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EVALUATING SOIL DEGRADATION IN SHWAN AND ALTUN KOPRI AREAS IN KIRKUK GOVERNORATE BY SOME SPECTRAL INDICATORS

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Abstract

The study aims to assess soil degradation the northeastern part of Kirkuk Governorate includes the districts of (Shwan) and (Altun Kopri) extends between longitudes (44̊ 22′ 29″-44̊ 38′ 22″) and latitudes (35̊ 42′16″-35̊ 43′ 53″) with a total area of (117,683.96 hectares). Spectral comparative indicators for the years (1997, 2014, 2020, 2023) were used to monitor the deterioration during these years using landsat 5 MSS, landsat 8 OLI and Arc GIS 10.4.1 software for mapping. The NDVI (low vegetation) decreased in 2023 compared to 1997, while the percentage of (medium vegetation) and (dense vegetation) in 2023 increased compared to previous years., As for the SAVI, class (very few) has decreased its area in 2023 compared to 1997, while for the rest of classes (few), (moderate), (good) and (very good), their areas have increased in 2023 compared to previous years. As for CI class, the (medium) class increased in 2023 compared to 1997, while the (strong) class was the opposite of the aforementioned class, as it decreased in 2023 compared to previous years, As for the BSI, the (no degradation), as it decreased in 2023 compared to 1997, while the class (little degradation) increased in 2023 compared to previous years, while the class (medium degradation) increased its percentage compared to 1997, As for the NDMI indicator, the class (dry lands) in the year 2023 has decreased compared to 1997, as for the second class (low moisture lands), a noticeable increase was observed in the year 2023 compared to 1997.

Keywords: Spectral indicator, Remote sensing, Soil degradation.

تقييم تدهور التربة في ناحيتي شوان وألتون كوبري في محافظة كركوك باستخدام بعض المؤشرات الطيفية

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الخلاصة

تهدف الدراسة الى تقييم تدهور التربة في الجزء الشمالي الشرقي من محافظة كركوك ويشمل ناحيتي شوان والتون كوبري ويقع بين خطي طول (″22 ′38 °44−″29 ′22 °44) ودائرتي عرض ′43 °35−″16′42 °35) (″53) وبمساحة اجمالية قدرها (117,683.96 هكتار). تم استخدام المؤشرات الطيفية للسنوات (1997,2014,2020,2023) لرصد التدهور الحاصل باستخدام المتحسس للقمر الصناعي landsat 5 MSS, landsat 8 OLI باستخدام برنامج Arc GIS 10.4.1 لعمل خرائط هذه المؤشرات التي تشمل (NDVI)، (SAVI)، (CI)، (BSI)، (NDMI)، (NDSI). لاحظ أن مؤشر NDVI (الغطاء النباتي المنخفض) انخفض في عام 2023 مقارنة بعام 1997، في حين ارتفعت نسبة الغطاء النباتي المتوسط والغطاء النباتي الكثيف في عام 2023، أما بالنسبة لمؤشر SAVI فقد انخفضت مساحة قليلة جدا في عام 2023 مقارنة بعام 1997، بينما بالنسبة لبقية الفئات قليلة ومتوسطة وجيدة وجيدة جدا، فقد زادت مساحاتها في عام 2023، أما CI فقد زادت المتوسطة في عام 2023 مقارنة بعام 1997، بينما كانت الطبقة القوية معاكسة للفئة المذكورة أعلاه، حيث انخفضت في عام 2023، أما بالنسبة لمؤشر BSI فقد تغيرت (لا تدهور) حيث انخفضت في عام 2023 مقارنة بعام 1997، في حين زادت (التدهور القليل) في عام 2023، في حين زادت التدهور المتوسط من نسبتها مقارنة بعام 1997، اما بالنسبة لمؤشر NDMI فقد انخفضت الأراضي الجافة في العام 2023 مقارنة بعام 1997، أما بالنسبة للفئة الثانية (الأراضي منخفضة الرطوبة) فقد لوحظ ارتفاع ملحوظ في العام 2023 مقارنة بعام 1997.

كلمات مفتاحية: المؤشرات الطيفية، التحسس النائي، تدهور التربة.

Introduction

The earth is a balanced ecosystem, but this balance may undergo changes that go to some of its elements and the imbalance may be the result of environmental emergencies such as droughts or floods, environmental disturbance may occur as a result of human misuse of the land and its resources. Therefore degradation is the decline in the ability of lands fir agricultural production (6). Found (12) that soil degradation means reduced biomass productivity, increased erosion rates, reduced productivity and appropriate land use soil degradation represents a decrease in soil quality resulting from the wrong use of humans (7). soil degradation is a decrease in the productive capacity of the soil in arid, semi-arid, humid and sub-humid areas with agricultural and pastoral use as a result of natural and human factors, which result in salinization, erosion and the formation of sand dunes (5). Remote sensing data and GIS were used widliy in last decaids in styding soil degradation (4, 8 and 10).

Used (11) remote sensing techniques in his study of the Ruste Basin in Erbil Governorate, which aimed to assess the basin size, appearance and external appearance in order to assess flooding and erosion rate that may negatively affect soil and water sustainability and natural resource management.

Indicates (2) in his study on the management of irrigated soil with axial sprinklers with large areas the possibility of using remote sensing techniques in monitoring, following-up, counting and studying the changes of these lands, these indicators were found to be related to soil degradation. (9) Used a number of evidence and indicators related to the research topic, and a number of evidence were calculated, including the Natural Vegetation Cover Difference Index (NDVI), the Barren Soil Index (BSI), the Modified Vegetation Cover Soil Index (SAVI), the Salt Content Difference Index (NDSI) and the Water Content Difference Index (NDWI).

Found (3) in the study conducted in Nineveh Governorate, which was dealing with assessing the state of desertification and degradation of this governorate, where he stressed that the times of satellite data must be taken into account when calculating the NDVI directory, what appears as green meadows will appear as arid lands at other times for the same area.

