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GEOMORPHOLOGICAL AND PEDOLOGICAL STUDIES ON SOUTHEAST QATTARA DEPRESSION, EGYPT USING RS AND GIS

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ABSTRACT: ***Remote Sensing (RS) and GIS techniques are used in this study to identify the geomorphic units and produce the geomorphic map in addition to soil map of southeast Qattara Depression, Western Desert, Egypt. Soil classification and land evaluation for this area are also performed.***

According to the RS and GIS works, seven geomorphic units are recognized in the studied area. These units are gently undulated Low Terraces (29.0%), undulated Low Terraces (25.0%), gently undulated High Terraces (15.0 %), undulated High Terraces (17.0 %), Out Wash Plains (8.0 %), Alluvial Plains (3.0 %) and Residual Hills (4.0 %). The soils of the different geomorphic units were represented by 22 soil profiles. The soil morphological description was carried out and 65 disturbed soil samples were collected for physical and chemical analyses. The correlation between geomorphic units and their soils was carried out and then the soil map was created using the Arc- GIS 10.x software. Based on the land characteristics, the studied soils were classified up to the family level according to Soil Survey Staff (2014). These soils could be affiliated to Aridisols and Entisols orders.

The soils are evaluated according to their capability for agriculture in the current and potential situations. The results revealed that, the studied soils could be categorized into four classes namely, moderately suitable (S2), marginally suitable (S3), current not suitable (N1), and permanent not suitable (N2). The limitations affected these soils are texture, salinity & alkalinity and $CaCO_3$. The potential capability of these soils are predicted when their limitations well be remedied. Also, the suitability for cultivation four main crops namely wheat, barley, potato and olive in the studied area are assessed. The results indicated that, olive was the most suitable for growing in these soils.

***Key words:** RS, GIS, geomorphic units, soil classification, land evaluation*

INTRODUCTION

Agricultural expansion in the Western Desert outside the old valley is one of the most vital objectives in the desert areas to meet the food security requirements. Due to it's diverse characteristics of land and water resources, the Western Desert covers an area of about 68% of Egypt area. South east Qattara depression is one of the main promising areas of the Western Desert with soils and groundwater potentialities for agricultural expansion. According to the aridity index of Hulme & March (1990), the studied area is located under arid climatic condition.

Satellite remote sensing (RS) in conjunction with geographic information system (GIS), have been widely applied and recognized as a powerful and effective tools in analyzing land use categories (Ehlers *et al,* 1990; Harris & Ventura 1995 and Weng, 2001). GIS provide indispensable tools for decision makers. Both RS and GIS techniques are

considered very important geometric tools, which are fully utilized in the developing countries (Arafat, 2003). The integration of remotely sensed data, GIS and spatial statistics provides useful tools for modeling variability to predict the distribution, presence, and pattern of soil characteristics (Kalkhan *et al.,* 2000). The potential of the integrated approach in using GIS and RS data for quantitative land evaluation has been demonstrated by Martin & Saha (2009).

The aim of the current investigation is to identify the main geomorphic units and their soil taxonomic ones as well as land evaluation in some promising areas of the southeast Qattara Depression.

MATERIALS AND METHODS

Location

The area under consideration covers about 112484.0 Feddans of the Western Desert and extends between latitudes 28° 28' 14" and 28° 46' 38" N and longitude 29° 16' 38" and 29° 40' 58" E (Fig. 1) .

Meteorological properties

The climatic data of studied area indicate that the total rainfall doesn't exceed 12 mm/year. The mean minimum and maximum annual temperatures are 18.5 and 31.0 °C respectively. The lowest evaporation rate (4.0 mm/day) was recorded in January, while the highest value (12.1 mm/day) was recorded in June (CLAC, 2010).

Pre-field work:

Pre- field work was started by training on soil methodology, collection of all existing data and information on topography, geology, land resource maps, digital elevation model and satellite image about the study area. Then preliminary interpretation of image, selection of sample area and preparation of working sheets werecarried out.

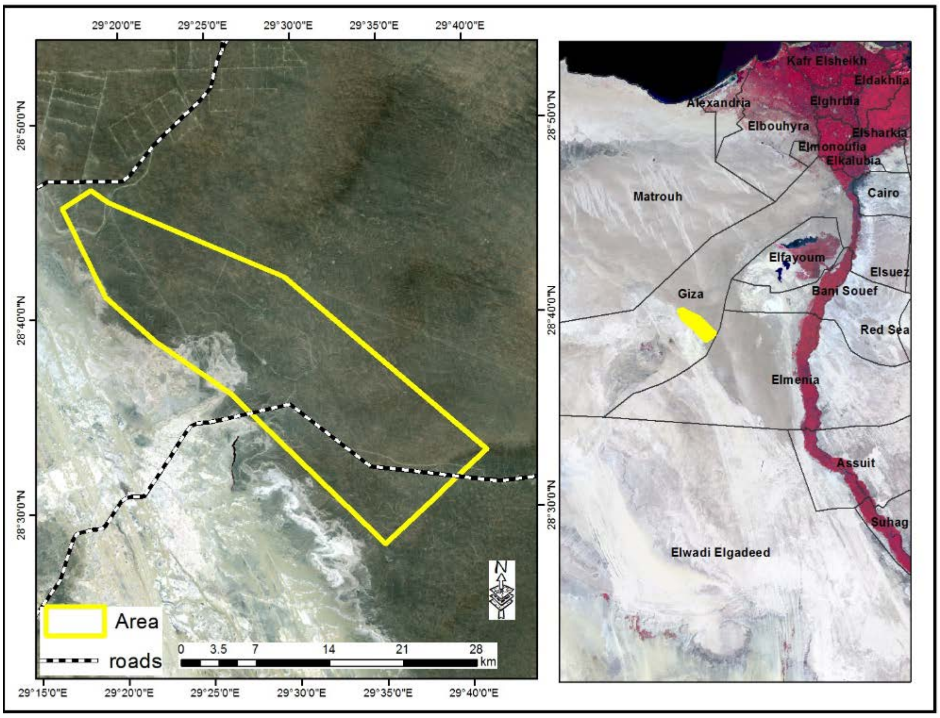

Fig (1): Location map of the studied area

Geomorphic mapping of the study area:

Topographic maps of the area with scale 1:25000 and data of sentinel 2 image taken during the April 2018 were used in this study for geomorphic mapping. The extracted data form topographic maps are contour line (Fig. 2). The geomorphology of the study area was defined throughout the following steeps.

1- Digital elevation models (DEM) of the study area (Fig. 3) have been generated from the vector contour lines.

2- Data of sentinel 2 image 2018 (Fig. 1) and digital elevation model (DEM) was used in ERDAS Imagine 2014 software to produce the geomorphic map of the study area (Dobos *et al,* 2002).

