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THE ASSESSMENT OF SALINITY-AFFECTED LANDS IN SOUTHERN IRAQ USING SATELLITE IMAGERY

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Abstract

This study aimed to monitor, map and assess the salinity of land in southern Iraq. Where the country suffers greatly from land degradation and desertification problems, especially in the central and southern parts. This study was conducted to monitor the manifestations of salinity in the Najmi area located within the administrative boundaries of the Muthanna Governorate, which has an area of (2066 hectares) and lies between longitudes 44°21'0" to 44°31'0" East and latitude circles 30°11'0" to 32°27'0" North with the help of remote sensing technology through the use of satellite images from the Landsat 8 satellite with field observations. A map of soil units was prepared using Erdas software, Arc GIS for processing, management and analysis of raster and subject data sets. Soil samples were taken from each site for physical and chemical analysis, and the study is summarized as follows: the results indicated when using the spectral index represented by the standard difference index of vegetation cover (NDVI), whose value ranged between (0.47-0.30). It was found that the study area suffers from a lack of vegetation cover by (64%); as for the salinity index values, they ranged between (-0.30-0.49) and therefore the study area suffers from a chemical deterioration represented in the salinity of the soil estimated at (69%); where the values of the dry lands index ranged between (1.37-0.73), and the desertified lands within the study area by (45%); as for the land degradation index, its value ranged from (0.00 to 99.60), and the percentage of degraded lands was estimated at (60%) of the total study lands.

Key words: *salinity, remote sensing, GIS, deterioration index.*

INTRODUCTION

Soil salinization, which is a common form of soil degradation, is one of the world's most widespread environmental problems (Farifteh, 2006). This global problem results in land degradation, especially in irrigated areas in arid and semiarid environments as well as in some subhumid regions. Soil salinization has become increasingly serious in recent decades, with salinization exceeding the average level of soil salinity in the past few years because of unsustainable agricultural practices that lead to the accumulation of soluble salts in soil (Zewdu, 2017). Soil salinization reduces the land value and productivity. By reducing the soil quality, soil salinization limits the suitability of the land for agriculture or reclamation and can increase soil dispersion and erosion.

Soil salinization is a severe environmental hazard that influences almost half of the existing irrigation plans of worldwide soils facing the threat of secondary salinization. General estimates indicate that approximately 1 billion hectares of land are affected by salinization worldwide, constituting 7% of the continental area of the Earth and 58% of the irrigated land (Noroozi et al., 2011). The main causes of soil salinization in dry regions include irrigation (i.e., overpumping), poor water drainage, and climate change (Zewdu et al., 2017). Therefore, areas of agricultural or arable lands will dwindle because of salinization. Additionally, many countries are confronted with varying degrees of soil salinization. The Food and Agriculture Organization has estimated that 397 million hectares of the world's agricultural or nonagricultural lands have been affected by soil salinization. Thus, it is crucial to determine which lands are affected by soil salinization, evaluate soil salinity, and determine the root causes of salinization to help decision makers develop management plans for ensuring the sustainability of agricultural land. This must be prioritized globally because soil salinization has deleterious impacts on the soil quality and

