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LAND CLASSIFICATION FOR THE RIGHT BANK OF EUPHRATES PROJECT IN ANBAR GOVERNORATE, IRAQ, USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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Abstract

Land classification is the aggregation of similar units of soils in terms of their administrative needs or powers for one or more types of products based on the type of classification and its degree and identifying of the production determinants or its obstacles and also to identify the soil response when subjected to a specific use such as the cultivation of a specific crop. The study area is located in the lower part of the Euphrates River Basin and within the flood plain of the Euphrates River according to the major and secondary physiographic division of Iraq presented by (Buringh, 1960) in a report on the soil and conditions of Iraq. The study area is located near the Euphrates River and to the west of the city of Fallujah within (path 169 and Row 37) of the European satellite Sentinel. 2. The project is located within the boundaries of the Fallujah district and is about 3 km west of it between the longitude (37 E43 and 50 E43) and two latitudes (33N 22 and 33N 09) and the northern part of it, known as the province of 5/Al-Nassaf, was chosen, bordered to the north and east by the Euphrates River and the Saqlawiyah Project and from the south and west by high desert lands.This study aims to lands classification of the study area according to their productive capability by using remote sensing technology and geographic information systems and to investigate the classes of the study area after investigating their production capability using the standard addition method and then producing maps evaluating. Besides, classifying lands and building a database of soil characteristics with less effort and fewer costs, where the satellite image is taken from the Sentinel 2 satellite was used, and the image that was taken by the visual image and the cut off from the visual of the study area was classified by theun supervise classification method using the ERDAS IMAGEN program 2014. A full survey of the study area was then conducted, after which a profile was drilled for each site by ten profiles representing the study area and (20) surface sample that was described morphologically and soil samples were taken from each horizon, the samples taken were then analyzed after preparing for the physical and chemical laboratory analyzes, and after that the image was classified by conducting the supervise classification method by ERDAS IMAGEN 2014. After that, an evaluation of the lands was conducted in the study area, after estimating all the characteristics involved in the evaluation that affect the suitability of the lands mentioned in SYS 1993, starting from the lands that are very suitable to the permanently not suitable lands. Furthermore, the lands of the study area were classified and the classification was conducted, after the land evaluation and then giving weight to each characteristic of the characteristics included in the classification of lands, which was to give weight forevaluation, weight for salinity, slope and internal drainage. The slope was extracted through the digital elevation model and the creating maps using inverse distance weighting, as the lands of the study area were classified into (7) classes represented from the first class, which represents the vary suitable lands for cultivation to the seventh class which permanently not suitable for cultivation. Anywhere, the first class was represented by the lands near the Euphrates River, which are agricultural uses near water sources and subject to good management operations with low salinity and suitable for cultivation of various types of crops. The area of the first class was (11.94) ha and represented (0.22%) of the total area, while the second class was its area (82.39) ha and its percentage (1.53%) of the total area, as for the third class was (645.68) ha by a percentage of (12.04%) of the total area. However, the fifth class was (1589.16) ha by a percentage of (29.65%) of the total area and the sixth class with an area of (1396.30) ha and a percentage of (26.05%), as for the seventh class with an area of (233.24) ha by a percentage of (4.35%) of the total area. As for the soil texture, it is considered one of the basic and important characteristics, as the soil textures of the study area ranged from fine to medium texture, where the soils were loam and loamy sand and sandy loam. The study indicated that the soil is deep in most of the study area lands, that is, there are no determinants in the soil uses for agricultural purposes except for the plateau lands and the mountainous region. The study results indicated that the internal drainage of all pedons was medium and the

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results also indicated that the soils of the study area have a saline content, which are results consistent with the nature of dry climatic conditions as well as poor drainage where the salinity was ranging between (0.40- 65 des). The study showed that the lands of the study area indicated that there are three levels of soil, according to the content of the cation exchange capacity (CEC) and the first-class contained a percentage of less than (16 Meq Cation/100g soil) with an area of (1395.68 ha), while the second class, its CEC ranged between (16-24) with an area estimated to (1975.30 ha), as for the third and last class, their CEC was greater than (24) with an area of (1988.96). The study results showed that the soil of the study area has a content of organic matter with two contents (<0.4 to >0.4). Furthermore, the study results was also indicated that the content of gypsum in the study lands ranged between (<3) to (>20) and these percentages are appropriate for agricultural uses and the study results also indicated that the soil reaction of the study area were between (7-8.2), where these soils were classified as moderate to light, whereas the spectral reflectivity of the lands, they were inversely proportional to the land classes of the study area, as the percentage of spectral reflectivity in the first class was the lowest percentage, where it was the lowest value (86), while the highest value (255) and the average reflectance for the first class (200.709) and these values were increased with the second class and this indicates that the reflectivity is few in the cultivated land classes and increases with the uncultivated or barren lands such as the lands of the plateau region, which was within the lands of the study area, represented by the sixth and seventh class of lands, because the lands with dense vegetation cover have little reflectivity.

Introduction

Classification is the process of gathering similar things in units organized by a system and this system in which the relationships between these units are clarified, such as reflecting certain phenomena that are within the objectives of classification. The primary purpose of classification is to know the type of land use suitable for agricultural use or non-agricultural uses and others. One of the most important reasons for classifying lands is to designate productive lands and graduated them for using, choosing the areas to be used, and assigning important crops to each type of suitable soil in the form of land units. As for the land classification, it is gathering of similar soil units in terms of their needs or administrative powers for one type of production or more based on classification degree and classification type. The classification of lands has a purpose, and this purpose is to enable people to manage the soil based on understanding the specifications and recording them in a way that facilitates the process of reviewing soil conditions, in addition to its economic need to save effort, money and time in managing that land. Classification in other words is a process of classifying the main thinking steps in any field, and it can be summarized as the process of setting rules that depend on the characteristics of soil in the diagnosis and organization of soils within specific information limits. Besides, specifications that depend on the characteristics statistically heterogeneity to reflect the relationship between the soil and the development degree and the amount of information available - survey work and through it can be achieved other interpretive classifications known as land classification, where the classifications have varied in the world. The efforts of multiple nations in each country according to its experience, availability of the soil types that deal with it and the scientific level of each of them, as the process of surveying, inventorying and classifying the land and the land cover is an essential step in the planning process. In addition, the traditional methods of classifying lands require effort, time, and cost in producing classification maps, as remote sensing techniques and geographic information systems have been provided an advantage that traditional methods cannot provide through surveys and inventories of the natural and human components. As well as through satellite visuals that save effort, time and cost after processing them and determining the uses of the land, in addition to the slope and natural evidence included in the classification of the land. However, the role of geographic information systems is represented by the classification of lands and in preparing a database for these lands or to be identified in the future through this database and producing maps of the characteristics of new soils using the best methods of spatial interpolation and lands classification (Food and Agriculture Organization, FAO). Finally, due to the lack of researches in the use of sensing techniques and GIS, therefore, the study aimed to achieve the following goals; Lands classification of the study area after extraction the class and the subclass and capability unit in the environment of GIS. Besides, identifying the land class is suitable for cultivation use or not and the suitability of crops.

