

Assessment of soil sensitivity to desertification in Basrah Governorate based on the soil quality index, according to the MEDALUS model,

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Abstract

The study was conducted to evaluate the sensitivity of soils to desertification in the province of Basrah, which is located within the arid zone in the south of Iraq, between latitudes 29°.06' , 31°.18'N, and longitudes 46°.34' , 48°.36'E. The study depends on the soil quality index, according to the model developed by the desertification and land use program for the Mediterranean countries (MEDALUS), through the geometric mean of eight indicators: parent material, soil depth, soil texture, degree of slope, degree of natural drainage, soil salinity, percentage of organic matter, and percentage of solid carbonates Which was estimated based on the results of the analysis of soil samples collected from the study area to a depth of 1 meter during September 2020, in addition to the data of the Digital Elevation Model (DEM) obtained from the US Geological Surveys website (USGS) to determine the degree of slope. Maps were prepared for spatial distribution and area calculation using ArcGIS v.10.7.1. The results showed a variation in the value of soil texture, drainage, soil salinity, percentage of organic matter, and total carbonates, with the stability of values of soil depth, parent materials, and regression in terms of their impact on desertification events. The study area had distributed between moderate-quality and high-quality soils, where the percentage of moderate-quality soils reached 82.0%, while the percentage of high-quality soils reached 11.27% of the study area, and the remaining of areas were water areas

Keywords: desertification, Soil Quality Index, MEDALUS, DSI, GIS.



Introduction

Desertification, land degradation, and drought constitute challenges with a global dimension, as they contribute to economic, social, and environmental problems such as poverty, forced migration, health problems, food insecurity, loss of biodiversity, water scarcity, and low ability to adapt to climate change, which represents serious challenges to sustainable development in all countries affected by desertification (19). Diagnosing the degraded areas and determining the extent of their deterioration and the causes that led to this deterioration is the first step in the field of combating desertification, which precedes the adoption of integrated strategies for the rehabilitation of land and water resources, increasing their productivity, preserving and managing them sustainably through mobilizing resources, building capacities, providing scientific support and awareness, exchanging successful experiences and transferring Technology and assistance in implementing sound policies at the national and regional levels (19). Dengiz *et al.* (10) stated that the Soil Quality Index (SQI) represents the ability of the soil to function within the boundaries of the ecosystem and land use to maintain biological productivity, and environmental quality, promoting plant, animal, and human health. It is a measure of the overall quality of the soil determined based on several physical, chemical, and biological factors. An important tool for farmers, land managers, and researchers to assess soil health and identify management practices that can improve soil quality. Afzali *et al.* (2) stated that the soil quality index is a major factor in the desertification process through its impact in soil physical properties as cohesion and its ability to retain water. Kosmas *et al.* (13) showed that soil quality indicators for desertification sensitivity maps can refer to available water and erosion resistance and

can be evaluated through simple soil characteristics or official soil survey reports such as soil depth, soil texture, drainage, parent material, degree of slope, state of stony...etc. The use of these characteristics to describe and map environmental sensitivity requires defining ranges of varieties depending on the degree of soil protection from desertification. This need to study some of the relationships or overlaps such as soil depth, vegetation cover under different climates, stony, topographical condition, parent material, available water, soil ability to hold water, and soil texture. The soil quality factor is an efficient tool for monitoring the effects of natural factors and soil management because of its great flexibility in terms of the possibility of adding or deleting some of the factors included in it according to their importance and availability, as well as the possibility of obtaining its elements from the reports of field and environmental surveys (1). Al-Hiti and Al-Rawi (4) used four indicators: soil texture, soil depth, parent material, and soil slope to determine the soil quality index when studying soil sensitivity to desertification using the model developed by the Land Use and Desertification Program in the Mediterranean region (MEDALUS). Lahloui *et al.* (14) add the organic matter as a fifth factor for determine the soil quality index. Plaiklang *et al.* (17) used six factors to estimate the soil quality index, including electrical conductivity, when using the MEDALUS model to assess soil sensitivity to desertification in Thailand.

In the study conducted by Aziz *et al.* (6) on the state of desertification in Kirkuk governorate, the soil quality index was used according to the (MEDALUS) model through the analysis of several indicators, namely (Texture, slope, pebbles and stones, drainage, parent material, organic matter, calcium carbonate, and soil depth). The results of the study conducted by

Hamad *et al.* (11) in Maysan Governorate, southern Iraq, indicated that 25% of the study area was of medium quality, 21% was of low quality, while 54% was very low quality, depending on the Soil Quality Index (SQI). In a study conducted in Turkey by Demirağ Turan (9), the soil quality index was determined through the geometric mean of eight factors: texture, parent material, slope, soil depth, soil salinity, degree of soil interaction, percentage of organic matter, and calcium carbonate.

Because of the exacerbation of the problem of desertification in arid and semi-arid regions in general. This study was conducted to assess the sensitivity of the

soil in the province of Basrah to desertification relying on the soil quality index through the analysis of eight indicators: parent material, soil depth, texture, slope, drainage condition, soil salinity, percentage of organic matter, and percentage of total carbonate .

Materials and Methods

Study Area

The study was conducted in the province of Basrah, which is located within the arid areas in the western part of the continent of Asia, south of Iraq, between latitudes 29°06` , 31°18`N and longitudes 34°46` , 48°36` East, with a total area of 19070 km² (Fig. 1).