Confirmed (1) that the analysis of spectral indicators of satellite data proved its high efficiency in detecting the state of degradation and general weakness of the vegetation cover of the Wadi Al-Muhammadi basin for NDVI,CI. This study aimed to assess the state of degradation of the soil of the region based on geospatial technologies and the use of some spectral indicators.

Materials and Methods

The study area is geographically located in the northeastern part of Kirkuk Governorate, includes the districts of Shwan and Altun Kopri, extends between longitudes (44° 22′ 29″-44° 38′ 22″) East and latitudes (35° 42′16″-35° 43′ 53″) North with a total area of (117683.96 hectares).

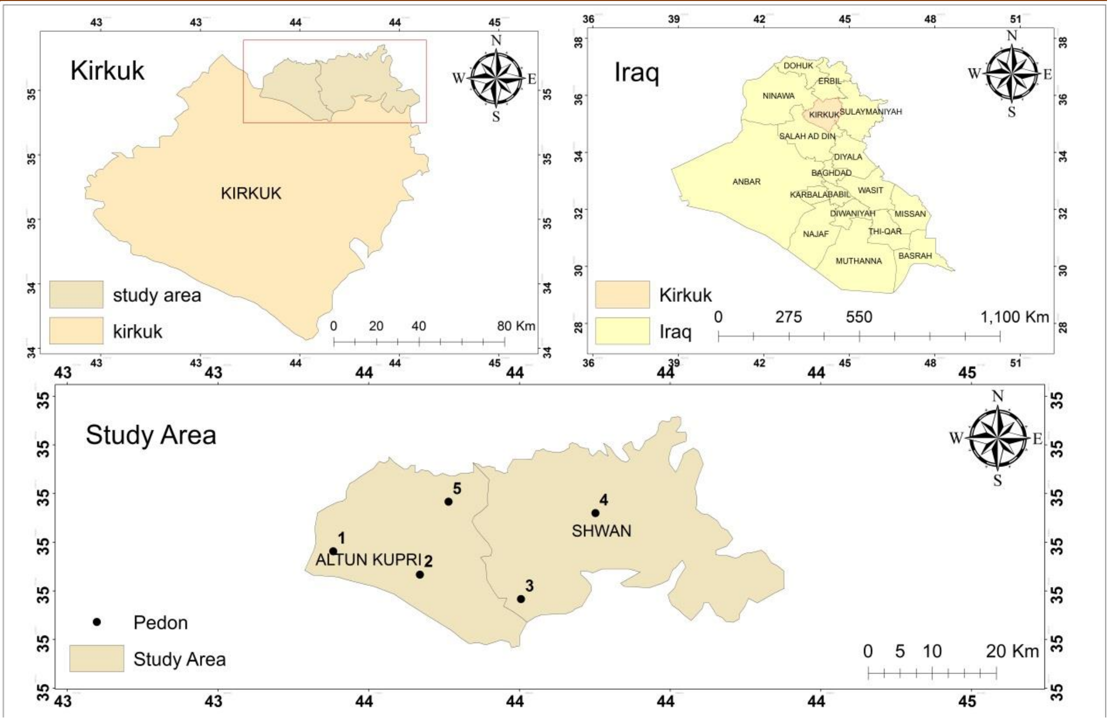

Fig. 1: Study area location and selected pedons sites.

Office Work: The landsat 5 MSS, landsat 8 OLI images were acquired from the website of the Geological Survey (USGS) (Table 1) for the area located within the administrative boundaries of Kirkuk Governorate, with the aim of monitoring the areas where changes occur in the land covers during the mentioned years, and the initial treatments of the satellite visualizations were carried out and inhanced. Arc GIS 10.4.1 was used in mapping spectral indicators.

Table 1: History of visual capture by satellite.

No.	The Satellite	Years
1	Landsat 5	1997/8/3
2	Landsat 8	2014/7/20
3	Landsat 8	2020/7/20
4	Landsat 8	2023/7/21

Classification of soil degradation using spectral indicators:
Spectral comparative indicators for the years 1997, 2014, 2020, 2023 were used to monitor the degradation during these years and find appropriate solutions.

The Normalize Difference Vegetation Index (NDVI): (13) This indicator depends on red and infrared spectrum, when there are areas with vegetation cover in its best condition, chlorophyll in plant leaves absorbs red spectrum, on the contrary, in areas without vegetation or in poor condition reflect infrared spectrum .The values of this indicator range between 1 + and 1- and that 1 + is evidence of the presence of good vegetation cover and if this value decreases indicates the exposure of vegetation cover to degradation (Table 2) The value of this indicator is calculated according to the following equation:$NDVI = (NIR - RED)/(NIR + RED)$……(1)
Whereas: NIR:Near infrared Red: The red spectrum.

Table 2: Ranges NDVI.

No.	Range	Description	NDVI
1	0	Water or barren soil	1
2	0-0.2	Little vegetation cover	2
3	0.2-0.4	Moderate vegetation cover	3
4	0.4 <	Hight vegetation cover	4

Soil Adjusted Vegetation Index (SAVI): This indicator was proposed by (13) and its main motivation was to prepare a global digital model for monitoring soil and vegetation cover through remotely sensed data, this indicator works to calculate vegetative differences in addition to soil reflection

This indicator it can be obtained through the following equation:

$\boldsymbol{SAVI} = ((\boldsymbol{NIR} - \boldsymbol{RED}))/((\boldsymbol{NIR} + \boldsymbol{RED} + \boldsymbol{L})) * (\boldsymbol{1} + \boldsymbol{L})$…..(2)

Whereas: NIR:Near infrared, Red:The red spectrum, L: The constant value of the soil line is equal to 0.5.

Values SAVI ranged between 1-,1+ (Table 3).

Table 3: Ranges SAVI.