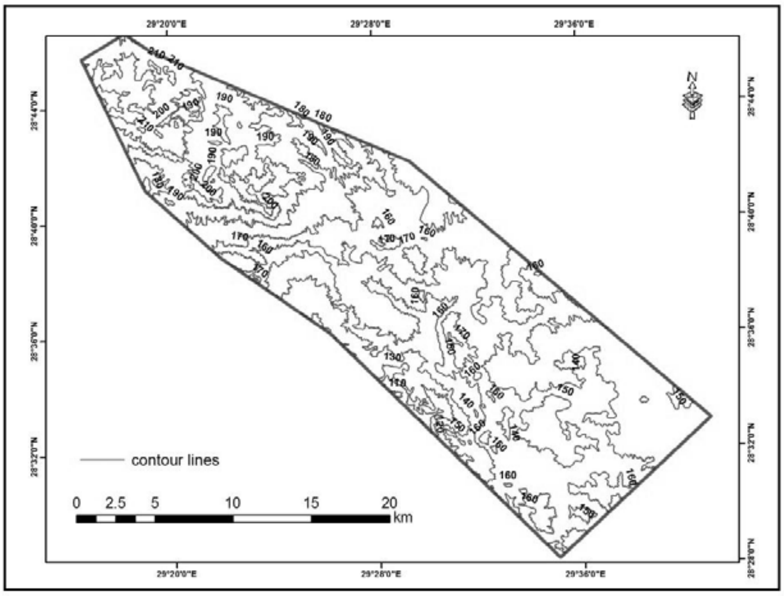

Fig (2): Contour map of the studied area

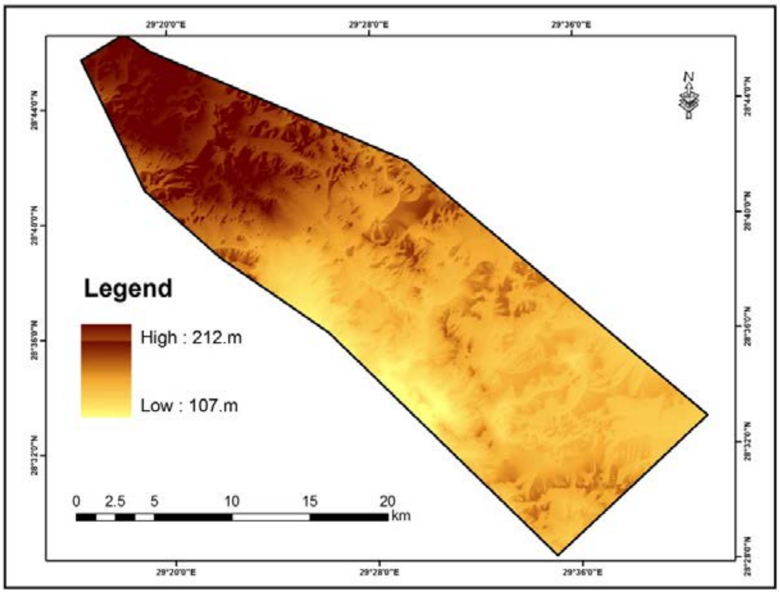

Fig (3): DEM map of the studied area

Fieldwork

The first stage includes auguring and mini pits of 100 sites in order to check the validity and accuracy of boundaries and to find out new boundaries based on fieldwork to cover all the deferent mapping units. A total number of 22 soil profiles were chosen to represent the different geomorphic units of the studied area. The soil profiles were dug to a depth of 150 cm except those limited by bedrock. The soils and profiles were morphologically described according to FAO (2006). Sixty five disturbed soil samples were collected from the studied soil profiles according to their vertical variations for Physicochemical analyses.

Laboratory analysis

The physicochemical analyses were carried out namely: particle size distribution, CaCO3, O.M, EC, soil reaction (PH) and gypsum content according to Rebecca Burt (2004).

Soil Classification

The studied soils were classified up to the family level according to Soil Survey Staff (2014).

Land Capability Evaluation:

Land capability evaluation was assessed according to FAO (1985), Sys and Verheye (1978) and Sys *et al.* (1991) as soil suitability for agriculture according to the following equation:

$$Ci = \frac{t}{100} \times \frac{w}{100} \times \frac{s_1}{100} \times \frac{s_2}{100} \times \frac{s_3}{100} \times \frac{s_4}{100} \times \frac{n}{100} \times 100$$

Where:

Ci=Capability index (%)	S_2 = Soil depth
t = Slope	S_3 = $CaCO_3$ content
w=Drainage conditions	S_4= Gypsum content
S_1 = Texture	n=Salinity and alkalinity

Capability classes are defined according the values of the following index:

Capability classes		index (CI) %
highly suitable	S1	> 75
moderately suitable	S2	75-50
marginally suitable	S3	50-25
not suitable	N	< 25

Land suitability evaluation for specific main crops.

The suitability of the studied soils for four main crops namely, wheat, barley, potato and olive was evaluated in the current and potential situations according to Sys *et. al,* (1993) by implementing the FAO Framework for Land Evaluation (FAO, 1976 b). Soil characteristics of the different mapping units were compared and matched with the requirements of each crop. The suitability maps were produced.

RESULTS AND DISCUSSION

Geomorphology of the studied area

The geomorphology of the studied area has been studied based on sentinel-2 image taken during April 2018, digital elevation model (DEM), topography and field check. Accordingly, seven geomorphic units were identified namely, gently undulated Low Terraces, undulated Low terraces, gently undulated High terraces, undulated High Terraces, Out Wash Plains, Alluvial Plains, and Rock out crop Hills. These units and the location of their representative soil profiles are presented in Table (1) and Fig. (4). as shown in the following discussion.

Soil Characteristics of the Studied Geomorphic Units

The soil characteristics of the studied geomorphic units are presented in Table (2) and could be discussed as follows:

1- Gently undulated Low Terraces

The areas of this unit are located at the northern and northeastern part of the studied area having about 32152.0 Feddans (29% of the studied area).This unit is represented by six profiles (1, 2, 3, 4, 5 and 6).

The upper surfaces of these terraces have a gently undulated relief affected by wind action which forming a desert pavement phenomenon composed of different size of gravels. The analytical data in Table (2) showed that, the soil depth ranged between 95 and 130 cm. These soils have loamy sand to sandy loam texture with 70.5 to 83% sand fraction. These soils are non-saline to strongly saline with ECe values between 0.98 and 40.4 dSm^{-1}. These soils have slightly to moderately alkaline reaction indicating from their pH values that varied between 7.64 to 8.47. $CaCO_3$ content varied from 3.79 to 24.4 %. Gypsum content is ranged between 1.3 and 15.8 %. ESP values are ranged between 1.07 and 37.71%. The highest ESP values are found in profiles 1 and 3 indicating sodic action.

Table (1): Geomorphology and units of the studied area.