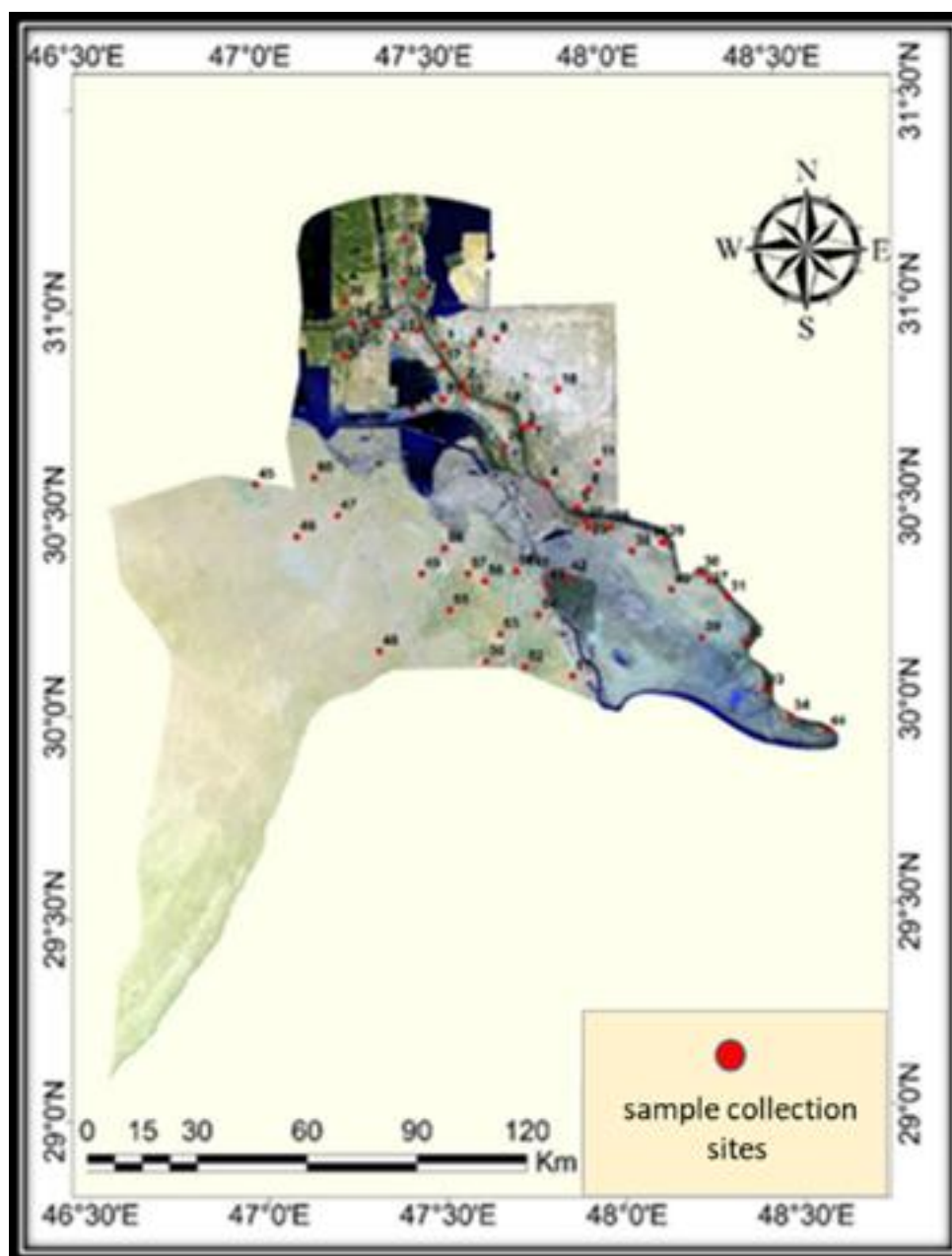


Figure 1 Map of the study area with soil sample collection sites

The meteorological data of the Al-Hussein neighborhood station in Basrah Governorate during the period 1988-2020 (8) showed that the annual average hours of actual brightness reached 8.8 hours day⁻¹, with a range between 6.3-11.3 hours day⁻¹, while the annual average temperature was 26.9 degrees Celsius, at a monthly rate. It ranged between 13.2-36.9 degrees Celsius, and the annual rate of precipitation was 124.9 mm.year⁻¹, while

the annual evaporation rate during the same period was about 2889.1 mm.year⁻¹. Northwesterly winds prevail in the study location, which reach their highest levels during June and July, reaching 5.3 m.s⁻¹. The soils of the study location are considered to be hyperthermic, because the average annual temperature is more than 22 degrees Celsius, and the moisture system is torric (Aridic), due to the

exposure of soils to drought throughout the year.

Assessment of Soil Properties

To estimate soil characteristics, the study area was physiographically divided into two parts, the eastern part, which is located within the southern end of the Mesopotamian plain region, and the western part, which is an extension of the Western Desert, represented by the Dibdaba formations. the contour line 5 m is the boundary between the two regions. Soil samples were collected from the eastern section by free surveying method from several paths, which were represented by leaves, tails, basins of river, dried marshes, and coastal plains. As for the western region, which represents desert soils, it was classified into cultivated areas and uncultivated areas. Soil samples, stirred and unstimulated, were collected from each section separately, up to a depth of 1 meter, and placed in bags of Polyethylene. The depth of groundwater and the depth of mottling were also determined at each site. Soil samples were transferred to the laboratory for conducting chemical and physical analyzes on them, the soil texture was estimated by the pipette method, and the bulk density was estimated by the core sample method for clay soils and the funnel method for sandy soils. the mean weighted diameter

was estimated as a guide to the stability of soil aggregation using the wet sieving method, as stated in Black *et al.* (7). The electrical conductivity of the extract of soil was measured by an EC-meter, the degree of soil reaction was measured using the pH-meter, and the solid carbonate was estimated by oxidizing it with 1N HCl, as stated in Jackson (12). Organic matter was estimated by the method of Walkley - Black reported by sparks *et al.* (18). Table 1 represents the general averages of soil properties at each site. The digital elevation model (DIM) data obtained from the US Geological Surveys site (20) were used to determine the degree of slope. Spatial distribution maps and area calculations were prepared using the program ArcGIS v.10.7.1. Soil quality was estimated through the geometric mean of eight factors: Parent (Pm) material, soil depth (Dep), texture (Text), slope (Sl), drainage state (Dr), soil salinity (Sa), percentage of organic matter (OM), and percentage of calcium carbonate (Ca), after assigning a weight to each indicator that ranged between 1-2, according to its role in causing desertification, as stated in Mostafa *et al.*, (15). As shown in Table (2). Then the soil quality index was calculated according to the following equation