productivity and is ubiquitous in the arid and semiarid parts of the world (Shrivastava, 2015). Researchers have recently shown significant interest in evaluating and mapping soil salinity in many regions around the world, especially in arid and semiarid areas that are heavily affected by salinization. For soil salinity evaluation and mapping, data must be collected using traditional soil sampling and laboratory analysis methods. However, these methods are time-consuming and costly, thereby limiting surveys to small areas (Lhissou et al., 2014). To overcome this limitation, several techniques have been developed for evaluating soil salinity. One such technique is based on remote sensing (RS), which has demonstrated considerable success in mapping and assessing soil salinity (Asfaw et al., 2018).
Metternicht and Zinck et al. (2003) observed that meaningful results could be obtained by studying the spectral properties and radar backscatter of saline soils. Some researchers have studied soil salinity based on moisture content using the normalized difference infrared index. Other researchers have assessed the relations between soil salinity and vegetation indices (Iqbal et al., 2011). Other studies have analyzed soil salinity using the thermal and short infrared wavelength bands (Goossens et al., 1998) to examine the relation between soil salinity and the land surface temperature (LST). These studies used satellite imagery containing thermal bands such as a moderate resolution imaging spectroradiometer (MODIS), which provides useful information about the soil properties (Ibrahim et al., 2018). Recently, the multispectral data derived from sources, such as the System Pour I, Observation de la Terre (SPOT), IKONOS, Quick Bird, Indian Remote Sensing, and Landsat satellites, have been used to explore map soil salinity. Several other indices, such as the salinity index and the soil adjusted vegetation index, are also commonly employed to monitor soil salinity. However, Eldeiry and Garcia and Hu et al. recommended the combined use of spectral response index and best band (Abou Samra et al., 2018).
The RS tools and data must be integrated with the field measurements of salinity to achieve soil salinity evaluation and monitoring. RS is an efficient tool for spatial analysis of soil salinity in arid and semiarid areas; therefore, we aimed to estimate the soil salinity using specific spectral indices combined with field measurements. The soil salinity mapping model developed in this study is based on the electrical conductivity (EC) of soil and shows a promising correlation, which can be further improved by considering the soil salinity NDVI relation. This model is helpful to develop effective soil salinity forecasting strategies for sustainable development and land management.

MATERIALS AND METHODS

The study area is located in Al-Muthanna Governorate. It is bounded on the north by the highway, on the west by Al-Najmi, on the south by the Shinafiya district project, and on the east by Diwaniyah Hamza Road. The project lands are confined between longitudes 00-10° 45 = 00-26° 44 and latitudes 40° 31° 00 and 30-30 00. The total area of the project, including residential areas and water bodies, is estimated at 100,000.1 dunums. Figure 1 represents a site map of the study area. Numerous villages are spread throughout the study area, in addition to the center of Al-Najmi district. Climate has an active and influential role in soil formation processes after the occurrence of geological processes responsible for the formation of terrain such as eruptions and folds. Variation differences in temperature and its geographical distribution in the globe. The efficiency of irrigation depends on the climatic conditions. The climate of the study area is considered dry, hot in summer, cold in winter with little rain, i.e. a desert climate.

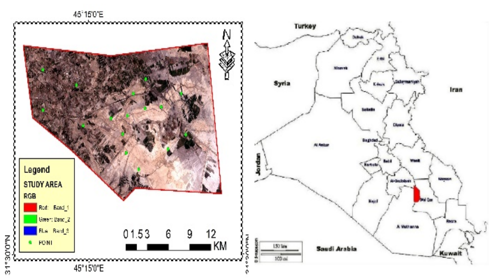

Figure 1. The Map of the study area

With regard to the project soil, the process of salinization is prevalent. Climate also plays a role in biological diversity, cropping, irrigation methods and cultivation pattern, in addition to the effective influence on soil distribution. It was possible to analyze the changes of the important climate elements, temperature, humidity, rain, evaporation, wind, depending on the climatic information available at the weather station in the city of Samawa, which is 3 m above sea level. The study, with a minimum average of 17°C in January and a highest average of 46°C in July (Table 1).

Table 1. Average temperatures, relative humidity and rainfall in Al-Muthanna Governorate

Climate element	J	F	M	A	M	J	T	A	S	O	N	D	Per year
Temperature	17	25	36	42	46	46	44	39	33	26	21	17	**31.9**
Rains	18.8	16.9	4	0.1	0	0	0	4.3	8.2	12.9	16.2	20	**115**
Evaporation	88	138	251	359	467	497	459	371	269	198	118	88	**3300**
Relative humidity	66	57	48	41	30	26	26	28	31	41	56	64	**506**

Laboratory analyzes were carried out on soil samples extracted from the horizons of soil potholes: mechanical analysis to find out the proportion of clay, sand and silt, the percentage of calcium carbonate (calcium) and calcium sulfate (gypsum), the percentage of exchanged sodium (ESP) and percentage of adsorbed sodium (SAR), soil interaction pH and salinity ECe (the electrical conductivity of the saturated extract of the soil solution), the percentage of organic matter and negative and positive ions values (Tables 2, 3).

