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MONITORING LAND COVER VARIATION USING SOME SPECTRAL INDICATORS IN AQRA REGION USING GEOSPATIAL TECHNIQUES

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ABSTRACT

The study was conducted in the Aqra area of northern Iraq, which represents lands with various agricultural uses located 80 kilometers from Nineveh Governorate, between latitudes (37° 2' 5.42" - 36° 29' 59.26") N and longitudes (43° 35' 56.84" - 44° 18' 31.56") E to study the five spectral indices related to soil salinity and vegetation cover for three years (2003, 2013, 2023) in March using Landsat satellite data (7, 8, 9), The most appropriate indicators were selected to determining the degradation of agricultural lands. Surface soil samples were collected from (40) locations with different agricultural uses and prepared for laboratory analysis. The results showed that the pH values were moderate in most sites, with other places was slightly alkaline. The Ec values ranged between (0.12-1.24) dS m^{-1}, while $CaCO_3$ content ranged between (110-460). gkg^{-1} The higher values are attributed to the nature of soil parent material. The results showed that almost all lands were affected by salinity in 2003 and were represented by five SI index classes, with values ranged from the lowest (57.688 - 69.777) to the highest value (82.908 - 110.837). Since most of the percentages in the areas of cultivars for the year 2013 were higher than in the other two years, where we note that the highest percentages for the best variation reached (39.772%, 22.683%, 18.397%, 11.400%) for SI, NDSI, OSAVI, and EVI, respectively, the study indicated that the area of vegetative loss between the three years was caused by the influence of climate, especially rainfall.

INTRODUCTION

Geographic information systems, according to NCGIA, (1990) are a collection of information equipment, programs, and automated processes that enable the scanning, storing, managing, analyzing, modeling, and displaying of data pertaining to their geographical locations to address challenging planning and management issues. The importance of adopting salinity surveys and maps for any region, as well as diagnosing agricultural land management systems and integrating them with remote sensing data, was highlighted by Douaik *et. al.* (2004); Khalid, (2012) and Ali *et.al.* (2013). These tools are helpful in identifying and diagnosing the type of salts and the extent to which they have spread throughout the soil through the use of special spectral standards, such as the salinity variation index and the salinity index (SI). NDSI .According to Thenkabail (2000), vegetation spectral criteria are vital-physical

functions which play an essential role in defining the natural distribution of plants. Shallal *et. al* (2007) and Khalid, (2019) used VI and SAVI to to determine the role of land uses on Pedogenic Properties in Mosul and he noticed that SAVI had a value for vegetation cover higher than VI and it was calculating the soil effect on the background on vegetative cover. They are numerous markers whose values fluctuate as the chemical status of the soil, development stages, and plant health change. They have mathematical equations that contribute to the derivation of spatial numerical values in the data of each pixel by submitting spectral bands to certain mathematical operations prescribed by the suggested spectral standard's mathematical formula. Khalaf and Hussien, (2021), the spectral indices LAI, SI5, and OSAVI were appropriate for monitoring desertification and deterioration in the research area. Add spatial variation in spectral indices such as NDVI and LAI. Aljumaily and Kashmoola, (2022) were able to draw spatial maps for three years (2002, 2012, 2022) by projecting spectral evidence values onto the map in the ENVI program, and the resulting images were processed using the Arc map program to distinguish them by color and perform the reclassification process (Reclassify) for the resulting map. Muhammad, (2023) eventually determined that the integration of geographical technology programs and the variety of treatment approaches Digital provided a tremendous deal of flexibility in studying and processing satellite imagery, as well as calculating indicators and digital confirmation. All indicators demonstrated that the study area experienced severe drought during the summer, with percentages based on the following indications (77%, 71.30%, 71.60). %, 73.70%, and the reason for this is due to the region's climatic conditions, which are represented by high and harsh temperatures, a lack of precipitation, and the blowing of hot dusty winds that cause soil drying. Vegetation indices are critical for collecting significant information about plant health, density, and distribution from remotely sensed data (Khalaf, 2019). EVI, GDVI2, NDSI, SI, and OSAVI, each with its spectral sensitivity, provide information about vegetation status and stress variables. These indicators are useful in identifying land cover types, monitoring vegetation behavior, and analyzing environmental changes. Several remote sensing indices, including the salinity index (SI) and the normalized difference salinity index (NDSI), were used to study how these indices operate for soil salinity mapping in arid environments (Yang *et al.* 2020). The salinity index (SI), which includes the blue and red bands, responds to surface reflectance of salt-affected terrain with minimal vegetation cover (Wang et al. 2021).
The Aim of the study:

1. Calculating spectral indicators related to soil salinity and vegetation cover for three years and diagnosing soils affected by salinity.
2. Monitoring the changes that have occurred in land use through maps drawn for spectral indicators for the three years and choosing appropriate indicators to determine the deterioration occurring in agricultural lands.

MATERIALS AND METHODS

Study Area

The study area was chosen in northern Iraq, represented by lands with different agricultural uses belonging to Aqra District, 80 km from Nineveh Governorate. It extends between latitudes (37°2¯5.42˭ N - 36°29¯59.26˭ N) and longitudes (43°35¯56.84˭ E -44°18¯31.56˭ E) as shown in Figure (1).

