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Land Evaluation of Some Soils of Western Esna District, Egypt Using Remote Sensing and GIS Techniques

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ABSTRACT

The Western Esna area represents one of the highest priority areas for future development in the country. The studied area is located between longitudes 32° 15′ 58.0" to 32° 39′ 50.14" East and latitudes 24° 59′ 27.8" to 25° 33′ 2.93" North and represents an area of about 193557 Feddans. The purpose of this study is to evaluate some soils in Western Esna district using Remote Sensing (RS) and Geographic Information System (GIS). For this purpose, eighteen soil profiles were described in the field and their representative samples were analyzed. Using geological map, Digital Elevation Model (DEM) and visual interpretation of satellite data, a geomorphic map was created to present mapping units of the studied area. The area under investigation was classified into six mapping units, i.e. old terraces (87237 Feddans, 45.07 % of the total studied area) and soil classification of this unit is Typic Torriorthents, Typic Haplosalids with Typic Haplocalcids as inclusions. Recent terraces (21241 Feddans , 10.97 % of the total studied area) and soil classification of this unit is Typic Torriorthents, Typic Haplosalids with Typic Haplocalcids as inclusions. Outwash plain (38892 Feddans , 20.09 % of the total studied area) and soil classification is Typic Torripsamments with Typic Hapocalcids as inclusions. Wadi bottom (12975 Feddans , 6.71 % of the total studied area) and soil classification of this unit is Typic Torriorthents. Wadi plain (8865 Feddans , 4.58 % of the total studied area) and soil classification of this unit is Typic Torriorthents. Rocky land (24347 Feddans , 12.58 % of the total studied area). Land capability was used to evaluate the soils of studied area. According to Sys model, the studied area was classified into three capability classes, i.e. S2, S3 and N2. The soils of S_2 have moderate limitations for agricultural crops, whereas texture is the main limiting factor (76.14 % of the total area). The main limiting factors of soils of S_3 are texture and soil depth (11.28 %), while the soils of N2 (12.58 % of the total studied area) include rocky areas, Four crops were selected to assess soil suitability for cultivation in the studied area, i.e. wheat, barley, tomato and olive. The results indicated that olive was more suitable for growing in such soils.

Keywords: Land evaluation, Remote sensing (RS), GIS, Soils, Digital Elevation Model (DEM), Esna, Egypt.

INTRODUCTION

Desert and uninhabited land represent approximately 95% of the total area of Egypt. Consequently, the majority of the population is concentrated around the Nile River. This unbalanced distribution of inhabitants causes serious social and economic problems, such as the fact that the ever-increasing population has resulted in a decrease in agricultural area per capita from 0.13 ha in 1947 to 0.05 ha in 2004 (FAO, 2005).

The studied area is considered as a main region that represents one of these promising land resources in the Western Desert of Egypt, which is needed for the agricultural development facing the pressure of the inevitable food requirement.

Remote sensing is defined as the acquisition of information about an object without being in physical contact with it (Elachi and Zyl, 2006). Therefore, the intrinsic characteristics of agriculture make remote sensing an ideal technique for its monitoring and management (Zhongxin *et. al.*, 2004). Geographic Information System (GIS) is considered as organized collection of computer hardware, software and spatial and non-spatial data that can help users for the efficient capture, storage, update, manipulation, analysis and management of all geographically referenced information. Remote Sensing (RS) in combination with GIS techniques proved to be more effective in soil sustainability and planning studies (DeVries, 1985).

Land evaluation is concerned with the assessment of land performance when used for specified purposes. Land evaluation is a tool for strategic land use planning. A specific agricultural use and management system on land that is most suitable according to agro-ecological potentialities and limitations is the best way to achieve sustainability (FAO, 1976 a).

Land capability is very important step in the reclamation process of the desert to determine the capability of soil cultivation to meet the requirement of the population. To make the evaluation were used by Sys rating systems a methodology produced by Sys *et. al.* (1991). The Sys rating systems were suggested under the structure of the FAO Framework for Land Evaluation (FAO, 1976 b).

The produced agricultural land use could provide decision makers, land managers and farmers with the information needed for improving the quality of land use decisions and guide them as to what crops are mostly suitable for the area, especially in cases where they have insufficient agricultural knowledge about the new area's land characteristics.

The objectives of the present investigation are to evaluate land resources of the Western Esna as well as producing land capability maps for irrigated agriculture and land suitability maps for specific crops.

MATERIALS AND METHODS

1-General description of the studied area

a) Location:

The studied area is located in the south Western Desert adjacent to Esna District New Valley governorate (Figure 1) between longitudes 32° 15′ 58.0" to 32° 39′

50.14" East and latitudes 24° 59′ 27.8" to 25° 33′ 2.93" North and represents an area of about 193557 Feddans.

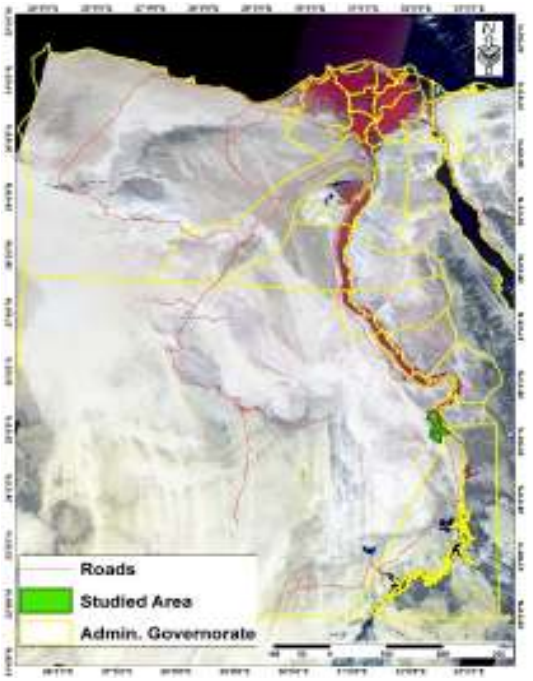

Figure 1. Location map of the studied area.

b) Climate:

The metrological data recorded of Luxor station (means of 10 years, 2007 to 2017 (Meteorological Authority, 2017) and show that: the Wesetern Desert is absolutely dry, where it lies in the largest direst place on the earth. The studied area is characterized by extremely arid climatic arid as indicated by:

- The total mean rainfall is 0.6 ml year $^{-1}$.
- The mean relative humidity is 23 %.
- the average of evaporation is 9.76 mm
- Main monthly temperature range between 15.5^{o}C in January and 35.5^{o}C in July.