Table 2. The physical characteristics of the study soil materials

No.	Depth (cm)	pH	O.M. %	NO_3^{-1} (ppm)	Partical size analysis Clay, %	Silt, %	Sand, %	Lab. texture	Gypsum, %	Lime, %
1	15-0	7.27	0.5	43.5	51	42	7	SiC	2.9	36.4
2	20-0	7.33	0.5	36.5	4.2	50.6	45.2	SiL	13.4	28.6
3	30-0	7.32	0.6	87.5	15	72	13	SiL	7.85	33.2
4	23-0	7.49	0.7	236.5	27.5	49.1	23.4	CL	4.07	31.4
5	25-0	7.1	-	235	-	-	-	0	5.8	26.4
6	30-0	7.68	0.6	16.75	28.1	45.4	26.4	CL	-	25.4
7	26-0	7.07	0.5	208	53	43	4	SiC	4.13	36.8
8	26-0	7.14	0.9	5	25.5	46.5	28	L	6.02	30.4
9	38-0	7.34	1.8	138	37	48	15	SiCL	0.41	36
10	13-0	7.85	-	39	29.8	56.2	14	SiCL	2.35	28.2
11	13-0	7.03	0.6	36.5	28.5	54.1	17.4	SiCL	-	31.8
12	16-0	7.4	1.1	215	-	-	-	-	10.3	27.8
13	35-0	7.18	0.9	32.5	35.5	55.5	9	SiCL	5.04	29.6
14	13-0	7.02	1.2	3.63	12.5	75.1	12.4	SiL	3.63	31.2
15	18-0	7.02	-	174.5	32.3	49.7	18	SiCL	6.7	29
16	17-0	7.07	0.5	5	30.2	60.2	9.6	SiCL	2.9	30

Table 3. The chemical characteristics of the study soil materials

No.	Depth (cm)	ECe ds/m	Cations, meq/L			K^{+1}	Anions, meq/L			
			Ca^{+2}	Mg^{+2}	Na^{+1}	ppm	CL^{-1}	SO_4^{-2}	CO_3^{-2}	HCO_3^{-1}
1	15-0	37	62	171	181	40	345	108	0	3.8
2	20-0	204	300	600	2860	600	3240	360	0	1
3	30-0	165.1	240	700	1870	600	2256	380	0	1.2
4	23-0	89.2	200	580	680	170	490	380	0	1.6
5	25-0	176.9	620	600	1740	400	3000	280	0	1.8
6	30-0	9.43	34	42	41	52.5	40.8	66	0	3
7	26-0	109.6	82	222	1000	850	1302	218	0	1.8
8	26-0	227	280	360	3300	700	3740	260	0	12
9	38-0	29.2	160	260	143	90	270	220	0	2
10	13-0	43.5	104	22	284	80	432	76	2.6	0
11	13-0	4.64	28	14	14.78	32	18	40	0	2
12	16-0	206	400	660	2000	800	3360	300	0	1.2
13	35-0	87.8	60	60	770	90	850	77	0	1.4
14	13-0	96.1	250	540	458	125	1236	342	0	1.2
15	18-0	86.7	68	142	830	155	1000	160	0	1.4
16	17-0	69.3	92	58	694	110	768	116	0	1.4

The study relied on satellite images that provide a lot of information about spatial space, especially multispectral visualizations (MULTISPECTRAL IMAGERY), which include information on the number of beams and are the source of obtaining satellite visuals after processing and extract data from it. It included one scene that covered the study area (2021) for sensor data (ETM) obtained by the American satellite (Landsat and sentinel A2) for the sensor (OLI) and (TIRS). It was obtained from the (USGS) site as a punch in the panels (-) present in the map (1), which was used to classify the land cover of the study area, to determine the most important aspects of desertification to derive the vegetation cover and the locations of the spread of saline soil areas and to determine its areas. Satellite images were obtained, from the website of the University of Maryland, Institute for Advanced Computer Studies, USA, Figure 1 and visual images were mostly corrected and rendered by Universal Transverse Mercator (UTM), all visuals were in the form of files (tiff).