Materials and Methods

General characteristics of the study area

Location and area

The study area was chosen as shown in Fig. 1 as a result of its distinguished diversity of geomorphologic phenomenon as well as its agricultural uses, as it located in the lower part of the Euphrates River Basin and within the flood plain of the Euphrates River according to the main and secondary physiographic division of Iraq presented by (Buringh, 1960) in a report on the soil and conditions of Iraq. The study area is located near the Euphrates River and to the west of the city of Fallujah within (path 169 and Row 37) of the European satellite Sentine l.2. The project is located within the boundaries of Al-Fallujah district and is about 3 km west from it between longitudes (37 E43 and 50 E43) and two latitudes (09 33 and 22 33). The northern part of it, known as District 5 / Al-Nassaf was chosen and is bordered on the north and east by the Euphrates River and the Saqlawiya project, from the south and west a high desert lands, in addition to Lake Habbaniyah, the area of the study area reached (5359 ha). (Burring, 1960) indicated that the original soil materials consisted mainly of modern deposits of limestone origin, as well as aeolian deposits transported from the desert that mixed with river deposits.

Use of land and natural vegetation

According to the map of the natural vegetation of Iraq (Guest, 1956), the study area is located within the sub-desert zone, and through field observation, the natural vegetation is of low density and weak growth, and this may be due to the lack of rain and soil conditions. It differs in its distribution and spread according to climate conditions and the available soil types, degree of salinity, hydrological and agricultural uses. The following natural plants dominant in the study area: *Imperata cylindrica, Tamarix mannifera*, *Schanginia aegyptiaca*, *Alhagi maurorum medik*, *Cressa cretica*, *Cyperus rotundus, Aeluropus littoralis* and *Cynodon dactylon* and other plants. The entire area of the study area is subjected to the surface irrigation system, as well as irrigation by pumps from the Euphrates River, which discharges into irregular and unlined channels. Agricultural uses in the northern part of the Saqlawiya project and the southern part of the right bank of the Euphrates project is weak due to severe salinization conditions. The agricultural activities

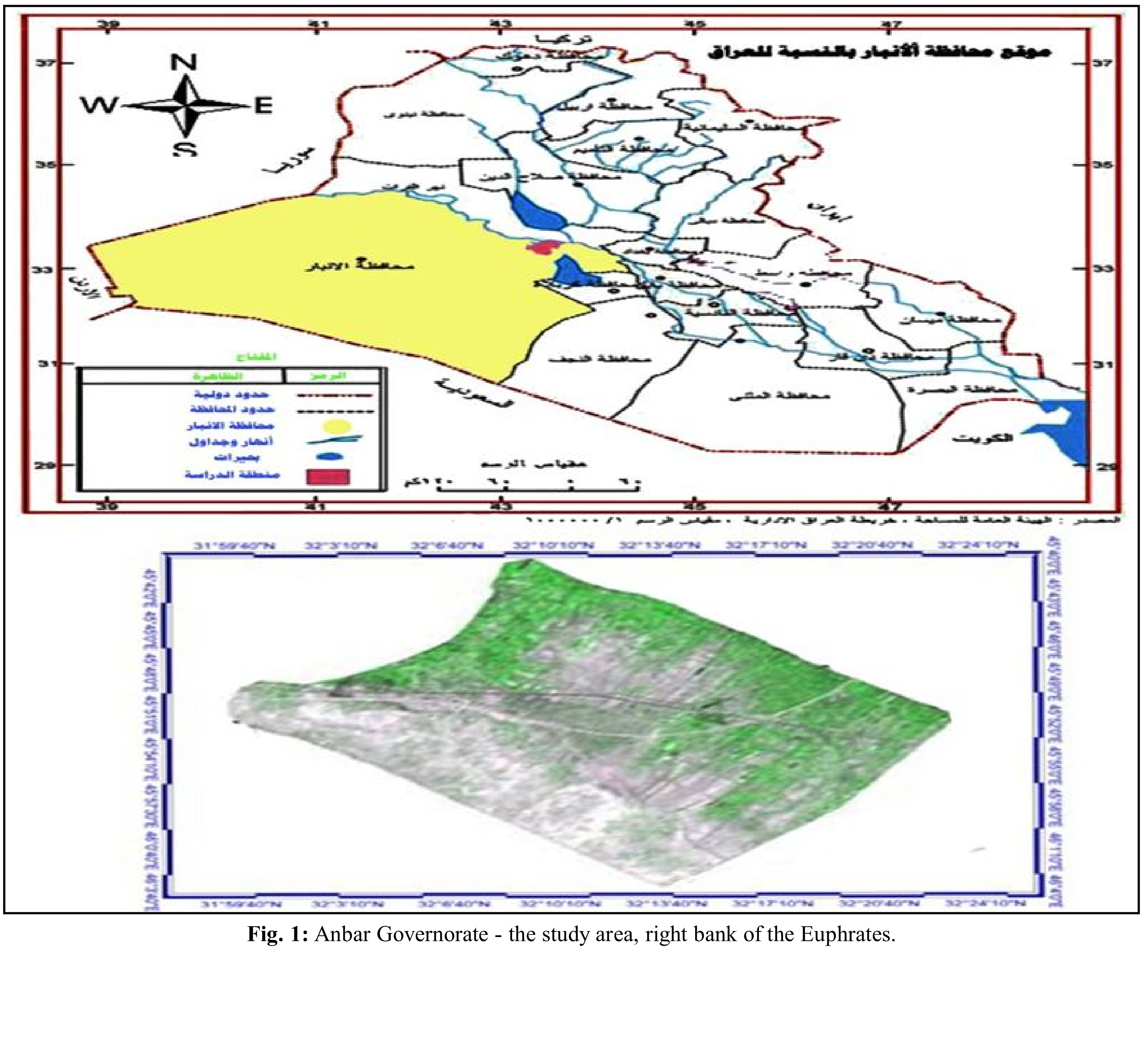

Fig. 1: Anbar Governorate - the study area, right bank of the Euphrates.

were concentrated within a narrow strip and parallel to the running of the Euphrates River, and in the winter season were concentrated on wheat, barley, and jet crops, while in summer, yellow maize is the main crop in the region, in addition to the presence of some orchards of palm trees and fruits. In general, the level of agricultural production is a week.

Schanginia aegyptiaca.

Prosopis farcta L.

Office work

Unsupervise classification

The unsupervise classification process was performed using the application of ERDAS Imaging 2014 (Earth Resources Data Analysis System) program, ERDAS program represents one of the basic programs used in digital image processing which its applications coincide with (ArcGIS 10.3), that it is one of the programs specialized in geographic information systems. The classification process of the data is carried out automatically without interference from the analyst, which does not require conducting field studies in advance, but the computer classifies determining the number of classes by the user and according to his experience in predicting the number of classes within the area under study. Somewhat, the main points or clusters are gathered over the convergence and similarity of their spectral reflectivity characteristics, forming what is known as Spectral Classes and then their identity is determined by comparison with the maps.

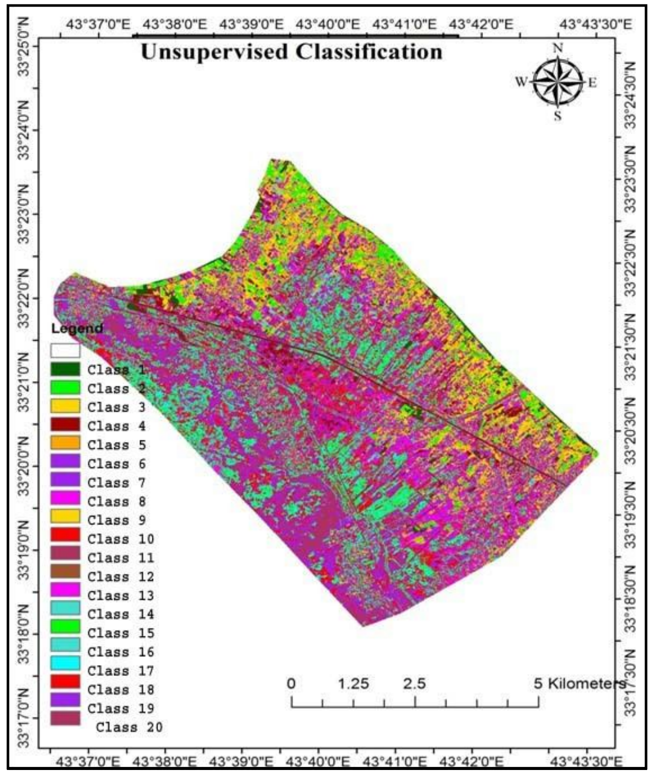

Fig. 2: Un supervise classification.

