ENVIRONMENT SENSITIVITY MAPS OF LAND DEGRADATION AND DESRTIFICATION USING MEDULAS MODEL AND REMOTE SENSING IN SHIRQAT CITY/IRAQ

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ABSTRACT

This research of aims to study environment sensitivity of desertification and land degradation using MEDULAS project and remote sensing in AL-Shirqat City/Salahadin/Iraq. A 10 soil pedons were chosen from study area depending on difference in soil preperties, landuse and causes of desertification and degradation as (Salinity, Erosion, Gypsum and vegetation cover). Soil profile description, soil samples and GPS were conducted. The physical (texture) and chemical ($CaCO_3$, $CaSO_4.2H_2O$, O.M, EC and pH) properties were determined. The Soil were classified as Torrifluvents in the (P_1, P_2, P_3), Torripsamments in the (P_5 and P_7), Calcigypsids in the (P_6, P_8 and P_{10}) and Calcids in the P_4. The landsat 8 image at 20sep. 2019 and 19 sep. 2013 were aquired in the spectral indices calculate and spatial maps by using ERDAS 15 and GIS 10.2. The result show contrast in soil propreties as sand, clay, soil gypsum, CaCO3, OM and EC that reflect on Soil Quality Index (SQI) which were (60)% poor quality and (40)% moderate quality degradation. While (19.10) % that moderate quality and 80.90% that poor quality for Vegetation Quality Index. The results show that 0.1% of the study area is classified as C1; 25.35% as C2; 74.55% of the areas as C3. The spectral indices as LAI, SI5, OSAVI were approporiate for monitor of desertification and degradation in study area. Add, spatial change in the spectral indices as NDVI and LAI. The results shown that MEDALUS model is a important model in the areas disposed to desertification and degradation.

Key word: Remote sensing, MEDULAS project, NDVI, Desertification, LAI.

خرائط الحساسية البيئية للتصحر وتدهور الاراضي باستخدام انموذج MEDULAS والتحسس النائي في قضاء الشرقاط/ صلاح الدين/العراق.

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المستخلص:

يهدف هذا البحث إلى دراسة الحساسية البيئية للتصحر وتدهور الأراضي باستخدام مشروع MEDULAS والتحسس النائي في قضاء الشرقاط / صلاح الدين / العراق. تم اختيار 10 بدونات تربة من منطقة الدراسة تبعا للاختلاف في خواص التربة واستخدامات الأرض وأسباب التصحر والتدهور مثل (الملوحة، التعرية، الجبس، الغطاء النباتي). تم إجراء الوصف المورفولوجي واستحصال نماذج التربة وتثبيت المواقع باستخدام نظام تحديد المواقع العالمي. تم تقدير الصفات الفيزيائية (نسجة التربة) والكيميائية ($CaCO_3$ ، $CaSO_4.2H_2O$، O.M، EC، pH). تم تصنيف التربة على أنها Torrifluvents في المواقع P_1 و P_2 و P_3 و Torripsammentsفي المواقع P_5 و P_7 و Calcigypsids في المواقع P6 و P8 و P10 و Calcids في P4 تم الحصول على صورة لاندسات 8 في 20 ايلول 2019 و 19 ايلول 2013 في حساب المؤشرات الطيفية والخرائط المكانية باستخدام ERDAS 15 و GIS 10.2. أظهرت النتائج تباينًا في خصائص التربة مثل الرمل والطين والجبس وكاربونات الكالسيوم و المادة العضوية والايصالية الكهربائية التي تنعكس على مؤشر نوعية التربة والذي شمل صنفين وهما الصنف الفقير poor ومساحته (60) ٪ و الصنف المعتدل النوعية والذي شكل (40) ٪من مساحة منطقة الدراسة. اما مؤشر نوعية الغطاء النباتي فكانت (19.10) ٪ متوسط النوعية و 80.90٪ فقير النوعية. أظهرت النتائج أن 0.1٪ من مساحة الدراسة كانت تحت الصنف C1؛ و 25.35٪ تحت الصنف C2 و 74.55٪ من المناطق صنفت C3 .. كانت المؤشرات الطيفية LAIو SI5 و OSAVI مناسبة لرصد التصحر والتدهور في منطقة الدراسة وهناك تغاير مكاني في المؤشرات الطيفية للادلة NDVIوLAI . لذا فان نموذج MEDALUS هو نموذج مهم في المناطق المعرضة للتصحر والتدهور.

الكلمات المفتاحية: التحسس النائي، نموذج MEDULAS، التصحر وتدهور الأراضي، دليل LAI، NDVI.

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INTRODUCTION

Desertification is important pheno-mena in arid and semi-arid environments. In the context of the EC MEDALUS (Mediterranean Desertification and Land Use), the focus here is primarily on European Mediterranean environments where physical loss of soil by wind erosion, water erosion, salinization, overgrazing and loss of nutrient status in soil. Wind erosion, salinization and drought are more problems affected in arid and semi arid. Land degradation is among the most serious environmental problems at global, regional, and local scales (13) which leads to a depletion of soil fertility and productivty loss. One third of the world's drylands have already lost more than 25% of their productive capability. Each year the world loses 10 million ha of land for desertification and approximate 30% of the Earth's surface area is at risk of desertification affecting one billion people worldwide almost two billion people are located over the dryland (22). The more studies are depend on medulas project in evaluatation of soil degradation, land degradation and desertification at the large scales (2,6,13,15,16,19,20,27). Assessment of the sensitivity of the soil in the rural area of Čukarica municipality to the processes of degradation is considered.The results ob- tained show that 41.54% of the study area is classified as critical; 22.34% of the surface as fragile; 8.47% of the areas are potentially endangered and 9.58% not threatened to degradation processes (18). Kadović et al., 2016 was used MEDALUS for detection and evaluation of land degradation in Deliblato sands. Remote sensing technique has great value in monitoring desertification and land degradation. use of remote sensing (RS) and Geographic Information System (GIS) for Change Detecting Spatial and Temporal Variability of Soil Salinity in Al-Latifiya Project, Iraq (9). depending more than satellite images and spectral indices as (NDVI, VI, TNDVI, SAVI, MSAVI, IPVI) in northern iraq and the results ensured on the possibility of using of technique remote sensing as a device active and accurate in estimated size of area of degradation and desertification which extended to rangelands especially in the last few years (3). The determine soil deterioration degree based on NDVI to that were in the range of moderate to severe deterioration. Some physical deterioration as represented by soil texture, coarse sand texture, and chemical deterioration due to high level of salinity on some locations. The high level of gypsum and biological deterioration indicated by low level of organics and missed plant cover (26). The present study aimed to assess the environmental sensitivity of desertification and land degradation in the Shirqat district in Salah Al-Din Governorate / Iraq using the Medulas model and remote sensing.