In order to know the saline areas and the deterioration of vegetation cover, two indicators are proposed: the salinity index (SI) and the natural differential salinity index (NDSI) in this study. SI is the ratio of the red band to the infrared band (NIR), while NDSI is the percentage difference between red and NIR divided by the sum of the two. This concept came from Red Edge's concept of mapping the vitality of vegetation. In the red edge concept, the spectral reflectance of the NIR radiates with a red band, which gives very high values of vegetation compared to other land properties. Here, if the opposite is taken into account, then lower values plants are obtained, thereby suppressing vegetation and highlighting the soil. SI and NDSI are calculated as follows (Mekeberiaw, 2009):

NDSI = [(Band 8- Band 4) / (Band 8 + Band 4)]

NDVI= [(Band 4 - Band 8) / (Band 4 + Band 8)]

RESULTS AND DISCUSSIONS

Soil color

The results of the morphological examination of the soil sources indicate that all the headlands of the study area represent the state of the newly formed soils that are not developed, and this was reflected in the absence of distinct horizons such as the subsurface horizons, that the horizons that are dry for part of the year and wet in the other part have two colors or more due to cases oxidation and reduction, and these colors are a medium between the color of good piercing soil and poor piercing soil.

Soil color is one of the most important and most widely used morphological characteristics to distinguish and determine the horizons of soil conditions, and its importance lies in its direct relationship in the interpretation of some pedological phenomena, especially the evolutionary state of the soil, and the possibility of identifying some of the prevailing pedological processes in the soil. In addition to the ease of sensing the color of the soil using the human eye with some simple auxiliary factors, the color of the soil is a reflection of the mineral and organic compositional nature of the soil and its moisture content, in addition to that it is an helpful guide in determining the types of pedological processes responsible for the formation and development of soil. Soil color has been given special importance and was used as a distinctive characteristic in diagnosing and naming soils, adding the ancient and modern soil classification systems used in different countries. Dark soils have good productivity due to the increase in organic matter and nutrients, while light colored soils have low productivity due to the lack of nutrients in them.

As for the water models, chemical analyzes were conducted on them in the laboratories of the National Center for Water Resources Management, such as the interaction of soil, salinity, positive and negative ions for the purpose of evaluating them and knowing their varieties, their suitability for irrigation operations, the degree of pollution and the effect of their toxicity on the plant.

Soil texture

Tissue is one of the important basic characteristics that directly affect the composition and texture of the soil in addition to its impact on the water content ready for the plant, soil permeability, nutrient retention, soil shrinkage speed, soil drainage, and soil vital activities. The texture is also important in evaluating the suitability of the soil for irrigation and being an important criterion in the process of classifying the soils at the lower levels (series and phase). The texture varies throughout the project from one region to another, especially in the first meter because the soil is sedimentary. The common texture in the soils of the study area is medium fineness (Alluvial clay mixture SICL and clay mixture CL) in the surface layer and becomes soft-textured in the second meter SIC, and according to the quadruple classification of soil texture, it has been classified into four classes (Table 4).

Table 4. Types of tissues according to the Quaternary classification (1982 - SOLR)

Symbol	Texture Class	Soil Texture
1	Fine	Silty Clay, Clay
2	Moderately fine	Silt Clay Loam, Sandy Clay Loam, Clay Loam
3	Medium	Silt Loam, Loam, Sandy loam
4	Coarse	Loamy Sand, Sand

Soil structure

The structure or structure of the soil means the regularity of the primary particles and their aggregates in a particular system. In other words, it is the summation of the elementary particles into groups within geometric shapes.