According to the temperature, rainfall and evaporation aspiration values, the soil moisture regime is Torric or Ardic and the soil temperature regime is Hyperthermic.

C) Geology:

According to the geological map (scale 1: 500000), produced by EGSA (1988) Wadi Deposits is the main formation which represents an area of about 53463 Feddans (27.62 %) of the total studied area, covering the middle and western parts, followed by Pliocene Deposits, Undifferentiated representing an area of 43040 Feddans (22.24 %) of the total studied area, which concentrated in the eastern part of the studied area (Figure 2 and Table 1).

Table 1. Geological formations of the studied area

Geological Formation	Area Fed.	%
Wadi Deposits	53463	27.62
Pliocene Deposits,Undifferentiated	43040	22.24
Prenile Deposits	38411	19.85
Undifferentiated Quaternary Deposits.	30646	15.83
Dakhla Formation	23181	11.98
Esna Formation	3318	1.71
Protonile Deposits	930	0.48
Neonile Deposits	568	0.29
Total	193557	100.00

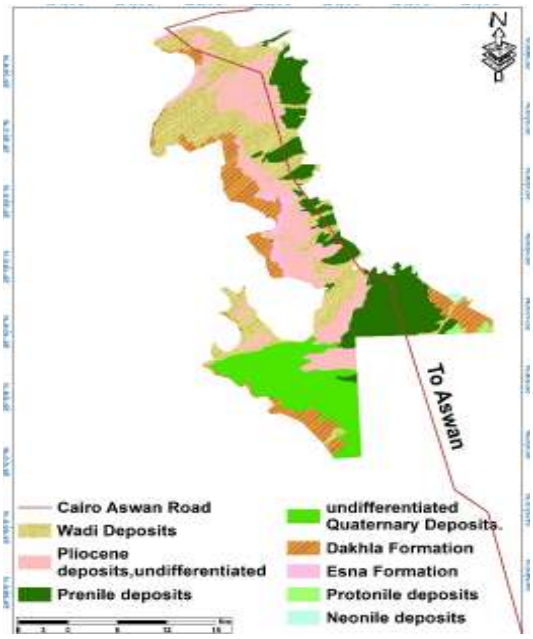

Figure 2. Geological map of the studied area

d) Water Resources

Hydrologically, the only source of water for irrigation is ground water. According to National Water Resource Center (NWRC, 1999) subdivided ground water of the studied area into two classes as follows; extensive and moderately to low productive aquifers insignificant surface recharge and limited sub-surface recharge deeper highly productive aquifers not excluded, and non auriferous clays and shells. Generally underlain by deeper more productive aquifers.

e) Digital Elevation Model (DEM)

Using geo-statistical analysis throughout interpolation ordinary Kriging method, which uses the semi-variogram parameters (Stein, 1998) (Figure 3).

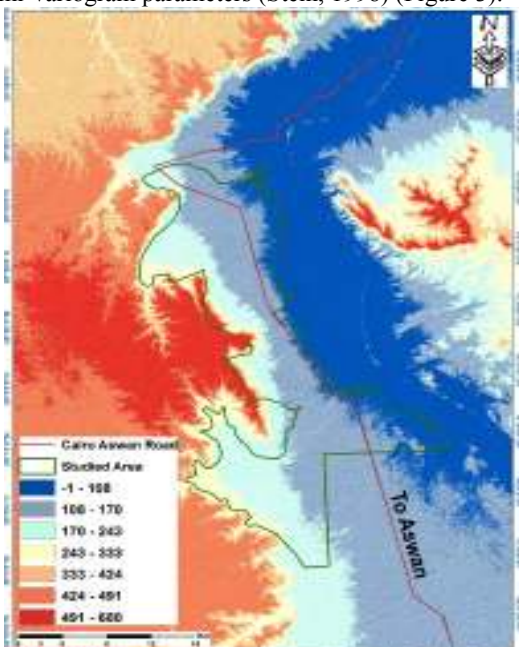

Figure 3. Digital Elevation Model (DEM) of the studied area

f) **Satellite data:**

The data of sentinel 2 dated 12/3/2017 with spatial resolution of 10 m (Figure 4) and spectral resolution of the bands 5, 3 and 2 used for delineating the geomorphic units of the studied area by the visual analysis, by aid topographic maps, geology map and Digital Elevation Model (DEM). Spatial enhancement was done to have an output image with enhanced edges that related to soil. The pixel values are not manipulated individually but in relation to their four neighbors. This modifies the value of each pixel on neighboring brightness values (Daels, 1986). Colour enhancement was done to create new images from original in order to increase the amount of information that can be visually interpreted from the data.

The data and the output maps used the parameters for GIS displays were Egyptian Transverse Mercator projection (ETM) (Daels, 1986).

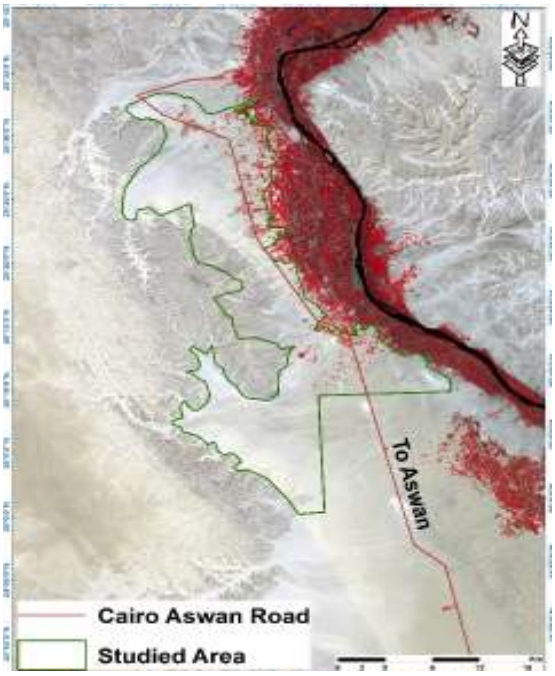

Figure 4. Sentinel image of the studied area

2. Field Work:

Eighteen soil profiles were taken to represent the different mapping units of the studied area. Eighty two minipits were used for checking the boundaries between mapping units. Morphological descriptions were worked out for the soil profiles in the field according to FAO (2006) (Table 2). Soil Taxonomy System (USDA, 2014). The ground truth for the different geomorphic units was conducted according to the edit of boundaries using some of minipits. Soil representative samples of the different layers of soil profiles were taken for laboratory analyses