MATERIALS AND METHOD

Study area. The Sharqat district is located between longitudes (42 ° 52'31.77 "E and 42 ° 58'43.756" E) and two latitudes (35 ° 39'41.352 "N and 35 ° 15'27.392" N) in the northern part of Salah Al-Din Governorate / Iraq. Its area is approximately (1577) km^2 and had the population 220000. An study area of 214.99 km^2 was chosen for the study, based on the variation in soil properties according to the physiographic units (Alluvial soils, mountain and Al- desert Jazeera soils but according to Soil Survey Staff (2006) are classify Torrifluvents (P_1, P_2, P_3), Torripsamments(P_5, P_7), Calcigypsids(P_6, P_{10}) and calcids(P_8, P_9). It suffers from several causes of desertification phnomena as (wind erosion, water erosion, salinization, sand movement, overgrazing and gypsum content). As well as, agricultural exploitation, the quality of irrigation water and mismanagement. Average annually rainfall ranges between 150 - 250 mm, average maximum temperatures range between 13.5 - 42.50 C°, and minimum temperatures range between 3.3 - 26.2 C°. the mean temperature is increase in July and August, and lowest in January and February. The several locations were selected which involve (10) ten pedon and its morphological description was done according to the (Soil Survey Staff 2006). In addition, the coordinates of the study location were determined using GPS. Soil samples were taken and transferred for laboratory, and the soil physical (Soil Texture) and chemical properties (OM, $CaCO_3$, $CaSO_4.2H_2O$) were determined in the Department of Soil Science and Water Resources at the Tikrit University. Slope was analyzed using the DEM Digital Elevation Model and ArcGIS Ver 10.2 software and ranged between 0-19.5% as (Fig.1).

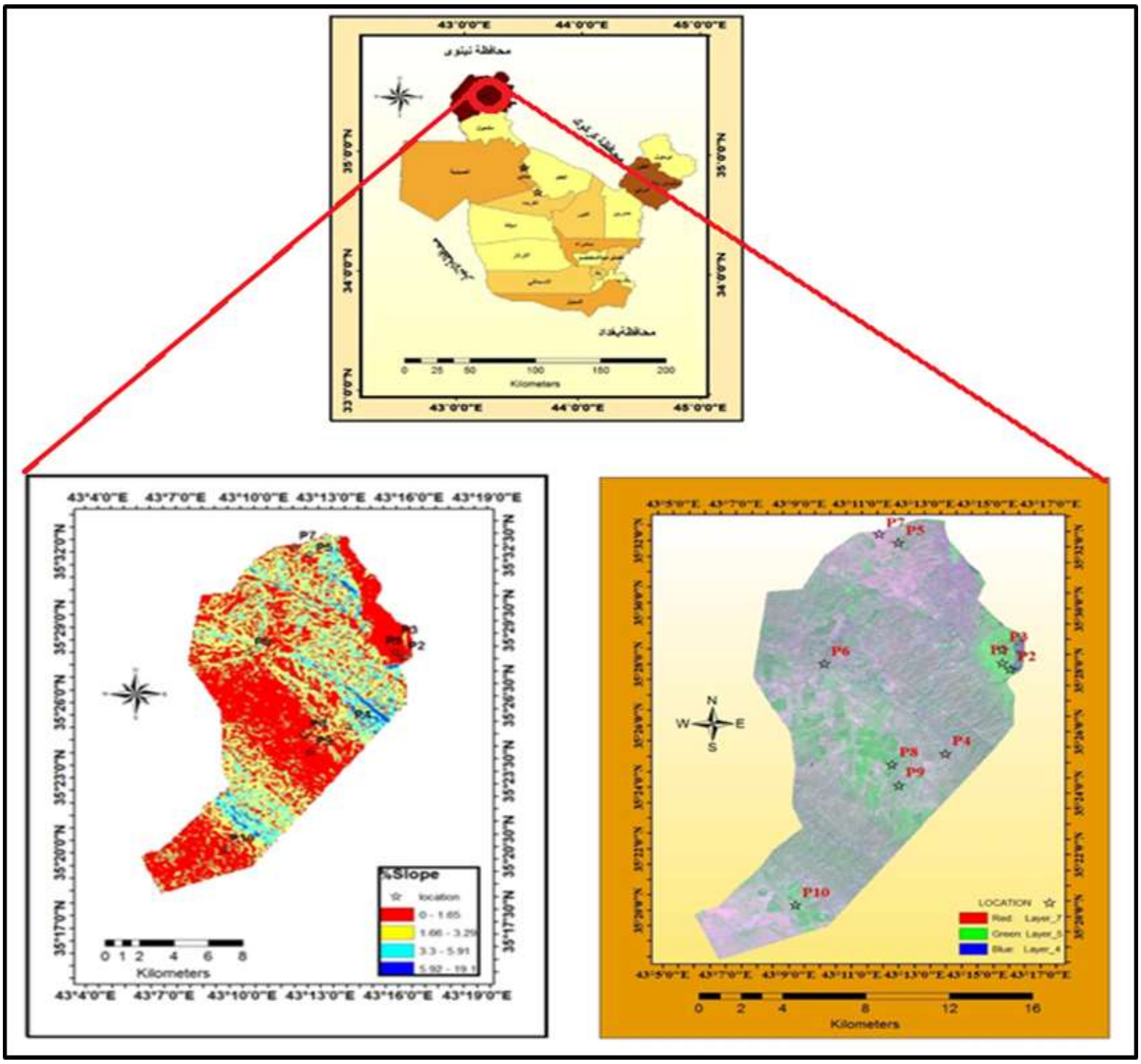

Fig. 1. Map of Study area and DEM

Medalus project. The environment sens-itivity to land degradation and deserti-fication are defined using the Environmental Sensitive Area Index (ESAI) according to the model data (Kosmas et al., 1999; Kosmas et. al. 2014, Kadović, 2016; Lamqadem, 2018; Zambon, 2017; Mostafa, 2020). The Soil Quality Index (SQI), Climate Quality Index (CQI), Vegatation Quality Index (VQI) were used. Spatial distribution maps of Soil quality indices, vegetation quality indices and environment sensitivity were conducted using ArcGIS Ver 10.2. The areas of environmental sensitivity classes of land degradation and desertification were calculated using the inverse distance method.

Soil quality index

For the soil quality estimation one topographic (slope) and seven soil properties (soil texture, EC, organic matter, calcium carbonate, soil gypsum, rock fragment of surface layer and soil Albedo) were selected. Soil quality index (SQI) was calculated as following equation:

Soil Quality Index-SQI=$(X1 \times X2 \ \ldots\ldots Xn)^{1/8}$ (1) then X= Soil properties as mentioned in table (1) respectively.

Table 1. Classes, description, and assigned weighting indices for the parameters.