Landscape	Relief	Geomorphic units	Code	Area		
				Feddan	km^2	%
Plateau PU	Gently undulating	Low Terraces	PU111	32152	135.0	28.6
		High Terraces	PU112	16962	71.2	15.1
	Undulating	Low Terraces	PU121	28643	120.3	25.5
		High Terraces	PU122	18877	79.3	16.8
Alluvial Plain AP	Almost flat to gently undulating	Out Wash Plains	AP111	8503	27.6	7.6
	Gently undulating	Alluvial Plains	AP121	3392	14.2	3.0
Residual hills Hi	Hills	Rock out crop Hills	Hi111	3955	24.8	3.5
Total				112484.0	472.4	100.0

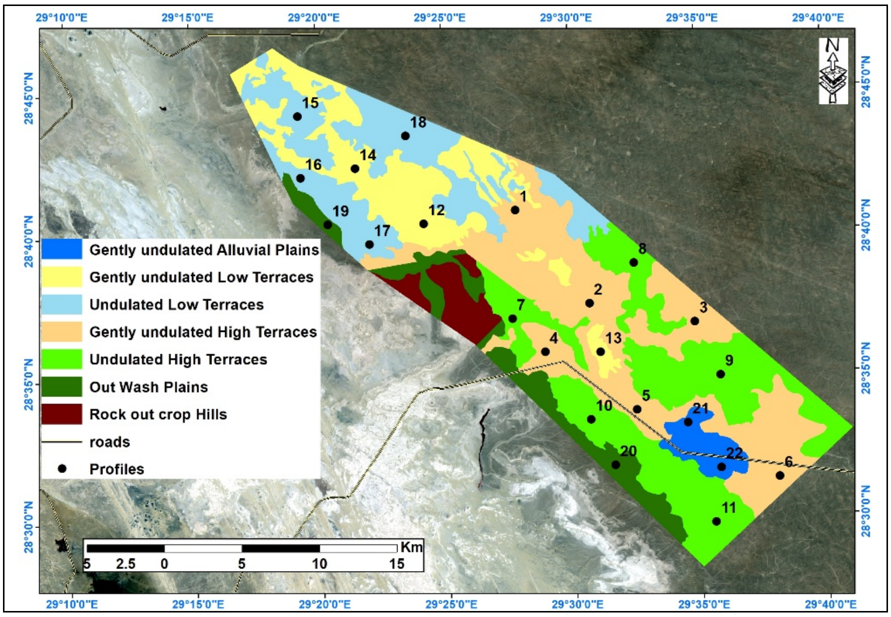

Fig (4): Geomorphic map of the studied area.

Table (2): Some physical and chemical properties of the studied soils.

Profile No	Depth (cm)	pH	EC dSm^{-1}	Sand (%)	Silt (%)	Clay (%)	Texture class	$CaCO_3$ (%)	Gypsum (%)	ESP (%)
	Gently undulated Low Terraces									
1	0-20	7.85	25.8	73.0	22.0	5.0	Sandy Loam	7.59	5.10	37.71
	20-65	7.79	40.4	73.0	23.0	4.0	Sandy Loam	17.34	6.50	22.87
	65-120	7.93	20.6	74.0	20.0	6.0	Sandy Loam	23.45	4.60	24.56
2	0-25	8.05	0.98	73.0	23.0	4.0	Sandy loam	8.41	1.30	1.07
	25-65	7.99	2.84	72.0	20.5	7.5	Sandy loam	6.90	4.30	3.20
	65-120	7.79	5.84	73.0	21.1	6.0	Sandy loam	3.79	3.40	6.35
3	0-30	7.99	5.69	80.0	13.0	7.0	Loamy Sand	6.4	4.50	6.60
	30-60	8.1	8.85	76.0	16.0	8.0	Loamy Sand	6.8	10.40	13.33
	60-130	8.05	22.2	78.0	15.0	7.0	Loamy Sand	6.1	15.60	26.65
4	0-20	8.22	16.66	73.0	20.0	7.0	Sandy loam	7.40	2.40	15.14
	20-65	8.47	3.11	72.0	22.1	6.0	Sandy loam	5.80	5.20	2.75
	65-120	8.17	11.92	73.0	22.0	5.0	Sandy loam	5.40	5.40	15.66
5	0-30	8.01	6.56	72.0	17.7	10.3	Sandy loam	5.40	3.60	5.97
	30-70	8.04	7.94	72.4	17.3	10.3	Sandy loam	6.30	6.20	6.19
	70-95	8.05	8.71	70.5	19.9	9.6	Sandy loam	6.20	9.40	5.62
6	0-25	7.64	4.36	82.0	10.0	8.0	Loamy Sand	6.15	1.30	5.04
	25-70	7.75	9.1	83.0	12.0	5.0	Loamy Sand	15.41	2.40	7.58
	70-105	7.77	13.76	81.0	9.5	9.5	Loamy Sand	24.40	1.60	9.70
	Undulated Low Terraces									
7	0-20	7.72	25.50	82.0	10.0	8.0	Loamy sand	3.60	3.20	30.20
	20-50	7.54	25.10	83.0	12.0	5.0	Loamy sand	3.50	1.40	28.45
	50-110	8.10	5.35	81.0	9.5	9.5	Loamy sand	4.20	3.20	0.90
8	0-25	7.90	1.05	72.0	20.0	8.0	Sandy loam	6.00	1.40	1.61
	25-65	7.81	0.87	71.0	19.5	9.5	Sandy loam	9.60	2.10	0.98
	65-120	7.99	2.06	72.0	20.5	7.5	Sandy loam	9.80	2.40	1.20
9	0-30	8.12	2.71	90.3	5.3	4.4	Sand	4.0	1.40	10.85
	30-75	8.33	0.79	90.1	5.3	4.6	Sand	4.1	2.50	1.83
	75-120	8.17	4.75	90.0	5.4	4.6	Sand	4.3	2.40	23.85
10	0-20	8.10	1.49	80.4	12.0	7.6	Loamy Sand	7.2	2.10	5.78
	20-60	8.05	0.68	89.2	5.9	4.9	Sand	15.3	1.50	11.33
	60-110	8.33	4.08	90.3	5.8	3.9	Sand	15.6	3.40	13.66
11	0 - 30	7.90	9.81	91.0	6.0	2.0	Sand	5.00	3.60	16.89
	30 - 70	7.91	8.58	92.0	5.0	3.0	Sand	3.60	6.40	14.87
	70 - 95	7.94	9.23	91.1	4.7	4.2	Sand	4.00	9.70	15.08
	Gently undulated High Terraces									
12	0-25	8.18	5.81	80.00	17.50	2.50	Loamy sand	7.60	2.5	2.85
	25-50	8.15	11.52	90.80	4.90	4.30	Sand	3.20	8.4	10.74
	50-105	8.15	10.30	90.00	8.00	2.00	Sand	7.90	7.50	8.20
13	0-20	7.85	0.87	75.00	15.00	10.00	Sandy loam	14.80	3.10	1.04
	20-50	7.94	1.37	70.00	20.00	10.00	Sandy loam	19.20	9.60	2.78
	50-120	7.90	1.05	70.00	18.00	12.00	Sandy loam	25.60	7.40	1.61
14	0-20	8.11	2.56	83.00	12.00	5.00	Loamy sand	5.6	2.40	4.18
	20-70	7.91	3.36	83.00	10.00	7.00	Loamy sand	15.2	8.60	5.51
	70-105	7.94	6.96	83.00	12.00	5.00	Loamy sand	15.4	7.40	6.32

Table (2): Cont.