3. Laboratory Analyses:

The collected soil samples were air dried, crushed and prepared for laboratory analyses, to determine some soil chemical and physical properties (USDA, 2004).

Laboratory analyses were carried out for particle size distribution using the pipette method, calcium carbonate content using Collin's calcimeter, gypsum content by precipitation with acetone and soil pH in the soil paste using pH meter and salinity as electrical conductivity (EC) in the soil paste extract, cation exchange capacity and exchangeable sodium percentage. Furthermore, the studied soils were classified according to the Soil Taxonomy System (USDA, 2014).

Water Samples analyses

Ten water samples were collected from the distribution wells in the studied area (Fig.5). The water samples were analyses to determine some chemical properties according to USDA (2004). These included the electric conductivity (ECe), pH, TDS, soluble cations and anions, SAR, RSC and some trace elements (B, Fe, Mn, Zn and Cu). Suitability of water for irrigation was determine according to the limitations outlined by FAO (1985).

4- Land Capability:

Land evaluation for the purpose of the agricultural capability was assessed according to the method of Land Capability techniques that done using the rating tables suggested by FAO (1985), Sys and Verheye (1978) and Sys et al. (1991) as common method for land evaluation according to the 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 (%)
t = Slope
w = Drainage conditions
S_1 = Texture
S_2 = Soil depth
S_3 = $CaCO_3$ content
S_4 = Gypsum content
n = Salinity and alkalinity

Capability classes arbitrary defined according to the value of the index as follows:

Capability class	Land index (Ci) %	Definition
S1	> 75	Soils are highly suitable for cultivating all crops.
S2	75-50	Soils are moderately suitable for agriculture
S3	50-25	Soils are marginally suitable for agriculture
N	< 25	Soils are not suitable for agriculture

Table 2. Morphological Description of the studied soil profiles.

Profile No.	Depth (cm)	Relief	Physiografic units	Soil colour			Soil Texture	Soil structure	Consistence	Efferv-esce-nce	Boundary	Others
				Hue	Dry	Moist						
5	0-15	undulating	Old Terraces	10YR	6/4	5/4	SL	st.less	so.sl.st. sl.pl.	st	c.s	many soft CaCo3
	15-30				6/4	5/4	SCL	ma.	fr. sl.st. sl.pl.	st.	c.w	
	30-120				7/8	6/8	SL	st.less	so.sl.st. sl.pl.	mo.	--	
6	0-25			10YR	6/6	5/4	SL	st.less	so.sl.st. sl.pl.	st	c.w	many soft CaCo3.
	25-100										c.w	
	100-150										--	
7	0-30			10YR	6/3	5/3	SL	st.less	so.sl.st. sl.pl.	St	c.w	many soft CaCo3, Few crystal gypsum
	30-120			5YR	5/4	4/4	SL			st	--	
8	0-30			7.5YR	5/4	4/4	SL	st.less	so.sl.st. sl.pl.	mo.	c.i	moderate Soft CaCo3
	30-80			10YR	5/4	4/4	LS	sn.g.	l n.st. n.pl	mo.	c.i	
	80-120			10YR	5/3	4/3	LS	sn.g.	l n.st. n.pl.	mo.	c.w	
	120-150				5/3	4/3	S	sn.g.	l n.st. n.pl	mo.	--	
9	0-30	gently undulating	Recent Terraces	10YR	5/6	5/4		ma.	so n.st. n.pl.	mo.	c.w	--
	30-60			5YR	5/4	4/4	LS	sn.g.	l n.st. n.pl.	mo.	c.w	
	60-120			5YR	5/3	4/3		sn.g.	l n.st. n.pl	mo.	--	
10	0-30	undulating		10YR	6/8	5/8	S	sn.g.	l n.st. n.pl.	mo.	c.w	--
	30-80				6/6	5/5				mo.	c.w	
	80-110				7/6	6/6				mo.	--	
11	0-25			10YR	6/8	5/8	SL	st.less	so.sl.st. sl.pl.	mo.	c.w	few crystal gypsum
	25-50			10YR	6/6	5/8	S	sn.g.	l n.st. n.pl.	mo.	c.w	
	50-120			5YR	5/3	4/3	SL	st.less	so.sl.st. sl.pl.	mo.	--	
1	0-30	almost flat	Out Wash Plain	10YR	6/8	5/8	S	st. less	soft	mo.	c.s	many Soft CaCo3.
	30-60				6/6	5/6	S				-	
	60-120				6/6	5/6	LS					
2	0-15			10YR	6/6	5/6	S	sn.g.	l n.st. n.pl.	mo.	c.w	many soft CaCo3 Few crystal gypsum
	15-50				7/8	6/8		st. less	so n.st. n.pl.	st.	c.w	
	50-150				7/8	6/8		st. less	so n.st. n.pl.	st.	--	
3	0-20			10YR	7/8	6/8	S	sn.g	l n.st. n.pl.	st.	c.w	many soft CaCo3
	20-60				7/6	6/6				mo.	c.w	
	60-130				6/6	5/6				mo.	--	
4	0-35			10YR	6/6	/65	SL	st. less	so.sl.st. sl.pl.	st.	c.w	many soft CaCo3
	35-80				7/6	6/6	S	sn.g.	l n.st. n.pl.	mo.	c.w	
	80-150				7/8	6/8	S	sn.g.	l n.st. n.pl	mo.	--	
18	0-30			10YR	6/4	5/4	S	sn.g.	l n.st. n.pl.	mo.	c.s	--
	30-120				7/6	6/6	S			mo.	--	
12	0-45	almost flat	WadiB Bottom bottom	10YR	7/8	7/6	S	sn.g.	l. n.st. n.pl.	mo.	c.w	--
	45-105				6/8	5/6				mo.	c.w	
	105-150				7/8	7/6				mo.	--	
13	0-40			10YR	5/8	6/8	S	sn.g.	l. n.st. n.pl.	mo.	c.w	--
	40-80									mo.	c.w	
	80-150									mo.	--	
14	0-35			10YR	7/6	6/6	S	sn.g.	l. n.st. n.pl.	mo.	c.w	--
	350-60				6/6	5/6				mo.	c.w	
	60-110				6/6	5/6				mo.	--	
15	0-30	almost flat		10YR	5/6	4/6	SL	st.less	so n.st. n.pl.	so.sl.st. sl.pl.	c.w	--
	30-70				5/6	5/6					c.w	
	70-100				6/8	6/8					--	
16	0-35	gently undulating	Wadi Plain Plain	10YR	6/6	5/6	S	sn.g.	l. n.st n.pl	mo.	c.w	--
	35-75				7/4	7/2	LS	st.less	so.n.st.n.pl..	w	c.w	
	75-110				6/6	5/8	S	sn.g.	l. n.st n.pl	w	c.w	
17	0-30	almost flat		10YR	7/6	6/6	S	sn.g.	l. n.st n.pl	mo.	c.w	--
	30-60				6/8	5/8				w	--	

