about 25% (250 hectares or 595 feddans) of the total area, moderate erosion quality indexes account for approximately 65% (650 hectares or 1547 feddans), and low and very low erosion quality indexes account for approximately 35% (100 hectares).

Table 5. The classes and areas of quality indices of the modified MEDLAUS methodology

Indicator	Class	Quality	Range	Area		
				hectare	feddan	%
Soil quality index	1	High	<1.13	400	952	40
	2	Moderate	1.3-1.45	600	1428	60
	3	Low	>1.45	00	00	00
Climate quality index	1	Semi-arid	<1.4	00	00	00
	2	Arid	1.4-1.6	00	00	00
	3	Hyper-arid	>1.6	1000	2380	100
Management quality index	1	High	<1.25	100	238	10
	2	Moderate	1.25-1.5	100	238	10
	3	Low	>1.5	800	1904	80
Erosion quality index	1	Very High	<1.0	50	119	5
	2	High	1-1.2	200	476	20
	3	Moderate	1.2-1.5	650	1547	65
	4	Low	1.5-1.8	50	119	5
	5	Very low	2	50	119	5
Vegetation quality index	1	High	<1.2	00	00	00
	2	Moderate	1.2-1.4	00	00	00
	3	Low	1.4-1.6	00	00	00
	4	Very low	>1.6	1000	2380	100

Vegetation Quality Index (VQI)

The data obtained showed that the area under study is characterized by a very low vegetation quality index and occupies about 100% of the total area (Table 5), due to it being barren and uncultivated land and exposure of the soil surface to erosion and the normalized of different vegetation cover (NDVI) is very weak and sensitive to desertification.

4. Desertification Sensitivity Spatial Model (DSSM)

Desertification is one of the most serious challenges to long-term development in many countries with arid, semi-arid, and semi-humid climates. Wind erosion, soil salinization, water erosion, rapid urban sprawl, overgrazing, and sand encroachment are all examples of global phenomena caused by natural processes and human activities. Geographic information system (GIS) and spatial analyses were used to assess the sensitivity of environmental desertification in the investigated area based on soil characteristics and the Mediterranean Desertification and Land Use (MEDALUS) equation, which uses five desertification indicators, including soil factor, soil erosion, climate, vegetation, and land management (Kosmas *et al*., 1999; Sepehr *et al*., 2007).

To identify areas where sensitivity increases over time, a desertification sensitivity model (DSSM) based on remote sensing data and GIS tools is required. The DSSM is intended to assess and map the sensitivity of land to desertification in the study area, as this assessment is critical for land and natural resource management in this area. As a result, the physical and chemical properties of the soil samples were classified and weighed to determine the sensitivity of the land to be mapped to desertification.

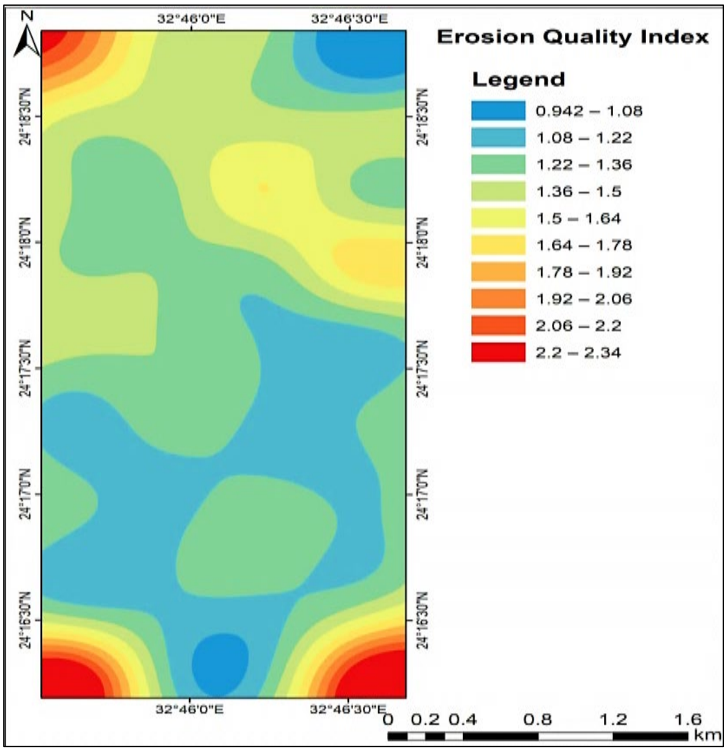


Figure 4. Erosion quality index classes of the studied area

According to the desertification sensitivity equation (MEDALUS) and the desertification spatial model (DSSM), the data indicated that there are two categories of desertification sensitivity in the studied area, including, sensitive, and very sensitive classes, as given in Table (6) and illustrated in Figures (5, and 6).