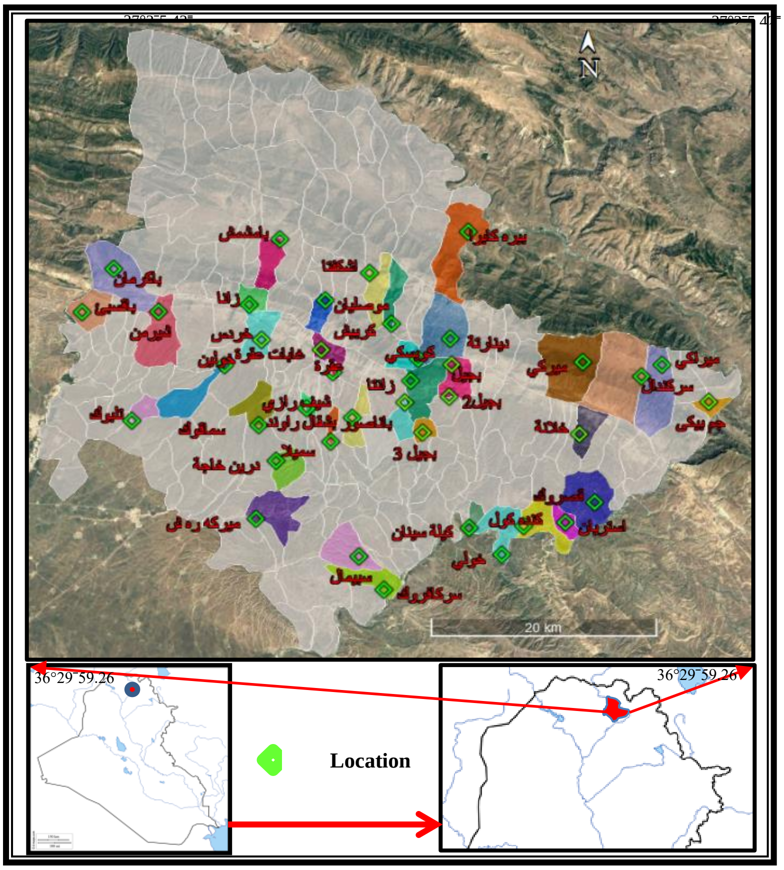

Figure (1): Map of the study area

Geology of the study area

The study area is part of the Zagros Fold and Thrust Belt in northern Iraq. It also represents part of the current northeastern edge of the Arabian Plate, and according to the local tectonic divisions, it is located within the range of high folds, as well as the southern and southwestern flank of the Aqra anticline. It represents the southern and southwestern borders of the High Folded Zone in this region along with the Foothill Zone (Buday and Jassim, 1987). The Aqra anticline is an asymmetrical, locally inverted anticline with two dips extending from the Bejil region in the east and to the Packerman region in the west, with an axial length of approximately 34 km (Al-Sumaidaie *et.al.* 2020). The anticline is bordered to the north by the Pers anticline, while to the east it is bordered by the Berat anticline, and to the northwest by the Atrush anticline, and the city of Aqra is located on the southern side of the anticline, Figure (2).

Climate of the region

The climate of the Aqra region falls within the Mediterranean climate, as it is characterized by a subtropical and semi-arid continental climate with a difference between the seasons of the year based on the Koppen-Geiger classification and distribution of climate regions, which depends on the volume of rainfall and monthly and annual temperatures. The highest annual rainfall rate during 2018-2019 was about (1384) mm, Figure (3). Temperatures affect the evaporation of surface water and groundwater near the surface, noting that the highest value of the monthly average maximum temperature was in July (41.8 °C) for the period 2020. -2010, and the lowest average was in January (11.4 °C), Figure (4). As for the minimum temperatures, the highest temperature was recorded in August, which reached (28.2 °C), and the lowest average was in January as well, which reached (3.2 °C) Figure (5).

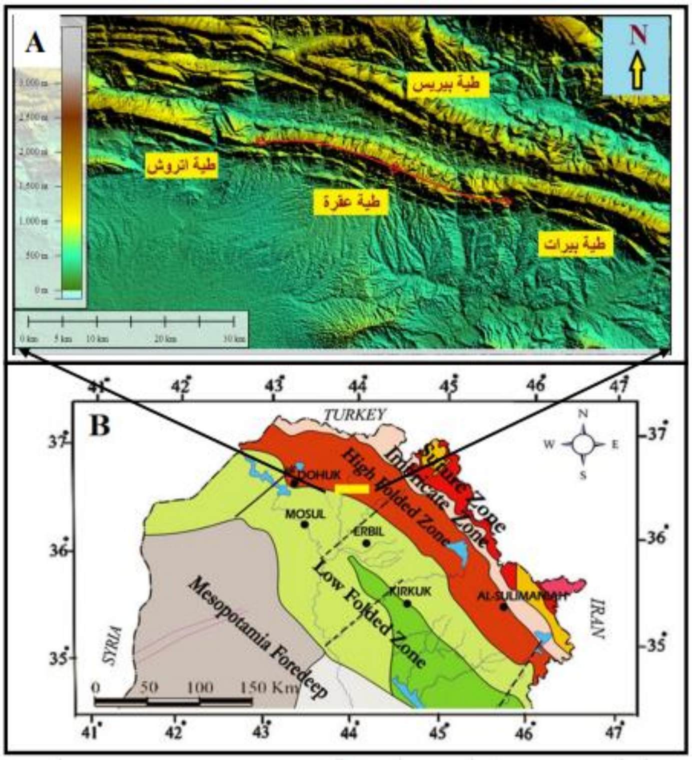

Figure (2): Tectonic divisions of Iraq, showing the areas surrounding the area studied (Fouad, 2015)