Soil structure
ma = massive
sn.g = single gain
st.less= structure less

Consistence
1 = lose (dry)
so=soft (dry)
fr = friable (dry)
npl = non plastic (moist)
nst = non sticky (moist)
slpl = slight plastic (moist)
slst = slight sticky (moist)

Soil texture
s = sand
sl = sandy loam
LS= loamy sand
scl = sandy clay. loam

Effervescence
we = weak
sl = slight
mo =moderate
st =strong

Boundary
di = diffuse irrigular
cw = clear wavy
cs = clear smooth

5. Land suitability assessment for specific crops.

The assessment of land suitability for four different land use types (LUT) has been conducted for soil units using 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

1. Geomorphic map

Visual interpretation of sentinel 2 image was done on false colour composite of bands 5, 3, 2 scale 1:50000 to produce a base map according to the difference in landscape for the field work activities. The integration between geology, Digital Elevation Model and visual interpretation was carried out to produce a base map. This base map was used in the field to check, confirm, correct and modify the mapping unit boundaries, coupled with the results of the field work to produce final geomorphic map of the studied area (Figure 5 and Table 3).

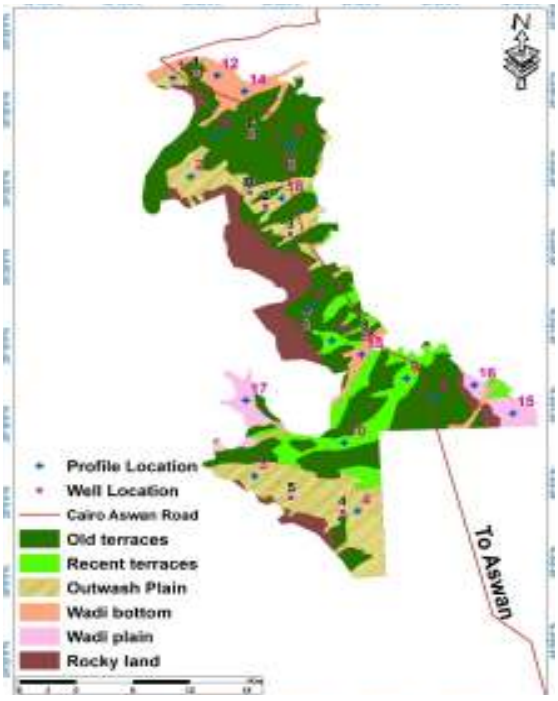

Figure 5. Location of soil profiles and geomorphic map of the studied area

Table 3. Estimated areas of geomorphic units of the studied area

Geomorphic Unit	Area Fed.	%
Old terraces	87237	45.07
Recent terraces	21241	10.97
Outwash Plain	38892	20.09
Wadi bottom	12975	6.71
Wadi plain	8865	4.58
Rocky land	24347	12.58
Total	193557	100.00

2. Soil Properties of mapping units:

Mapping Unit of old terraces:

This unit represented by profiles 5,6,7 and 8 and covered an area of about 87237 Feddans (45.07 % of the total studied area). The soils of this unit are deep (more than 120 cm in depth), the dominant texture sandy loam. The soils of this unit are highly saline where the EC dS/m values are more than 8, except for the surface layer of profile No. 8 whereas EC is 3.2 dS/m . The soils are alkaline in reaction and not sodic as pH values are more than 7 and less than 8.1. Exchangeable sodium percentage is between 7.3 and 14.9 % except for profile No.5. Cation exchange capacity varied from 2.4 to 14.6 meq 100 g^{-1}. Calcium carbonate content less than 6 % except for areas affected by calcic horizon (Profile 8). All values of gypsum content are less than 1% for all layers of the studied profiles (Table 4). The soils are classified into Typic Torriorthents, Calcic Haplosalids , Sodic Hapocalcids and Gypsic Haplosalids according to USDA (2014) as shown in Table 5.

Mapping Unit of recent terraces:

This unit is covering an area of about 21241 Feddans (10.97 % of the total studied area) and representing by soil profiles Nos. 9, 10 and 11. The soils of this unit are deep (from 110 to 120 cm in depth), soil texture ranges from sand to loamy sand. The EC values between 2.6 and 31.8 dS m^{-1} and there is no clear trend for the different layers of the soil profiles. The soils are alkaline in reaction and not sodic as pH values are more than 7 and less than 8.5. Exchangeable sodium percentage ranges from 4.2 to 14.9%. CEC values varied from 1.1 to 6.2 meq 100 g^{-1}. Calcium carbonate content less than 5 % except for areas effected by calcic horizon (Profile 9). All values of gypsum content are less than 1% for surface layers, except for deep layer of profile No. 10 is 5 % (Table 4). The soils are classified into Typic Torripsamments, Typic Haplosalids and Typic Haplogypsids according to (USDA, 2014).