It can be separated into smaller aggregates at the surfaces of the weakness common to them. Some of the outer surfaces of the aggregates unit have thin sheaths of uniform color. The difference in the regularity of these particles and aggregates between soils and other leads to a difference in the sizes of shapes and the regularity of the pore spaces in the soil, which it is considered.

One of the most important direct effects of soil composition on its other properties. The construction of the soil also leads to changing the effect of the tissue on many properties of the soil, such as water holding capacity, water movement, bulk density, fertility, and the effectiveness of microorganisms (Al-Rawi, 2017).

The degree of cohesion between the granules of these aggregates varies, some of them are weak, which break into smaller parts by hand, and others are strong, which do not disintegrate easily. The construction is important in classifying the soil and its impact on soil productivity.

Through the field work in the study area, it was noticed that the structure of most of the project soils is a weak subangular blocky or massive structure, especially in Typic Aquisalids, because of its high salinity, as the sodium ion causes dispersion of colloids, which affects the quality of construction and soil permeability.

Salinity

The problem of salinity exists if the salt concentrations of salt rise in the root zone of the crop in proportions that cause a lack or loss of the yield. In irrigated areas, these salts often arise from high and saline ground water or from the salts found in the water used. The decrease in yield occurs when salts accumulate in the root zone to the extent that the crop is not able to extract sufficient water from the soil saline solution. Salinity is widespread in most of the study area and its sources are known, as the soil contains large amounts of dissolved ions such as calcium, sodium, chlorine, sulfates and others, which are derived from the irrigation water that carries these substances as the water evaporates and the salts accumulate. Ground water is another source of salt when it is close to the surface, where the water rises by capillary action, and when the evaporation process occurs, the salts are concentrated at the surface, and the increase in the addition of fertilizers that carry some ions causes an increase in the concentrations of these salts ions.

The field work and the tested results of the salinity of the soil of the area of the study showed that according to the classification of the polluted Muffin Qaffal (Solr, 1982) Table 5, that (6.14%) of the project had low salinity and (70.4%) high salinity and (15%) is highly saline and not suitable for agriculture as in Table 6. According to this classification, a soil salinity map was prepared for the entire project. This map represents the soil salinity rate for a depth of one meter from the surface (Figure 7). According to Table 5, we note that (85.4%) of the lands of the studied area have high to very severe salinity and are not suitable for cultivation.

Table 5. Classification of soil salinity according to SOLR, 1982

Symol	Salinity classes	Ds / m
S0	Very slightly saline	0-4
S1	Slightly saline	4-8
S2	Moderately saline	8-16
S3	Strongly saline	16-25
S4	Very strongly saline	25-50
S5	Extremely saline	>50

As for the proportion of arable land, it constitutes (14.6 percent) only, and it has low to moderate salinity (Table 6).

Table 6. Distribution of areas for soil salinity classes in the project

Salinity classes	Map symbol	Area Donum	Percentage
Moderately saline	S2	14000	14.6%
Strongly saline	S3	37750	39.2%
Very strongly saline	S4	30000	31.2%
Extremely saline	S5	14350	15%
Total	96.100 Donum Conc. + Vill. +Hills		100%

Soil reaction

Soil interaction is one of the factors affecting the soil's ability to prepare nutrients, as the readiness of nutrients is affected by the degree of soil interaction (Figure 2).

The process of absorption of nutrients and minerals by the plant through direct competition between the hydrogen ion and other ions in the soil when the process of absorption by the plant, especially the calcium, potassium and magnesium ions necessary for plant growth, where many nutrients and their readiness are directly affected by the value of the interaction of the soil, such as phosphorous and trace elements, which are considered the elements most affected by the value of the soil reaction, especially when the reaction is basic to slightly basic. As for the rest of the other microelements such as iron, manganese, zinc, and boron, their validity for absorption decreases by increasing the acidity to a certain extent. The growth of each plant requires a certain degree of interaction, for example, that the jet plant grows well at pH (6.8-7.2). The importance of soil interaction is not limited to plant growth, but has to do with weathering processes, biological activity, and the effectiveness of hydrogen ions in the solution, where bacteria predominate in soils that are neutral or less basic. It is generally preferable that the pH of the soil does not exceed 8.5 so that the plant can obtain the elements more easily. The pH in the project ranged between (7-7.8) meaning that the soil of the project is neutral.