Fieldwork

A field visit was conducted to the study site for sampling and disclosing the nature of the study area, sampling locations have been identified from several locations for a part of the bank of Euphrates project in Anbar Governorate.

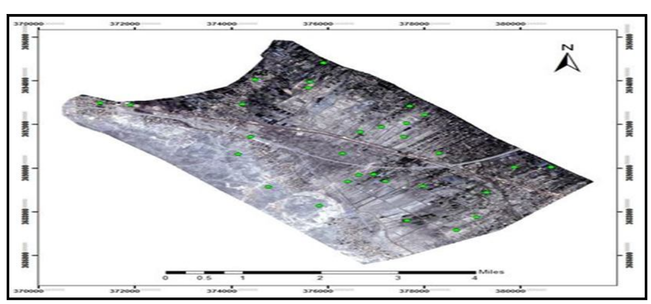

Fig. 3: Sampling locations.

The locations of the diagnosed soils were determined after obtaining the satellite visual (unsupervise classification), the soil survey map was approved and 40 soil samples that included 9 profiles were identified, where 9 profiles were drilled for different depths and 12 surface soil samples were collected from the profiles for different depths on 10-7-2019 and 11-7 until 17-7-2019. The coordinates of those samples were also determined using the GPS. Profiles were described as morphologically according to the modern system (Soil survey staff 2014), and the results of the soil survey carried out were used.

Field procedures

The study area was surveyed several times as a preliminary step to note the changes within the study area in soil formation factors, as well as observing changes in the surface characteristics of the soil, as field observations focused on studying the type and density of natural vegetation, topography, hydrology and physiographic units, as well as the state of salinity and the nature of agricultural uses within the physical units. The geographical coordinates of the study locations were determined by the Global Position System (Garmin Terex 2004). The coordinates of the locations were determined in the form (N/E), on which the spectral data would be extracted from the satellite images later, as well as dividing these locations into digital maps and visuals and creating a shape file for them for mapping the evidence and criteria used in this study. These locations were updated and described morphologically, and soil models were taken for laboratory analysis of some physical and chemical characteristics. Observations on natural vegetation and agricultural uses were also recorded at each location, and according to the results of field study and the current laboratory analyzes, soils were classified.

Laboratory procedures

After obtaining soil samples from the diagnosed horizons, they were placed in nylon bags, then air-dried and crushed by a wood hammer, then sifted with a sieve 2 mm holes diameter, and transferred to the central laboratory of the Soil Science and Water Resources Department/College of Agricultural Engineering Sciences/ University of Baghdad, after preparing them for laboratory work, some physical and chemical analyzes were conducted on it, that included all of the following analyzes:

PH - Ec - CEC - Texture - Caso3 - Caso4 - Organic matter.

Laboratory procedures

Soil texture estimation

The relative size distribution of soil separates was estimated by the hydrometer method mentioned in (Richards, 1954).

Estimating the chemical properties of soil

- The electrical conductivity ECe was estimated in an extract of saturated soil paste according to (Richards, 1954).

- The soil reaction pH was estimated in an extract of saturated soil paste according to (Richards, 1954).

- Calcium carbonate was estimated by the CO_2 weight loss method according to the method 23b mentioned by (Richards, 1954).

- Organic matter was estimated according to the Walkely and Black method mentioned by (Jackson, 1958).

- Calcium sulphate (gypsum) was estimated by extraction with distilled water through choosing a suitable dilution ratio soil: water according to the 22b method mentioned by (Richards, 1954).

- The cation exchange capacity (CEC) was estimated using sodium acetate method as reported in (Bashour and Al-Sayegh 2007).

Land evaluation

The characteristics that affect the suitability of land for the cultivation of wheat and barley crops have been identified. The standard addition method mentioned in (Sys *et al.,* 1993) was used, by collecting estimates of the appropriateness of the land characteristics of the crops selected with each other to obtain the final estimate of the land evaluation through which it is determined the class of land suitability.

Table 1: Degrees of earth suitability.

Index	Suitability Class
85-100	S1: very suitable
60-85	S2: moderately suitable
40-60	S3: marginally suitable
25-40	N1: Currently unsuitable
0-25	N2: Permanently Not suitable

The information in table 5 and 6 has been accepted as a basis for determining the suitability of soil characteristics for growing wheat and barley crops. If the value of at least one of the most important critical factors (ECe, O.C., Texture, Gypsum and Lime) is less than the final average suitability, then the final classification will be the lowest value.

Evaluating the suitability of soil characteristics for growing wheat and citrus crops

In this stage, the soil characteristics and its suitability

Table 2: Soil and topographical requirements for the wheat crop as reported in (Sys *et al.,* 1993) system.

Land characteristics		Evaluation scale, Degree of limitation, Classes					
		S1		S2	S3	N1	N2
		0	1	2	3	4	
		100 95	85	60	40	25	0
Topography	(t)						
Slope %		0-1	1-2	2-4	4-6	-	>6
wetness	(w)						
Flooding		F0	-	F1	F2	-	F3+
Drainage		Good	Moder.	Imperf.	Poor and aeric	Poor, but drainable	poor> not drainable
Physical soil characteristics	(S)						
Texture/struct.		C<60S,SiC,Co, Si,SiL,CL	C<60v,SC, C>60s,L	C<60v, SCL	SL,LfS	-	Cm,SiCm, LcS,FS,cS
Coarse fragm (vol%)		0-3	3-15	15-35	35-55	-	>55
Soil depth (cm)		>90	90-50	50-20	20-10	-	<10
$CaCo_3$(%)		3-20	20-30	30-40	40-60	-	>60
Gypsum (%)		0-3	3-5	5-10	10-20	-	>20
Soil fertility characteristics	(f)						
Apparent CEC(Cmole(+))/g clay)		>24	24-16	<16 (+)	-	-	-
Base saturation (%)		>80	80-50	50-35	<35	-	-
Sum of basic cations (Cmole(+))/g)		>8	8-5	5-3.5	3.5-2	<2	-
pHH_2o		7.0-7.6	7.6-8.2	8.2-8.4	8.4-8.5	-	>8.5
Organic carbon (%)		>0.6	0.6-0.4	<0.4	-	-	-
Salinity & alkalinity	(n)						
ECe ($ds.m^{-1}$)		0-4	4-8	8-12	12-16	16-20	20-24
ESP (%)		0-15	15-20	20-35	35-45	-	>45

for growing wheat and citrus crops were evaluated, after which the Arc GIS.V. (9.2) program was used to produce the final suitability maps.

Production of soil characteristic and land use maps

The lands of the study area were evaluated, and one of the spatial inter polation methods was used to produce maps of soil characteristics included in the evaluation of the land in the environment of geographic information systems (Inverse Distance Weighting). The (Sys, 1993) method was used in the evaluation of the land (addition method). This method relies on collecting the estimates of the characteristics chosen in evaluating the land suitability to obtain the final estimate of the evaluation as shown in equation (1), where the following variable is described in table 4.