Mapping Unit of outwash plain:

This unit representing by profiles 1,2,3,4 and 18 and covered an area of about 38892 Feddans (20.09 % of the total studied area). The soils of this unit are deep (more than 120 cm in depth), dominant soil texture is sand in most areas. The EC dS m^{-1} values ranged between 1.1 and 6.4 therefor the soils are slightly to moderately saline. The soils are alkaline in reaction and not sodic as pH values ranged from 7.2 to 7.9. Exchangeable sodium percentage ranged from 1.1 to 12.9 % and CEC from 0.9 to 5.7 meq $100g^{-1}$, respectively. Calcium carbonate content less than 5 % except for areas effected by calcic horizon (Profile 3). All values of gypsum content are less than 1% (Table 4). The soils are classified into Typic Quartzpsamments and Typic Haplocalcids according to (USDA, 2014).

Table 4. Some chemical and physical properties of mapping units

Profile No	Depth	pH	EC dSm^{-1}	S* %	Si* %	C* %	Texture Class**	$CaCO_3$ %	Gypsum %	ESP %	CEC meq $100g^{-1}$
						Old Terraces					
5	0-15	7.8	10.9	71.22	17.03	11.75	SL	0.1	0.1	15.6	6.1
	15-30	7.7	19.2	53.09	18.66	28.25	SCL	0.4	0.2	15.3	14.6
	30-120	7.6	9.2	68.57	15.68	15.75	SL	6.3	0.2	7.3	8.1
6	0-25	7.9	9.2	55.63	27.12	17.25	SL	0.1	0.1	13.9	8.8
	25-100	7.5	39.1	64.22	19.3	16.48	SL	0.2	0.3	14.2	8.8
	100-150	7.7	20.2	70.69	17.06	12.25	SL	0.1	0.3	14.9	6.9
7	0-30	8.0	8.3	64.66	22.09	13.25	SL	0.4	0.1	14.4	6.9
	30-120	7.6	20.8	60.38	25.62	14	SL	0.1	0.1	14.8	7.1
8	0-30	7.2	3.2	74.65	12.93	12.42	SL	5.1	0.1	7.5	6.3
	30-80	7.8	14.4	84.64	7.01	8.35	LS	7.4	0.2	12.1	4.4
	80-120	7.7	19.7	85.63	7.57	6.8	LS	18.1	0.9	14.3	3.6
	120-150	7.5	12.2	90.48	6.1	3.42	S	11.6	0.2	14.9	2.4
						Recent Terraces					
9	0-30	7.9	7.9	78.47	14.28	7.25	LS	8.4	0.2	11.4	3.8
	30-60	8.1	4.6	84.28	9.27	6.45	LS	14.3	0.2	6.6	3.5
	60-120	8.2	2.6	81.01	10.39	8.6	LS	15.2	0.2	10.0	4.3
10	0-30	7.9	3.7	94.69	3.06	2.25	S	0.1	0.2	4.2	1.1
	30-80	8.0	3.3	91.33	5.42	3.25	S	0.1	0.2	5.1	1.6
	80-110	7.9	3.3	93.7	2.25	4.05	S	1.1	5.0	5.6	3.3
11	0-25	7.8	18.9	66.26	21.49	12.25	SL	4.9	0.2	14.9	6.2
	25-50	7.8	7.7	88.08	6.42	5.5	S	0.2	0.2	6.2	3.0
	50-120	7.4	31.8	78.87	13.7	7.43	SL	0.2	0.3	14.7	6.0
						Out wash plain					
1	0-30	7.5	1.9	96.37	0.88	2.75	S	0.8	0.1	1.4	3.2
	30-60	7.7	1.8	96.25	1.00	2.75	S	0.8	0.1	3.1	2.6
	60-120	7.6	2.4	85.64	6.01	8.35	LS	1.1	0.2	5.3	5.4
2	0-15	7.9	1.1	92.58	1.17	6.25	S	0.4	0.4	1.8	4.8
	15-50	7.6	4.3	93.44	3.06	3.5	S	0.4	0.1	8.7	1.8
	50-150	7.7	5.6	88.98	5.75	5.27	S	4.2	0.1	10.5	2.7
3	0-20	7.2	5.5	93.27	3.18	3.55	S	5.1	0.1	1.2	1.2
	20-60	7.5	2.7	92.61	4.59	2.80	S	10.5	0.1	1.1	0.9
	60-130	7.9	1.0	95.81	2.74	1.45	S	15.2	0.1	12.3	5.7
4	0-35	7.9	1.0	70.29	18.51	11.20	LS	4.2	0.1	1.3	1. 1
	35-80	7.9	1.0	96.22	2.03	1.75	S	4.3	0.1	1.7	0.5
	80-150	7.5	1.0	96.22	2.93	0.85	S	0.5	0.1	2.0	1.2
18	0-30	7.5	6.4	91.37	2.63	6.00	S	0.4	0.1	4.5	3.3
	30-120	7.8	5.4	94.33	2.50	3.17	S	0.4	0.1	12.9	1.8
						Wadi bottom					
12	0-45	8.8	1.6	98.26	1.04	0.7	S	5.5	0.2	2.2	0.4
	45-105	8.0	1.4	95.12	3.68	1.2	S	4.2	0.4	2.1	0.6
	105-150	7.9	1.4	98.13	0.87	1	S	0.4	1.0	2.5	0.6
13	0-40	7.6	7.9	92.35	5.9	1.75	S	0.4	1.1	11.7	1.2
	40-80	7.7	6.7	92.28	4.97	2.75	S	0.4	1.1	10.1	1.7
	80-150	7.8	4.1	89.38	8.17	2.45	S	0.8	1.4	4.8	1.3
14	0-35	8.0	1.4	90.22	6.53	3.25	S	16.5	1.2	4.1	2.5
	35-60	8.2	3.8	93.27	5.48	1.25	S	24.8	1.0	3.5	1.3
	60-110	8.2	2.6	84.6	5.4	10	S	6.7	1.8	4.3	5.7
						Wadi plain					
15	0-30	8.4	3.9	84.6	9.95	5.45	LS	0.6	0.2	3.1	4.4
	30-70	8.1	3.2	70.29	18.51	11.20	LS	4.2	0.1	3.1	4.4
	70-100	8.1	3.5	83.72	10.08	6.2	LS	0.7	1.6	3.4	4.3
	100-										
16	0-35	7.8	3.2	93.61	5.14	1.25	S	0.3	0.2	0.8	0.8
	35-75	8.0	1.6	85.68	6.32	8.0	LS	0.6	0.2	3.1	4.1
	75-110	8.0	1.6	85.68	6.32	8.0	LS	0.6	0.2	3.1	4.1
	100-										
17	0-30	8.1	0.5	93.84	3.96	2.2	S	0.2	0.2	0.7	1.0
	30-60	8.1	3.9	96.84	1.06	2.1	S	0.5	3.9	0.8	1.0
	60-										