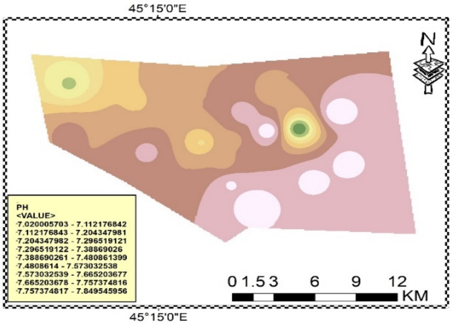

Figure 2. Soil reaction in the study area

Calcium Carbonate $CaCO_3$

This salt is formed by the union of carbonate with calcium ion to form calcium bicarbonate (Figure 3). Salt loses to heat and dehydration part of the carbon dioxide in the form of gas forming calcium carbonate. Calcium carbonate is one of the most important carbonate salts and is common in most arid and semi-arid regions. It is very slightly soluble, as its solubility does not exceed 0.031 g/liter.

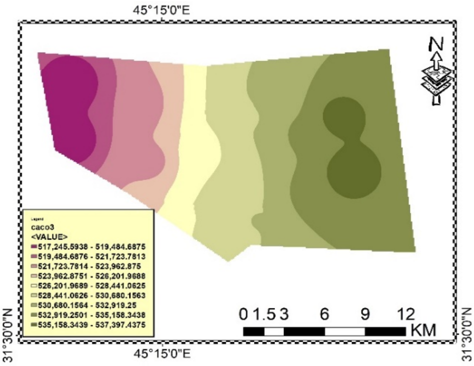

Figure 3. Calcium carbonate content in the study area

Also, the solubility of this salt is related to the degree of reaction of the solution, which increases as the pH value decreases and vice versa. The calcium carbonate solution is characterized by the degree of basic reaction, when there is no amount of carbon dioxide, the calcium carbonate is subjected to hydrolysis, forming an alkaline solution. Irrigation water and groundwater are the main source of lime formation in the soil, because they contain a quantity of bicarbonate and calcium, where carbonates are deposited when the solution reaches the state of saturation, when this water is exposed to drought, which leads to the volatilization of part of the carbon dioxide.

Most of the calcium carbonate in Iraqi soils (Katea, 2007) was transported with the waters of the Tigris and Euphrates its tributaries are in the form of fine particles from the upper north and were deposited and combined with other soil particles in the alluvial plain.

The laboratory results showed that the percentage of calcium carbonate was high, ranging between 20.6-46%.

Soils that contain a percentage of this salt in excess of (45.5%) need frequent and varying irrigations because calcium carbonate reduces the ability of the soil to retain water. It is known that the lack of nutrients such as phosphorous, manganese and zinc is caused by fixation by calcium carbonate. Also, the low ratios of these Carbonates help stabilize soil aggregates and improve the physical properties of soils.

Organic Matter

Soil productivity is affected by the quantity and quality of organic matter because it contains nutrients and elements essential for plant growth and improving its productivity (Figure 4). Soils in dry areas have a low content of organic matter because of their easy decomposition due to high temperatures. Organic matter is necessary for soil fertility and improving its physical, chemical, and biological properties such as soil construction and permeability. It is considered as an effective factor in evaluating and defining the diagnostic horizons that are used in soil classification.