Table 1. General rates of soil properties in the study area

Physical And Chemical Properties	Eastern Region					Western Region	
	River Banks	River Tails	River Basins	Dried Marshes	Coastal Areas	Cultivated Desert	Uncultivated Desert
Number of Profile	21	6	6	7	4	9	7
Sand (g kg ⁻¹)	159.39	110.21	82.19	82.23	172.79	823.69	830.83
Silt (g kg ⁻¹)	510.79	513.08	496.08	503.68	423.77	86.58	70.23
Clay (g kg ⁻¹)	329.82	376.71	421.73	414.09	403.44	89.73	98.94
texture	SiCL	SiCL	SiC	SiC	SiC	LS	LS
Bulk density (Mg m ⁻³)	1.37	1.37	1.38	1.4	1.33	1.54	1.6
MWD (mm)	0.3	0.25	0.21	0.28	0.28	0.16	0.15
pH	7.71	7.74	7.57	7.61	7.77	7.69	7.73
EC (ds m ⁻¹)	8.53	15.74	48.44	14.39	29.76	3.63	4.21

OM (g kg ⁻¹)	8.68	4.68	3.42	8.59	5.15	6.15	2.87
CaCO ₃ (g kg ⁻¹)	421.11	422.71	441.38	422.36	410.25	156.72	138.71
Groundwater (cm)	101.73	131.67	86.67	107.14	0	>500	>500
Mottling (cm)	65	66.67	68.33	66.43	0	no	no

Results and discussion

Parent Material

parent material In the study area, it falls within the category of soils with little cohesion, so it was given a value of (2) as a weight for the degree of influence of the parent material on desertification events for all the soils included in the study (note Table 2). This is consistent with what was mentioned by Yassin (21), who explained that The parent material in Basrah governorate consists of sand, silt, and clay deposits transported from outside of it, where the thick sandy Dabdaba formations, cover the western region, while clay and alluvial sediments transported by water and

wind prevail in the eastern region, which represents the floodplain in the study area. Muhammad (16) mentioned that there is a close correlation between the soil and the parent material from which it was formed, where the soils composed of different parent materials interact differently with soil erosion, vegetation cover, and desertification. Soils composed of Limestones usually tend towards soft-textured, slow-permeability soils with high saturation of bases with an abundance of nutrients, while soils formed from sandstones tend towards coarse-textured soils with high permeability and low pH with a low concentration of nutrients.

Table 2. Categories and weights for the values of the indicators included in the calculation of the soil quality index

indicator parameter		class	description	score
Parent Material	1	Good	Shale, Schist, Basic, Ultra Basic, Conglomerates, Unconsolidatee	1
	2	Moderate	Limestone, Marble, Granite, Rhyolite, Ignimbrite, Gneiss, Siltstone, Sandstone	1.5
	3	Poor	Marl, Pyroclastics	2
Soil depth (cm)	1	Deep	>0.75	1
	2	Moderate	75-30	1.33
	3	Shallow	30-15	1.66
	4	Very Shallow	<15	2
Texture	1	Good	L, SCL, SL, LS, CL	1
	2	Moderate	SC, SiL, SiCL	1.33
	3	Poor	Si, C, SiC	1.66
	4	Very Poor	S	2
Slope %	1	Very Gentle To Flat	<6	1
	2	Gentle	6-18	1.33
	3	Steep	18-35	1.66
	4	Very Steep	>35	2
Drainage (mottling depth cm)	1	Excessively Well Drained	>150	1
	2	Well	90-150	1.2
	3	Moderate	50-90	1.4
	4	Imperfectly Drained	25-50	1.6
	5	Poorly Drained	<25	1.8



	6	Very Poorly Drained	waterlogged	2
Soil Salinity (ds m-1)	1	Slightly Saline	<4	1
	2	Moderately Saline	4-8	1.33
	3	Strongly Saline	8-16	1.66
	4	Very Strongly Saline	>16	2
Organic Matter %	1	Very High	>3	1
	2	High	2-3	1.25
	3	Moderately	1-2	1.5
	4	Low	0.5-1	1.75
	5	Very Low	<0.5	2
Solid Carbonates %	1	Very Low	<3	1
	2	Low	3-10	1.25
	3	Moderate	10-25	1.5
	4	High	25-50	1.75
	5	Very High	>50	2
Soil Quality Index	1	Good	<1.33	1
	2	Moderate	1.33-1.66	1.5
	3	Low	>1.66	2

Soil Depth:

The depth of the soil is one of the important indicators in estimating the quality of the soil used to determine the sensitivity of the soil to desertification. It represents the amount of soil expressed in vertical depth. In agricultural terms, the increase in soil depth indicates the quality of the soil. The depth of the soil determines its capacity to retain water and nutrients and the extent of plant roots that work to stabilize the soil and prevent its erosion and degradation. The effect of the soil depth index appears clearly in mountainous and sloping areas, where the extent to which it is affected by the rates of soil erosion and erosion depends largely on the thickness and quality of the surface soil and the nature of the subsurface soil. As for the deep soils, they are not greatly affected by erosion processes and are resistant to desertification, especially in the presence of vegetation cover works to stabilize them. The depth of the soil

represents the distance between the surface of the soil and the layer of basic rocks (bedrocks) constituting its parent material. Sedimentary soils are often deep and of high quality in terms of the effect of soil depth on the values of soil sensitivity to desertification. Soil depth is large within the limits of the study area and given A value of (1) as a weight for this indicator in all borders of the study area (Table 2), and this is consistent with what was indicated by Al-Atab (3) from The soils of Basrah governorate consist of Al-Dabdaba formations that cover the western region, which are thick sandy formations with a thickness of up to 140 m at the city of Safwan, and their thickness increases as we head towards the west, while the eastern region consists of water and air deposits, the thickness of which varies from place to other and ranges between 4-20 m.. Figure 2 shows the distribution of soils in the study area according to their height above sea level.

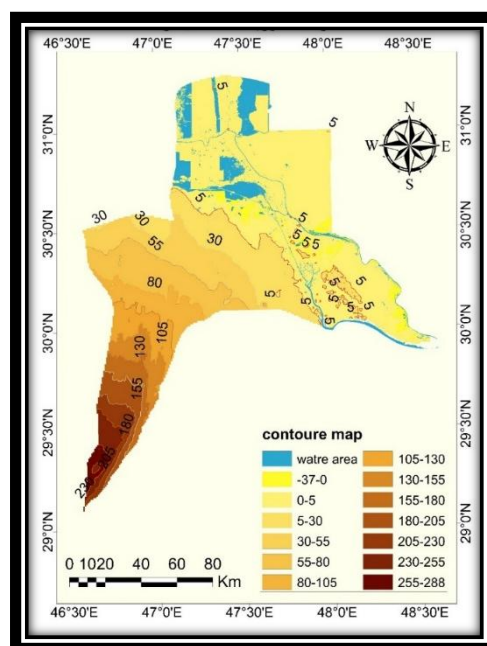


Figure 2. The spatial distribution of soils in the study area according to altitude above sea level

Soil Texture Index

Figure 3 and Table 3, represent the distribution of spatial types of soil texture according to their effect on desertification events. Soil particle distribution represents the most important characteristics through which soil quality and its susceptibility to desertification can be determined, as it determines many soil properties such as its ability to retain water, soil permeability, soil temperature, fertility, productivity characteristics, and its susceptibility to erosion. The soil of the study area ranged between, good soils (first class) represented by loamy sand, sandy loam, and silty loam, which were concentrated in the eastern part of the western region, and some soils of the leaves of rivers, at a rate of 11.66% of the total region area. While the soils of moderate quality, occupied the largest part of the area of the eastern region, with parts of the western region, at

a rate of 39.41% of the area of the study area. and it was represented by medium-soft soils, and the poor soils represented by soft-textured, and very poor soils, represented by coarse sandy soils, were concentrated in the southeastern parts of the eastern region. In the southwestern parts of the western region, rates amounted to 21.82 and 20.38% for the third and fourth classes, respectively. The reason for the great disparity in soil texture between the eastern and western regions is due to the difference in the source of the parent material for the soil in both regions, as the soil in the eastern region arose from the deposition of particles carried by the waters of rivers, in which silt and clay particles prevailed, while the soils of the western region arose from sediments Gravel and coarse sand carried by runoff water from the desert areas west of the study area.

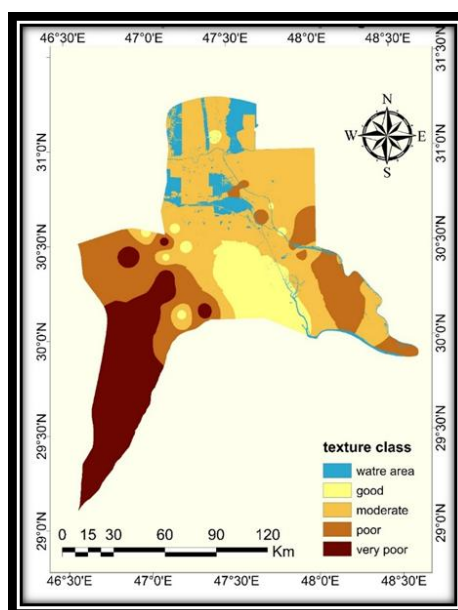


Figure 3. The spatial distribution of soil texture classes according to their influence on desertification events in Basrah Governorate.

Table 3. Represents the soil texture classes according to the medalus model, with the weight, area, and percentage of each class.

area %	area km2	weight	texture	class
6.73	1283.41	-	-	water area
11.66	2224.21	1	LS,SL,SiL,CL	good
39.41	7515.78	1.33	SiCL	moderate
21.82	4161.04	1.66	SiC	poor
20.38	3885.56	2	S	verypoor

Surface

Slope

Figure 4 shows the spatial distribution of the degree of slope in the study area, which represents the degree of slope of the surface based on the analysis of the digital elevation model. Table 4 shows the relative distribution of the degrees of slope, which shows that the rate of the slope of the study area ranged between 0-1.6%, meaning that all the study area falls within the first category. With a slight slope rate (less than 6%). Accordingly, all the soils of the study area fall within the good category in terms of the effect of the slope factor in the study area, and a weight of 1 is given to all the studied area (Table 2). The slope of the surface is one of the

specific indicators of soil quality according to the MEDALUS model, which reflects the impact of the slope on the sensitivity of the environment to desertification through its impact on the activity of water and wind erosion factors, which increase with the increase of the surface slope, as well as its impact on the distribution of matter and energy between sites at the bottom and top of the slope and the consequent deterioration in soil quality. as the soil erodes sharply when the slope angle exceeds the critical limits, then the soil erosion increases logarithmically. The effect of the degree of slope varies according to the different climatic regions

and according to the annual precipitation rate. (13).