Profile No	Depth (cm)	pH	EC dSm^{-1}	Sand (%)	Silt (%)	Clay (%)	Texture class	$CaCO_3$ (%)	Gypsum (%)	ESP (%)
	Undulated High Terraces									
15	0-30	8.28	8.72	64.94	19.04	16.02	Sandy loam	8.62	1.30	17.42
	30-75	8.16	15.34	65.88	18.47	15.65	Sandy loam	6.90	3.20	23.28
	75-110	8.16	20.10	61.50	28.00	10.50	Sandy loam	5.17	4.20	21.21
16	0-30	8.40	5.36	81.04	11.38	7.58	Loamy Sand	8.00	1.70	2.23
	30-65	7.60	13.03	81.00	11.00	8.00	Loamy Sand	7.60	7.80	13.05
	65-130	7.70	12.50	81.00	11.50	7.50	Loamy Sand	7.20	8.6	16.33
17	0-25	8.76	2.41	74.00	20.00	6.00	Sandy Loam	4.10	2.40	4.59
	25-55	8.10	2.88	82.00	10.00	8.00	Loamy Sand	4.83	8.40	0.49
	55-120	8.05	4.16	82.00	10.50	7.50	Loamy Sand	5.17	12.60	1.48
18	0-15	8.40	6.70	83.00	12.00	5.00	Loamy Sand	6.90	2.10	2.20
	15-40	7.84	16.25	83.00	10.00	7.00	Loamy Sand	3.40	7.50	15.48
	40-90	8.06	19.29	83.00	12.00	5.00	Loamy Sand	5.60	9.60	47.61
	Out Wash Plains									
19	0-20	8.01	7.41	73.00	23.00	4.00	Sandy loam	6.55	4.50	13.14
	20-60	8.03	18.29	72.00	20.50	7.50	Sandy loam	6.54	9.70	20.71
	60-110	7.84	12.71	73.00	21.10	6.00	Sandy loam	4.00	7.60	17.22
20	0-25	8.06	3.72	83.00	12.00	5.00	Loamy Sand	12.80	3.4	1.49
	25-105	7.41	11.17	83.00	13.00	4.00	Loamy Sand	22.40	8.70	9.22
	Alluvial Plains									
21	0-35	7.81	0.72	82.00	10.50	7.50	Loamy sand	6.4	3.20	2.12
	35-65	8.31	6.12	82.00	10.00	8.00	Loamy sand	4.0	8.70	5.98
	65-120	7.72	2.68	81.00	11.00	9.00	Loamy sand	3.2	4.20	4.67
22	0 - 20	7.87	4.09	82.00	10.00	8.00	Loamy Sand	6.15	1.30	5.49
	20 - 50	7.89	36.40	82.00	10.50	7.50	Loamy Sand	6.25	6.80	7.60
	50 - 90	7.87	6.43	90.80	4.90	4.30	Sand	8.60	5.40	6.40

2- Undulated Low Terraces

The areas of this unit are located at the northern and northeastern part of the studied area having low elevation and clearly undulated relief. This unit is represented by five profiles (7, 8, 9, 10 and11) and covered about 28643.0 Feddans (25.0 % of the studied area).

The soil surfaces have a desert pavement phenomenon composed of small to medium gravels. The analytical data in Table (2) showed that, the depth of soils is ranged from 95 to120 cm. The soils have sand to sandy loam texture. These soils are non-saline to strongly saline indicating from their ECe values that ranged between 0.87 and 25.5 dSm^{-1}. Soil pH varied from 7.54 to 8.33 indicating slightly to moderately alkaline reaction. $CaCO_3$ content varied from 3.5 to 15.6 %. Gypsum content is ranging between 1.4 and 9.7 %. The soils of this unit have a relatively high ESP values > 15% in profiles 7, 9 and 11 indicating a sodicty effect.

3-Gently undulated High Terraces:

The areas of this unit are located at the northern and northwestern part of the studied area with relatively higher elevation than that of Low Terraces and covered about 16962 Feddans (15.0% of the studied area). The soils surfaces have gently undulating relief covered with

desert pavement phenomenon composed of medium to coarse gravels. This unit is represented by three profiles (12, 13 and 14).

The analytical data in Table (2) showed that, the soils have a depth ranging from 105 to120 cm. These soils have sand to sandy loam texture. They are non-saline to moderately saline, where the ECe values ranged between 0.87 and 11.52 dSm^{-1}. Soil pH varied from 7.90 to 8.18 indicating slightly to moderately alkaline reaction. Calcium carbonate content varied from 3.2 to 25.6% and increased with depth. Gypsum content is ranged between 2.5 and 9.6 %. ESP values are < 15% indicating no sodicty effect.

4- Undulated High Terraces

The areas of this unit are located at a high elevation of the northern and northwestern part of the studied area having about 18877.0 Feddans (17. 0 % of the studied area). This unit is represented by four profiles (15, 16, 17 and 18). Such terraces are composed of coarse gravels in upper surfaces. The soil surfaces have a particularly undulating relief, desert pavement phenomenon composed of many medium to coarse gravels and Aeolian deposits.

The analytical data in Table (2) indicated that, the depth of soils is ranged between 90 and 130 cm. The dominant soil texture is loamy sand that having 61.5 to 83% sand fraction. These soils are slightly to highly saline, where the ECe values ranged between 2.41 and 20.10 dSm^{-1}. Soil pH varied from 7.6 to 8.40 indicating slightly to moderately alkaline reaction. $CaCO_3$ content varied from 3.4 to 8.62 %, without clear trend with depth. Gypsum content is ranged between 1.3 and 12.6 %, with increasing trend with depth. ESP values are > 15% in some horizons of profiles 15, 16 and 18 indicating sodicity effect.

5- Out wash plains

The areas of this unit are located at a relatively lower elevation than that of the other soil units in the southern and southwestern part of the studied area covering about 8503 feddans (8.0% of the studied area). This unit is represented by two profiles (19 and 20).