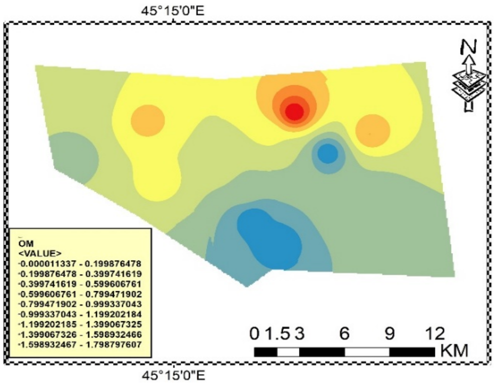

Figure 4. The organic matter content of the soil in the researched area

Through laboratory analysis, it was found that the percentage of organic matter ranged between 0.3%-1.4% in the surface layers and it is less in the subsurface layers, as it ranged between 0.1%-0.2%, and in general the percentage is less than 1% is low (SOLR, 1982), so the project soil needs to be fertilized when carrying out its agricultural exploitation.

Cation Exchange Capacity (CEC)

The exchange capacity is one of the important chemical properties of the soil in relation to plant nutrition, and through it we can know the main components of the clay particles, 52 me/100 g.

The high values of the exchange capacity of the soil of the region is closely related to the high proportions of clay and organic matter (Figure 5). Since the values specified as a minimum exchange capacity in the soil are me 100 g soil/24, and therefore there is no problem of in terms of the exchange capacity of the project soil in terms of soil fertility.

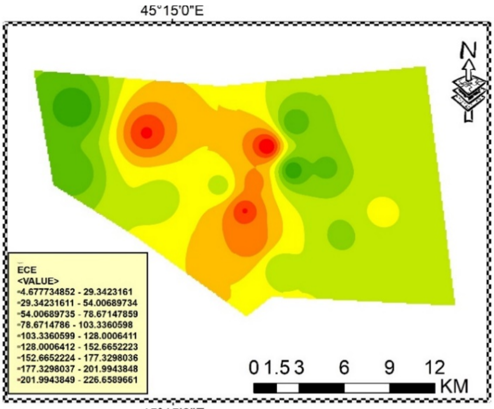

Figure 5. Cation exchange capacity of the soils in the studied area

Normalized Difference Vegetation Index (NDVI)

The results indicated that the values of the Normalized Difference Vegetation Index (NDVI) ranged between 0.47 to -0.30 (Figure 6, Table 6). The reason is due to the existence of a clear variation in the distribution of the type of land cover prevailing in the study area and in a disparate manner spread between agricultural lands and natural plants and plants growing in the marsh areas (Shallal et al., 2007).

The variety, which represents the absence of vegetation cover, occupied an area of about 13,684 hectares of the total the study area, at a rate of 15% due to the presence of barren lands affected by salinity, while the variety with poor vegetation cover an area estimated at about 1132368 hectares and a rate of 39% due to the high rate of salinity and the impact of difficult climatic conditions, which include the lack of rain and high temperatures, which affected the growth of plants, which in its turn led to reduction of the vegetation cover area. As a result, most of the lands of the studied area are not agricultural use.

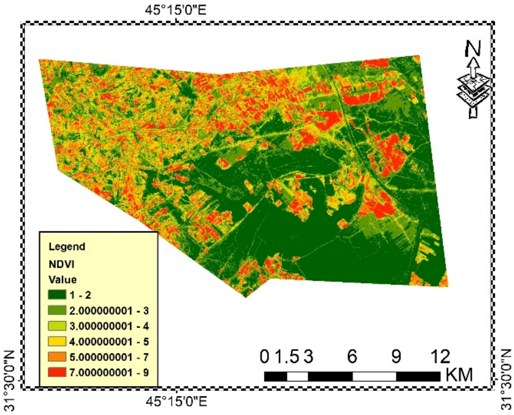

Figure 6. The Natural Vegetation Index (NDVI)

Table 6. Ranges of land degradation and its relationship to Normalized Difference Vegetation Index (NDVI) and natural cover of the study total area (Zaiboon et al., 2015)

NDVI Range	Area, km	Veg. Cover ratio	Land salinity
Non Veg	29114.45	82%	High salinity
Moderate veg	6850.026	14%	Low salinity
Very veg	14000	4%	Not salinity

As for the medium vegetation type, it occupied an area estimated at 591996 hectares, at a rate of 27%. The reason for this may be due to the growth of some plants that coexist with difficult environmental conditions, such as high salinity in the soil, high temperatures and low amounts of rain. As for the cultivar dense vegetation and very dense, it is estimated at 326098 and 109,146 hectares, at a rate of 14%

and 4%, respectively, and the reason is due to the fact that these lands fall into the banks of the rivers, or that they are agricultural use of economic crops or plantations (Ibrahim, 2008).