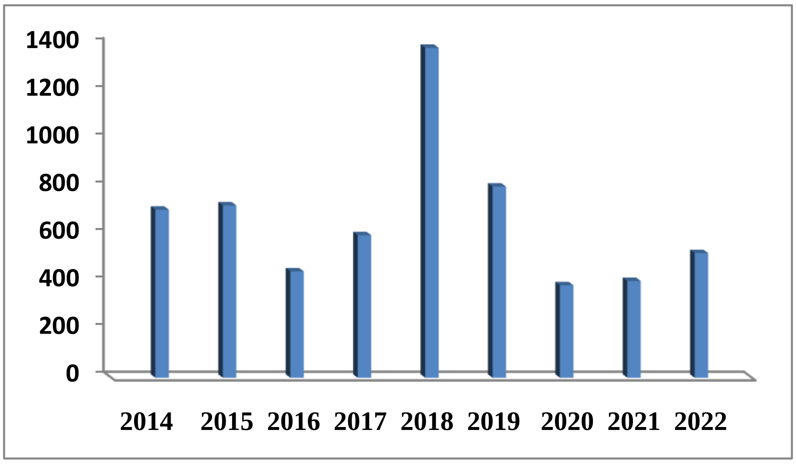

Figure (3): Average monthly rainfall (mm) for the period (2013-2023) (Ministry of Agriculture/Agricultural Meteorology Center).

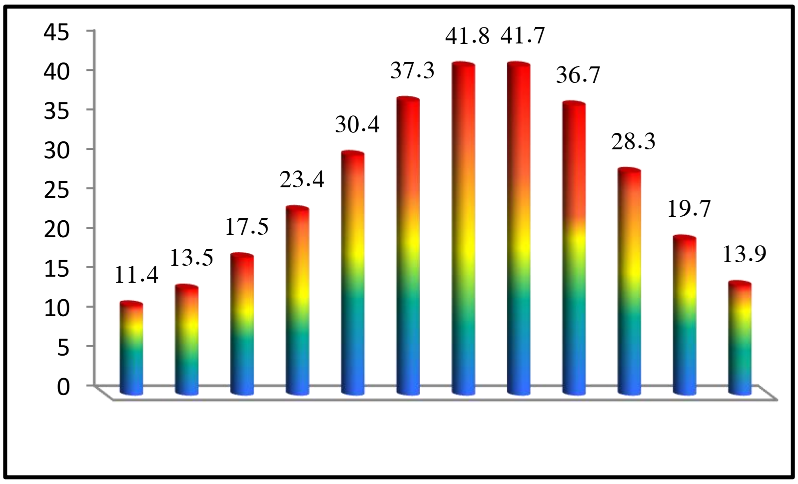

Figure (4): Monthly average highest temperature (C°) during the period (2010-2020)

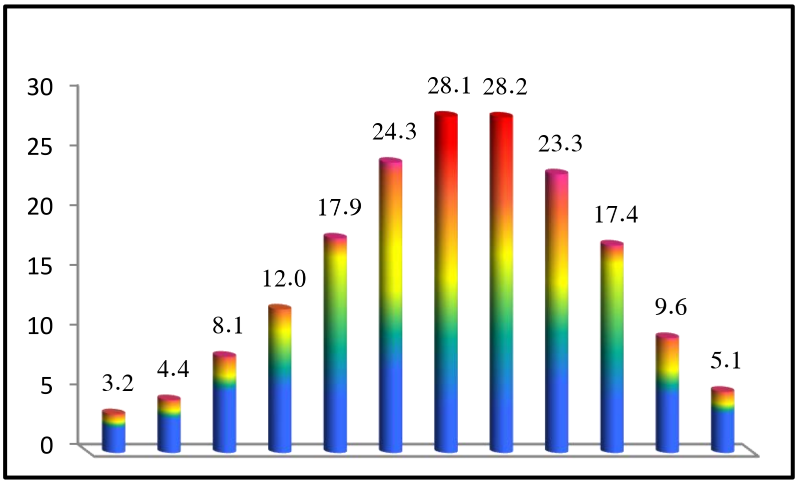

Figure (5): Monthly average minimum temperature (C°) in the period (2010-2022)

Soil Sampling

Agricultural lands in Al-Aqra District were chosen, with different areas and different locations. The coordinates of the locations under the study were read based on the (GPS) Global Positioning System Table (1). Composite soil samples were collected from (40) agricultural areas, with a representative sample for each place. The samples were taken at a depth of (0 - 15) cm, then air-dried, then ground with a wooden hammer, then passed through a sieve with a diameter of (2) mm and kept in plastic bags for laboratory analyses. Electrical conductivity (EC) and pH were estimated in the saturated soil paste extract according to the method presented (Page *et. al.* 1982). Organic matter was estimated according to the method mentioned in Jackson (1958). As for calcium carbonate, it was estimated using the titration method using hydrochloric acid (HCL) with a concentration of (1N) according to what was stated in Ryan *et al.* (1996). Gypsum was determined by precipitating the filtrate with acetone. According to Richard (1954). CEC was also estimated according to the method described in Black (1965).