Parameter	Class	Description	Susceptibility class	Weight index
Soil Texture	1	Good	L, SCL, SL, LS, CL	1
	2	Moderate	SC, SiL SiCL	1.2
	3	Poor	Si, C, SiC	1.6
	4	Very Poor	S	2
OM %	1	Very high	<3	1
	2	high	3 -2	1.2
	3	moderate	2-1	1.5
	4	poor	1-0.5	1.7
	5	Very poor	<0.5	2
EC dSm^{-1} Kossmas, 2014	1	Free	0-2	1
	2	Slightly	2-4	1.2
	3	moderate	4-8	1.5
	4	Sever	8-15	1.8
	5	Very sever	>15	2
Slope % (DEM), ArcGIS	1	Level	<6%	1
	2	Gentle	6-18	1.2
	3	steep	18-35	1.5
	4	Very steep	>35%	2
$CaCO_3$ %	1	Very low	<3%	1
	2	Low	3-10	1.2
	3	moderate	10-25	1.5
	4	High	25-50	1.8
	5	Very high	>50%	2
ROCK FRAGMENTS	1	Very stony	>60	1
	2	Stony	20-60	1.3
	3	Bare to slightly	<20	2
CaSO4. $2H_2O$	1	low	<2	1
	2	moderate	2-10	1.5
	3	high	10-25	1.8
	4	Very high	>25	2
Soil Brightness Lamqadem, 2018	1	Dark	0-0.20	1
	2	Moderate dark	02-0.25	1.5
	3	Lighte	0.25-1	2

Vegetation quality Index

The main factors affecting vegetation status in the area are erosion (wind and water), plant cover (necessary in reducing wind affect and fertility layer loss) and drought condition. Erosion protection, drought resistance and vegetation cover cretiria. Different vegetation classes and scored were derived using the equation formula as following (table 2):

$$VQI = (VgC\% \times Erosion \times Drought)^{1/3} \quad (2)$$

Vegetation Cover -VgC%

The equation mentioned by (Puredorj, 1998) was used to calculate the percentage of vegetation cover in the study area which range 0 -100%.Vegetation green Cover (VgC %) was calculated using ArcGIS Ver. 10.2. The ERDAS program Ver. 15 was used to calculate the NDVI, which expresses the vegetation density and its values between -1,+1, as the closer to 1 the higher the plant density. The index represents the difference between the near infrared (B5), in which the plant has a high reflectance, and the red wavelength in which the plant has a strong absorption and represents the chlorophyll absorption area as following.

$$VgC\% = 0.65\times (-4.337-(3.733\times NDVI) +161.968\times (NDVI)^{0.5} \quad (3)$$

Where, NDVI-Normalized Difference Vegetation Index.

$$NDVI= (NIR-R)/(NIR+R) \quad (4)$$

Where, NIR-Near Infrared (B5 at the OLI, landsat 8 according to aquire R-RED (B4 at the OLI, landsat 8).

Erosion. The index for soil erodibility is express the product of multiplying the wind erosion, water erosion, and soil crust index

$$E = EF\times WEF\times SCF \quad (5)$$

Where, EF Wind erodible Fraction, WEF-Water erodibility and SCF-Soil Crust Factor as fallowing:

Erodible Fraction-EF. The wind erosion hazard is severe in regions of low precipitation and high temperatures and wind velocity where soil is bare. The risks of wind erosion are exacerbated by wind blowing across long, bare fields on soils of single-grain or weak structure and having a loamy texture (Lal et. al., 2004). It depends in its calculation on soil characteristics that decrease soil erodibility to wind erosion as (organic matter and clay) or increase soil erodibility to wind erosion as (sand content and structurless) as following equation (Fryrear et al., 2000). According to Dregne (1983) criteria were classified as Sligh-tly, Moderate, Sever, and very sever degradation.

EF=29.09 + (0.31× sand%+ 0.17×silt% + 0.338×sand/clay% -4.66×OM%-0.95× $CaCO_3$%)/100.. (6)

Water erodibility Index –WEF: Sandy soils have larger macropores and absorb water more rapidly than clayey soils. Under low intensity rains, sandy soils produce less runoff than clayey soils. Most of the rain falling on clayey soils is into runoff due to the small micropores, which decrease water infiltration. (Blanco and Lal, 2008). It depends in its calculation on Soil texture as following

WEF= (0.37× (Silt +vfsand %)×(0.28 ×Clay %)+14.87)/100 (7)

Surface Crust Index-SCF: Soil crust index is inversely proportional to the clay content. The higher the clay content, the lower the soil crust rate and in turn, the lower the degree of protection of the soil surface from the effect of erosion. Crusts are more thick, firm, and strong to erosion than uncrusted soils. The rate at which crusts are degraded depends on the degree of the abrasive forces of the wind.). It depends in its calculation on soil clay content as following:

SCF=1/ (1+0.0049× $(CLAY)^2$ (8)

Lang Factor: Richard Lang established a climate classification based on a ratio factor between precipitation and temperature. The Lang climate factor (L) is calculate using the following formula:

L =P/T (9)

Where, P: Annual total precipitation (mm), T: Annual temprature mean (C˚).

Table 2. Classes, description, and assigned weighting indices for the parameters

Parameter	Class	Description	Susceptibility	Weight
Erosion	**1**	**Low**	**<0.039**	**1**
Anonymous,1995	**2**	**Moderate**	**0.039-0.053**	**1.3**
	3	**High**	**0.053-0.066**	**1.8**
	4	**Very High**	**>0.066**	**2**
VgC%	**1**	**Very dense**	**100-81**	**1**
	2	**dense**	**80-61**	**1.2**
	3	**moderate**	**60 -41**	**1.5**
	4	**poor**	**40- 21**	**1.8**
	5	**Very poor**	**20-0**	**2**
Aridity Index	**1**	**Humid**	**>160**	**1**
	2	**Semi Humid**	**160-40**	**1.5**
	3	**dry**	**40-10**	**1.8**
	4	**Very dry**	**10-0**	**2**

Climate quality. The data were obtained from Iraq Meteorological through period 1980-2019. Climate quality is assessed by using parameters that influence water availability to the plants such as amount of rainfall, air temperature and aridity, as well as any climate threats as frost which might inhibit or even prohibit plant growth. Annual precipitation is classified in three classes considering the annual precipitation of 280 mm as a critical value for erosion and plant. As result of the fact that the study area is under the influence of the same climatic conditions (dry and semi-arid and there is no variation in temperature and total rainfall, so the climate factor is the same for all the selected locations (1.67). Classes and assigned weighting indices for climate quality assessment in (table 3). Climate quality index (CQI) was calculated according to formula:

Climate Quality Idex = $(Rainfall × BGI)^{1/2}$ (11) Where, CQI=1.67

Table 3. Classes, description, and assigned weighting indices for CQI

Parameter	Class	Description	Susceptibility class	Weight index
Rainfall (mm)	2	Humid	>650	1
	3	Dry-humid	650-280	1.5
	4	Dry	<280	2
BG Index	1	Very humid	<50	1
	2	Humid	50-75	1.1
	3	Humid -Dry	75-100	1.2
	4	Semi dry	100-125	1.4
	5	Dry	125-150	1.8
	6	Very dry	>150	2

ESAI (Environmentally Sensitive Areas Index). Environment Sensitivity Area Index to desertification and land degradation using multiply (soil quality, climate quality and vegetation quality). Classifying the area into four main classes and eight classes as mentioned in (table 4).