Salinity Index (NDSI)

The results showed that the salinity index values ranged between -0.49 to - 0.30, as the results shown in Table 7 and Figure 7, indicates that there are 7 categories that represent salinity index values in the study area NDSI.

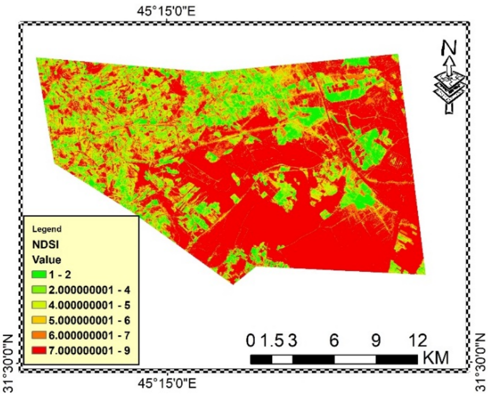

Figure 7. Map that shows the salinity index

Table 7. Ranges of the salinity index values

NDSI range	Area of salinity, Ha	Salinity cover ratio
Not salinity	14000	15%
Low salinity	37750	39%
High salinity	30000	31%
Very high salinity	14350	15%

As the non-salinity category occupied an area estimated at about 1561671 hectares of the study total area with rate of 15% as it is cultivated land or it is located in the banks of rivers, and this in turn is a natural drainage, as for the low-salinity variety, it occupied an area of 4659021 hectares, at a rate of 39%, this reflects the bad category of water and its scarcity, rather than reduction of the ratio of cultivated lands. While the medium salinity variety occupied an estimated area of 4787938 hectares, this is due to the fluctuation of ground water levels and the high percentage of salts in it. It has effectively contributed to the emergence of salinization processes in the soils, which negatively affected the growth and development of vegetation cover and the deterioration of the physical and chemical properties of the soil, while the highly saline and very salty variety occupied an area estimated at 5717664 and 2830104 hectares, with ratios of 15% and 31% respectively, and this indicates the presence of marshland soils (Al Zabidy, Metternicht and Zinck, 2003).

CONCLUSIONS

The study showed the ability of remote sensing and geographic information systems to survey, monitor, identify, analyze and classify aspects of land salinization in the study area and to discover spatio-temporal changes that may occur.

Satellite images are used for regional studies that are performed over a relatively large area due to the relatively low spatial resolution, ranging from 6-10 m, and the accuracy of their results is increased by spectral and spatial improvements and matching processes with reference information, be it maps or images.

The digital indicators (INDEX) contributed to highlighting the features of the land very effectively in clarifying the picture of the spatial distribution and the quantitative and qualitative assessment of the types of manifestations of land degradation in the study area, such as the visuals resulting from the index of natural differences of vegetation cover, salinity guide.

It highlighted the need to develop plans in short and long term to address the situation of land degradation and to combat desertification and loss of water bodies in most of the studied counties of the study area. The efforts should be directed to the improved irrigation situation would enhance farmland productivity, and hence reduce over-cultivation and grazing. If the reasonably water resource in the area could be adequately utilized through agricultural projects, it would be feasible to gradually re-vegetate the degraded lands. Briefly, no single means can work effectively in isolation without the support. Coordinated efforts aimed to reducing and reversing desertification must given to the study area. Rehabilitation endeavors should be directed to both areas of severely degraded and also to the area that are not at high risk to lessen the overall of desertification.

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