*** S = Sand, Si = Silt and C = Clay**

**** S= Sand, LS = Loamy Sand, SL=Sandy Loam, SCL = Sandy Clay Loam**

Table 5. Soil taxonomic units of the studied soil profiles.

Order	Sub-order	Great group	Sub-group	Family	Representative soil profile	Symbol of Key to Soil Taxonomy
Aridisols	Salids	Haplosalids	Gypsic Haplo-salids	Coarse loamy, mixed, hyperthermic.	7	GBBD
			Calcic Haplo-salids	Coarse loamy, mixed, hyperthermic.	6	GBBE
	Calcids	Haplocalcids	Typic Haplo -salids	Sandy over coarse loamy-skeletal, mixed, hyperthermic.	11	GBBF
			Typic Haplo-calcids	a. Sandy, siliceous, skeletal, hyperthermic.	1, 3	GFBU
				b. Sandy, siliceous, hyperthermic.	2,4,14	
			Sodic Haplo-calcids	fine loamy over loamy, mixed, hyperthermic.	5	GFBP
Entisols	Psamments	Quartzip samments	Typic Quartzi-psamme	Siliceous, hyperthermic.	12,13, 18	LCCM
				Siliceous, skeletal, hyperthermic.	10, 16, 17	LCCM
					15	LDEL
		ipsamments	Typic Torripsamme	Siliceous, hyperthermic.	9	LDEL
	Orthents	Torriorth-ents	Typic Torriorth-ents	Sandy- skeletal, mixed, hyperthermic.	8	LCBH

Mapping Unit of wadi bottom:

This unit represents by profiles 12, 13 and 14 and covered an area of about 12975 Feddans (6.71 % of the total studied area) The soils of this unit are deep (from 110 to 150 cm in depth), soil texture for all soil layers is sand and there are rock fragments inside soil profile. The EC values varied between 1.4 and 7.9 dS m^{-1} therefor the soils are slightly to moderately saline. The soils are alkaline in reaction and not sodic as pH values are more than 7 and less than 8.5. Exchangeable sodium percentage and cation exchange capacity ranged from 2.1 to 11.7% and 0.8 to 4.4 meq 100g $^{-1}$, respectively. Calcium carbonate content less than 6 % except for areas effected by calcic horizon (Profile 14). All values of gypsum content are less than 2% (Table 4). The soils are classified into Typic Quartzpsamments and Typic Haplocalcids according to USDA 2014.

Mapping Unit of wadi plain:

This unit is covering an area of about 8865 Feddans (4.58 % of the total studied area) and represented by profiles 15, 16 and 17. The soils of this unit are moderately deep (from 60 to 100 cm in depth), soil texture ranges from sand to loamy sand. All values of EC dS m^{-1} less than 4. The soils are alkaline in reaction and not sodic as pH values ranges from 7.8 to 8.4. Exchangeable sodium percentage and CEC ranges from 0.7 to 3.4 % and 0.8 to 4.4 meq 100 g^{-1}, respectively. Calcium carbonate content less than 1 % . All values of gypsum content are less than 5% (Table 4). The soils are classified into Typic Torripsamments and Typic Quartzpsamments according to USDA 2014.

Mapping Unit of rocky land:

This unit is concentered along the western part of the studied area and represent an area of about 24347 Feddans (12.58 % of total the studied area).

Water availability and quality

Water availability and quality plays an important role in land use planning and agriculture reclamation. The area is relying on ground water for irrigation purposes; however, the quality, particularly salinity is crucial for agricultural purposes. Ten water wells were used to test the water quality in the studied area measuring the ECe, pH, TDS, soluble cations and anions, SAR, RSC and some trace elements. Table 6 shows that these water samples are considered suitable for irrigation for the wells of the studied area except for the well No.3 where it is not suitable for irrigation when ECe exceed 2000 ppm salts according to guide line mentioned by FAO (1985).

The studied ground water samples was classified according to salinity and alkalinity hazards, where (C3 – S2) class (high salinity and medium alkalinity) represents water of wells Nos 2, 4, 7, 9 and 10, while ground water samples Nos1, 5, 6 and 8 were classified as (C3 – S1) class (high salinity and low alkalinity). This water can be used in irrigation with little danger of SAR harmful level. On the other hand, ground water samples of well No. 3 was classified (C4 – S2) (very highly saline and medium sodium water). This water is considered not suitable for irrigation where it contains more than 2000 ppm salts.