The soils surfaces have a particularly almost flat to gently undulating relief. Table (2) indicated that, the soils depths are ranging from 105 to 110 cm. These soils have loamy sand to sandy loam texture. These soils are slightly to moderately saline indicating from their ECe values that ranged between 3.72 and 18.92 dSm^{-1}. Soil pH is ranged between 7.41 and 8.03 indicating slightly alkaline reaction. Calcium carbonate varied from 4.0 to 22.40 %. Gypsum content is ranged between 3.4 and 9.7 %. The soils of profile 19 have ESP values > 15% indicating sodicity effect.

6- Alluvial Plains

Alluvial Plains are located at the southern part of the studied area with a relatively low elevation and covering about 3392.0 Feddans (3.0% of the studied area). This unit is represented by two profiles (21 and 22).

The soils have gently undulating relief. The analytical data in Table (2) show that, the soils depths are ranging from 90-120 cm. These soils have mostly loamy sand texture. These soils are slightly to extremely saline indicating from their ECe values that ranged between 0.72 and 36.40 dSm^{-1}. The pH values are varied from 7.72 to 8.31 indicating slightly alkaline reaction. Calcium carbonate contents varied from 3.2 to 8.60 %. Gypsum content is ranged between 1.3 and 8.7 %. These soils have ESP values < 15%.

7- Rock out crop Hills

The areas of this unit have a hilly relief and cover about 3955.0 Feddans (4.0% of total investigated area).

Soil Classification:

Based on the meteorological data, morphological, physical and chemical characteristics, the studied soils were classified up to the family level according to Soil Survey Staff (2014) as presented in Table (3) and Fig (5). Some of these soils haven't any diagnostic horizons and therefore are classified into Entisols order. Most of these soils showed the features of Calcic, Gypsid, Salid and/or Natric horizons and therefore are classified under Aridisols. The soil classification could be summarized as follows:

1- Gently undulated Low Terraces

A Calcic horizon could be recognized in the soil of profile 1. A Gypsic horizon could be found in all profiles except profiles 2 and 6. Accordingly the soils of this unit could be classified as Gypsic Haplosalids (profile 1), Typic Torriorthents (profile 2), Sodic Haplogypsids (profiles 3 and 4), Typic Haplogypsids (profile 5), and Typic Haplocalcids (profile 6).

2- Undulated Low Terraces

A Calcic horizon could be noticed in the soil of profile10. A Gypsic horizon could be found in profile 11. Accordingly the soils could be classified as Typic Torriorthents (profiles 7 and 8), Typic Quartzipsamment (Profile 9), Typic Hapocalcids (profile 10) and Sodic Haplogypsids (profile 11).

3- Gently undulated High Terraces

A calcic horizon could be noticed in the soils of profiles13 and 14. A gypsic horizon could be found in all soil profiles. These soils could be classified as Typic Hapogypsids (profile 12) and Typic Calcigypsids (profiles 13 and 14).

Table (3): Classification of profiles represented the studied soils.

Order	Sub order	Great group	Sub great group	Family	Profile No
Aridisols	Salids	Haplosalids	Gypsic Haplosalids	Coarse loamy, mixed, hyperthermic.	1
				Sand, mixed, hyperthermic.	22
	Clcids	Haplocalcids	Typic Haplocalcids	Sand , mixed, hyperthermic	6 and10
	Gypsids	Haplogypsids	Sodic Haplogypsids	Coarse loamy, mixed, hyperthermic.	4 and 19
				Sand, mixed, hyperthermic.	3,11, 16 and 18
			Typic Haplogypsids	Coarse loamy, mixed, hyperthermic.	5
				Sand, mixed, hyperthermic.	17
				Sand, mixed, hyperthermic.	12 and 21
		Calcigypsids	Typic Calcigypsids	Coarse loamy, mixed, hyperthermic.	13
				Sand, mixed, hyperthermic.	14 and 20
Entisols	Orthents	Torriorthents	TypicTorriorthents	Sand , mixed, hyperthermic	7
				Coarse loamy, mixed, hyperthermic.	2, 8 and 15
	Psamments	Quartzipsamment	Typic Quartzipsamment	Sand, Siliceous, hyperthermic.	9

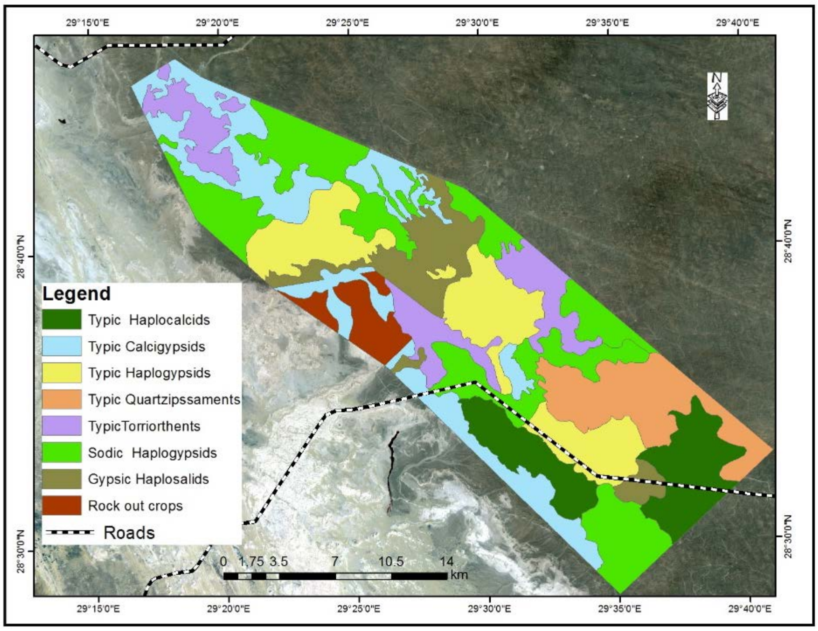

Fig (5): Soil classification map of the studied area.

4- Undulated High Terraces

A Gypsic horizons could be identified in the soils of all profiles except profile 15. These soils are classified as Typic Torriorthents (profile 15), Sodic Haplogypsids (Profiles 16 and 18), and Typic Haplgypsids (profile 17).

5- Out wash plains

A Calcic horizon could be noticed in profile 20. Also, a Gypsic horizon could be found in the studied soil profiles of this unit. These soils are classified as Sodic Haplogypsids (profile 19) and Typic Calcigypsids (profile 20).

6- Alluvial Plains

The soils of this unit are classified as Typic Haplogypsids (profile 21) and Gypsic Haplosalids (profile 22).

Land Evaluation

The land evaluation was performed to estimate both of the land suitability for agriculture (land capability) according to Sys *et al.* (1991) as well as the suitability for growing certain four major crops in the studied soils according to Sys *et al.* (1993).

I Land suitability for agriculture

The land capability was performed as land suitability for agriculture in the current land situation as well as in the potential situation that could be resulted after executing major land improvements to correct or reduce the severity of limitations exiting in the studied area. The ratings of characteristics, suitability indexes (Ci) for the soils representing studied geomorphic unites were calculated for their current (Cs) and potential situations (Ps) as shown in Table (4).