ESAI = (SQI *CQI *VQI)$^{1/3}$ (12)

Where, SQI: Soil Quality Index, CQI: Climate Quality Index, and VQI:Vegetation Quality Index.

Table 4. ESA, Soil, Vegetation, Climate Quality index

Quality	SOI	VOI	CQI
high	<1.13	<1.13	1.15
moderate	1.13-1.45	1.13-1.45	1.15-1.81
Low	>1.45	>1.45	>1.81
ESA index			
Degree	Class	subclass	Weight
1	N	-	<1.17
2	P	-	1.22-1.17
3	F	F1	1.26-1.22
		F2	1.32-1.26
		F3	1.37-1.32
4	C	C1	1.41-1.37
		C2	1.53-1.41
		C3	1.53 <

N: Non affected; P: Potential; F: Fragile; C: Critical

Spectral Indices

The satellite image at 26 Sep 2019 and 20 Sep 2013 were used. The ERDAS imagen Ver. 15 in the processing, interpretation and change detection was used and in indices calculate as follows**:**

Leaf Area Index (LAI): The Leaf area index (LAI) is a dimensionless measure of the one-sided area of canopy foliage (m^2) per unit ground surface area (m^2) (Scurlock and Hicke, 2003; Garrigues et al., 2008). Leaf area index (LAI) was calculated using spectral reflectance and SAVI as follows:=

$$LAI = \frac{\ln[\frac{0.69 - SAVI}{0.59}]}{0.91}$$

Soil Adjective Vegetation Index (SAVI): It indicates the effect of the interaction between soil reflectivity and vegetation cover as in the following equations**.**

$$SAVI = \frac{(1+L)(B5-B4)}{(L+(B5+B4))} Where\ L = 0.5$$

$$OSAVI = \frac{(B5-B4)}{((B5+B4+0.16)}$$

$$GOSAVI = \frac{(B5-B3)}{((B5+B3+0.16)}$$

Soil Salinity Index (SI5)

$$SI5 = \frac{BLUE}{RED} \quad (Abbas\ and\ Khan, 2007)$$

$$where\ the\ B5 = Near\ Infrared\ band; B4 = Red\ Band\ and\ B3 = Green\ band\ with\ landsat8$$

RESULTS AND DISCUSSION

Soil Qaulity Index-SQI

The spatial variation in soil characteristics reflects its sensitivity to desertification and land degradation processes in arid and semi-arid regions. Soil characteristics results indicate that P_5 and P_7 had a high sand content, reaching more than 70%. While P_1, P_2 and P_8 were suffering from salinity, it reached more than 15 dSm^{-1} in the surface layer of soil. The results indicate that the locations P_6, P_8 and P_{10} suffer from high gypsum content in the soil, reaching 25.00, 11.05 and 9.95%, respectively. The results show that soil quality index ranged between (1.23 and 1.52) as it reached the lowest value at P_3, which is located within alluvial plain, for plant growth and the highest organic matter content compared to other sites. The highest value is for the fifth pedon, P_5 and P_7, which have a very fragile structure and loose as a result of the sandy texture, sparse vegetation cover and low organic matter. The indices within the soils of moderate and poor quality, as the result is an interrelated result of many physical, chemical and morphological characteristics. Figures (2) indicate the spatial distribution of the soil quality index, as the percentage of poor soil quality index reached 67%, which includes P5, P6, P7, P8, P10 and other sites fall within the moderate quality, which constitutes 33% of area study.