No.	Range	Description	SAVI
1	0.1	Very few	1
2	0.1-0.2	Few	2
3	0.2-0.3	Moderate	3
4	0.3-0.4	Good	4
5	0.4 <	Very good	5

Crust Index (CI): This indicator is used to monitor the impermeable thin layer, which is one of the most important forms of ground physical degradation, as the thickness of these layers varies according to the nature of the composition of the soil of the region, where crust may form in sandy lands and surface layers of the land that are very cohesive and have a high apparent density and poor permeability, which affects air exchange in the ground as well as heat exchange and thus reduce soil moisture and degradation.

It is obtained according to the following equation $\boldsymbol{CI} = (\boldsymbol{Red} - \boldsymbol{Blue})/(\boldsymbol{Red} + \boldsymbol{Blue}) - \boldsymbol{1}$……(3)

Whereas:Red: The red rays, Blue:The Blue rays. This indicator value are between 0-2 (Table 4).

Table 4: Ranges CI.

No.	Range	Description	CI
1	0-0.4	Very weak	1
2	0.4-0.8	weak	2
3	0.8-1.2	Moderate	3
4	1.2-1.6	hard	4
5	1.6-2	Very hard	5

Bare Soil Index (BSI): This indicator is used in the possibility of distinguishing soil without vegetation cover. The values of this indicator range between (zero - 1-) where the high value means that the land is free of vegetation, while the low values indicate the presence of vegetation (Table 5). It is obtained through the following equation:

$BSI = ((RED + SWIR) - (NIR + BLUE))/((RED + SWIR) + (NIR + BLUE))$ ……. 4))

Whereas: RED:The red spectrum,SWIR:Short near infrared ,NIR: Near infrared,Blue:The Blue spectrum.

Table 5: Ranges BSI.

No.	Range	Description	BSI
1	0	Non-deg.	1
2	0-0.1	Light-Deg.	2
3	0.1-0.25	Moderate Deg.	3
4	0.25-0.5	High Deg.	4
5	0.5 >	Very high Deg.	5

Normalized Difference Moisture Index (NDMI): One of the most important features of this indicator is the high resolution and good spatial coverage in all terrain and one of its most important uses is to monitor drought that may affect agriculture and surface water bodies.

The indicator is calculated by the following equation:

$NDMI = (NIR - SWIR)/(NIR + SWIR)$ …..(5)

Whereas:NIR: Near infrared

SWIR: Short near infrared

It ranged between -1,+1 (Table 6).

Table 6: Ranges NDMI.

No.	Range	Description	NDMI
1	-0.1-0	Dry lands	1
2	0-0.2	Low-moistrure lands	2
3	0.2-0.4	Medium- moistrure lands	3
4	0.4 >	High-- moistrure lands	4

Normalize Difference Salinity index (NDSI): It is an indicator of interest in inferring the content and type of salts in the soil. The values of this indicator range from (1_1-) (Table 7), where the closer the value to 1 indicates that the soil is affected by salinity, and on the contrary, the lower the value indicates that the soil is free of salinity.

It can be obtained by the following equation:

$NDSI = (Red - NIR)/RED + NIR)$..…(6)

Whereas: RED:The red rays , NIR: Near infrared.

Table 7: Ranges NDSI

No.	Range	Description	NDSI
1	0	Low salinity	1
2	0.1	Moderate salinity	2
3	0.3	High salinity	3

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Results and Discussion

The Normalize Difference Vegetation Index (NDVI): This indicator was classified into four classes according to the study area (Table 8) and figures 2, 3, 4, 5 The area of the class (low vegetation) was in 1997 covering 97.48% of study area after which there was a slight increase in 2014 (97.58%) after it began to decrease in the following years 2023, 2020 to 96.21% and 95.65% respectively, as for the class (medium vegetation) it covered an area of 2.01% in 1997 then it began to decrease in 2014 to 1.89% after that began to gradually increase in the following years, as it covered 3.12% and 3.66% of the study area, while the last class (dense vegetation) was the lowest area in 2014 (0.05%) After that, a remarkable increase was observed in the years 2020, 2023 by 0.11% and 0.29% respectively.

It is noted from the above that the (low vegetation) class has decreased its percentage in 2023 compared to 1997, while the percentage of (medium vegetation) and (vegetation dense) classes in 2023 increased compared to previous years, This discrepancy between the special varieties of this indicator was due to several factors, including climatic extremes represented by high temperatures and rainfall fluctuations, in addition to human factors, The reason behind the increase in these two varieties may be attributed to the expansion of agricultural land areas, especially for the crop of yellow corn irrigated using fixed and pivotal sprinkler irrigation systems, which have increased in recent years, which helped and contributed to increasing the areas of agricultural land and increasing the density of vegetation cover.

Table 8: The Normalize Difference Vegetation Index (NDVI) for the years 1997, 2014, 2020, 2023.

Description	1997		2014		2020		2023	
	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio
Water or barren soil	607.16	0.52	573.86	0.49	657.65	0.56	467.48	0.40
Little vegetation cover	114717	97.48	114831.49	97.58	113227.54	96.21	112567.46	95.65
Moderate vegetation cover	2359.71	2.01	2224.52	1.89	3668.26	3.12	4304.5	3.66
Hight vegetation cover	0.09	0	54	0.05	130.5	0.11	344.44	0.29
Total	117683.96	100%	117683.96	100%	117683.96	100%	117683.96	100%

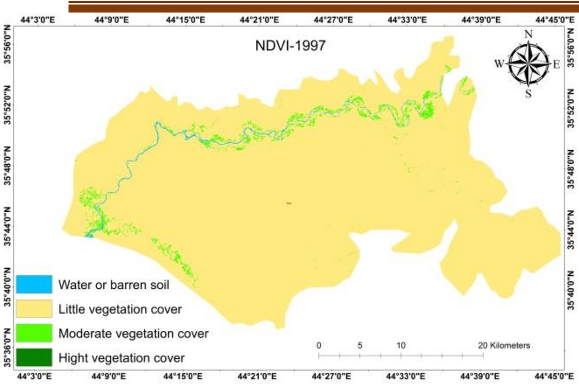

Fig. 2: The Normalize Difference Vegetation Index (NDVI) of 1997.