Table (1): Agricultural use and GPS coordinates of soil sample locations in the study area

No	Location	Land use	E	N	No	Location	Land use	E	N
1	Banasor	Cucumber	43°58'8.03"	36°43'5.84"	21	Merge	Hawthorn trees	44°13'28.64"	36°45'1.04"
2	Bejel	Rice	44° 0'55.35"	36°44'59.92"	22	Bakerman	Grape	43°39'35.82"	36°49'32.07"
3	Bejel 2	Fig	44° 0'46.48"	36°43'23.79"	23	Meslyain	Apples	43°53'22.01"	36°48'11.65"
4	Bejel 3	Walnut	43°59'10.76"	36°41'32.28"	24	Mergarush	Kuja trees	43°50'11.35"	36°37'19.49"
5	Aqra Fori.	Pine trees	43°53'8.22"	36°45'43.06"	25	Zana	Fig trees	43°48'49.64"	36°47'57.29"
6	berkhwlen	Rice	43°44'1.15"	36°43'16.14"	26	Semela	pomegranate	43°53'44.11"	36°41'6.71"
7	Telbok	Maize	43°41'52.61"	36°42'6.42"	27	Shefrazi	Wild reeds	43°52'17.54"	36°42'46.68"
8	Smaqok	Olive	43°49'26.42"	36°41'55.29"	28	Kherdes	Purple trees	43°49'34.52"	36°46'11.82"
9	Znta	Tomato	43°58'28.34"	36°44'11.07"	29	Eshkefta	Mountain thyme	43°55'59.43"	36°49'34.75"
10	Gelasenan	Peaches	44° 2'0.17"	36°36'49.12"	30	Kerbesh	Walnut trees	43°57'12.69"	36°47'21.50"
11	khooly	Broccoli	44° 2'57.85"	36°36'48.41"	31	Denartah	Almond trees	44° 1'22.57"	36°46'34.84"
12	kendaqul	Cowpeas	44° 7'20.23"	36°36'4.47"	32	Kuske	Mazo trees	43°58'55.40"	36°45'16.89"
13	Esteryan	Pumpkin	44° 7'44.12"	36°37'6.23"	33	Bemeshmesh	Grapes	43°50'44.28"	36°51'24.02"
14	qasrook	Okra	44° 9'28.64"	36°38'6.93"	34	Derenkhaja	Pepper	43°50'43.43"	36°39'17.28"
15	Sebimal	Cucumber	43°56'48.18"	36°35'16.25"	35	Erkafrok	Eggplant	43°56'56.95"	36°33'41.72"
16	khelana	Olive	44° 8'33.11"	36°41'31.98"	36	Beqasbe	Cowpeas	43°38'23.35"	36°47'24.53"
17	sherman	pomegranate	43°43'25.16"	36°47'34.70"	37	Kholeen	Radish	43°47'22.92"	36°44'54.93"
18	jembeke	Clover	44°16'16.29"	36°43'9.90"	38	Bash.Rawand	Orange	43°55'8.90"	36°42'32.79"
19	merge	apples	44° 8'44.23"	36°45'9.02"	39	Berakabra	Green bean	44° 1'52.54"	36°51'39.84"
20	Sergendal	Oak	44°12'15.09"	36°44'26.02"	40	Akri	pomegranate	43°53'50.28"	36°44'35.27"

Remote Sensing Applications

A set of space data recorded by a group of Operational Land Imager and thermal infrared sensors (ETM), (OLI/TIRS) belonging to the satellite (Landsat7-8-9) was chosen for the years (2003, 2013, 2023) all taken in March with path (169) and row (35). The research region was then deduced from satellite data and processed and improved using the ERDAS tool. The spectral indexes were then estimated using the Arc GIS 10.3 programs.

1-Salinity Index (SI): As stated by Khan *et al.,* (2005) and shown in the equation below:

$$\mathrm{SI} = \sqrt{\mathrm{BLUE} \times \mathrm{RED}}$$

2-Normalized Differential Salinity Index (NDSI): as shown below (Khan *et al.,* 2005).

$$\mathrm{NDSI} = (\mathrm{RED} - \mathrm{NIR})/(\mathrm{RED} + \mathrm{NIR})$$

3- Optimized Soil Adjusted Vegetation Index (OSAVI): This is the optimized guide to the modified soil index developed by Rondeaux *et. al.* (1996).

$$\mathrm{OSAVI} = (\mathrm{NIR} - \mathrm{RED})/(\mathrm{NIR} + \mathrm{RED} + 0.16)$$

4- Enhanced Vegetation Index (EVI): It is an advanced vegetation index that was created with greater sensitivity to biomass, atmospheric background, and soil condition, and has a correction factor represented by G, C1, C2, and L, as stated by researcher Huete *et al.* (1997).

$$EVI = \frac{[(G) \times (NIR - RED)]}{[(NIR) + (C1) \times (RED - (C2) \times (BLUE) + (L)]}$$

Where is:

$G = 2.5$, $C_1 = 6$, $C_2 = 7.5$, $L = 1$

5- Generalized Difference Vegetation Index ($GDVI^2$): are used in RS to assess the health and vitality of vegetation. Wu *et al.,* (2014).