Table 6. Desertification sensitivity index and their areas

No.	Desertification Sensitivity (DSSM)	Area			
		km^2	Hectare	feddans	%
1	Sensitive areas	0.503	50.3	119.70	5.03
2	Very sensitive areas	9.497	949.7	2261.25	94.97
	Total	10.00	1000	2380.95	100

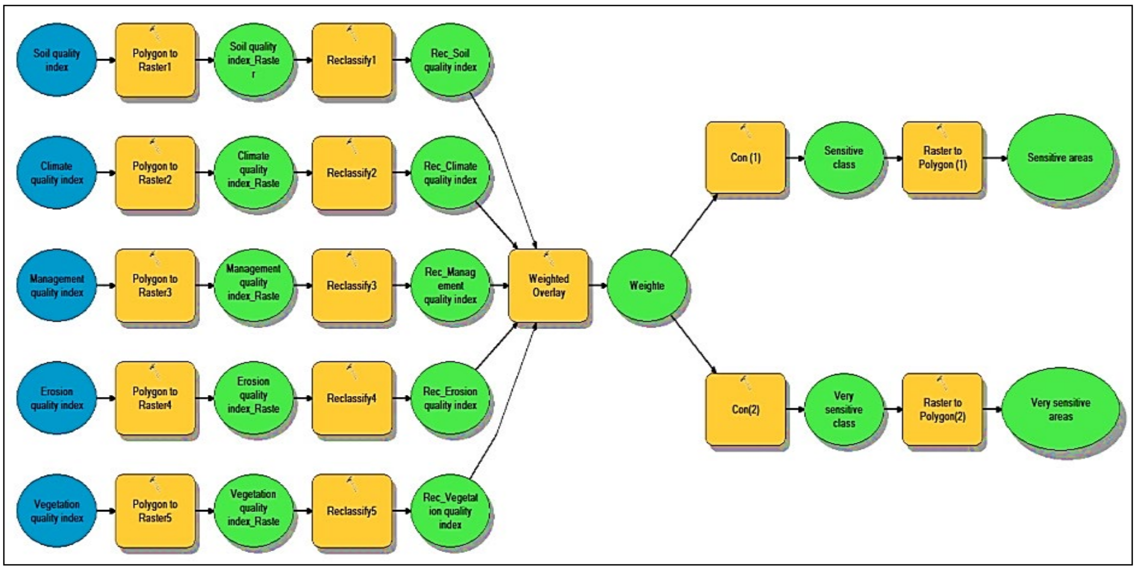


Figure 5. Designed desertification sensitivity spatial model (DSSM) flowchart.

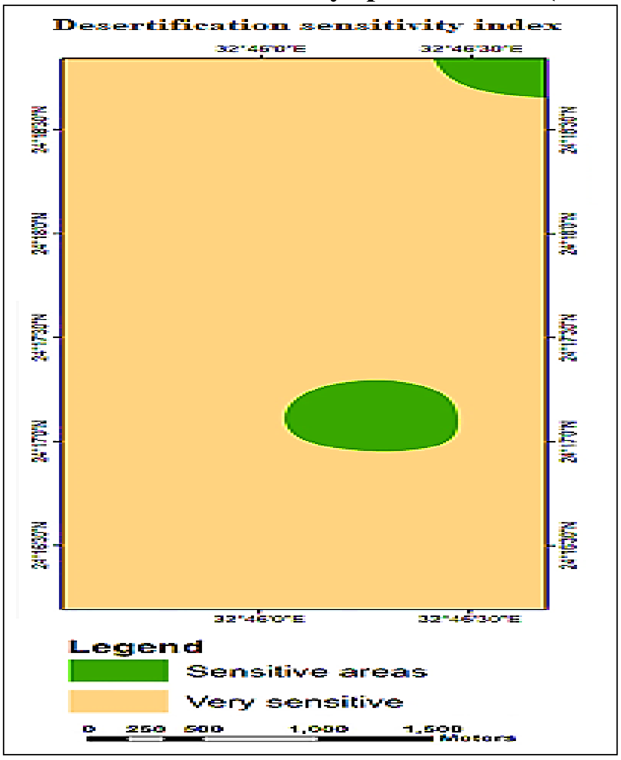


Figure 6. Desertification sensitivity classes of the studied area.