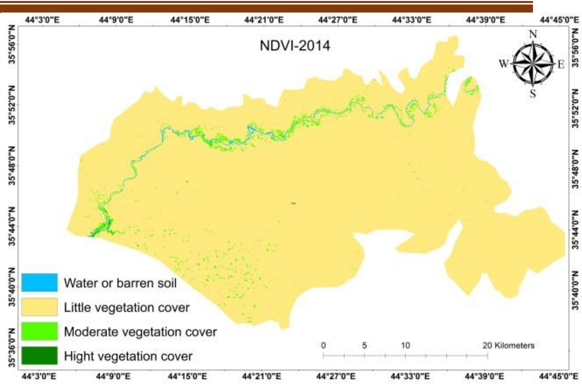

Fig. 3: The Normalize Difference Vegetation Index (NDVI) of 2014.

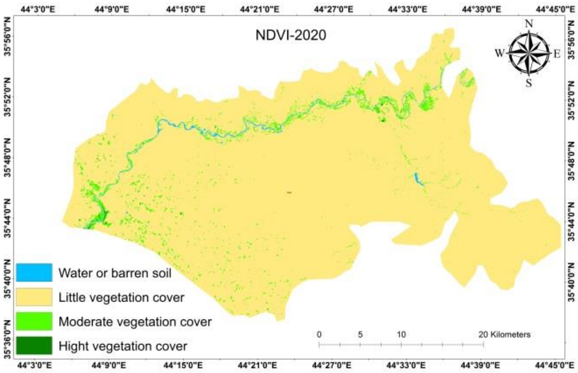

Fig. 4: The Normalize Difference Vegetation Index (NDVI) of 2020.

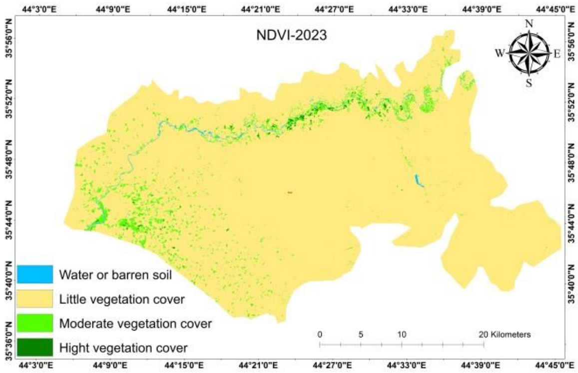

Fig. 5: The Normalize Difference Vegetation Index (NDVI) of 2023.

Soil Adjusted Vegetation Index (SAVI): Table 9 and Figures 6, 7, 8, 9 shows that the largest area covered the study area for the first class (very few) was in 1997 78.32% after that it began to gradually decrease in 2014 and 2020 to 19.66% and 9.1% respectively, then it was noted that there was a small increase in 2023 with an area that covered 11.66%, As for the second class (few), it was the least occupied area in 1997 (17.89%) after which it began to gradually increase in 2014 and 2020, unlike the first class, where it occupied 76.3% and 83.14% respectively, while in 2023 it decreased by a remarkable percentage of 80.64% of the study area, As for the third variety (moderate), it was in 1997 covering an area 1.79%, where it was the lowest percentage in this year, but in 2014 and 2020, there was a remarkable change and increase, as it covered 2.11% and 4.53% In 2023, it decreased by a small percentage of 3.75% of the total areas. As for the fourth class (good), it was in 1997 occupying 1.43% after which it was noted that the area of this class in 2014 has decreased and became 1.08% but in the following years it began to increase gradually, as it covered 1.73% and 1.8% in 2020, 2023 respectively. As for the last category (very good), it was the lowest percentage in 1997 estimated at 0.57% and then began to gradually increase by 0.86%, 1.5% and 2.15% for the years 2014, 2020 and 2023 respectively. It is noted from the above that the (very few) class has decreased its percentage in 2023 compared to 1997, while for the rest of the classes (few), (moderate), (good) and (very good), their percentages have increased in 2023 compared to previous years, The reason may be attributed to the state of deterioration of the soil as a result of the low content of organic matter and the high percentage of calcium carbonate, which led to a decrease in the readiness of nutrients or depletion of the soil in addition to the lack of rainfall, high temperatures and increased evaporation rates, all of which led to the lack of vegetation cover and degradation, in addition to the lack of good methods in soil and plant management in the conditions of these areas and led to a gradual deterioration of the soil, as for the rest of the varieties (moderate), (good) and (very good), their percentages increased in 2023 compared to previous years, and this corresponds to the results of the NDVI index for the same year.

Table 9: Soil Adjusted Vegetation Index (SAVI) for the years 1997, 2014, 2020, 2023.

Description	1997		2014		2020		2023	
	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	**Ratio**
Very few	92169.85	78.32	23134.69	19.66	10709.66	9.1	13720.28	**11.66**
Few	21048.87	17.89	89789.45	76.3	97841.95	83.14	94905.12	**80.64**
Moderate	2106.08	1.79	2481.75	2.11	5333.95	4.53	4410.34	**3.75**
Good	1688.01	1.43	1265.36	1.08	2032.9	1.73	2115.53	**1.8**
Very good	671.15	0.57	1012.63	0.86	1765.5	1.5	2532.6	**2.15**
Total	117683.96	100%	117683.96	100%	117683.96	100%	117683.96	**100%**

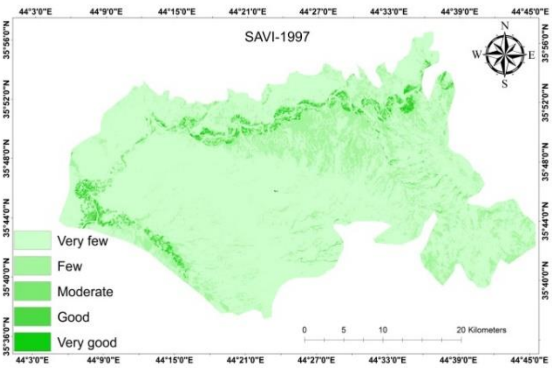

Fig. 6: Soil Adjusted Vegetation Index (SAVI) of 1997.