Table 6. Chemical properties of irrigation water and quality classes of some selected wells in the studied area

Water Properties	Samples water code 1	2	3	4	5	6	7	8	9	10
pH	7.74	7.75	7.20	7.55	7.46	7.38	7.58	7.57	7.20	7.37
EC dS m^{-1}	2.61	2.04	3.63	1.25	1.73	2.16	1.61	1.6	2.15	2.83
TDS (ppm)	1670.4	1305.6	2323.2	800	1107.2	1382.4	1030.4	1024	1376	1811.2
Anions										
CO3=	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
HCO3-	3	1.6	2.6	4.2	4.4	5	3.8	4	5	3.4
Cl-	16	13	18	7	10	14	10	9	7	19
SO4=	8.07	4.53	20.68	6.77	4.72	3.78	5.35	3.17	8.3	8.01
Cations										
Ca ++	6.11	2.78	12.22	2.78	3.33	5.55	2.22	2.77	5.56	6.67
Mg++	6.52	2.48	7.77	0.38	4.56	4.98	6.2	2.49	2.33	9.11
Na+	14.18	13.71	20.99	14.6	11.06	11.99	10.09	10.75	12.16	14.34
K+	5.64	8.45	6.64	11.65	2.57	2.23	5.16	6.63	6.12	5.11
SAR	9.63	4.26	7.86	13.74	6.01	6.06	5.97	7.85	7.21	5.9
RSC	6.60	10.08	7.86	13.74	6.01	6.06	5.97	7.85	7.21	5.90
I.W.q*	C3-S1	C3-S2	C4-S2	C3-S2	C3-S1	C3-S1	C3-S2	C3-S1	C3-S2	C3-S2
Trace elements										
B	0.03	--	0.83	0.6	3.76	0.2	0.35	0.54	0.05	0.37
Fe	2.43	2.33	1.99	3	2.01	2.52	1.74	2	2.51	2.85
Mn	2	1.98	1.87	2.54	1.9	2.11	1.64	1.71	2	2.44
Zn	0.19	0.2	0.21	0.23	0.21	0.24	0.3	0.31	0.24	0.24
Cu	1.12	1.04	1.11	0.3	0.25	0.27	0.39	0.25	0.75	0.77

I.W.q : irrigation water quality

3. Current land capability assessment

A land capability model was built using Arc GIS 10.4 software (database) and the resulting tables were imported into Arc GIS to produce the capability map. Based on the Sys model as shown in Figure 6 was classified into three capability classes which reflect the limitation factors, i.e. S2, S3 and N2 (Table 7). The soils of S2 have moderate limitations for agricultural crops, as texture is the main limiting factor with area 147370 Feddans (76.14 % of the total area). The soils of S3 representing two mapping units (wadi bottom and wadi plain) where texture, depth and rock fragment are the main limiting factors, occupies an area of 21839 Feddans (11.28 %), while the N2 occupied 24347 Feddans (12.58 % of the total studied area) including the areas rocky land.

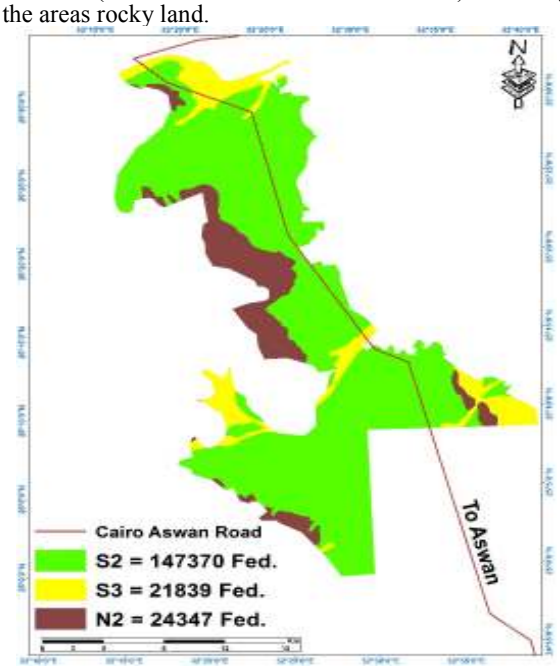

Figure 6. Current land capability map of the studied areaPotential Land capability assessment

Potential capability refers to the capability of units for a defined use after necessary specified major improvements (FAO, 1976 b).In the studied area the major limitations are: coarse texture, coarse fragment, salinity, and soil depth. By applying the major improvements such as the use of organic fertilizers and modern irrigation, the current capability class of S2 the could be developed to S1 (Table 7 and Figure 7).

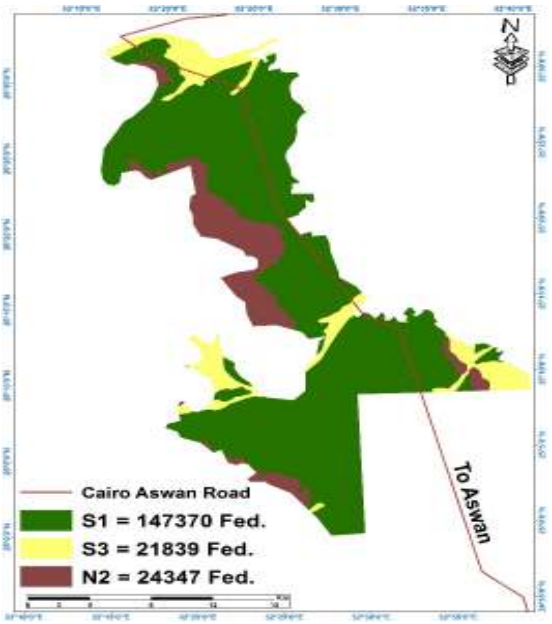

Figure 7. Potential land capability map of the studied area

5-Land suitability for specific crops:

Land suitability for five different crops, i.e. wheat, barley, tomato and olive was tested for the soils using Arc GIS 10.4 software. The results were imported to Arc GIS to display maps. Soil characteristics of the different mapping units were compared and matched with the crop requirements of each land use type, i.e.

crop (FAO, 1976 b). The matching led to the current and potential suitability for each crop using the parametric approach and land index as mentioned by Sys *et. al.* (1993) (Table 8-9 and Figures 7-11).