Cs = (A + B + C + D + E + F + H + I)/8 … (1)

Cs = Ph + Ec + Texture+ Gy + O.M +CEC+ CaCo3 + Drainge +

Where Cs = Cabality suitable

Land classification

The classification was conducted for the lands of the study area after evaluating the lands, and then giving weight to evaluatethe salinity weight, slope weight, and internal drainage weight according to the equation:

*(Land Evaluation * Weight + EC * Weight + Slop * Weight + Draining * Weight) = result * 10 (Class)*

It has proven results that are similar to reality, where the Slop was obtained through the Digital Elevation Model. Then was produced the inverse distance weighting method, after that, the land classes in the study area were obtained according to (Al-Akidi *et al.,* 1986) as a class, subclass and capability unit, where The details of each of these classification levels are given below: (Walid Al-

Table 4: Addtion method varaibles.

Suitability value	Cs
A: Evaluating the degree of reaction	pH
B: Salinity evaluating index	EC
C: Texture evaluating index	Texture
D: Gypsum evaluating index	Gypsum%
E: Organic Carbon evaluating index	Organic matter ratio / 1.72
F: Cation exchange capacity evaluating index	CEC
H: $CaCO_3$ evaluation index	%$CaCO_3$
I: Drainage evaluation index	Drainage

Table 3: Soil requirements for citrus crop mentioned in (Sys *et al.,* 1993).

Land characteristics	Evaluation scale, Degree of limitation, Classes					
	S1		S2	S3	N1	N2
	0	1	2	3	4	
	100	95	85	60	40	25 0
Topography (t)						
(1)	0-1	1-2	2-4	4-6	-	6<
(2)	0-2	2-4	4-8	8-6	-	16<
(3)	0-4	4-8	8-16	16-30	30-50	50<
Slope (%)	Fo	-	-	-	-	fl
Wetness(w)	good	good	moderate	imperf.	poor but drainable	poor not drainable
Flooding	ground<150cm	ground				
Drainage		100-150cm				
Physical soil characteristic						
Texture / structure	SL,Sil,L, Sicl,Cl, Si	ScL,Ls,Lfs	C<60S, Sc, S,FS,C0	C<60V C>60S	-	Cm,SiCm C>60V
Coarse fragm (Vol%) Soil	0-3	3-15	15-35	35-55	-	>55
depth (CM)	>200	200-150	150-100	100-75	-	<75
CaCo3(%)	0-3	3-5	5-10	10-25	-	>25
Gypsum(%)	0-1	1-2	2-3	3-5	-	>5
Soil fertility characteristies(f)						
Apparent CEC(Cmole(+))/g clay)	>16	<16 (-)	<16 (+)	-	-	-
Base saturation (%)	>35	35-20	<20	-	-	-
Sum of basic cations (Cmole(+))/g)	>3.5	3.5-2	<2	-	-	-
pH H2o	6.5- 5.8 6.5 – 7.0	5.8-5.5 7.0-7.6	5.5-5.2 7.6-8.0	5.2-5.0 8.0-8.2	<5.0	>8.2
Organic carbon (%)	>1.5	1.5-0.8	<0.8	-	-	-
Salinity and Alkalinity (N)						
ECe (ds/m)	0-2	3-4	3-4	4-6	-	>6
ESP(%)	0-4	4-8	8-12	12-15	-	>15

Akidi *et al.,* 1986). The class level: it has eight classes, each class symbolizes with a Latin number starting from the first I and representing the best soil classes until the last VIII which represents the worst in terms of suitability for economic agricultural purposes, and was produced a map of land classification in the information systems environment.

Productive capability * Weight + Salinity * Weight + Slop * Weight + Draining * Weight = Output * 10 The following are the land types according to (Al-Akidi,1986), where the characteristic weight is (0.4, 0.3,015 and 0.15) for the productive capability, Salinity, Slop and Draining

*(Productive capability * Weight + Salinity * Weight + Slop * Weight + Draining * Weight) = result * 10*

1- The following are the land classes according to (Al-Akidi, 1986):

Class I

It contains all good and excellent soil classes that are deep, productive, with a flat topographical to almost flat with no erosion and that their erosion is very little and is suitable for growing field crops in general without maintenance precautions (Akidi *et al.,*).

Class II

It contains all good soils that can be grown safely without adopting maintenance procedures, these soils are deep and productive but require fertilization and possibly adjusting their pH. Its topography has a slight slope that can be handled by contour cultivation.

Class III

It contains the soils of medium quality in characteristics and productivity. These soils can be cultivated using normal management methods with maintenance procedures.

Class IV

This class includes soils with medium productive characteristics, as their slopes range from (12-18%) which are big slopes and their erosion ranges between medium and severe, it is the most suitable for growing forage and pastures with procedures and maintenance.

Class V

It contains all soils that are not suitable for growing regular crops and at the same time characterized by any cases of water logging or stone or exposure to floods and others. It is suitable for pastures and forests with few obstacles as well.

Class VI

This class is for soils that are not suitable for cultivating field crops because of their many problems and production obstacles, but they are suitable for pasture cultivation when using adequate administrative procedures with fertilization and re-seeding, their slopes ranging between 26-18% with gullies and deeperosion.

Class VII

The soil of this class is not suitable for growing crops, but it may be suitable for growing some weeds and some trees if the adequate management methods are present. The characteristics of these soils are shallow depth, their slopes ranging between (26-60%), topographic roughness, and drought.

Class VIII

The soils of this type of land are certainly not suitable for field crops or pastures, as well as for planting trees. However, it is suitable for tourism, hunting.

2- The subclass

Soils that included within one class are classified again into subgroups and according to selected classification factors related to production and management, these four factors are:

- Erosion and symbolized by the letter E

- Waterlogging, and symbolized by the letter W

- Shallowness or lack of depth and symbolized by the letter S

- Climate extremes (cold, drought) and symbolized by the letter C.

3- Capability unit

The land capability is an expression of how the soil is suitable for most types of field crops and it refers to units of the agricultural capability of similar types but of varying intensity of restrictions and provides information on the type of management problem or restrictions and the capability units were divided according to the subcategory. Each category may include many different classes of soils after determining a level of subclass for specific soil and documenting its symbol, the classifier continues to divide. In addition to classify soils, parts or sub-classifiers from a level of subclass according to the same classification factors that were used at a level of the subclass, but instead of using the obstacle type, it can determine the intensity of obstacle and then use and document it in one of the four degrees.

Uses of the land classes

The land has uses that differ from one class to another depending on the type of land and its productivity. The lands are divided according to their use into

- The first, second, third and fourth classes for planting field crops

- The fifth and sixth classes for planting sustainable crops in descending order

- The seventh class its best used in forests and afforestation

- The eighth class is suitable for non-agricultural purposes

Producing land classification maps in geographical information systems

- Preparing the digital map

The distribution map of the soil units implemented by (Hider and Jassim 1992) was converted into a digital map using geographic information systems and based on the project coordinates through the Geo-referencing process.

Calculation of the Normalized Difference Vegetation Index(NDVI)

The NDVI index was calculated using the following equation:

$$NDVI = \frac{NIR - R}{NIR + R}$$

NDVI: Normalized Difference Vegetation Index

R : reflectivity in the visible red wave

NIR : reflectivity in the near-infrared wave

This is to verify the state of variation like vegetation covers prevailing in the study area, which expresses the state of variation in the productivity of the land.