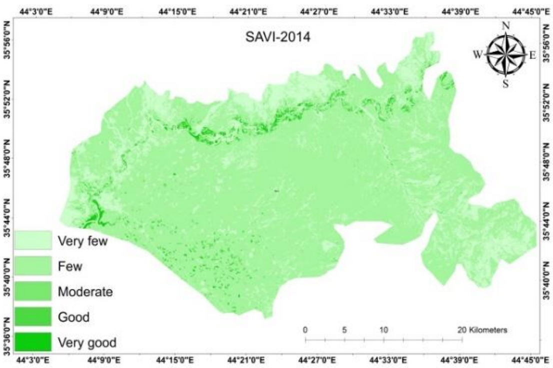

Fig. 7: Soil Adjusted Vegetation Index (SAVI) of 2014.

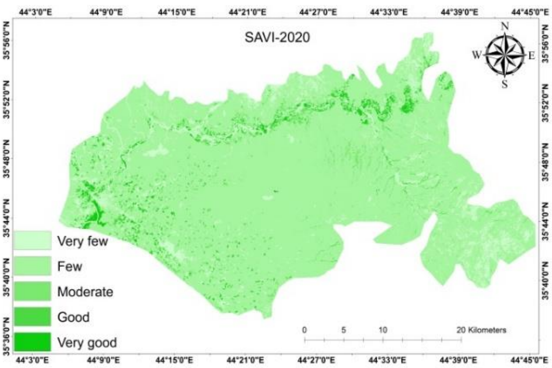

Fig. 8: Soil Adjusted Vegetation Index (SAVI) of 2020.

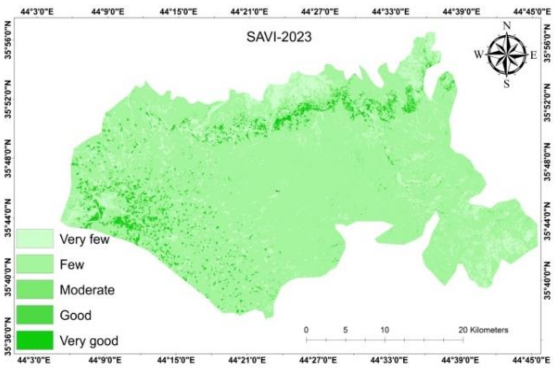

Fig. 9: Soil Adjusted Vegetation Index (SAVI) of 2023.

Crust Index (CI): Table 10 and figures 10, 11, 12, 13 It was noted that the classes (very weak) and (weak) did not appear in any of the years mentioned above, as for the class (medium), its area was 1.79% in 1997, then it was noted that its area decreased as it reached 0.33% in 2014 and then began to increase gradually in 2020 and 2023, where its area ,estimated percentage of 3.31% and 3.34% respectively, As for the (strong) class, it was its greatest sovereignty in all years, as it was noted that it is gradually increasing starting from 1997 to 2023, where it occupied areas estimated to 99.63%, 99.67% and 96.69%, But in the year 2023, a very small change was observed, as it became 96.65%, As for the last class (very strong), it did not appear in any of the years mentioned earlier. The (medium) class has increased in 2023 compared to 1997, while the (strong) class was the opposite of the aforementioned class, as it decreased in 2023 compared to previous years, and this confirms the formation of a thin crust in all study areas and an increase in its intensity over time.

Table 10: Crust Index (CI) for the years 1997, 2014, 2020, 2023.

Description	1997		2014		2020		2023	
	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	**Ratio**
Very Weak	-----	-----	-----	-----	-----	-----	-----	**-----**
Weak	-----	----	----	----	0.27	0	0.27	**0**
Moderate	440.39	1.79	387.01	0.33	3899.3	3.31	3936.47	**3.34**
Strong	117243.49	99.63	117296.95	99.67	113784.39	96.69	113747.22	**96.65**
Very strong	-----	----	-----	----	----	---	----	**----**
Total	117683.96	100%	117683.96	100%	117683.96	100%	117683.96	**100%**

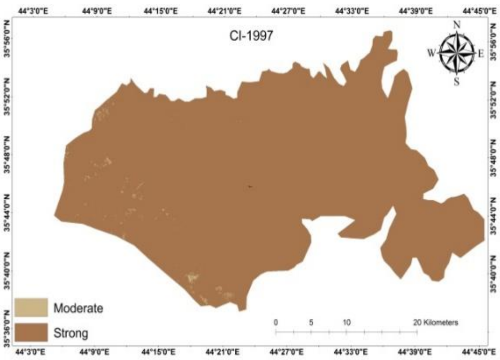

Fig. 10: Crust Index (CI) of 1997.

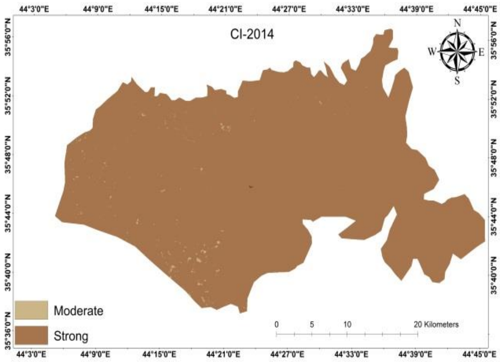

Fig. 11: Crust Index (CI)of 2014.