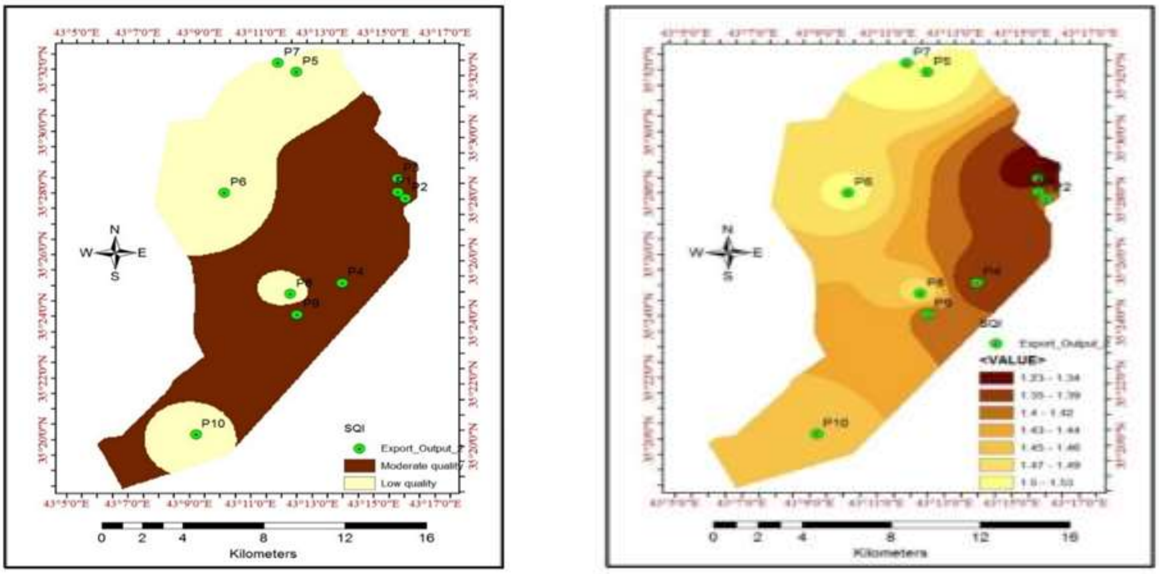

Fig. 2. Soil Quality Index maps

Vegetation Quality Index-VQI

Erosion Index: Soil erosion is one of the most important criteria in evaluating desertification and land degradation, due to detachment soil particles, reduce its fertility, and effect on agricultural crops. The results indicate the variation in the wind soil erodibility, which is related to its calculation on important soil characteristics that have the ability to aggregate soil particles more than 1 mm that increase its resistance. Wind soil erodibility was increased at P_5 and P_7 (0.75 and 0.62), while the decrease in the alluvial plain locations at P_1, P_2, and P_3, which have the good structure, higher organic matter and lower content of sand. According to Dregne (1983) criteria that refer to the effect of wind erosion on soil degradation which classify to Slightly, Moderate, severe and very severe degradation was its area 134.01, 54.78, 18.04 and 8.16 km^2 and as percent(62.33, 25.48, 8.39 and 3.80)%. The P_7 and P_5 locations, which is suffer from very sever degradation, while most location was at moderate and slightly. The results refer to that locations with high sand content, weak structure and dispersed vegetation cover have higher erodibility to wind erosion. Sandy soils are less cohesive than clayey soils and thus aggregates with high sand content are more easily detached. The results of Figure (3) showed water soil erodibilty ranged between 0.23-0.40 for each of the P_2 and P_5, respectively. May be relate to the content soils from cementing materials between soil particles, which leads to the formation of large aggregates and a cohesive structure. The soil organic matter is one of the key factors that control the aggregates stability. It physically, chemically, and biologically cement primary particles into aggregates. The soil ability to erosion depends on its structure. Soils with weak soil structure are more detachable. According to figures (3) that indicate the water soil erodibilty, that the location soils of the alluvial plain P_1, P_2, and P_3 are the most water erosion range 0.35 - 0.39. According to Dregne cretiria, they occurred within lands of degradation The area was severe degradation formed an area of 80.63km^2 and a percentage of 37.50%, while the sites P_5 and P_7 were the least exposed to water erosion because water infiltration is positively correlated with an increase in coarse soil particles and decrease in fine particles (25). Sandy soils have larger macropores and absorb water more rapidly than clayey soils. Macropores conduct water more rapidly than micropores.

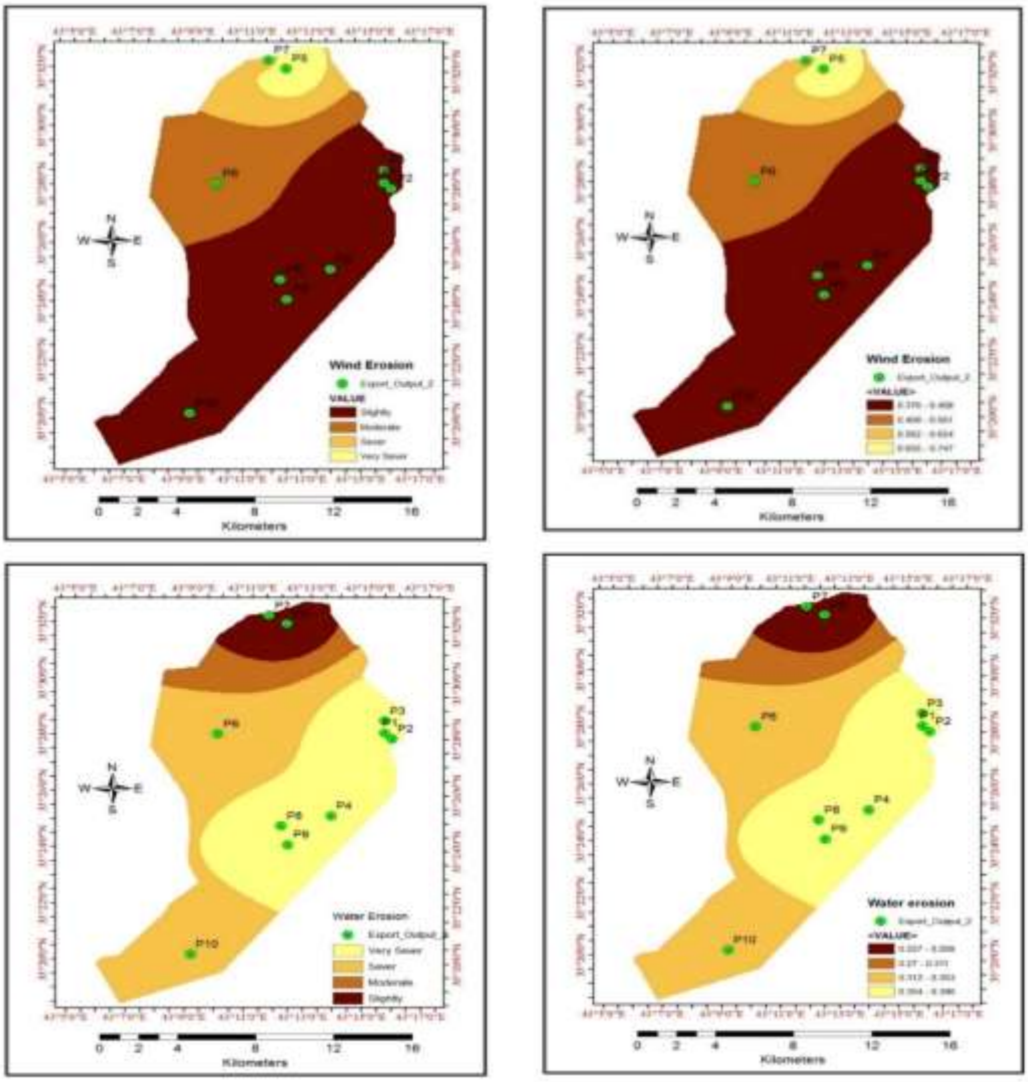

Fig.3 A map of wind and water soil erodibility

The results of Figure (4) that the SCF index was relatively high in the sites P5, P6, P7 reached 0.984, 0.984 and 0.799 because weak structure, high gypsum and sand content. According to Dregne (1983) that P_5 and P_7 is within area of Very sever degradation formed 13.81 km2 (6.42) %. While the area of moderate degradation and slightly degradation was 39.66 km^2 and 39.66 km^2(18.45 and 54.78)%. Thus, the crust is one of the indicators that protect the soil surface from the intensity of winds and raindrops on the occurrence of erosion and its degradation, and this crust depends on the content of the clay.