$$GDVI^2 = \frac{[(B4)^2 - (B3)]^2}{[(B4)^2 + (B3)]^2}$$

RESULTS AND DISCUSSION

Laboratory analyses

The results in Table (2) showed that the pH values differed by being neutral in certain sites, such as the Location number (38), and then inclined to slightly alkaline in most of the studied sites, where the value of soil reaction under the conditions of the study area was between (7.4-8.1) due to reduced precipitation, long periods of drought, and an abundance of calcium carbonate, which resists changing soil interaction. The results obtained were consistent with Feizas, (1996). The Ec values of soil samples varied from (0.12-1.24) dS m^{-1}. The salt content was higher at the Bagil 2 site. The increased salinity might be related to organic matter accumulation as well as the development of root group secretions. Organic matter content ranged between (3.4 -34.3) g kg^{-1}, indicating that there is a variation in the values of organic matter in all soils due to the nature of the dry climatic conditions, with these areas being exposed to low rainfall and high temperatures, resulting in less input of organic matter and nutrients from external sources, which is consistent with Hag Husein *et* *al*., (2021). The $CaCO_3$ varied from (110-460) g kg^{-1}, with the highest value obtained at site number (28).

Table (2) Chemical characteristics of soil samples

Location	pH	EC	OM	$CaCO_3$	CEC
		dSm^{-1}	gkg^{-1}		$Cmolkg^{-1}$
1	7.8	0.90	14.0	130	17.39
2	7.9	0.54	16.5	220	16.03
3	8.1	1.24	24.0	420	19.39
4	8.1	0.73	17.2	290	18.82
5	7.8	0.13	22.3	250	29.74
6	7.7	0.33	27.8	340	34.73
7	7.9	0.55	3.4	355	28.40
8	8.1	0.47	24.0	150	27.13
9	7.7	0.96	23.3	195	30.67
10	7.7	0.73	20.6	110	34.15
11	8.0	0.75	27.5	190	37.81
12	8.0	0.12	16.1	215	16.54
13	7.9	0.55	28.5	150	35.42
14	7.9	0.70	20.2	125	35.39
15	7.8	0.62	20.6	150	34.27
16	7.8	0.93	14.7	425	30.36
17	7.9	0.81	29.2	205	24.64
18	7.9	0.33	15.4	195	34.18
19	7.8	0.61	32.6	160	29.36
20	7.7	0.13	17.1	245	34.01
21	7.8	0.71	34.3	175	29.33
22	7.6	0.16	25.1	180	24.96
23	7.8	0.77	19.6	265	34.66
24	7.8	0.19	18.9	210	25.11
25	7.8	0.80	29.9	435	19.95
26	8.1	0.91	10.3	300	19.60
27	7.9	0.67	7.5	115	34.45
28	7.8	0.80	29.2	460	26.89
29	7.8	0.47	4.4	240	29.18
30	8.0	0.82	15.8	450	18.63
31	8.1	0.98	5.1	275	27.55
32	7.9	0.72	29.9	335	27.09
33	7.9	0.68	6.8	190	19.36
34	7.6	0.19	6.8	190	35.00
35	7.6	0.99	18.5	295	26.09
36	7.8	0.61	24.0	310	30.87
37	7.8	0.55	10.3	120	29.07
38	7.4	0.31	24.0	125	37.62
39	8.0	0.12	5.5	140	28.99
40	8.0	0.89	27.5	420	33.28

The chemical composition of the parent material of the soil, which is mainly rich in $CaCO_3$, may be ascribed to the high values in most studied areas. The geological formations of this region are rich in carbonate minerals, and the absence of rainfall causes CaCO3 accumulation in the subsurface horizons, this all consists of Taalab *et al*., (2019). Al-Taie and Khaled.(2023) ,

Table (2) shows that the CEC values of soils ranged from (16.03-37.81) Cmolkg^{-1}. These values were primarily determined by the soil's clay content, dissolved cations and anions, organic matter, and CaCO3 concentration, with increased clay and organic matter leading to an increase in the CEC values of the evaluated soils.

Results of Indicators

Salinity Index (SI)

According to the research results in Figure (6), salinity impacted the majority of the lands in the study region in 2003 compared to the other two years, with values that ranged from the lowest (57.688 - 69.777) to the highest (82.908 - 110.837). Table (3) shows that the green areas of the second class have grown over time, reaching 59.745%, while the green areas of the fifth class have dropped by 0.871%. It shows a decrease in salts in recent years. This is due to factors such as heavy rainfall, community awareness, and the quality of plant cover every year.

Table (3): Percentage and total area of each class according to the results of the spectral indices

Index SI		Landsat 7 2003		Landsat 8 2013		Landsat 9 2023	
		Area	%	Area	%	Area	%
SI	1	269.298	14.729	726.438	39.772	345.832	18.559
	2	595.151	32.551	652.352	35.670	1113.279	59.745
	3	615.479	33.663	341.788	18.689	334.380	17.945
	4	284.323	15.550	88.663	4.848	53.656	2.879
	5	64.087	3.505	19.562	1.069	16.228	0.871
NDSI	1	441.074	24.124	355.779	19.089	472.824	25.369
	2	720.927	39.430	1081.119	58.011	682.469	36.617
	3	666.339	36.445	426.782	22.898	709.466	38.012
OSAVI	1	283.348	15.498	336.441	18.397	278.040	15.203
	2	1215.108	66.460	1145.495	62.661	1395.307	76.296
	3	326.690	17.883	346.417	18.942	155.456	8.500
EVI	1	666.337	36.445	75.184	4.111	363.919	19.526
	2	656.194	35.890	792.873	43.354	898.624	48.215
	3	346.400	18.946	752.255	41.133	372.106	19.965
	4	159.407	8.719	208.489	11.400	229.110	12.292
$GDVI^2$	1	265.185	14.504	93.265	5.100	142.969	7.671
	2	550.615	30.116	874.147	47.799	707.781	37.975
	3	576.228	31.516	499.740	27.326	593.962	31.869
	4	342.712	18.744	282.887	15.468	301.307	16.166
	5	93.600	5.119	78.764	4.307	117.740	6.317