Determine the spectral signature for each land class after blending the spectral bands that have a spatial resolution of 10 * 10

The unsupervised classification method was used based on the ERDAS.V program. 11.02 of 2014, after obtaining the spectral signature of each expected land cover in the study area, as these spectral signatures were identified by revealing all types of land covers, based on which the visuals were later classified, as the inferred varieties were adopted in mapping the land cover prevailing in the region.

Result and discussion

Soil physical properties

Texture

Soil texture is one of the basic and important characteristics, as most of the pedological characteristics of soil are related to it and at the same time, it is a characteristic that changes little with time compared to other characteristics. The study results indicated that there were three types of texture in the study area are: (Loam - Sandy Loam - Loamy sand). Whereas, the percentage of lands with loam soil was (3.09%) with an area of (166.09) ha and the percentage of lands with Loamy sands oil was (26.64%) with an area of (1428.16) ha, while the percentage of lands with Sandy Loam soil was (70.25%) with an area of (3765.91) ha.

Table 5: Soil texture areas.

R	Texture	Area	Per %
1	Loam	166.09 H	3.09 %
2	Loamy sand	1428.16 H	26.64 %
3	Sandy Loam	3765.91 H	70.25 %

Normalized Difference Vegetation Index

Satellite data for the same study period were used for the purpose of clarifying the spatial and temporal variability of the dominant land cover nature in the study area based on the calculation of the NDVI values. Fig. 4 and table 5 showed that the values of the NDVI for the vegetation cover ranged between (-0.305717) and (0.724006) and it was observed from the Table that there is a temporal variation in the index values , which indicates the presence of variation in the type of land cover prevailing in the study area. The supervised classification results of the satellite data shown in Fig. 4 for the study area for the year 2020 indicated that the values of NDVI contain (9) varieties of the prevailing land cover.

Table 6: Results of chemical analysis of soil samples for the study area.

T	PH	Ec	Texture	OM%	CEC	$CaSO_4$	$CaCO_3$%	Y	X
P1	7.25	0.7	.Loam	0.49	18.22	0.81	25	3694056	374492
P2	7.93	50.2	Sandy loam	0.16	18.28	11.48	27	3693690	375596
P3	7.53	2.2	Sandy loam	0.47	18.03	13.84	17.83	3694821	375918
P4	7.49	17.7	Sandy loam	0.45	17.91	0.74	19.16	3692444	378012
P5	7.89	1.4	Sandy loam	0.47	18.87	11.3	25.62	3690696	378308
P6	7.68	25.1	Sandy loam	0.45	20.33	0.79	27.91	3692989	371275
P7	8.2	27	Sandy loam	0.6	18.11	18.11	12.52	3690645	374144
P8	8.14	2.3	Sandy loam	0.48	22.41	17.28	20.18	3689719	376958
P9	8.2	45	Sandy loam	0.29	18.14	7.12	26.08	3691673	376676
P10	8.3	29	Loamy Sand	0.51	17.91	16	12.8	3689392	376425
S1	7.25	14.7	Loam	0.44	19.13	11	25.83	3693967	375645
S2	7.93	1.4	Sandy loam	0.35	15	10.12	20.83	3692065	377633
S3	7.96	1	Sandy loam	0.45	18.87	16.85	19.61	3690060	380640
S4	7.91	66.94	Loam	0.45	17.91	10.81	7.11	3687178	378672
S5	7.52	5.32	Loamy sand	0.45	18.87	13.85	10.91	3689695	376648
S6	7.05	114.7	Loam	0.51	20.33	4.48	25.83	3692854	377697
S7	7.13	11.7	Sandy loam	0.4	18.11	13.23	20.83	3687612	377655
S8	7.6	49.13	Sandy loam	0.16	22.41	7.41	35	3691890	377110
S9	7.04	5.96	Loam	0.48	22.41	5.92	25.62	3689192	377976
S10	7.19	3.9	.loamysand	0.45	18.87	6.83	27.91	3692900	371898
S11	7.44	4.12	sand	0.51	17.91	13.85	2.83	3692938	374230
S12	7.88	25	Sandy.Loa	0.49	18.87	11.21	20.82	3691442	377585
S13	7.31	7.3	Loam	0.41	17.91	15.81	25.83	3689415	377193
S14	7.5	35	Sand.L	0.18	18.11	22.9	31.83	3688291	375834
S15	7.6	49.13	Loam	0.46	22.41	0.78	9.21	3687771	379087
S16	7.19	3.9	Loamy .san	0.44	18.87	0.89	27.91	3690058	379878
S17	7.44	4.12	Sandy Loam	0.48	17.91	16.85	26.16	3688884	379305
S18	7.42	25.07	Loamy sand	0.23	23	21.11	35	3689150	374761
S19	7.09	50	Loam	0.43	22.41	16.24	19.61	3690687	376313
S20	8.5	50.2	Sandy Loam	0.39	18.28	18.48	26.3	3691446	374411

Depending on the results of the field investigation and the values of the supervised classification, these varieties and the prevailing land covers in the study area can be identified. The most important types of ground cover that were diagnosed in the year 2020 are both dense land cover that was formed due to good management and water availability. The vegetation covers were divided into eight types, the dark red color represented the absence of vegetation cover, while the light blue color represented medium vegetation cover, the dark orange represented medium vegetation cover. The orange color represented above the medium vegetation cover, the light green represented dense vegetation cover, the green color represented a very dense vegetation cover, the dark green represented a very dense vegetation cover.

Table 7: The values of NDVI and vegetation cover density for the year 2020.

T	Land Cover	Collar	Histogram	*100m^2
1	Low NDVI Low variability	Read	151850	15185000
2	Low NDVI medium variability	Dark Red	120593	12059300
3	Low NDVI high variability	sky	59471	5947100
4	Medium NDVI Low variability	Dark Orange	39574	3957400
5	Medium NDVI Medium variability	Yellow	28898	2889800
6	Medium NDVI high variability	Light green	30853	3085300
7	High NDVI high variability	Green	52525	5252500
8	High NDVI Medium variability	Dark green	52512	5251200
9	High NDVI Low variability	Light Yellow	51510	5151000

Supervise Classification

Land uses map

After investigating the study area through repeated field visits, sampling, obtaining the satellite visual, conducting the wave classification process for the area and cut off the part of the study area. Also, preparing the systematic data through linear data (point - line) that was after loading Excel file in the database and collecting the spectral signatures of the types existing in the study area, which included (water bodies, buildings, vegetation cover. As well as, waterlogged or irrigated lands, the deserted uncultivated lands, railway, main and secondary roads, mountainous area, plateau) and after the supervised classification, it can explain the colors of each type.

1. The black color expresses the buildings in the study area with an area of (7728) m^2 * 100 = 772800 m^2.

2. The blue color expresses the water, water bodies and fish lakes located in the study area with an area of (2664) m^2 * 100 = 266400 m^2.