1- Current land capability

Current land capability refers to the capability of soils in their present situation without major improvement (FAO, 1976). It may refer to the present use of land, either with existing or improved management practices, or to a different use. The current capability of the soils in the studied area was estimated as land suitability for

agriculture according the system outlined by Sys *et al.* (1991). Table (4) and Fig (6) present the ratings of soil characteristics as well as the capability indexes (Ci) and classes in the current and potential situation of studied area.

Data in Table (4) indicate that, the studied soils could be affiliated to two orders (S and N) and four classes (S2, S3, N1 and N2) as shown in Fig (6). The characteristics of these classes could be given as follows:

Table (4): Ratings of soil characteristics as well as the capability indexes (Ci) and classes in the current (CS) and potential (PS) situations of studied area.

Profile No.	Topography (t)		Wetness (w)		Soil Physical Characteristics					Salinity/ alkalinity (n)		Current Capability		Potential Capability	
					Depth (S1)	Texture (S2)		Lime (S3)	Gypsum (S4)						
	CS	PS	CS	PS		CS	PS			CS	PS	Ci	Class	Ci	Class
Gently undulated Low Terraces															
1	95	100	100	100	100	75	90	80	95	50	100	27.1	S3	68.4	S2
2	95	100	100	100	100	75	90	95	95	100	100	64.3	S2	81.2	S1
3	95	100	100	100	100	75	90	93	85	50	100	28.2	S3	71.1	S2
4	95	100	100	100	100	75	90	95	95	80	100	51.4	S2	81.2	S1
5	95	100	85	100	90	75	90	95	95	85	100	41.8	S3	73.1	S2
6	95	100	95	100	95	75	90	90	100	80	100	46.3	S3	77.0	S1
Undulated Low Terraces															
7	90	100	95	100	95	75	90	100	100	55	100	33.5	S3	85.5	S1
8	90	100	100	100	100	75	90	90	100	100	100	60.8	S2	81.0	S1
9	90	100	100	100	100	60	80	100	100	100	100	54.0	S2	80.0	S1
10	90	100	95	100	95	60	80	85	100	100	100	41.4	S3	64.6	S2
11	90	100	85	100	80	60	80	100	95	80	100	27.9	S3	60.8	S2
Gently undulated High Terraces															
12	95	100	85	100	95	60	80	93	95	80	100	32.5	S3	67.1	S2
13	95	100	100	100	100	75	90	75	95	100	100	50.8	S2	64.1	S2
14	95	100	85	100	95	75	90	85	95	95	100	44.1	S3	69.0	S2
Undulated High Terraces															
15	90	100	95	100	95	75	90	93	95	50	100	26.9	S3	75.5	S1
16	90	100	100	100	100	75	90	92	95	60	100	35.4	S3	78.7	S1
17	90	100	100	100	95	75	90	100	95	95	100	57.9	S2	81.2	S1
18	90	100	80	100	80	75	90	95	95	45	100	17.5	N1	65.0	S2
Out wash plains															
19	100	100	90	100	95	75	90	95	95	50	100	28.9	S3	77.2	S1
20	100	100	85	100	95	75	90	75	95	75	100	32.4	S3	60.9	S2
Alluvial Plains															
21	95	100	100	100	100	75	90	100	95	100	100	67.7	S2	85.5	S1
22	95	100	80	100	90	75	90	93	95	45	100	20.4	N1	71.6	S2

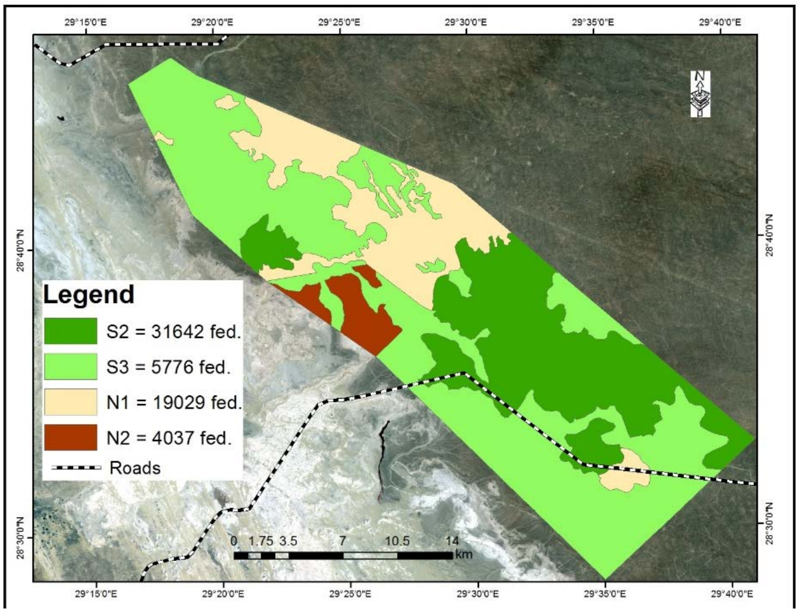

Fig (6): Current capability classes map.

S2: This class includes soils having a moderately land suitability for agriculture with index values ranged from 50.8 to 67.7% and occupies an area of about 31642.0 Feddans (28% of the studied area). These soils have a moderate intensity of topography, texture and a slightly intensity of salinity and CaCO3.

S3: This class includes soils having a marginally land suitability for agriculture with index values ranged from 26.9% to 46.3% and occupies an area about 57776.0 Feddans (51% of studiedl area). These soils have a moderate intensity of profile depth, texture, topography and salinity and alkalinity.

N1: This class includes soils currently not suitable for agriculture having index values ranged from 17.5 to 20.4% and occupies an area of about 19029 Feddans (17% of the studied area). These soils have sever intensity of salinity and texture as well as moderately intensity of topography, lime, and gypsum, and include two sub classes namely N1twsn and N1tsn.

N2: This class includes rocky land permanent not suitable for agriculture and occupies an area of about 4037 Feddans (4% of total area).

2- Potential land capability

Specific land improvements are required to correct or reduce the severity of limitations exiting in soils of the studied area such as ; Leveling undulated surfaces of high and low land areas, modern irrigation systems (drip and sprinkler) to save irrigation water and prevent the rise of ground water table, leaching of salinity and reclamation of alkalinity, using organic and green manures as well as soil conditioners to increase soil fertility and improve the physical and chemical soil properties.

Potential land capability classes of studied soils presented in Table (4) and illustrated in Fig (7) indicated that, these soils could be classified into three classes (S1, S2, and N2) as follows:

S1: This class could be included the soils having capability index values ranged from 75.5% to 85.5% and covered an area about 47687 Feddans (41% of the studied area). The rise of capability index values of these soils could be resulted from

the land leveling and leaching of their high salinity.