Normalized Difference of Salinity Index (NDSI)

Figure (7) shows that most of the lands in the study area were affected by salinity in the old satellite image (2003) and were represented by the presence of three classes, with index values ranging from (-0.3 to 0.2), while their values ranged from (-0.6 to 0.2) for both 2013 and 2023. For the years (2003, 2013, 2023), the Low NDSI variety occupied an area estimated at (441.074, 414.834, 472.824) hectares at a rate of (24.124%, 22.683% and 25.369%) respectively. The results showed that the third class, which represents the positive value related to soil salinity, occupied the most area in 2023, but its formula agreed with the SI index, as the NDSI value decreased in the third category for the year 2013, reaching 22.898% of the total area, which is consistent with the results of Al-Attabi *et al*. (2019), This might be because of the temperatures and amount of rain each year, which is in line with what Salman (2022) noted.

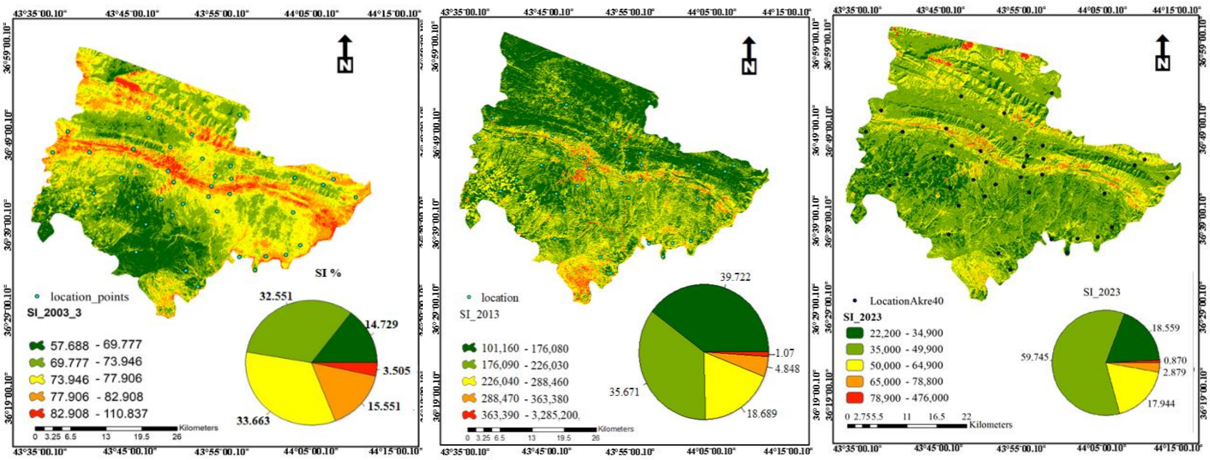

Figure (6): SI values with percentage of area for each class for the three years

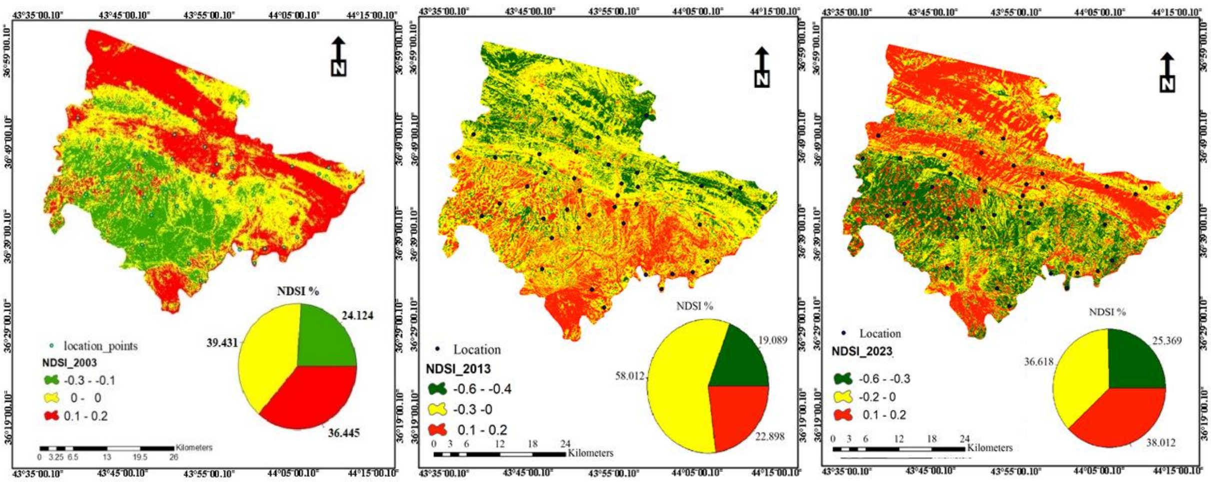

Figure (7): NDSI values with percentage of area for each class for the three years

Optimized Soil Adjusted Vegetation Index (OSAVI):