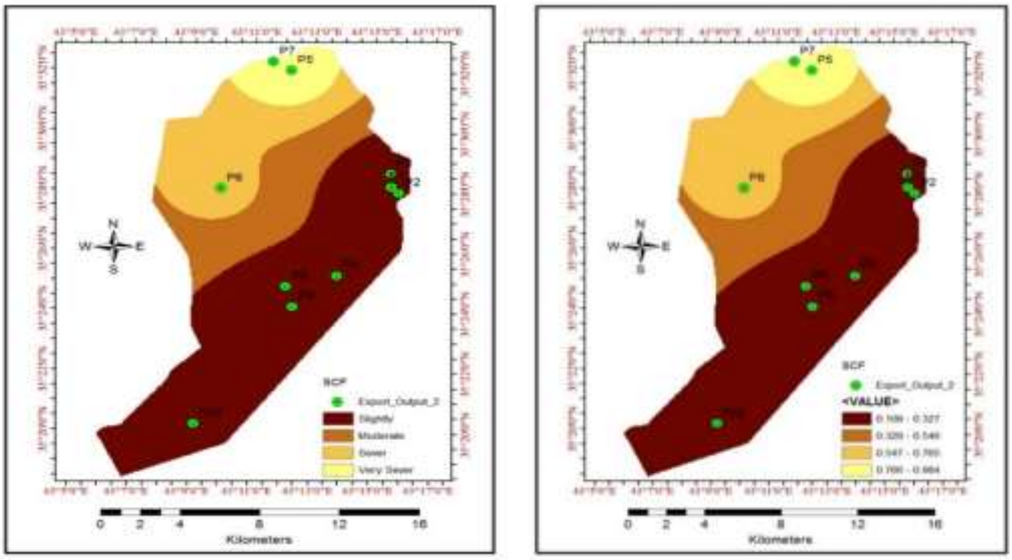

Fig.4. A map of Soil Crust Factor

Figure 5 indicates soil erodibilty ranged between 0.016 - 0.167 at P_1 and P_5 respectively, and it was found that the sites P5, P6 and P7 had the highest erosion potential (> 0.06) according to Medulas model and it was within the 4 class (very high) which formed an area of 24.16 km^2(11.24)%. In contrast, P_3, P_4, P_8, and P_{10} were within the moderate erod-ibility, ranging 0.039-0.053, which formed an area of 116.44 km^2 (54.16%). According to Dregne (1983) cretiria, the P_5, P_6 and P_7 within very severe degradation. As for the sites P_3, P_4, P_8 and P_{10}, they are within moderate degradation. Thus, wind erosion and soil crust factor have a higher degree of impact than water erosion, which led to the effect of wind erosion in the AL-Jazeera region which suffer from sand dune movement, strong wind, Gypsiferous soil, sandy to loam txture and missmanagement.

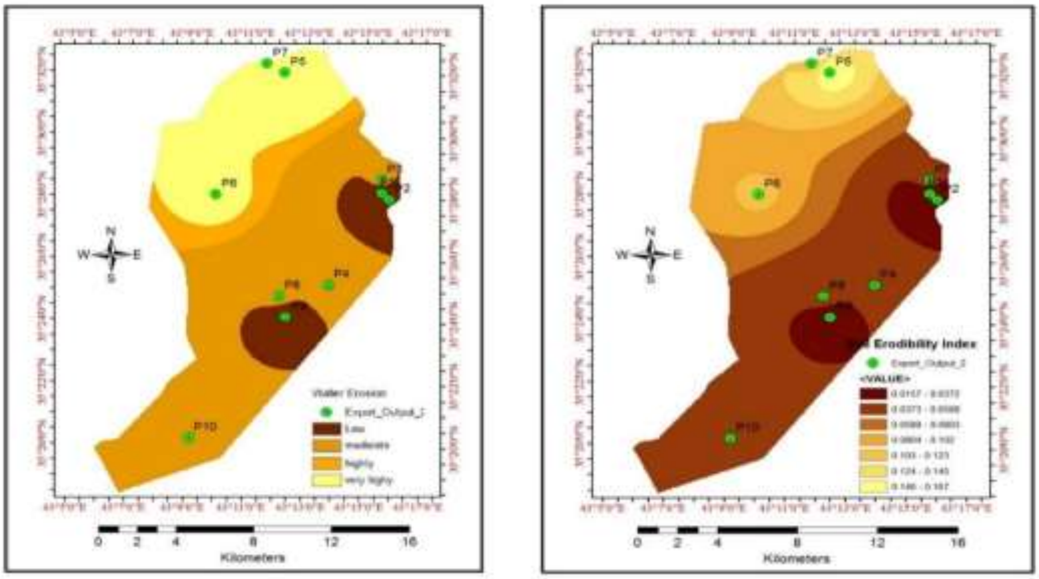

Fig. 5. Soil erodibility maps of study area

Vegetation green Cover-VgC % . The vegeta-tion cover usually ranged between 32.7 and 50.40 %. According to the obtained data that P_1, P_2 and P_3 had relatively higher vegetation cover and was within the class 3 (medium density), while the other pedons (68.09%) within the class 4 (low) density). Thus, according to the medulas criteria, the area of land with moderate vegetation 68.59km^2(31.91) %. While, land with poor vegetation, equivalent to 146.39km^2 (Figure. 6).

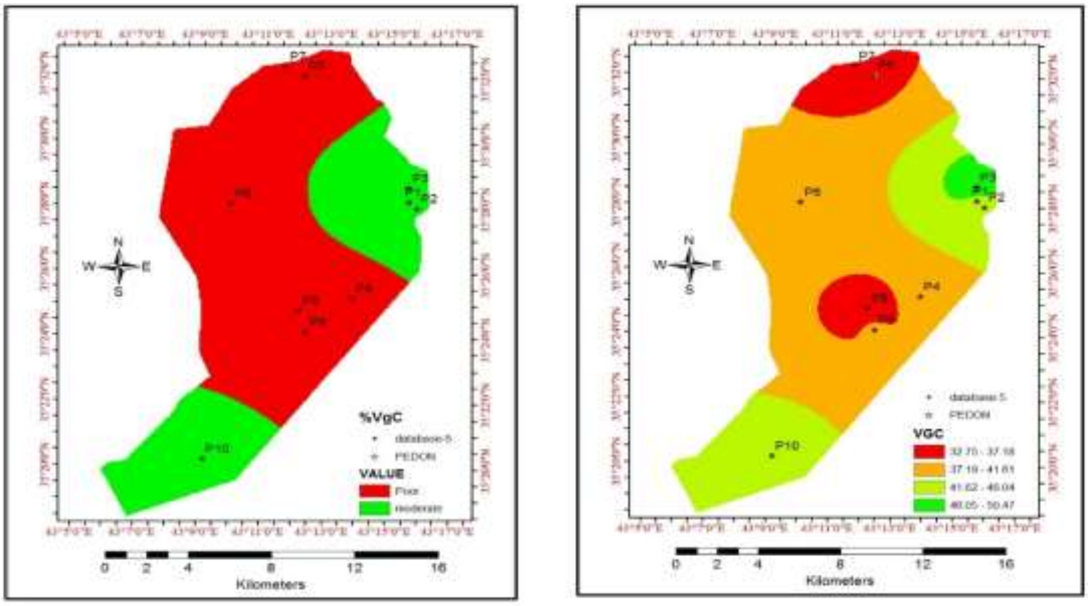

Fig. 6. Vegetation green Cover maps

VQI-Vegetation Quality Index

According to the obtained data from spatial distribution maps, that the P_9, P_3, P_2, P_1 within the moderate quality, which appears (71.06) km^2 (19.10) %. As for the rest of the pedones, which are P10, P8, P7, P6, P5, with an area of 143.93 km^2 (80.90) % within low quality (Fig. 7). Vegetation cover is one of the most important indicators to monitor of desertification and protect the soil surface from external factors, improves its internal system such as water, air, organic matter, organism activity, soil temperature, humidity, and permeability.