3. The dark green color expresses the

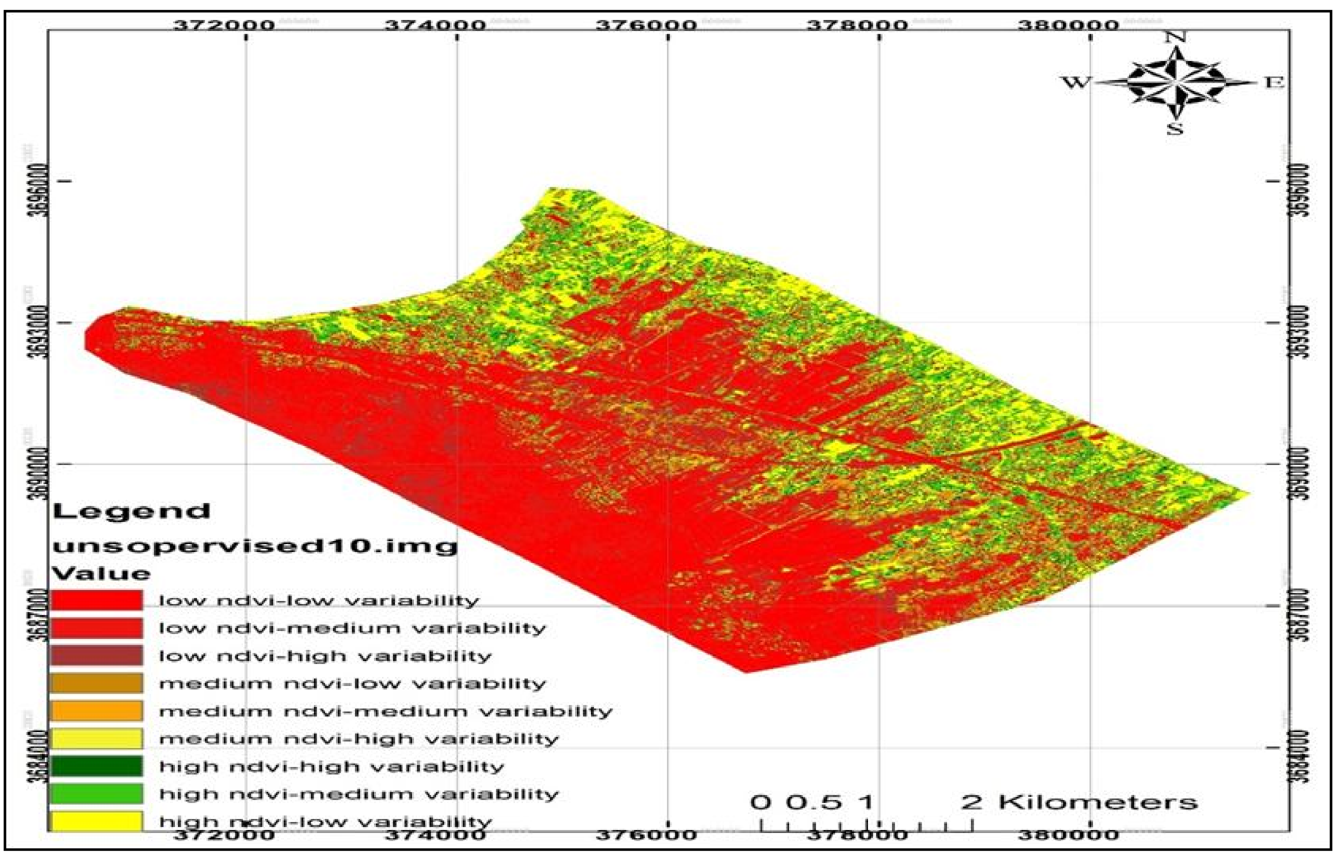

Fig. 4: Evidence of NDVI Natural Coverage for the year 2020 for the study area.

vegetation cover in the study area with an area of (115099) m^2 * 100 = 11509900 m^2.

4. The brown color expressed the irrigated or waterlogged lands with an area of (100373) m^2 * 100 = 10037300 m^2.

5. The dark red color expressed the uncultivated lands close to the agricultural fields with an area of (100306) m^2 * 100 = 10030600 m^2.

6. The yellow color expressed the areas of the plateau, which are lands that are independent agriculturally due to the presence of rocky blocks with an area of (62213) m^2 * 100 = 6221300 m^2.

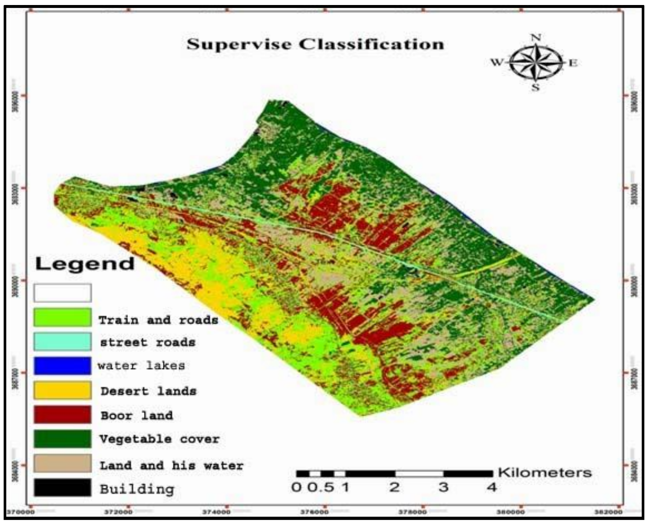

Fig. 5: Land use map.

7. The light blue color expressed the railway in the study area, as it was visible in the satellite image of the study area through the satellite visual with an area of (14584) m^2 * 100 = 1458400 m^2.

The light green color expressed the main roads in the study area with sites located close to the plateau represented by dirt quarries.

Evaluation of land suitability for cultivation:

The results indicated that the study area was divided into (5) regions according to their productive capability of wheat and citrus crops.

1. Very suitable S1: (100-85%) accounting 11.10% of the total area, with an area of 595.50 ha near the Euphrates River and was colored in dark green and was represented by the lands cultivated with fruit and vegetable crops, where these lands were planted with okra, tomato, henna, barley and jet, and some citrus trees and palms.

2. Suitable S2: (85-60%) accounting 38.77% of the total area, with an area of 2078.22 ha represented by lands that uses agriculturally containing palm groves and some vegetable crops, because of the conditions and the lack of support provided to farmers, some lands were changed to fish lakes.

3. Moderately suitable or marginally S3 (60-40%) accounting 21.20% of the total area with an area of 1136.77 ha, represented by the lands near the plateau that contain buildings, and the railway passed through it