The result in Figure (8) showed that the indicators ranged between (-0.17 - 0.23) and (-0.23 - 0.62) and (-0.22 -0.61) for 2003, 2013 and 2023 respectively This variation in the values of the spectral indices is a result of the influence of soil and atmosphere on the reflectivity of vegetation. However, the second category is represented by vegetation cover, which is near to (0) for the year 2023 compared to the previous two years, as its values were between (0.23 - 0.41) and its area reached around 1,395,307 hectares, which is 76% of the total area

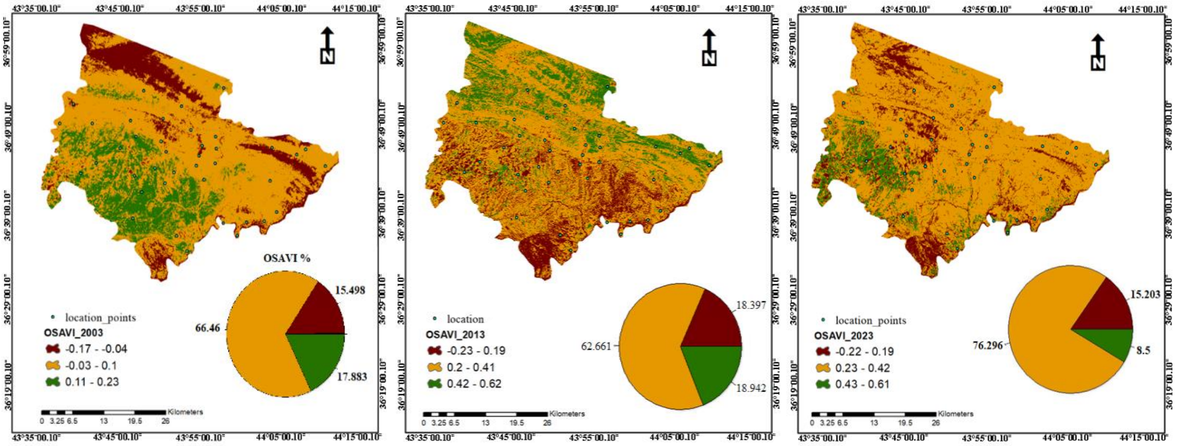

Figure (8): OSAVI values with percentage of area for each class for the three years

Enhanced Vegetation Index (EVI)

It is a more sophisticated plant indicator with increased sensitivity to live mass, atmospheric backdrop, and soil quality. Its value is between (-1 and +1). Table (3) clearly shows that the lands were subjected to drought in 2003, as the proportion of the first class reached 36.445% of the total area. Its value was less than (0), as shown in Figure (9), while the percentage of green areas increased, as represented by three degrees of other types, whose values increased from zero, and this corresponds to the amount of rain in recent years within the study area and the decrease in the amount of salts.

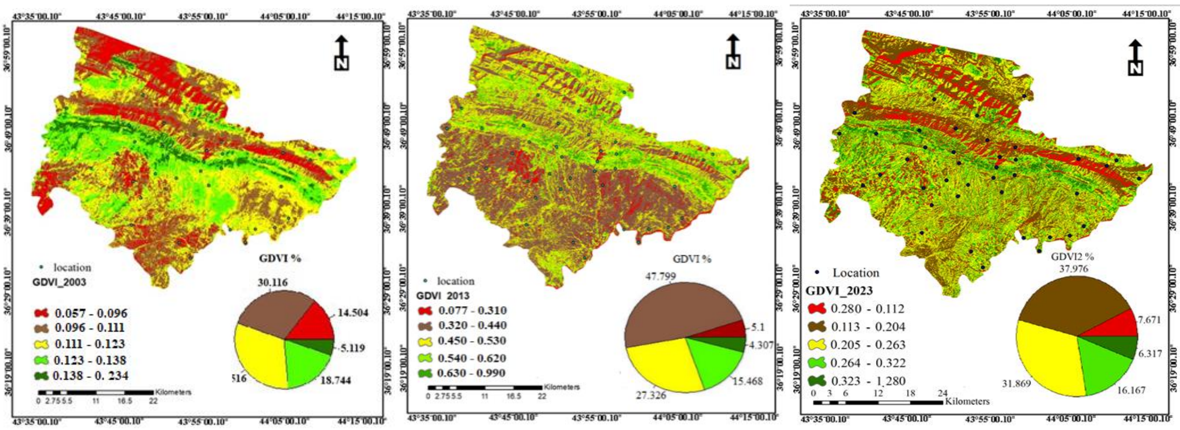

Figure (9): EVI values with percentage of area for each class for the three years

Generalized Difference Vegetation Index (GDVI2)

According to the results in Table (3) and Figure (10), there was a state of variation in the values of the GDVI2 index in the study area for the three years, as the values ranged between (0.057 - 0.234) for the year 2003, and although most of the classes were within the limits close to (+1), the fifth class had the largest area compared to other years, which amounted to 256,185 hectares. While the classes ranged between (0.077 - 0.990) for the year 2013, and the values were closer and higher in the year 2023, which ranged between (0.280 - 1.280). The highest area was recorded in the second class, which amounted to 707.781 hectares, at a rate of 37.975% of the total area, indicating that the plants were more vibrant, as in Year 2023.