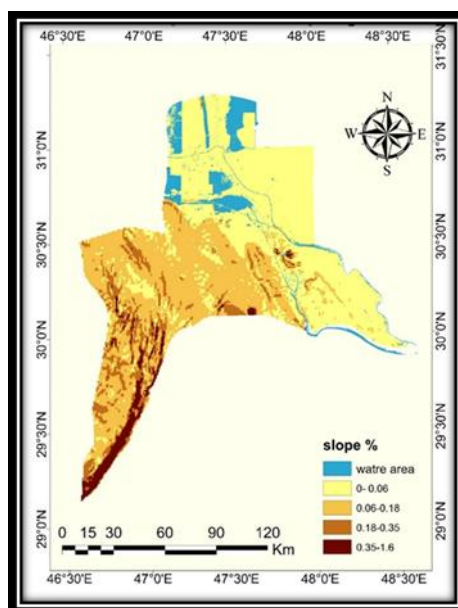


Figure 4. The spatial distribution of soils in the study area according to the degree of slope(%)

Table 4. The relative distribution of soils in the study area according to the degree of slope

area %	area km2	weight	slope%	class
6.73	1283.41	-	-	water area
47.05	8972.37	1	0-0.06	flat
34.65	6606.87	1	0.06-0.18	flat
8.21	1564.89	1	0.18-0.35	flat
3.37	642.46	1	0.35-1.6	flat

Drainage State

Figure 5 shows the spatial distribution of the state of drainage depending on the depth of the color spotting in the study area. It is noted from the figure that the soils in the western region were characterized by being devoid of drainage problems, due to the nature of their coarse-weave soils with high permeability, as well as their presence in areas high above sea level on contrast, we saw that most of the soils in the eastern region suffer from drainage problems of different degrees, depending on the degree of softness of the soil texture, its height above sea level, and

the availability of drainage networks. In general, a decrease in the degree of drainage is observed whenever we go from north to south in the floodplain region, Due to the decrease in the land level and the increase in the percentage of fine particles, Table 5 shows the proportions, area, and weight of each item according to the MEDALUS model. It is noted from table 5 that the percentage of fast-draining areas amounted to 47.83% of the area of the study area, which represents most of the area of the western region, as shown in Figure 5, while the percentage of lands reached Well drained 13.08% and distributed between the eastern and

western regions, where it concentrated in the eastern parts of the western region and the eastern and central parts of the eastern region, while the percentage of the regions of moderate drainage accounted for 19.69% of the area of the study area and were concentrated in the northern parts of the western region, while the soils of the southern parts of the eastern region were distributed among soils that lack drainage, poor and very poor, as it showed in Figure 5 and Table 5. The state of drainage is one of the important indicators in determining

the extent of Soil response to salinization processes that cause desertification, as the movement and concentration of salts in the soil depend on the balance of soil moisture and groundwater level (5). The rise in the groundwater level under the conditions of high temperatures and evaporation rates will lead to the movement of groundwater laden with salts towards the surface due to the difference in the water effort to reach a state of balance, which leads to the evaporation of water, leaving the salts to collect at the surface of the soil.

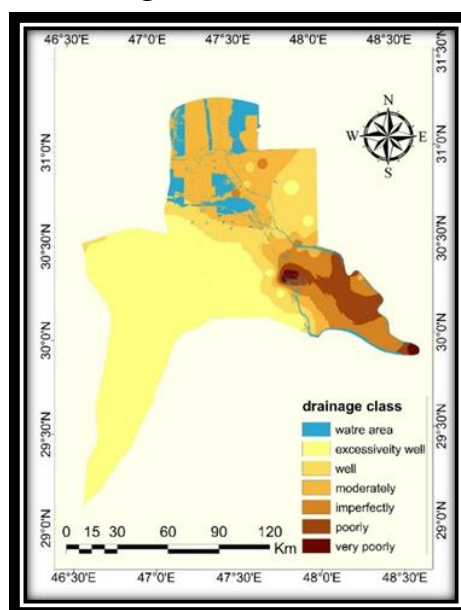


Figure 5. The spatial distribution of natural drainage types in the study area.

Table 5. Represents the natural drainage classes with the area and percentage of each class in the study area.

area %	area km2	weight	mottling depth	class
6.73	1283.41	-	-	water area
47.83	9121.43	1	>150	excessively
13.08	2494.74	1.2	90-150	well
19.69	3754.62	1.4	50-90	moderately
7.08	1350.34	1.6	25-50	imperfectly
5.09	970.82	1.8	<25	poorly
0.50	94.65	2	frequently ponded	very poorly

Soil Salinity Index:

Figure 6 shows the spatial distribution of soil electrical conductivity values, distributed according to their importance in desertification formation. It is noted from the figure that most of the soils of the study area suffer from the problem of salinity in varying degrees. It is noted that most of the soils of the western region fell within the second category, which represents moderately saline soils, with a rate of 51.79% of The area of the study area (Table 6), the presence of salts in these areas is due to the use of irrigation water with high salinity and the drip irrigation method, accompanied by high evaporation rates, which causes salts to accumulate in the surface layer of the soil. The rains, despite their scarcity and the high permeability of the soil, contributed to maintaining the salt balance within the moderate borders in these regions, while the soils of the eastern region were distributed between the third and fourth classes, which represent high and very high salinity soils, with rates of 30.50 and 9.94% of the study area for the two classes, and according to the order. The reason for the high rates of salinity in these regions is mainly due to the proximity of saline groundwater to the surface and the prevailing bad weather conditions,

represented by high evaporation rates, low rainfall, and the use of irrigation water of poor quality. As well as the nature of the soil of the region, which is characterized by the predominance of fine particles, low values of water conductivity of the soil, and the activity of the capillary property, which leads to the accumulation of salts, especially in the surface layer of the soil, and increases the difficulty of the leaching process of salts. It is noted that the soils of high salinity were concentrated in areas with soft-textured soils and Low elevations relative to sea level, which are often devoid of agricultural activities and far from freshwater sources with their lack of drainage networks, as the movement and distribution of salts on the surface and within the soil sector reflects the prevailing conditions of water balance and the depth of groundwater. Therefore, precipitation and evapotranspiration with the characteristics of the soil sector are important for the distribution of salts at the surface and within the soil sector. In general, the decrease in precipitation and the increase in evapotranspiration cause an increase in the salinity of the soil affected by salinity under the conditions of arid and semi-arid regions.

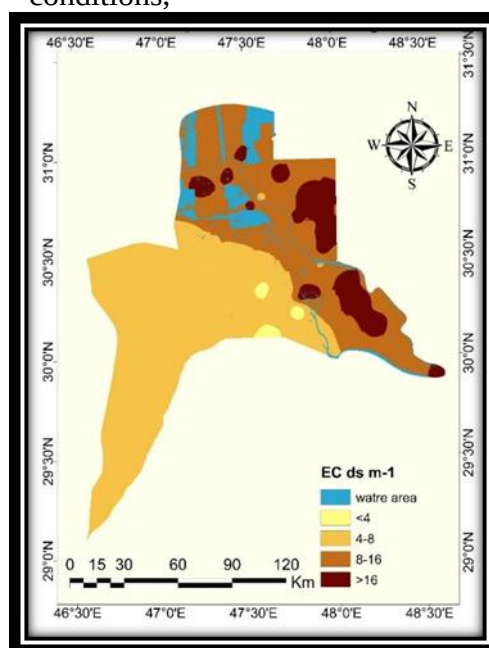


Figure 6. The spatial distribution of soil salinity classes in Basrah Governorate, according to its effect on desertification events.

Table 6. Weight of soil salinity classes with the area and percentage of each class in the study area

area %	area km2	weight	EC ds m-1	class
6.73	1283.41	-	-	water area
1.03	196.91	1	< 4	low
51.79	9877.20	1.5	4-8	moderate
30.50	5817.17	1.8	8-16	high
9.94	1895.31	2	> 16	very high

Organic Matter

Figure 7 shows the spatial distribution of soil content of organic matter classified according to its importance in desertification formation, while Table 7 shows the relative distribution of organic matter classes with the weight and area of each class. It is noted from the figure and the table that the soils in the study area were distributed between moderate, poor, and very poor soils in their content of organic matter. Most of the soils of the study area suffer from a deficiency in the amount of organic matter, as it was less

than 1% in most of the regions included in the study, as the percentage of soils that are very poor in their content of organic matter reached 49.64% of the study area and was concentrated in the western and some southern parts of The eastern region, While the percentage of poor soils in their content of organic matter reached 34.69% of the study area and was concentrated in the central and southern parts of the eastern region, and the percentage of soil with moderate content of organic matter was 8.94% and was concentrated in the northern parts of the study area, as shown in Figure 7.

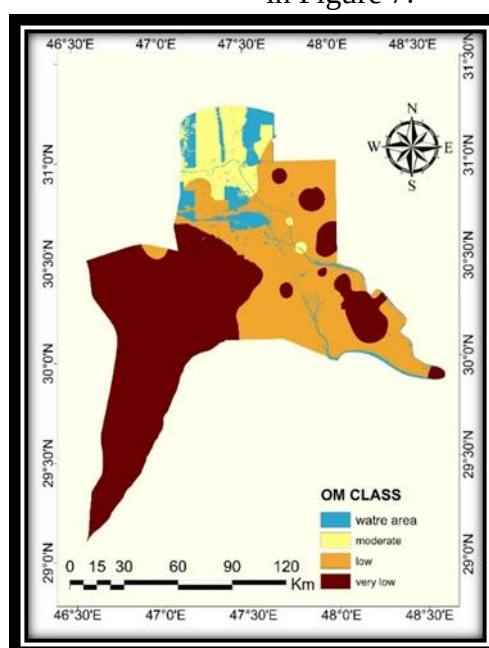


Figure 7. Spatial distribution of organic matter classes in Basrah Governorate

Table 7. Percentage distribution of organic matter classes with the weight and area of each class in the study area

area %	area km2	weight	%om	class
6.73	1283.41	-	-	water area
8.94	1705.02	1.5	1-2	moderate
34.69	6614.87	1.75	0.5-1	low
49.64	9466.70	2	< 0.5	very low

3.8. Solid Carbonates

The results of laboratory analyzes of the soils of the study area showed a discrepancy in the carbonate content, as the values ranged between 10.5% and 47.75%. Figure 8 shows the spatial distribution of carbonate values according to their importance in desertification events, where it is noted that the values ranged between high and medium, and the figure shows that the high values were concentrated in the eastern region of the study area, at a rate of 40.44% of the total of the study area, while the average values were concentrated in the western region of the

study area, at a rate of 52.83% of the total of the study area (Table 8). The effect of solid carbonate on soil desertification comes through its influence on the course of chemical interactions, the movement and readiness of some nutrients such as phosphorus and microelements, and the degree of soil interaction. Many studies have indicated that the increase in the content of solid carbons in the soils of arid and semi-arid regions, the source of which is either parent material rich in carbonates or the local chemical formation with weak leaching and removal of carbonates due to low rainfall rates of Precipitation and the dry climate prevails.