S2: This class could be included the soils having a moderately suitable with capability index values ranged from 60.8 to 73.1% and covered 60759 Feddans (54% of total studied area). These soils have slight intensity of texture, lime and gypsum.

II Land suitability for specific main crops

Land suitability for four main crops namely, wheat, barley, potato and olive was estimated in the studied soils using Arc GIS 10.x software. The results were imported to Arc GIS to produce the crops suitability maps. Soil characteristics of the different mapping units were compared and matched with the requirements of each crop (FAO, 1976 b). The matching led to estimate the current and potential suitability for each crop using the parametric approach and land index as mentioned by Sys *et. al.* (1993). The results are illustrated in Tables (5 and 6) and Figs (8 to 12).

Current crops suitability

Data in Table (5) and Figs (8, 10 and 12) indicated that, 28.13% of the studied soils are highly suitable (S1) for growing olive. Also, 51.36% and 28.13 % of the studied soils are moderately suitable (S2) for growing olive and potato respectively. On the other hand, 28.13% of these soils are marginally suitable (S3) for growing wheat and Barley.

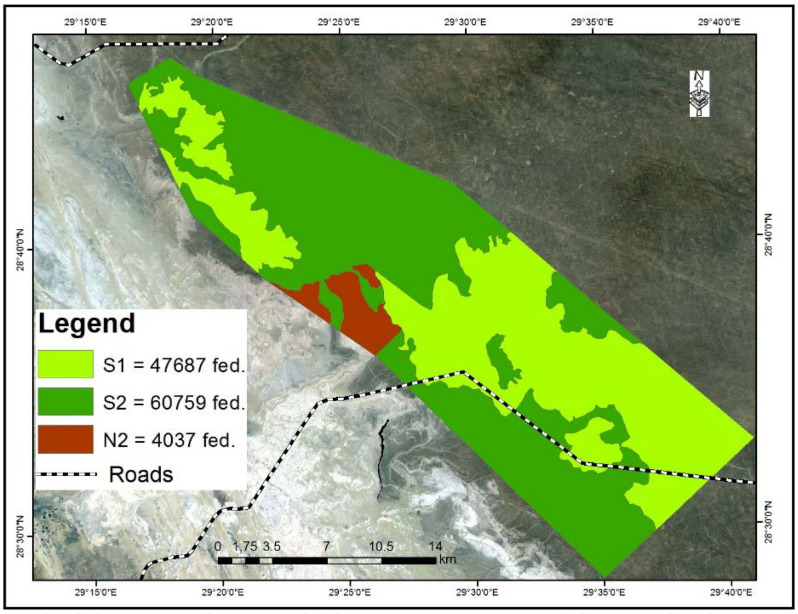

Fig (7): Potential capability classes map of the studied area

Table (5): Areas % of current suitability classes for growing crops in the studied soils.

Suitability class*	Wheat	Barley	Potato	Olive
S1	------	------	------	28.13 %
S2	------	------	28.13 %	51.36 %
S3	28.13 %	28.13 %	------	------
N1	68.31 %	68.31 %	68.31 %	------
N2	3.56 %	3.56 %	3.56 %	20.51 %
Total	100 %	100 %	100 %	100 %

* S_1 = highly suitable, S_2 = moderately suitable S_3= marginally suitable
N_1= currently not suitable N_2=permanently not suitable

Table (6): Areas % of potential suitability classes for growing crops in the studied soils

Suitability class*	Wheat	Barley	Potato	Olive
S1	------		28.13 %	28.13 %
S2	79.49 %	79.49 %	51.36 %	51.36 %
S3	16.95 %	16.95 %	16.95 %	------
N1	------	------	------	------
N2	3.56 %	3.56 %	3.56 %	20.51 %
Total	100 %			100 %

* S1 = Highly suitable, S2 = Moderately suitable S3= Marginally suitable
N1= Currently not suitable N2=Permanently not suitable

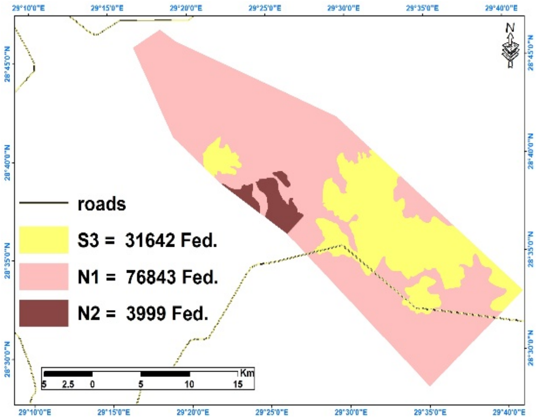

Fig (8): Current land suitability for growing wheat and barley in the studied area.

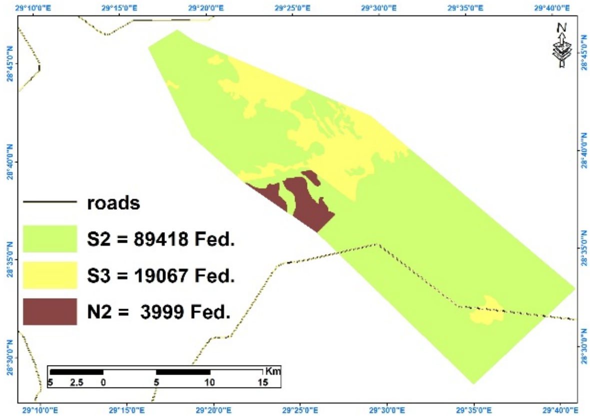

Fig (9): Potential land suitability for growing wheat and barley in the studied area.

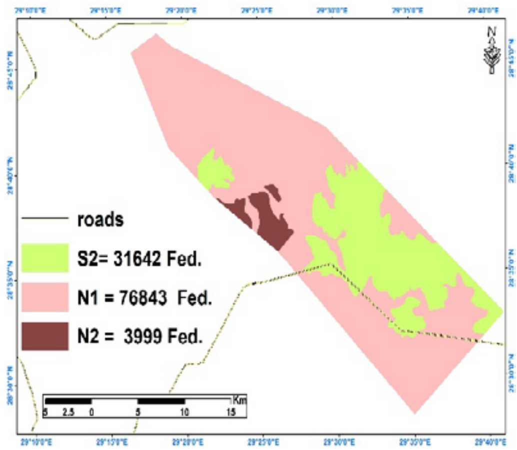

Fig (10): Current land suitability for growing potato in the studied area.