Sensitive class

This class occupies an area of 5.03% (50.3 hectares or 119.7 feddans) of the study area. On the other hand, these soils have severe limitations that restrict their use for arable culture. Accordingly, these soils have marginal capability and low productivity.

Very sensitive class

According to the results obtained, this area represents 94.97% (949.7 hectares or 2260.3 acres) and is prone to desertification due to scarcity of vegetation cover or lack of vegetation cover, soil quality, poor management, climatic conditions, wind erosion, high gravel content, and coarse soil. This area needs great efforts to overcome these phenomena by using effective management and policies to combat desertification. In general, these soils require good and proper management. Under good management can be selected crops that are moderate to high productivity.

Conclusion

From the previous discussion and the results obtained, it is clear that the area under study suffers from desertification sensitivity due to mismanagement, topographic conditions, scarcity of vegetation cover and lack of exploitation of the land, soil quality, and wind erosion, as well as climate conditions. Therefore, it can be concluded that an assessment of desertification sensitivity is very important to planning methods of control measures of desertification as well as improving the use of natural resources because most of the study area is exposed to desertification. In addition, the region needs great efforts from the Egyptian government and everyone to overcome desertification by using effective management and methods to combat these phenomena.

References

Abd El-Razik, T., and Razavaliaev, A. (1972). On the tectonic origin of the Nile Valley between Idfu and Qena, Egypt. J of Geology, 16 (2): 235-245.

Abdel Kawy, W.A., and Belal, A.A. (2011). GIS to assess the environmental sensitivity for desertification in soil adjacent to El-Manzala Lake, East of Nile Delta, Egypt. American-Eurasian J. Agric., and Environ. Sci., 10 (5): 844-856.

Afifi, A.A., Gad, A., and Refat, A. (2010). Use of GIS and Remote Sensing for Environmental Sensitivity Assessment of North Coastal Part, Egypt. J of American Science 6 (11): 632–646.

Ali, R.R. and El Baroudy, A.A. (2008). Use of GIS in mapping the environmental sensitivity to desertification in Wadi El Natrun depression, Egypt. Aust. Jour. Basic Appl. Sci. 2, 157–164.

Alvarenga, P., Palma, P., De Varennes, A., Cunha-Queda, A.C. (2012). A contribution towards the risk assessment of soils from the São Domingos Mine (Portugal): Chemical, microbial and ecotoxicological indicators. Environment Pollution, 161, 50- 56.

Bashour, I.I., Sayegh, A.H. (2007). Methods of Analysis for Soils of Arid and Semi-Arid Region, American University of Beirut, Lebanon. FAO, Rome.

Basso, F., Bove, E., Dumontet, S., Ferrara, A., Pisante, M., Quaranta, G. and Taberner, M. (2000). Evaluating environmental sensitivity at the basin scale through the use of geographic information systems and remote sensed data. An Example Covering the Agri Basin (Southern Italy). Catena, 40:19–35.

Borrelli, P.; Panagos, P.; Ballabio, C.; Lugato, E.; Weynants, M.; Montanarella, L. (2016). Towards a pan-European assessment of land susceptibility to wind erosion. Land Degrad. Dev. 27, 1093–1105.

DRC. (2005). Egyptian National Action Program to Combat Desertification; Desert Research Center (DRC), Ministry of Agriculture and Land Reclamation (MALR): Cairo, Egypt.

ESRI (2019). Are Map version 10.2.2. User Manual. ESRI, 380 New York Street Redlands, California, 92373-8100, USA.

Fadl, M.E., Abuzaid, A.S., Abdel Rahman, M.E., and Biswas, A. (2022). Evaluation of Desertification Severity in El-Farafra Oasis, Western Desert of Egypt: Application of Modified MEDALUS Approach Using Wind Erosion Index and Factor Analysis. Land, 11: 54.

FAO. (2006). Guideline for soil description, fourth edition. Rome.

Farrag, A.A. (1982). Hydrogeological studies on the quaternary water bearing sediments in the area between Assiut and Aswan. M.Sc. Thesis, Fac. of Sci., Assiut University.

Gad, A. and Shalaby, A. (2010). Assessment and mapping of desertification sensitivity using remote sensing and GIS. Case study: Inland Sinai and Eastern Desert 216 Wadies. US-Egypt Workshop on Space Technology and Geo-information for Sustainable Development, Cairo, Egypt, 14-17 June.

Gad, A. and Lotfy, I. (2006). Use of remote sensing and GIS in mapping the environmental sensitivity areas for desertification of Egyptian territory. The 2nd International Conf. on Water Resources and Arid Environment, 26 -29. King Saud University.