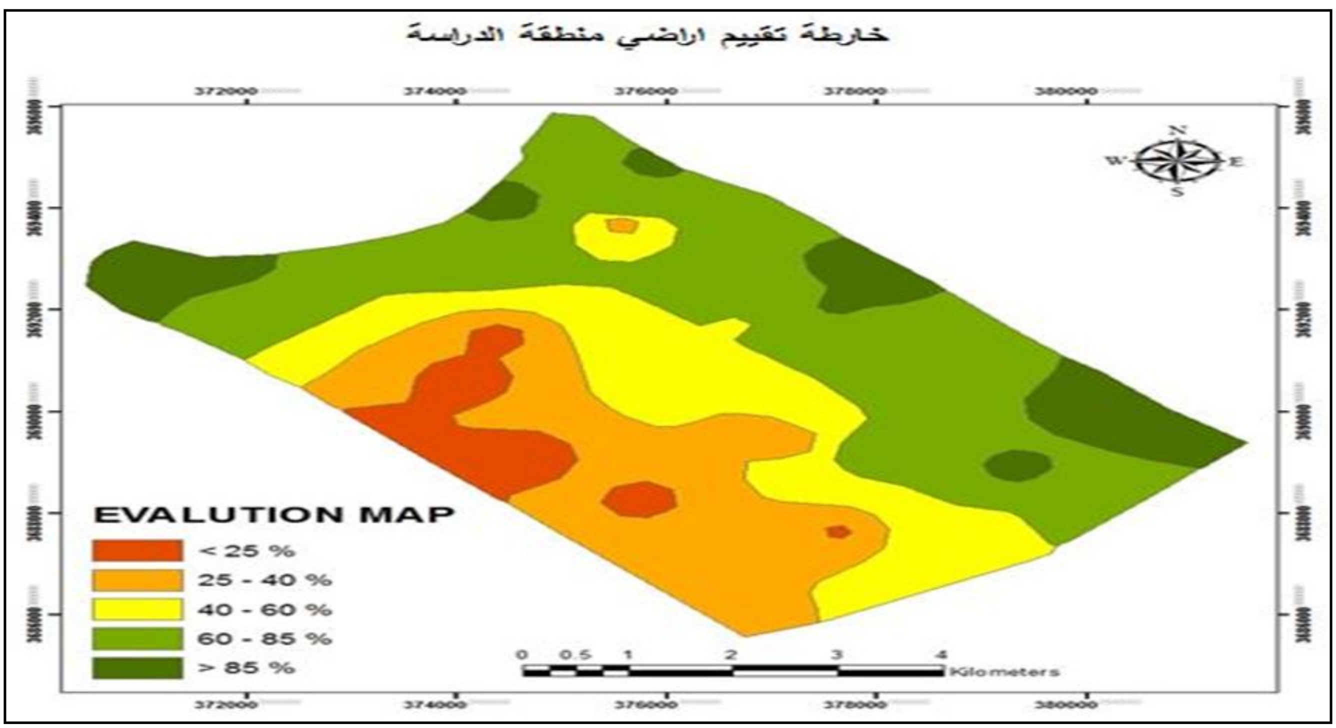

Fig. 6: A map for evaluating the lands of the study area.

Table 8: The land evaluation of the study area for the wheat crop.

P	PH	Ec	Texture	Slop %	ORG/ Caron%	CEC	Caso 4	Caco 3	E.V
P1	7.25	0.7	loam	1	0.49	22.45	0.91	.17.13	92.76 S1
	97.28	100	85	95	89.95	90	100	96.50	
P2	7.89	48.12	Sandy loam	4	0.16	12.2	5.3	32.56	28.47 N1
	86	0	50	55	0	0	80	80	
P3	7.03	0.9	Sandy loam	1	0.51	11.67	0.92	15.08	77.88 S2
	98	95.80	50	96	88.50	0	98	96.80	
P4	7.49	1.31	Sandy loam	1	0.45	22.38	0.97	17.16	88.3S1
	96.91	95.35	50	96	87.91	87	97.90	96	
P5	7.87	8.2	Sandy loam	2	0.47	20.17	3.89	17.62	83.96 S2
	87	8.3	50	86	88.80	85.95	95	96	
P6	7.19	4.09	Sandy loam	1	0.31	12.45	1.23	15.04	78.47 S2
	98	95	50	90	60	40	98	96.80	
P7	8.4	27	Sandy loam	6	0.3	20.93	7.63	35.67	24 N2
	50	0	50	10	0	86.50	61.20	62	
P8	8.4	49.21	Sandy loam	5	0.49	27.31	19.02	36.23	38.75 N1
	60	0	50	50	90	100	42.32	70	
P9	7.89	1.43	Sandy loam	5	0.39	13.14	5.45	15.78	72.25 S2
	88	97	50	87	0	0	80	96	
P10	8.3	38	Sandy loam	5	0.51	27.35	18.22	36.23	60. S3
	70	0	50	86	80	100	45	65	
S1	7.25	0.6	Loam	1	0.44	11.43	1.87	14.98	81.19 S2
	97	99	85	97	86	0	95	96.98	
	97.75	83.25	40	80	85	100	98.50	93	
S2	7.41	1.4	Sandy loam	1	0.35	23.63	4.89	15.93	77.37 S2
	96	97	50	95	0	98	87	96	
S3	7.22	11.12	Sandy loam	1	0.45	25.79	1.96	17.87	85.19 S1
	97	65	50	86	88.91	100	97.84	96.80	
S4	8.3	48.5	Loam	5	0.26	25.7	17.11	31.33	57.75 S3
	78	0	85	50	20	100	45	84	
S5	8.3	49.2	Loam sand	3.9	0.29	27.35	18.12	36.25	56.31 S3
	78	0	40	65	60	100	42.50	65	
S6	7.05	0.6	Loam	1.5	0.51	20.33	2.89	15.87	94.34 S1
	97.13	99	85	94	91.80	92.50	98.50	96.80	
S7	8.4	52.5	Sandy loam	4.9	0.16	26.82	20.92	37.19	23.75 N2
	60	0	50	58	25	100	56.90	95	
S8	7.41	1.28	Sandy loam	1.4	0.16	20.78	5.132	15.33	65.58 S2
	96	95	50	98.4	25	90.25	0	70	
S9	7.95	18.2	Loam	2.25	0.48	27.3	16.95	32.62	77.97 S2
	90	30	85	96	89.91	100	42.90	90	
S10	7.19	4.08	Loamy Sand	1	0.42	13.53	2.93	15.96	80.42 S2
	97.75	94.90	40	93.25	85.50	40	98.50	86	
S11	7.44	47.12	sandy Loam	1	0.51	13.89	2.98	13.83	59.67 S3
	96.90	0	50	95	95	40	49.50	99	
S12	7.18	1.21	Sandy. Loam	3	0.49	21.76	5.78	17.83	80.94 S2
	97.99	97.25	50	70	89.90	90	58.45	94	
S13	8.4	48.12	Loam	3.6	0.41	27.35	8.86	36.16	68.96 S3
	60	0	85	82.20	85	100	49.50	90	
S14	8.4	35	Sandy. Loam	7	0.18	14.97	9.262	36.21	21.31 N2

Table 8 Continued..........

and some major roads.

4. Currently, unsuitable N1 (25-40%) accounting 22.32% of the total area with an area of 1,196.89 ha, represented by the lands of the mountainous region or hills, and was colored in orange.

5. Permanently Not suitable N2 (0-25%) accounting 6.58% of the total area with an area of 352.89 ha of the study area represented by the plateau. As well as, some areas close to it, which extend from the edges of the study area to the Habbaniyah area and it was a barren desert lands containing large rocky blocks and due to wind erosion and lack of precipitation.

The lands classification of the study area

1- The class level for the lands of the study area

The results indicated that the study area contains (7) classes of lands according to the modern American classification system, which was referred to by Walid Al-Akidi and that the main reason for the classes variation in the study area is due to the difference and variation in the evaluation of lands from one area to another. The difference in the area topography and the variation in water sources, as the classification of land has an important role in identifying the type of land use for each land classes, and that each type has a specific use in agriculture, as the land is divided according to its uses into:

1- The first, second, third and fourth classes are preferred to be used in the cultivation of field crops in descending order.

2- The fifth and sixth classes are preferred to be used for sustainable pasture cultivation.

3- The seventh class, its best used in forests, afforestation and woodlands.

The eighth class, its best used for non-agricultural purposes.

Land Classification

Table 8 Continued..........

	50	0	50	0	0	40	0	60	
S15	8.3	22.13	Loam	4	0.3	25.43	9.35	33.12	60 S3
	70	0	85	60	45	100	50	96	
S16	7.19	8.25	Loamy Sand	3	0.44	26.42	9.39	14.62	85.68 S1
	97.75	83.25	40	80	85	100	98.50	93	
S17	8	19.3	Sandy loam	2.	0.48	27.83	16.89	32.97	64.43 S2
	88	28	10	93.50	90	100	50	80	
S18	8.4	25.07	Loamy Sand	7	0.23	14.70	8.652	39.96	20.75 N2
	50	0	40	0	0	40	0	64	
S19	7.87	13.5	Loam	3	0.37	23.5	6.36	34.23	58.87 S3
	90	58	85	80	.50	98.50	50	82	
S20	8.3	30	Loamy Sand	5	0.39	10.98	31.13	32.14	20.69 N2

Table 9: The areas of the study area according to its productive capability(evaluation).