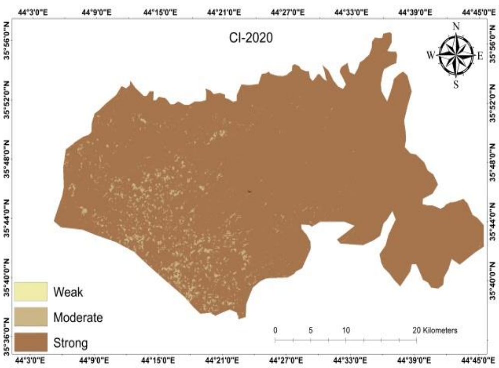

Fig. 12; Crust Index (CI) of 2020.

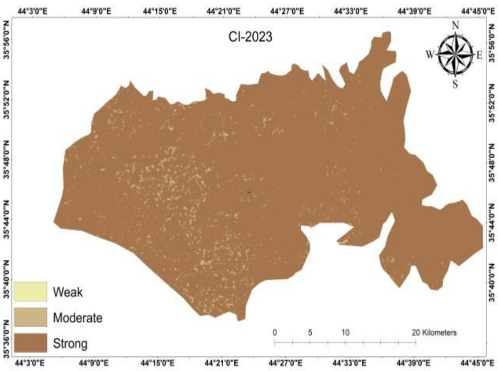

Fig. 13: Crust Index (CI) of 2023.

Bare Soil Index (BSI): This indicator is used in the possibility of distinguishing between barren and vegetation-free soil and vegetation cover soil, where the blue, red, near infrared and short infrared bands directed to capture differences in the soil is used. (Table 5) and figures 14, 15, 16, 17. The first class s (no degradation), its area in 1997 occupied 28.29%, then there was a significant decrease in the area of this class in 2014, where it reached 1.95%, but in the year 2020 and 2023, the percentages varied between increase and decrease by a small percentage, reaching 3.12% and 3.7% for the two years, respectively, As for the second class (little degradation), a gradual increase was observed for 1997, 2014, 2020 and 2023, as it occupied areas of 71.54%, 84.44%, 91.4% and 96.3% respectively as well. As for the third class (medium degradation), its percentage was variable, as it was in 1997 it had reached 0.17%, but in 2014, there was a remarkable change, as its percentage became 13.61% and, then this percentage decreased in 2020 until it reached 5.48%, as for the classes (high degradation) and (very high degradation), they did not appear in all the studied years.

It is noted from the above that the (no degradation) class has changed its area remarkably, as it decreased in 2023 compared to 1997, while the class (little degradation) increased its percentage in 2023 compared to previous years, while the class (medium degradation) increased compared to 1997, which shows that there were cases of soil degradation to varying degrees during the study years

Table 11: Bare Soil Index (BSI) for the years 1997, 2014, 2020, 2023.

Description	**1997**		**2014**		**2020**		**2023**	
	Area of class(ha)	**Ratio**	**Area of class(ha)**	**Ratio**	**Area of class(ha)**	**Ratio**	**Area of class(ha)**	**Ratio**
Non-deg.	3375.48	28.29	2294.99	1.95	3674.11	3.12	4356.07	3.7
Light-Deg.	84994.95	71.54	99369.65	84.44	107557.42	91.4	113327.89	96.3
Moderate Deg.	29311.55	0.17	16019.23	13.61	6450.26	5.48	-----	-----
High Deg.	1.89	0	-----	-----	2.16	0	-----	-----
Very high Deg.	-----	-----	-----	-----	-----	-----	-----	-----
Total	117683.96	100%	117683.96	100%	117683.96	100%	117683.96	100%

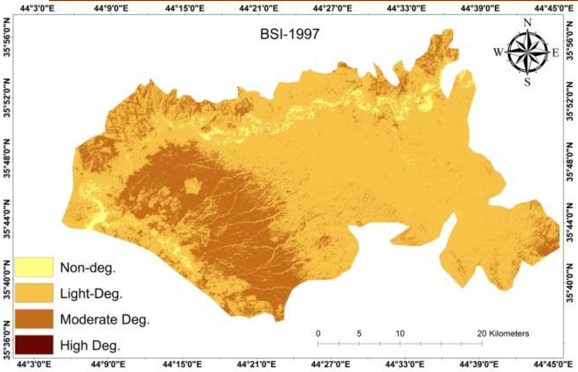

Fig. 14: Bare Soil Index (BSI) of 1997.

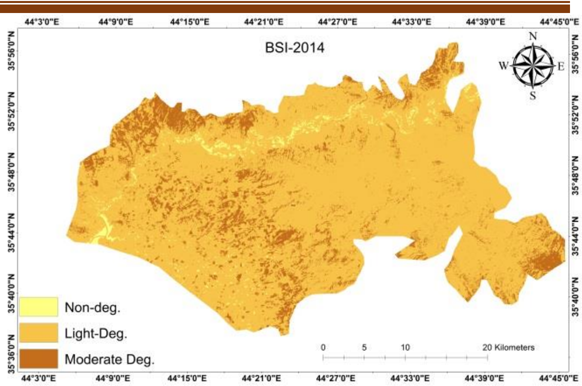

Fig .15: Bare Soil Index (BSI) of 2014.

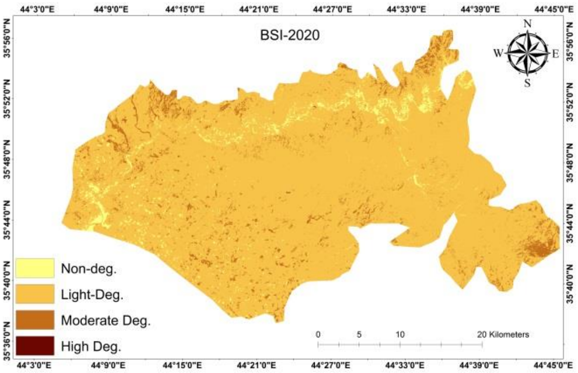

Fig. 16: Bare Soil Index (BSI) of 2020.