Gavlak, R., Horneck, D., Miller, R.O. (2005). Soil, Plant, and Water Reference Methods for the Western Region. Oregon State University Corvallis, OR. USA.

Herrmann, S.M., & Hutchinson, C.F. (2005). The changing contexts of the desertification debate. Journal of Arid Environments, 63(3), 538-555.

Hesse, P.R. (1998). A Textbook of soil chemical analysis. CBS Publishers & Distributors. Delhi, India.

Hill, J. (2005). Land and Soil Degradation Assessments in Mediterranean Europe-the GMES- LADAMER project, European Commission.

Houba, V.J.G., Van der Lee, J.J., Novozamsky, I. (1995). Soil analysis procedures: soil and plant analysis, part 5B. Department of Soil Science and Plant Nutrition, Wageningen Agriculture University, Wageningen.

Jackson, M.L. (1973). Soil chemical analysis. Prentice-Hall of India Private limited, New Delhi, p 498.

Kosmas, C, Ferrara, A., Briasouli, H., Imeson, A. (1999). Methodology for mapping environmentally sensitive areas (ESAs) to desertification. Mediterranean Desertification and Land Use (MEDALUS), European Union 18882. Pp: 31-47.

Lansbery, L. (2011). Geological and geomorphological evolution of the Egyptian Nile between Aswan and Kom Ombo: A remote sensing and field study approach. MS thesis. Missouri University of Science and Technology, Rolla, MO, 83.

Lavado, C.J.F., Schnabel, S., Mezo Gutierrez, A.G. and Pulido, F.M. (2009). Mapping sensitivity to land degradation, Extremadura, south-west Spain. Land Degrad. Dev. 20,129–144.

Luca S, and Sofia, B. (2011). Land sensitivity to desertification across Italy: Past, present, and future. Appl. Geog. 31:223-23.

MALR. (2018). Final Country Report of the Land Degradation Neutrality Target Setting Programme. Ministry of Agriculture and Land Reclamation (MALR). Desert Research Center. Cairo, Egypt. P 35.

Mohamed, E.S., (2013). Spatial assessment of desertification in north Sinai using modified MEDLAUS model. Arab. J. of Geosci., 6 (12): 4647-4659.

Mostafa, A.M., El-Kawy O.R., Osama R., Mohamed Y.I. and Khaled N.A.N. (2020). Desertification sensitivity analysis east of Siwa using GIS and Remote Sensing. Alex. Sci., Exch. J., 41: 1-14.

Nelson, R.E. (1982). Carbonates and Gypsum. pp: 181–197. In: A. L. Page, R. H. Miller and D. R. Keeney (eds). Methods of Soil Analysis, Part 2. American Society of Agronomy, Inc., Madison, Wisconsin, USA.

Okashaa, E.G.M. (2023). Land Capability and Suitability Assessment of New Aswan Area, Aswan Governorate, Egypt. M.Sc. Thesis, Fac. of Agric. and Nat. Res. Aswan Univ., Aswan, Egypt

Said, R. (1961). The Geology of Egypt. Elsevier Publishing Company, Amsterdam, New York, London.

Said, R. (1962). The Geology of Egypt (p. 377). Amsterdam, New York: Elsevier.

Saleh, A., Belal, A., and Jalhoum, M., (2018). Quantitative assessment of environmental sensitivity to desertification in Sidi Abdel-Rahman area, Northern West Coast of Egypt. Egypt. J. of Soil Sci., 58 (1): 13-26.

Salunkhe, S.S., Bera, A.K., Rao, S.S., Venkataraman, R., Raj, U. and Murthy, Y.V.N.K. (2018). Evaluation of indicators for desertification risk assessment in part of Thar desert region of Rajasthan using geospatial techniques. J. Earth Syst. Sci., (1-2) 127:116.

Schoenberger, P.J., Wysocki, D.A., Benham, E.C., Soil Survey Staff. (2012). Field Book for Describing and Sampling Soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Sepehr, A., Hassanli, A.M., Ekhtesasi, M.R., and Jamali, J.B. (2007). Quantitative assessment of desertification in south of Iran using MEDALUS method. Envi. Monitoring and Assess., 134 (1): 243-254.

Shokr, M.S., Abdellatif, M.A., El Baroudy, A.A., Elnashar, A., Ali, E.F., Belal, A.A., Attia, W., Ahmed, M., Aldosari, A.A., and Szantoi, Z. (2021). Development of a Spatial Model for Soil Quality Assessment under Arid and Semi-Arid Conditions. Sustainability. 13: 2893.