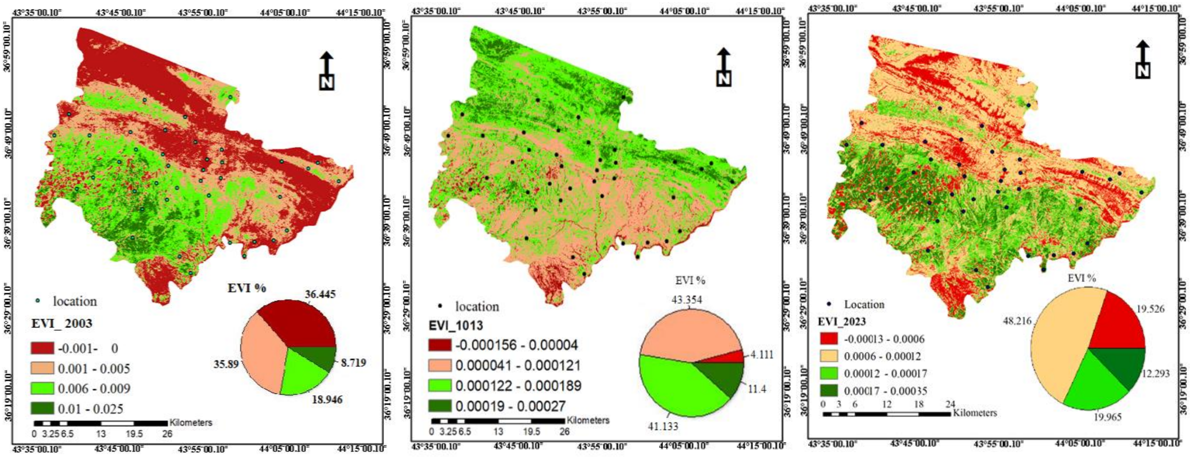

Figure (10): GDVI2 values with percentage of area for each class for the three years

CONCLUSIONS

The study showed that the spectral indicators used had important results in detecting changes in land cover such as soil and plants, and its results were characterized by high accuracy. There was similarity in distinguishing land cover into three classes of spectral indices (NDSI and OSAVI) to give it a clear meaning for the differentiation between soils, unlike other spectral indices that were distinguished into more than three land classes to read the differentiation between vegetative errors as well. The study demonstrated that the areas of vegetative loss over all of the three years were primarily caused by the influence of the climate, particularly rainfall and that the areas were under good agricultural management because the majority of the percentages in the 2013 variety area were higher than those in the other two years. Particularly, the best variety for each analysis achieved the highest percentages, which were 39.772%, 19.089%, 18.397%, and 11.400% for the indexes SI, NDSI, OSAVI, and EVI, respectively. Geographic information systems data and laboratory analyses of soil samples in 2023 agreed on many points, and the spectral indications of soil salinization agreed on most of the research area's results on Ec and CaCO3 content.

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CONFLICT OF INTEREST

The authors support the idea that this work does not conflict with the interests of others.

مراقبة التغاير في الغطاء الأرضي باستخدام بعض المؤشرات الطيفية في منطقة عقرة باستخدام التقنيات الجيومكانية

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الخلاصة

اجريت دراسة في منطقة عقرة شمالي العراق واشملت اراضي باستعمالات زراعية مختلفة وعلى بعد (80) كم من محافظة نينوى والتي تقع بين دائرتي عرض (36° 29' 59.26" – 37° 2' 5.42") شمالاً وخطي طول (44° 18' 31.56" – 43° 35' 56.84") شرقاً. استخدمت خمسة دلائل طيفية الخاصة بملوحة التربة والغطاء النباتي لثلاث اعوام (2003, 2013, 2023) لشهر اذار وبالاعتماد على بيانات الاقمار الصناعية Landsat (7, 8, 9) وتم اختيار المؤشرات الانسب في تحديد التدهور الحاصل في الاراضي الزراعية. جمعت نماذج ترب سطحية من (40) موقعاً باستعمالات زراعية مختلفة وتم تهيئتها للتحاليل المختبرية. بينت النتائج بأن قيم الـ pH كانت متعادلة لأغلب المواقع مع وجود مواقع مائلة للقاعدية قليلاً، تراوحت قيم الـ Ec بين (1.24–0.12) $dS\ m^{-1}$, محتوى $CaCO_3$ تراوحت بين (460–110)$g\ kg^{-1}$ ويعزى سبب ارتفاع القيم لبعض المواقع الى طبيعة مادة الأصل لترب المنطقة. أشارت النتائج الى ان معظم الاراضي كانت متأثرة بالملوحة في عام 2003 وتمثلت بخمسة اصناف لدليل SI، اذ تراوحت قيمها من اقل قيمة (57.688 – 69.777) الى اعلى قيمة (82.908 – 110.837). اثبتت الدراسة بأن مساحة الفقدان الخضري بين الأعوام الثلاثة كانت بسبب تأثير المناخ بالأخص كميات الامطار وان المناطق تقع تحت ادارة زراعية جيدة اذ تفوقت معظم النسب في المساحات الخاصة بالأصناف للعام 2013 مقارنة بالعامين الاخرين حيث نلاحظ ان اعلى النسب للصنف الافضل بلغت (39.772 %, 22.683 %, 18.397 %, 11.400 %) للدلائل SI, NDSI , OSAVI, EVI على التوالي.

الكلمات المفتاحية: التحسين، التدهور، العراق، الملوحة، دلائل الخضرة.

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