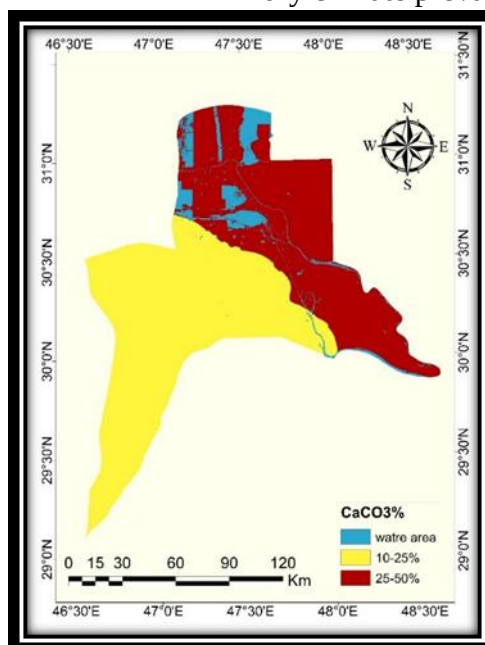


Figure 8. The spatial distribution of soil solid carbonate content classified according to its importance in desertification events

Table 8. The relative distribution of solid carbonate classes with the weight and area of each class in the study area

area %	area km2	weight	CaCO ₃ %	class
6.73	1283.41	-	-	water area
52.83	10073.85	1.5	10 - 25	moderate
40.44	7712.74	1.75	25 -50	high

Soil Quality Index Calculation

The soil quality index was found through the geometric mean of the weights of the values of eight indicators: the parent material, soil depth, soil texture, degree of slope, degree of natural drainage, soil salinity, percentage of organic matter, and the percentage of solid carbonates (Table 2). It is noted by examining the results of the indicators included in the calculation of the soil quality index that The values of the indicators of the degree of slope, the depth of the soil and the parent material were fixed values throughout the study area and therefore had no role in the occurrence of variation in the value of the soil quality index, while there was a variation in the values of each of texture index, degree of drainage index, soil salinity index, and organic matter index. The percentage of solid carbonates that led to a variation in the soil quality index values, as it appears from Figure 9 and Table 9 that the soils of the study area were distributed between medium-quality soils and high-quality soils, as the percentage of medium-quality soils reached 82.00%, while the percentage of high-quality soils reached 11.27% of the area of The study area. the main reason for the decline in soil quality are due to the overlapping effect between the quality of the soil texture and the degree of natural drainage, especially in the eastern region of the study area, which caused Soil salinity and a decrease in its quality. Salinity has a clear effect on the deterioration of soil characteristics and plant growth conditions, which caused the deterioration of its vegetation cover and a decrease in the proportions of organic matter This

indicates the existence of an interconnected chain leading to a decrease in soil quality represented by the poor irrigation and drainage system under bad hydrological and climatic conditions that led to soil salinization. and the deterioration of its vegetation cover and level of fertility, therefore, addressing the problem of soil quality deterioration must begin with the reform of the irrigation and drainage system through the establishment of an effective irrigation and drainage system that suits the conditions of the region with the need to maintain the quality of irrigation water by adopting ways to prevent pollutants from reaching it, whether they are drainage water or any other source of pollution with the work of a controlled irrigation system that contributes to increasing irrigation efficiency and reducing waste in the eastern region. In the western region, a closer look at the values of the indicators included in the calculation of the soil quality index, we can notice that the soil does not suffer from any problems in terms of Depth, slope, or state of drainage, but the problem lies in the texture of the soil, it's the content of organic matter, and the quality of the parent material, which can make the soil loose and Vulnerable to wind erosion with low ability to hold water and nutrients. However, the value of the quality index of these soils can be raised by adding conditioners such as organic fertilizers and others that work on soil cohesion and increase its ability to hold water and nutrients, which contributes to improving soil quality and increasing its productivity, which is a method currently used in most farms. as well as the use of modern



irrigation methods, covered agriculture, and soil covers, which helped in the growth of agricultural activity in the western region despite climate changes,

water scarcity, and the deterioration of its quality, which led to the deterioration of agricultural activity in the eastern region of the study area.

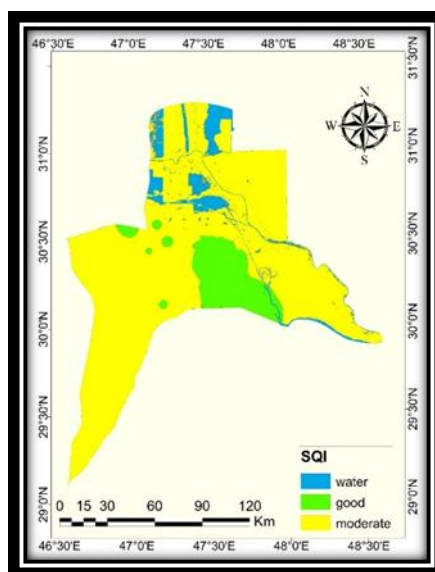


Figure 9. The spatial distribution of soil quality index values according to their impact on desertification events in the study area.

Table 9. The relative distribution of soil quality index cultivars with the area of each cultivar in the study area

area %	area km ²	range	class
6.73	1283.41	-	water area
11.27	2148.54	< 1.33	highly
82.00	15638.05	1.33-1.66	moderate

Recommendations

We recommend the adoption of the Soil Quality Index as a good indicator for tracking the state of variation in soil properties. This requires developing an evaluation and monitoring program with the establishment of a database of soil properties that is updated continuously. Providing data on soil quality helps in preparing agricultural development plans and taking the necessary decisions to prevent land degradation and in line with the United Nations directions for sustainable development.