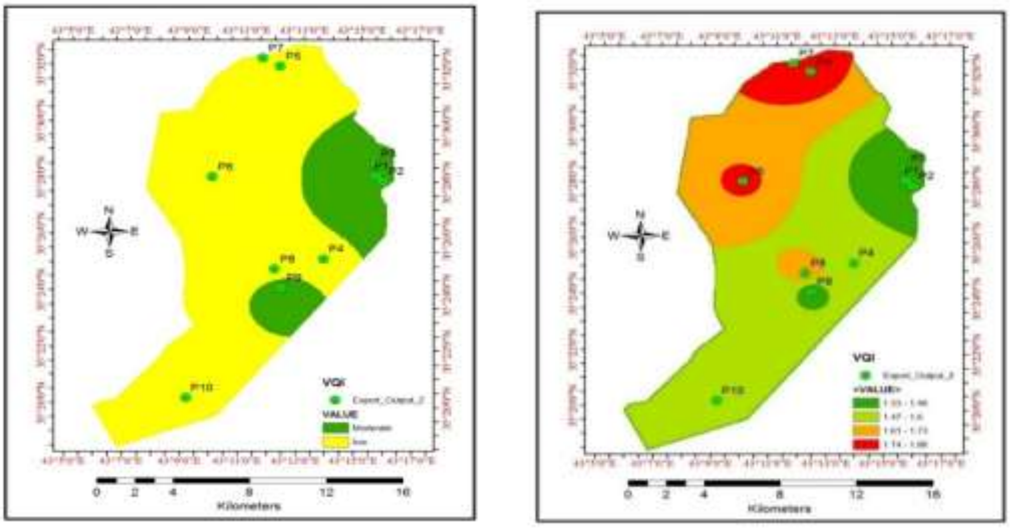

Fig. 7. VQI maps of study area

Desertification Environment Sensivitily-(ESAI). Most of the sites were within the class C and varied according to a subclass and they were within the class C1, which occupied a very small area of 0.22 km2 (0.10)%, and an area under C2 was 54.50 km2 (25.35)%, which included the sites P1, P2, P4 and P9 respectively, where their values were limited range 1.41-1.53. The subclass C3, so it was modified in this study to other classes (C31, C32, C33). Therefore, the sites P5, P6 and P7 were within the higher class C33 environmental sensitivity to desertification, range 1.62-1.68, its area was 34.45 km2(16.03)%, and the area of subclass C32, ranged 1.53-1.56, occupied a large part of the study area, reaching 87.70km2(40.79)%. In general, the C3 class total area occupied 74.55% of the area of the study area(Figures 8, 9).

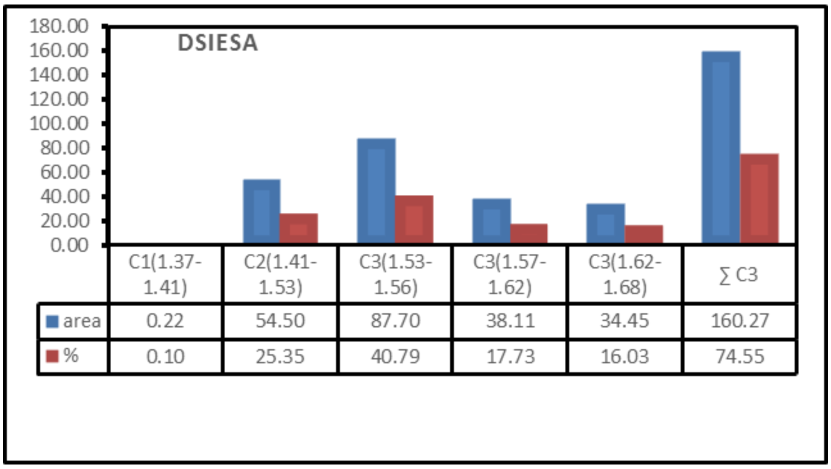

Fig. 8. Environment Sensitivity Area Index maps.

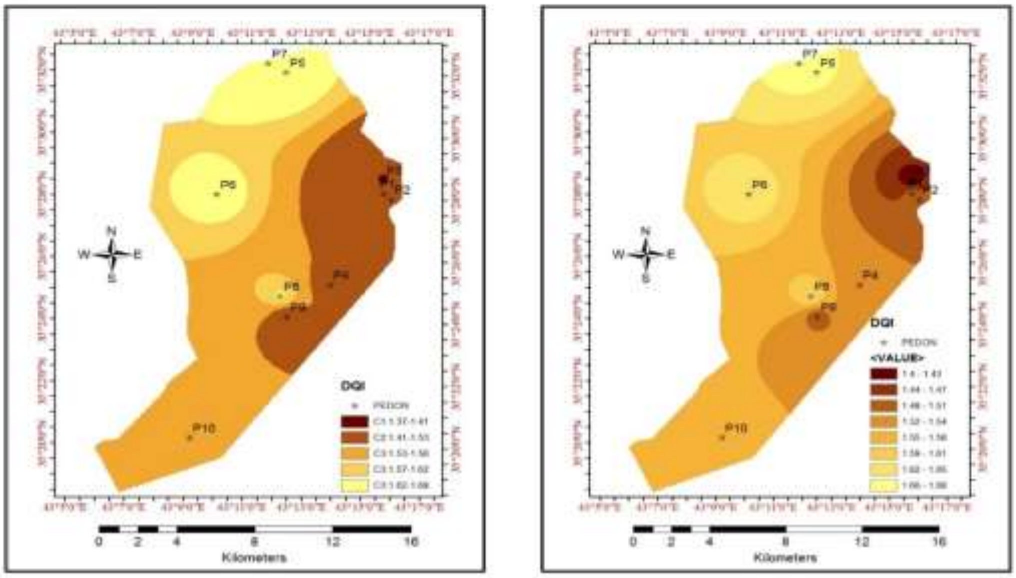

Fig. 9. Environment Sensitivity Area Index maps

According to the obtained data, 123.65km^2 (57.51 %) is suffering from very sever degradation at 19 sep.2013 and decrease an area at 20sep.2019 which occupies 63.39 km^2(29.48%) and change area between 2019 and 2013 was 60.25km^2. While, the areas of sever degradation about 120.86 km^2 of the total area (56.22%) at 20 sep.2019 while 80.86km^2 of the total area (37.61 %), and change area was 39.99km^2(40%) may be increase in rainfall totall and management practices(figures 10).