GRD	EV	AREA	% PER
1	%25>	352.89	6.58 %
2	%40-25	1196.89	22.32 %
3	% 60 - 40	1136.77	21.20 %
4	% 85 - 60	2078.22	38.77 %
5	% 100 - 85	595.50	11.10 %

Table 8: The land classes of the study area.

P	Index	Land Classification
1	80 - 100	Land Class 1
2	70 – 80	Land Class 2
3	60 – 70	Land Class 3
4	60- 50	Land Class 4
5	50 - 40	Land Class 5
6	40 - 30	Land Class 6
7	30 - 20	Land Class 7

Class I

It includes soils with high productive capability, good drainage and ventilated soil free of stones, its texture is resistant to wind erosion and it includes soil profiles (1, 3, 5), where its productive capability was (96, 84, 86). Besides, the locations of surface samples (13, 19, 20, 22) with productive capability (86, 84, 83.5, 80) and the soils of this class had good qualities in all respects and was colored green on the map (Walid Al-Akidi).

Class II

It includes good soils that are characterized by a little slope. However, their use for agriculture by regular methods needs some transfers to avoid water erosion, and its physical composition is resistant to wind erosion and needs some drainage procedures. It was represented by five locations from the study area locations, represented by the profile locations (3) with productive capability (70.25) and the surface samples (10, 11, 21, 26) with productive capability (76, 77, 75, 72) respectively, and was colored yellow on the map.

Class III

This class needs many treatments to avoid possible rapid water erosion when subjecting it to different cultivation methods, and it includes (6) soil locations, represented by the profile location (6), where its productive capability was (65) and the surface samples (15, 16, 18, 25, 27) and was colored gray on the map.

Class IV

They were represented by the profiles locations (7, 9) respectively, with productive capability (56.29, 57) and the surface samples (14, 17, 23, 29), where its productive capability was (56, 58, 51, 54.5), respectively and represented by lands that un used agriculturally and far from water sources, almost abandoned due to being abandoned (6) years due to the latter conditions in Anbar Governorate.

Class V

It was represented by the beginnings of the plateau in the study area, and it was represented by the surface samples locations (8, 24) respectively, as it represented by the mountainous region with productive capability (44, 52.5) respectively and it was represented by the mountainous region with large stone blocks, and it was colored on the map in pink (Walid Al-Akidi).

Class VI

It was represented by the plateau region soils and another region were the second profile location (2), in which the ground water level was high with high salinity, as its productive capability was (35) and the surface sample locations (28, 12) with a productive capability (38, 5, 36) and color, and it was colored on the map in reddish-orange (Walid Al-Akidi).

Class VII:

It was represented by the surface sample location (30) that was between the plateau and the mountainous region, where its productive capability was (20) and was colored on the map in red.

Subclass capability

Soils that included within one class are classified again into subgroups and according to selected classification factors related to production and management, as the study results indicated that the lands of the study area were divided into three classes (Climate extremes...

Table 9: The lands classification of the study area.

Classification	X 10	Result	Weight	Draining	Weight	Slope	Weight	Salinity	Weight	Productive capability	P
Class3	65	6.5	0.15	5	0.15	9	0.3	4	0.4	8	S8
Class1	84.5	8.45	0.15	10	0.15	9	0.3	8	0.4	8	S9
Class1	83	8.3	0.15	8	0.15	8	0.3	9	0.4	8	S10
Class2	75	7.55	0.15	5	0.15	8	0.3	8	0.4	8	S11
Class1	80	8	0.15	10	0.15	6	0.3	8	0.4	8	S12
Class 4	58	5.8	0.15	8	0.15	6	0.3	7	0.4	4	S13
Class5	44	4.4	0.15	10	0.15	4	0.3	5	0.4	2	S14
Class3	61.5	6.15	0.15	8	0.15	9	0.3	4	0.4	6	S15
Class2	72	7.25	0.15	10	0.15	9	0.3	4	0.4	8	S16
Class3	64	6.4	0.15	8	0.15	8	0.3	4	0.4	7	S17
Class6	36.5	3.65	0.15	5	0.15	8	0.3	3	0.4	2	S18
Class4	56	5.6	0.15	10	0.15	6	0.3	4	0.4	5	S19
Class7	20.7	2. 7	0.15	5	0.15	6	0.3	4	0.4	2	S20

Table 10: The areas of the land classes in the study area.

GRIDCODE	Classification	H-AREA	%PER
1	Class 1	11.94	0.22%
2	Class 2	82.39	1.53%
3	Class 3	645.68	12.04%
4	Class 4	1399.68	26.12%
5	Class 5	1589.16	29.65%
6	Class 6	1396.30	26.05%
7	Class 7	233.24	4.35%

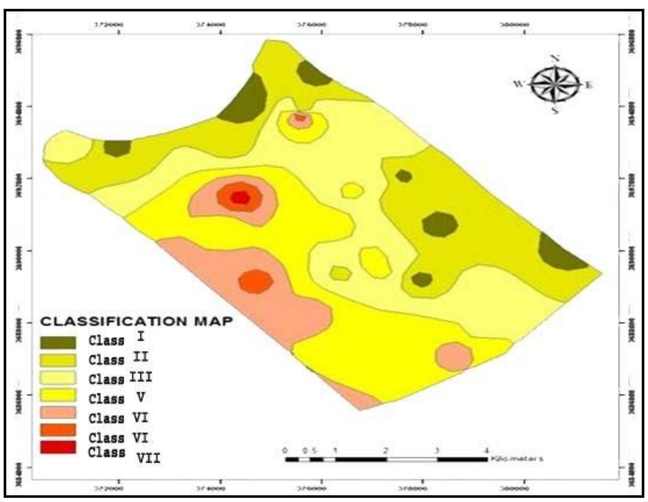

Fig. 7: Land Classification Map.

extreme cold and drought) and (Shallowness or lack of depth) and (erosion), which it symbolizes.

1. Erosion, and symbolized by the letter e.

2. Waterlogging, symbolized by the letter w.

3. Shallowness or lack of depth, symbolized by the letter s.

4. Climate extremes (cold, drought), symbolized by the letter C.

Capability unit

Land capability is an expression of how the soil is suitable for most types of field crops and it refers to units of the agricultural capability of similar types but of varying intensity of restrictions and provides information on the type of management problem or restrictions, and the capability units were divided according to a subcategory. As each category may include many different classes of soils after determining a level of subclass for specific soil and documenting its symbol, the classifier continues to divide, and classify soils into groups, parts or sub-classifiers from a level of subclass according to the same classification factors that were used at a level of sub class. However, instead of using the obstacle type, it can determine the intensity of the disobstacle ability and then use and document it, where the study results indicated that the lands of the study area were divided into (3) classes according to the intensity of obstacle:

Class IC1 Climate extremes and intensity1.

Class IIS2 Shallowness or lack of depth 2.

Class IIIe1 erosion and intensityof erosion 1.

Class V C1 Climate extremes and intensityof extremes 1.

Class VI e2 Water erosion because the lands of this class are located between agricultural lands and the mountainous region and the intensityof erosion 2.

ClassVI C2 Climate extremes and intensityof extremes 2.

Class VII e3 Wind erosion because the lands of this class are located in the plateau region and the intensityof erosion 3.

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