Soil Survey Staff. (2014). Keys to Soil Taxonomy. Natural Resources Conservation Service, U.S. Dept. Agric., Twelfth Edition, U.S. Government printing office, Washington, D.C., USA.

Soil Survey Staff. (2022). Keys to soil taxonomy.13th ed. United States Department of Agriculture, Natural Resources Conservation Service, Washington, DC.USA.

Tawardros, E., (2001). Geology of Egypt and Libya. Balkema, Rotterdam/Brookfield.468.

UNCCD. (2008). Desertification – Coping with today's global challenges in the context of the strategy of the United Nations Convention to combat desertification. United Nations Convention to Combat Desertification. Report on the High-Level Policy Dialogue. Bonn, Germany pp. 47.

UNEP. (1992). World Atlas of Desertification. (1st ed.). Edward Arnold Publication.

USDA. (2004). Soil survey laboratory methods manual. Soil Survey Investigation Report No. 42 Version 4.0.

Youssef, M.M., (2003). Structural setting of central and south Egypt: an overview. Micropaleontology, 49: 1-13.

Zambon, I.; Serra, P.; Sauri, D.; Carlucci, M.; Salvati, L. (2017). Beyond the Mediterranean city Socioeconomic disparities and urban sprawl in three Southern European cities. Geogr. Ann. Ser. B Hum. Geogr. 99: 319–337.

Zonn, I.S., Kust, G.S. and Andreeva, O.V. (2017). Desertification Paradigm: 40 Years of Development and Global Efforts. Arid Ecosys., 7 (3): 131-141.

استخدام نموذج MEDLAUS المعدل لتقييم الحساسية البيئية للتصحر في سهل الجلابة، مدينة أسوان الجديدة، أسوان، مصر

صلاح حسانين عبد العزيز[1*]، احمد غلاب محمد ابراهيم [2]، اسراء جمال محمد عكاشة [2] وعلاء هاشم عبد العظيم[2]

[1]قسم الاراضي والمياه، كلية الزراعة، جامعة اسيوط، مصر.

[2]قسم الاراضي والموارد الطبيعية، كلية الزراعة والموارد الطبيعية، جامعة اسوان، مصر.

الملخص

تهدف هذه الدراسة إلى استخدام نظام المعلومات الجغرافية (GIS) للتحليلات المكانية لتقييم حساسية التصحر البيئي في سهل الجلابة، مدينة أسوان الجديدة، محافظة أسوان، مصر، وذلك اعتمادًا على خصائص التربة ومنهجية MEDALUS المعدلة. تم أخذ خمسة مؤشرات رئيسية لتقييم الحساسية البيئية للتصحر، والتي تضمنت مؤشر جودة التربة، ومؤشر جودة المناخ، ومؤشر جودة الغطاء النباتي، ومؤشر جودة التعرية، ومؤشر جودة إدارة الأراضي. تم تصميم نموذج حساسية التصحر (DSSM) لتقييم ورسم خريطة حساسية التصحر لأراضي منطقة الدراسة باستخدام أداة التحليل المكاني من خلال برنامج Arc-GIS 10.2.2 اعتمادًا على متوسط وزن القطاع لبعض خصائص التربة ومنهج MEDALUS المعدل. تظهر البيانات المتحصل عليها أن 5.03% (50.3 هكتار أو 119.7 فدان) من منطقة الدراسة حساسة للتصحر. بينما اغلب المساحة 94.97% (949.7 هكتار أو 2260.3 فدان) من منطقة الدراسة تعتبر شديدة الحساسية جدا للتصحر.

توضح النتائج أن المنطقة قيد الدراسة تعاني من حساسية شديدة للتصحر بسبب سوء الإدارة، والحالة الطبوغرافية، وندرة الغطاء النباتي وقلة استغلال الأرض، ونوعية التربة، وتعرية الرياح، فضلا عن الظروف المناخية. لذلك، يمكن الاستنتاج أن تقييم حساسية التصحر مهم للغاية للتعرف على الطرق الفعالة لمكافحة التصحر وكذلك تحسين استخدام الموارد الطبيعية لأن معظم منطقة الدراسة معرضة للتصحر. بالإضافة إلى ذلك، فإن المنطقة بحاجة إلى جهود كبيرة من الحكومة المصرية والجميع للتغلب على التصحر باستخدام الإدارة والسياسات الفعالة لمكافحة هذه الظاهرة.