Conflict of interest

The authors declare no conflict of interest.

References

1. Abbas, J. A. 2022 . Assessment of land sensitivity to desertification for Al Mussaib project using MEDALUS approach. Caspian Journal of Environmental Sciences, 20(1), 177-196. DOI:[10.22124/CJES.2022.5415](https://doi.org/10.22124/CJES.2022.5415)
2. Afzali, S. F., Khanamani, A., Maskooni, E. K., & Berndtsson, R. 2021. Quantitative assessment of environmental sensitivity to desertification using the modified MEDALUS model in a semiarid area. Sustainability, 13(14), 7817. doi:[10.3390/su13147817](https://doi.org/10.3390/su13147817)

3. Al-Atab, S. M. S. 2008. Heterogeneity in soil properties and their classification for some regions of Basrah Governorate. Ph.D. thesis, College of Agriculture, Basrah University.
4. Al-Hiti, A. J. and Al-Rawi, M. K. 2017. Evaluation of Desertification in the East Al-Haffar project. *Anbar Journal of Agricultural Sciences*, 51.(5)
5. Ancona, V.; Bruno, D. E.; Lopez, N.; Pappagallo, G. and Uricchio, V. F. (2010). A Modified Soil Quality Index to Assess the Influence of Soil Degradation Processes on Desertification Risk: The Apulia Case Ital. J. Agron. / Riv. Agron. (3) pp: 45-55. <https://doi.org/10.4081/ija.2010.s3.45>
6. Aziz, D. R.; Reza, A. A.; Amr, M. Y. and Fakhreddine, L. H. 2019. Evaluation of the state of desertification using the soil quality index in the MEDALUS model for some soils in Kirkuk governorate. *Journal of Kirkuk University for Agricultural Sciences*, 2018 (special issue).
7. Black, C. A.; Evans, D. D.; White, L. L.; Ensminger, L. E. And Clark, F. E. 1965. Method of Soil Analysis, ASA Agron. No. 9 part I and II
8. Climate data 2021. The General Authority for Meteorology and Seismic Monitoring - Climate Department - Ministry of Transport and Communications - Republic of Iraq. (unpublished data)
9. Demirağ Turan, İ. 2021. Spatial analysis of soil quality assessment in the semi-arid ecosystem using a minimum data set. *Eurasian Journal of Soil Science*, 10(3):222-235. DOI: 10.18393/ejss.912986
10. Dengiz, O.; Sekan, İ. Ç.; Saygin, F., & İmamoğlu, A. 2020. Assessment of soil quality index for tea cultivated soils in Ortaçay micro catchment in Black Sea Region. *Journal of Agricultural Sciences*, 26(1), 42-53. DOI: 10.15832/ankutbd.468900
11. Hamad, A. I.; Alagele, S. M., & Hamid, B. A. (2021). Assessment of Environmental Sensitivity to Desertification With Medalus Model In GIS In Maymona Project-South of Iraq. *The Iraqi Journal of Agricultural Science*, 52(4), 1058-1069. doi.org/10.36103/ijas.v52i4.1417
12. Jackson, M. L. 1958. Soil chemical analysis. Prinite-Hall, Inc. Englewood. Cliffs, N.J.
13. Kosmas, C.; Kirkby, M. & Geeson, N. 1999. Manual on key indicators of desertification and mapping environmentally sensitive areas to desertification. European Commission, EUR, 18882. doi:[10.1007/1-4020-3760-0_25](https://doi.org/10.1007/1-4020-3760-0_25).
14. Lahlaoui, H.; Rhinane, H.; Hilali, A.; Lahssini, S. & Moukrim, S. 2017. Desertification assessment using MEDALUS model in watershed Oued El Maleh, Morocco. *Geosciences*, 7(3), 50. doi:[10.3390/geosciences7030050](https://doi.org/10.3390/geosciences7030050)
15. Mostafa, A. M.; El-Kawy, A.; Osama, R.; Mohamed, Y. I. & Khaled, N. A. D. N. 2020. Desertification Sensitivity Analysis East of Siwa Using GIS and Remote Sensing. *Alexandria Science Exchange Journal*, 41(JANUARY-MARCH), 1-14. DOI: [10.21608/ASEJAIQJSAE.2020.70346](https://doi.org/10.21608/ASEJAIQJSAE.2020.70346).
16. Muhammad, H. R. 2022. Environmental sensitivity to desertification in the northwest of Beni Suef governorate using the MEDALUS model. *Arab Geographical Journal*, 171: 1-63. DOI: [10.21608/agj.2022.229188](https://doi.org/10.21608/agj.2022.229188)
17. Plaiklang, S.; Sutthivanich, I.; Sritarapipat, T.; Panurak, K.; Ogawa, S.; Charungthanakij, S.; *et al.* 2020. Desertification assessment using MEDALUS model in upper Lamchiengkrai watershed, Thailand. *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 43, 1257-1262. <https://doi.org/10.5194/isprs-archives-XLIII-B3-2020-1257-2020>



18. Sparks, D. L.; Page, A. L.; Helmke, P. A. & Loeppert, R. H. (Eds.). 2020. Methods of soil analysis, part 3: Chemical methods (Vol. 14). John Wiley & Sons.
19. UNCCD. 2017. United Nations Convention to combat desertification, website <https://www.unccd.int/>
20. USGS. 2019. United States Geological Survey. Earth explorer, science for a changing world. <https://earthexplorer.usgs.gov/>
21. Yassin, B. R. 1998. Spatial relationships between surface level and agriculture in Basrah Governorate. Ph.D. thesis - College of Education - Basrah University.