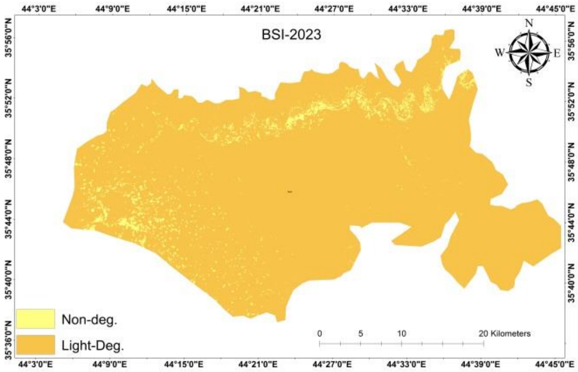

Fig. 17: Bare Soil Index (BSI) of 2023.

Normalized Difference Moisture Index (NDMI): Its shown in table 11 and shapes 18, 19, 20, 21 that the proportions of the first class (dry lands) were somewhat varied, as in 1997 it covered an area of 93.83% after which a small increase of the same class was observed in 2014, where its area to 93.86% , then it began to increase gradually for the rest of the years, As for the second class (low moisture lands) in 1997, its area was 6.17%, while in 2014, it maintained that area 6.14%, then it increased in 2020, as it covered 11748.48 hectares by 9.98%, as for the year 2023, it decreased by a small percentage 9.5% of the total areas.

It is noted from the above that the class (dry lands) in the year 2023 has decreased compared to 1997, while for the second class (low moistrure lands), a noticeable increase was observed in the year 2023 compared to 1997, unlike the first class.

Table 12: Normalized Difference Moisture Index (NDMI) for the years 1997, 2014, 2020, 2023.

Description	1997		2014		2020		2023	
	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio
Dry lands	110426.91	93.83	110462.2	93.86	105448.3	89.6	105591.13	89.72
Low-moistrure lands	7257.05	6.17	7221.68	6.14	11748.48	9.98	11289.01	9.59
Medium-moistrure lands	-----	-----	-----	-----	487.19	0.41	803.82	0.68
High--moistrure lands	-----	-----	-----	-----	-----	-----	-----	-----
Total	117683.96	100%	117683.96	100%	117683.96	100%	117683.96	100%

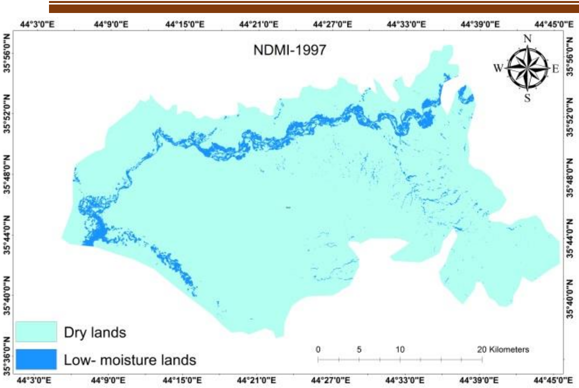

Fig 18: Normalized Difference Moisture Index (NDMI) of 1997.

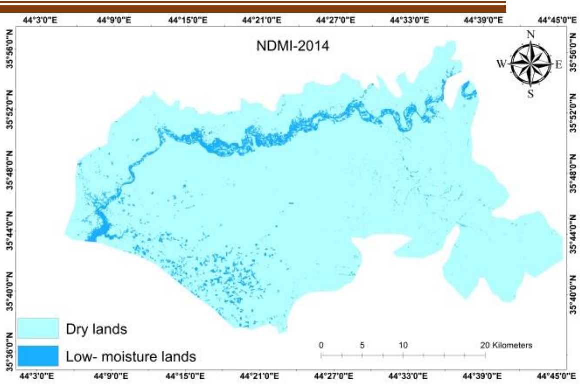

Fig 19: Normalized Difference Moisture Index (NDMI) of 2014.

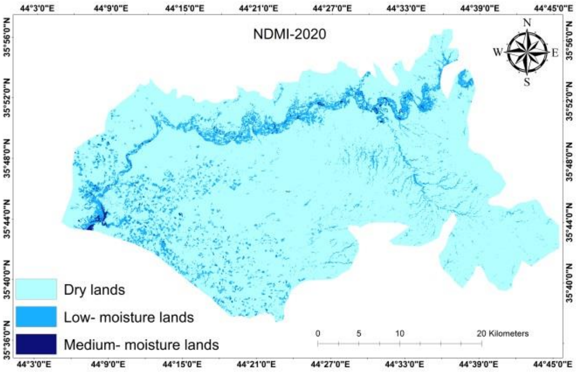

Fig .20: Normalized Difference Moisture Index (NDMI) of 2020.

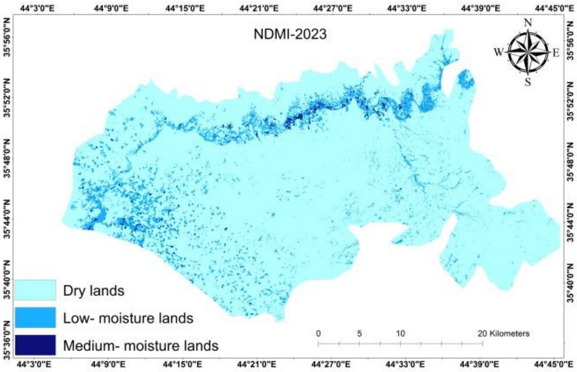

Fig .21: Normalized Difference Moisture Index (NDMI) of 2023.