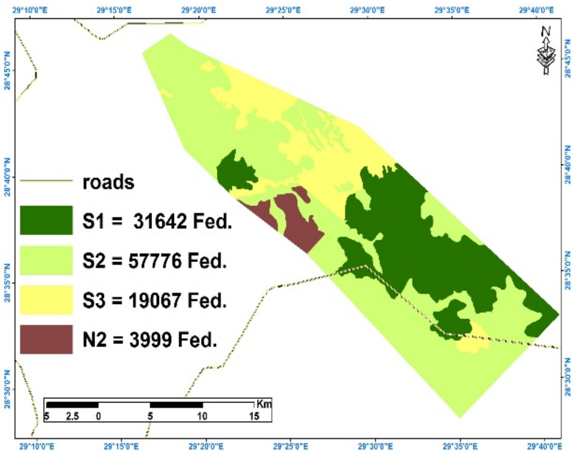

Fig (11): Potential land suitability for growing potato in the studied area.

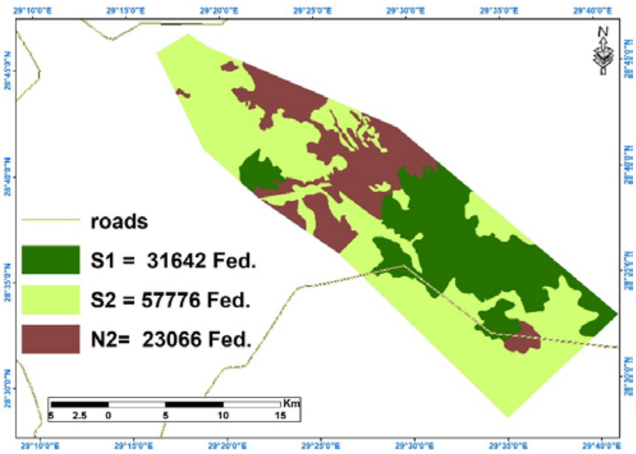

Fig (12): Current and potential land suitability for growing olive in the studied area.

Potential suitability

The main limiting factors affect the studied soil suitability for growing the specific crops were texture and salinity. These limiting factors can be improved using good management practices such as salt leaching, organic matter amendments, construction of a good drainage system and follow good agriculture practices for crops. These improvements could be developed the potential suitability of these crops for growing in the studied soils.

The results of potential suitability of these crops presented in Table (6) and Fig (9, 11 and 12) show that, 79.49 % of the studied area could be moderately suitable (S2) for wheat and barley. While an area of about 51.36 % could be moderately suitable (S2) for potato and olive.

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دراسات جيومورفولوجية وبيدولوجية لمنطقة جنوب شرق منخفض القطارة – مصر باستخدام الاستشعار من البعد ونظم المعلومات الجغرافية

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الملخص العربي

تهدف الدراسة الي استخدام صور الاقمار الصناعية ونظم المعلومات الجغرافية لانتاج الخريطه الرقمية وتصنيف القدره الانتاجية للأراضي الواقعه علي طريق سمالوط –الواحات البحرية بمحافظة المنيا يالصحراء الغربية ، وقد تم تحقيق هذا الهدف باستخدام صور الأقمار سينتال والمصوره عام (٢٠١٨) والنظام ثلاثي الابعاد لمنطقة الدراسة لتحديد الوحدات الجيومورفولوجية لمنطقة الدراسة ، ولقد اختير ٢٢ قطاعاً أرضياً لتمثيل هذه الوحدات ، ولقد وصفت هذه القطاعات الأرضية وصفاً مورفولوجياً ، وأخذ منها ٦٥ عينه تربه لإجراء التحليلات المعملية ، ولقد تم الربط بين هذه الوحدات الجيومورفولوجية وصفات التربه المورفولوجية والطبيعية والكيميائية لعمل خريطة التربة باستخدام برنامج Arc- GIS 10.x ، ولقد اوضحت النتائج ان منطقة الدراسة تشمل علي الوحدات الجيومورفولوجية التالية:

١- مصاطب رسوبية منخفضة خفيفة التموج بمساحة ٣٢١٥٢ فدان بنسبة ٢٩%
٢- مصاطب رسوبية منخفضة متموجة بمساحة ٢٨٦٤٣ فدان بنسبة ٢٥%
٣- مصاطب رسوبية عالية خفيفة التموج بمساحة ١٦٩٦٢ بنسبة ١٥%
٤- مصاطب رسوبية عالية متموجة بمساحة ١٨٨٧٧ فدان بنسبة ١٧ %
٥- سهول خارج الغسيل بمساحة ٨٥٠٣ فدان بنسبة ٨%
٦- سهول رسوبية بمساحة ٣٣٩٢ فدان بنسبة ٣ %
٧- مناطق صخرية بمساحة ٣٩٥٥ بنسبة ٤ %

وطبقاً لنظام التقسيم الأمريكي الحديث (Soil Survey Staff, 2014) فإن الأراضي المدروسة قد أجري تقسيمها حتى مستوى العائلة تحت رتبتي Aridisols و Entisols ، ويمكن أن تسكن تحت المجاميع الكبري التالية:

1- Typic Haplocalcids 2- Typic Calcigypsids 3- Gypsic Haplosalids 4- Typic Haplogypsids
5- Sodic Haplogypsids 6-TypicTorriorthents 7- Typic Quartzipssaments

ولقد قيمت القدرة الانتاجية لهذه الاراضي تبعاً للنظام المقترح بواسطة Sys et al. (1991) لتقييم الأراضي وقد اتضح ان معظم الاراضي تحت الدراسة تعاني من وجود كثير من محددات الإنتاج بدرجات متفاوتة من الشدة والتي تتمثل في الطوبوغرافية ، قوام التربة ومحتواها من الحصي والزلط ، ودرجة ملوحة وقلوية التربة ونسبة كربونات الكالسيوم ، كما وجد ان أراضي منطقة الدراسة بخصائصها الحالية تنتمي الي اربع مستويات من الصلاحية للإنتاج الزراعي هي:

١– أراضي متوسطة الصلاحية (S2)
٢– أراضي هامشية الصلاحية (S3)
٣– أراضي غير صالحه بسبب وجود معوقات يمكن اصلاحها (N1)
٤– أراضي غير صالحه بصفة دائمة (N2)

ويفرض بإجراء عملية تحسين واصلاح لمحددات الانتاج في التربة فإنه يمكن رفع قدرتها الإنتاجية ورفع دليل الصلاحية لمعظم الاراضي لتصبح درجات الصلاحية الكامنة هي:

١- **أراضي عالية الصلاحية** (S1)

٢- **أراضي متوسطة الصلاحية** (S2) .

٣- **أراضي غير صالحه بصفة دائمة** (N2)

ولقد تم اجراء تقييم لدرجة ملاءمة أربعة من المحاصيل الرئيسية (القمح والشعير والبطاطس والزيتون) للزراعة في هذه الأراضي طبقا لنظام Sys et al. (1993) **، وأوضحت النتائج أن الزيتون هو أفضل هذه المحاصيل للزراعة في هذه الأراضي.**

السادة المحكمين

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