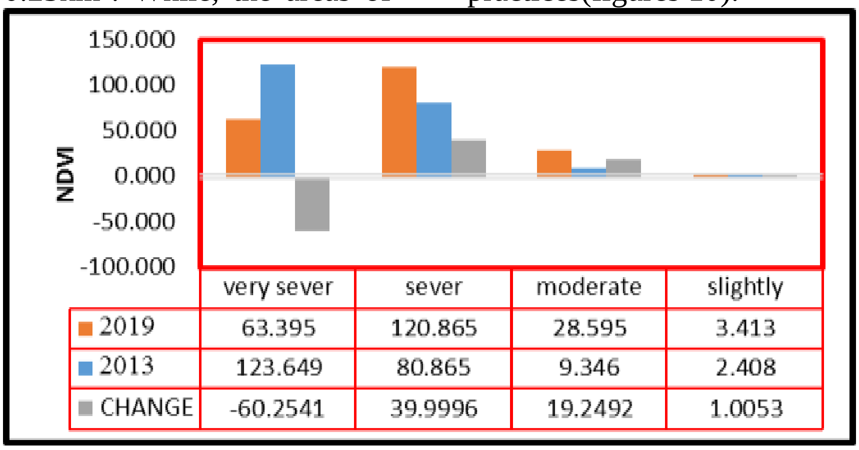

Fig. 11. Change detection of NDVI between 2019 and 2013

The Area Leaf Index (LAI) is one of the important vegetative indicators that express the state and health of vegetation cover. According to fig. (12), very sever degradation is occupies large area which reach 75.74 km^2 and 192.44 km^2 at 2019 and 2013 respectively, compared with other degree, 18.03km^2 for sever degradation(Fig.12).

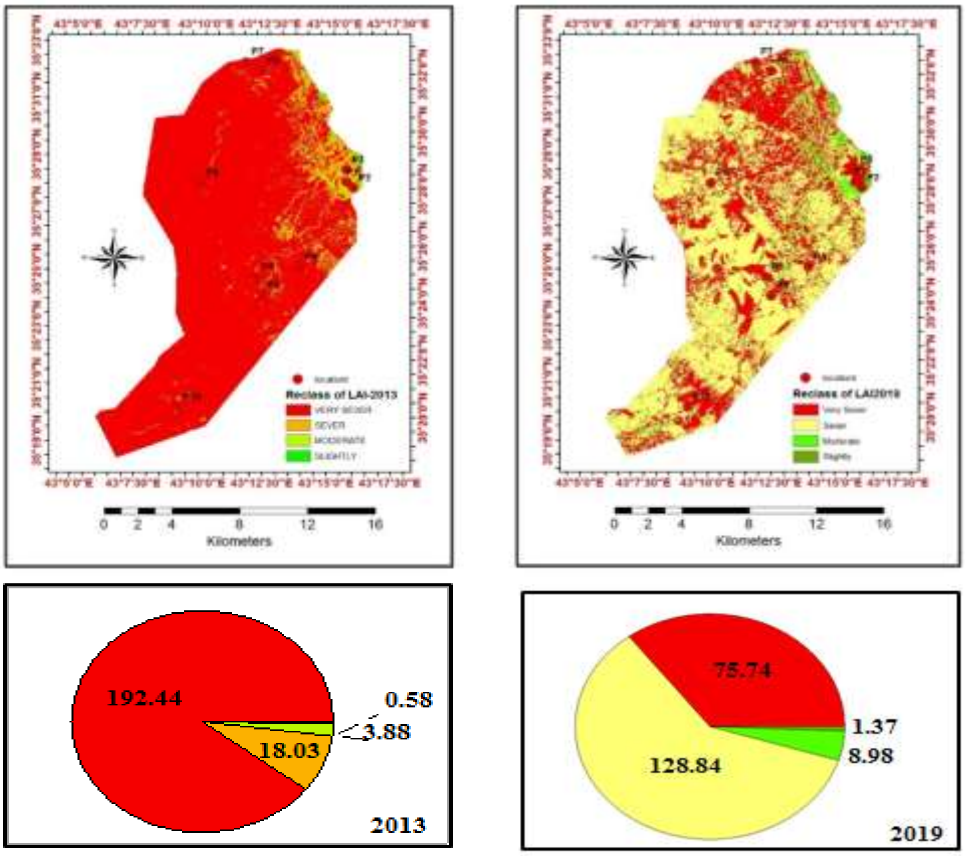

Fig. 12. Area Leaf Index maps of study area

The OSAVI and GOSAVI vegetation indicators ranged between 0.090 - 0.198 and 0.17 - 0.29 for the year 2013, and they ranged between 0.10 - 0.15 and between 0.14 - 0.22 for the year 2019. This variation in the values of the spectral indices is a result of the influence of soil and atmosphere on the reflectivity of vegetation. The SI5 salinity index ranged between 0.67 - 0.89, and the maximum height was reached in soils with high salinity levels such as P_1, P_2, and P_8 sites. This may be due to poor management and quality of irrigation water.

Table. 13. Vegetation and soil indices of study area

Loc.	Statistical	OSAVI		GOSAVI		SI5	
		2013	2019	2013	2019	2013	2019
P_1	Min	0.135	0.100	0.199	0.152	0.726	0.810
	Max	0.180	0.177	0.242	0.248	0.746	0.835
	Mean	0.157	0.150	0.219	0.218	0.735	0.823
P_2	Min	0.160	0.093	0.238	0.120	0.681	0.886
	Max	0.208	0.180	0.271	0.257	0.723	0.913
	Mean	0.173	0.151	0.246	0.218	0.700	0.8995
P_3	Min	0.190	0.094	0.287	0.135	0.602	0.618
	Max	0.206	0.114	0.307	0.162	0.632	0.737
	Mean	0.198	0.100	0.299	0.146	0.618	0.678
P_4	Min	0.084	0.109	0.176	0.192	0.618	0.674
	Max	0.109	0.145	0.207	0.218	0.660	0.739
	Mean	0.093	0.121	0.187	0.199	0.637	0.712
P_5	Min	0.086	0.092	0.191	0.170	0.595	0.670
	Max	0.093	0.140	0.199	0.206	0.612	0.795
	Mean	0.090	0.115	0.195	0.192	0.601	0.715
P_6	Min	0.084	0.109	0.169	0.189	0.674	0.627
	Max	0.090	0.133	0.175	0.236	0.698	0.733
	Mean	0.085	0.122	0.172	0.205	0.686	0.696
P_7	Min	0.088	0.095	0.182	0.182	0.630	0.684
	Max	0.097	0.110	0.198	0.189	0.682	0.740
	Mean	0.092	0.102	0.192	0.185	0.651	0.710
P_8	Min	0.097	0.077	0.197	0.134	0.653	0.881
	Max	0.159	0.150	0.227	0.266	0.756	0.876
	Mean	0.121	0.112	0.207	0.200	0.698	0.879
P_9	Min	0.099	0.107	0.199	0.161	0.596	0.661
	Max	0.191	0.165	0.252	0.254	0.771	0.761
	Mean	0.120	0.130	0.225	0.217	0.631	0.711
P_{10}	Min	0.102	0.102	0.187	0.187	0.618	0.840
	Max	0.222	0.222	0.266	0.266	0.737	0.926
	Mean	0.134	0.134	0.225	0.225	0.694	0.885

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