Normalize Difference Salinity index (NDSI): One of the reasons for soil degradation in arid and semi-arid areas is salinity, and as a result of progress and technological development, remote sensing techniques have succeeded in monitoring the phenomenon of salinization, as infrared spectrum are the best in monitoring soil salinity and at the level of discrimination between saline and non-saline soils, as saline soils have low spectral reflectivity values compared to non-saline soils for the visible part and near and medium infrared. (Table 13) and figures 22, 23, 24, 25. The first class (low salinity) occupied the highest percentage of an area in 1997, where it was 100%, then it was noted that there was a gradual and small decrease for the same class in 2014 and 2020 with an area of 99.51% and 99.44% respectively, then this percentage took an increase in 2023, where it occupied an area of 99.6%, As for the second class (Moderat salinity), its percentage in 2014 was 0.49%, then this percentage increased to 0.56% in 2020 and then decreased until it reached 0.40% in 2023.As for the third and last class (high salinity), it was non-existent in all the years mentioned above. It is noted from the mentioned that The soil of the study area was mostly non-saline and the reason for its low salinity may be due to the nature of the original material poor in salt ions and the depth of the ground water ,the class (medium salinity) has appeared in the lands located on the banks of the lower Zab River and is believed to be caused by the pollution of river water with some pollutants that encouraged the increase in salinity.

Table 13: Normalize Difference Salinity index (NDSI) for the years 1997, 2014, 2020, 2023.

Description	1997		2014		2020		2023	
	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	Ratio	Area of class(ha)	**Ratio**
Low salinity	117683.87	100	117110.46	99.51	117026.4	99.44	117216.58	**99.6**
Moderate salinity	-----	-----	573.5	0.49	657.56	0.56	467.3	**0.40**
High salinity	-----	-----	-----	-----	-----	-----	-----	**-----**
Total	117683.96	100%	117683.96	100%	117683.96	100%	117683.96	**100%**

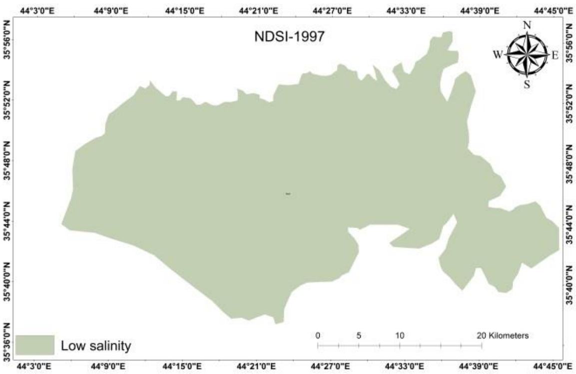

Fig. 22: Normalize Difference Salinity index (NDSI) of 1997.

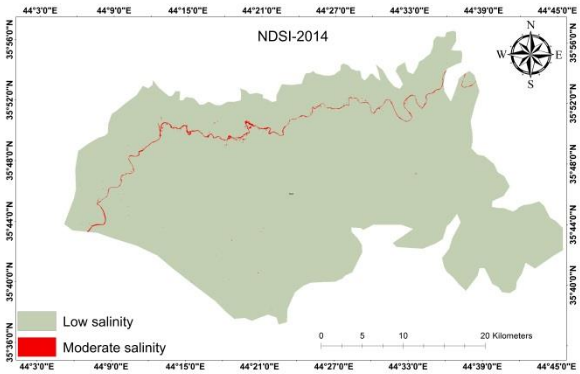

Fig .23: Normalize Difference Salinity index (NDSI) of 2014.

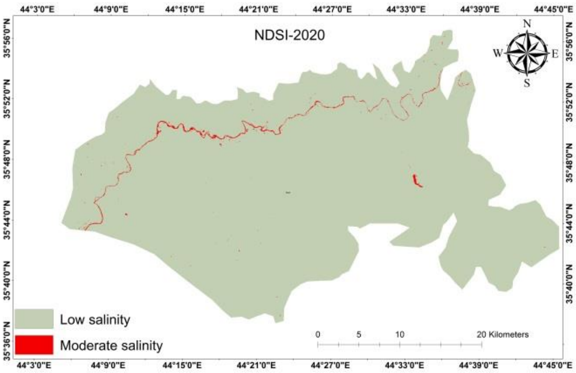

Fig. 24: Normalize Difference Salinity index (NDSI) of 2020.

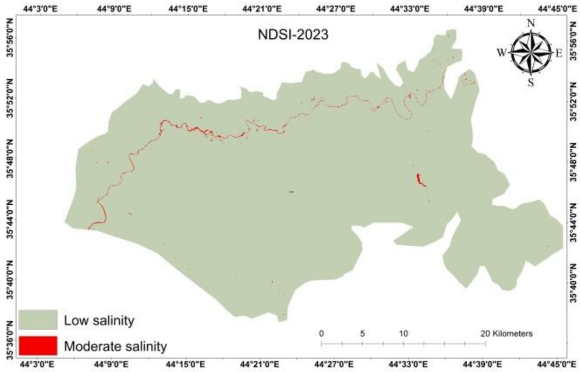

Fig 25: Normalize Difference Salinity index (NDSI) of 2023.

Conclusions

The analysis of spectral indicators of space data proved its high efficiency in detecting soil degradation and low density of vegetation cover for shwan and Altun Kopri regions, the results of the SAVI indicator showed a similarity with the NDVI indicator**,** where its results were similar, the BSI indicator revealed the existence of beginnings of the degradation of the study area, the results of the CI indicator showed the presence of a strong crust, which made the study area more vulnerable to the influence of climate factors, whether rain or wind, and this is a clear evidence of soil degradation.

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No Supplementary Materials.

Author Contributions:

Author 1; methodology, writing—original draft preparation, Author 1 and Author 2 writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement:

No Informed Consent Statement.

Data Availability Statement:

The study was based on primary data collected from a random sample of eggplant farmers in Anbar Governorate.

Conflicts of Interest:

The authors declare no conflict of interest.

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