Table 7. Current and land suitability for irrigation agricultural of the studied soil profiles

Prof. N0.	Topography (t)		Wetness (w)		Soil Physical Characteristics (s)					Salinity/ alkalinity (n)		Current Suitability		Potential Suitability	
					Depth	Texture		Lime	Gypsum						
	CS	PS	CS	PS		CS	PS			CS	PS	Ci	Class	Ci	Class
Old Terrace															
5	85	100	100	100	100	75	90	100	95	85	100	51.47	S2	85.5	S1
6	85	100	100	100	100	75	90	100	95	85	100	51.47	S2	85.5	S1
7	85	100	100	100	100	75	90	100	95	85	100	51.47	S2	85.5	S1
8	90	100	100	100	100	75	90	90	95	85	100	51.47	S2	85.5	S1
Recent Terrace															
9	100	100	100	100	100	75	90	90	95	90	100	64.12	S2	85.5	S1
10	85	90	100	100	100	70	90	100	95	100	100	56.52	S2	76.95	S1
11	85	90	100	100	100	75	90	100	95	85	100	51.47	S3	76.95	S1
Out wash plain															
1	100	100	100	100	100	70	90	100	95	100	100	66.5	S2	85.5	S1
2	100	100	100	100	100	70	90	100	95	100	100	66.5	S2	85.5	S1
3	100	100	100	100	100	70	90	95	95	98	100	61.91	S2	79.6	S1
4	100	100	100	100	100	70	90	100	95	90	100	59.85	S2	76.95	S1
18	100	100	100	100	100	70	90	100	95	98	100	65.17	S2	83.79	S1
Wadi bottom															
12	85	100	100	100	100	60	80	98	95	100	100	47.48	S3	74.48	S2
13	85	100	100	100	100	60	80	95	95	90	100	41.42	S3	64.98	S2
14	85	100	100	100	100	60	80	90	95	95	100	41.42	S3	64.98	S2
Wadi plain															
15	85	100	80	100	75	60	80	95	95	100	100	27.70	S3	54.15	S2
16	90	100	80	100	75	60	80	95	95	100	100	29.24	S3	54.15	S2
17	85	100	80	100	75	60	80	95	95	100	100	27.70	S3	54.15	S2

CS= Current Suitability, PS = Potential Suitability Ci = Capability index

Current suitability

The data in Table 8 and Figures (8, 10 and 12) show the current suitability classes for the selected studied crops. These data indicate that 76.14 % is highly suitable (S1) for olive. On the other hand, the same area (76.14 %) is moderately suitable (S2) for tomato. The table shows that 87.42 % (S3) is marginally suitable for wheat and Barley. The area of permanently not suitable for all crops (N2) is 12.58 %%.

Table 8. Current suitability classes and areas % for growing crops in the studied area

Suitability class*	Wheat	Barley	Tomato	Olive
S1				76.14 %
S2			76.14 %	
S3	87.42 %	87.42 %	11.28 %	11.28 %
N1	---	---	---	---
N2	12.58 %	12.58 %	12.58 %	12.58 %

*** S_1 = Highly suitable, S_2 = Moderately suitable $S_{3=}$ Marginally suitable**
N_1= Currently not suitable N_2=Permanently not suitable

Potential suitability

From the previous discussion, the main limiting factors were texture and salinity, which can be improved using good management practices such as salt leaching, use of organic matter amendments, construction of a good drainage system and follow good agriculture practices for crops. These improvements will raise the potential suitability.

The results in Table 9 and Figures 9, 11 and 12 show that 87.42 % of the area is moderately suitable (S2) for wheat, barley and tomato, while an area of about 12.58 % is permanently not suitable (N2) for all crops.

Table 9. Potential suitability classes and areas % for growing crops in the studied area

Suitability class*	Wheat	Barley	Tomato	Olive
S1				76.14 %
S2	87.42 %	87.42 %	87.42 %	
S3				11.28 %
N1	---	---	---	---
N2	12.58 %	12.58 %	12.58 %	12.58 %

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

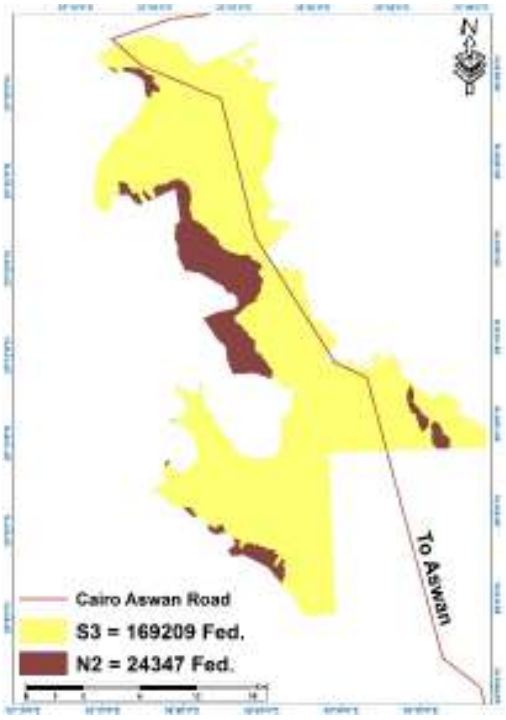

Figure 8. Current land suitability of wheat and barley in the studied area.

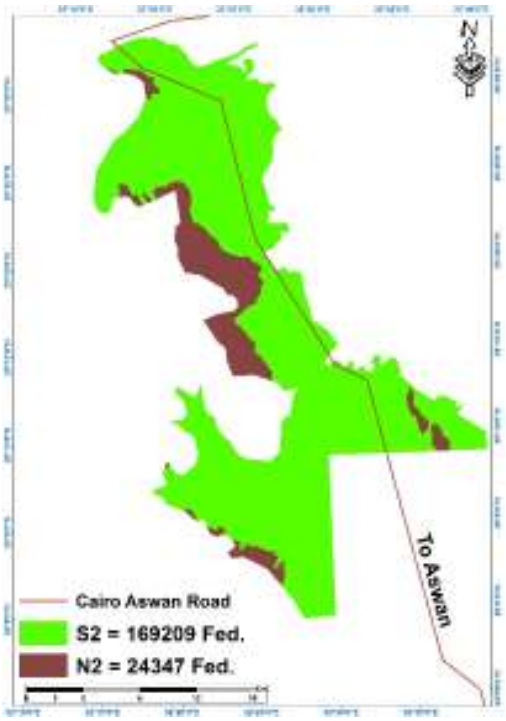

Figure 9. Potential land suitability of wheat and barley in the studied area.

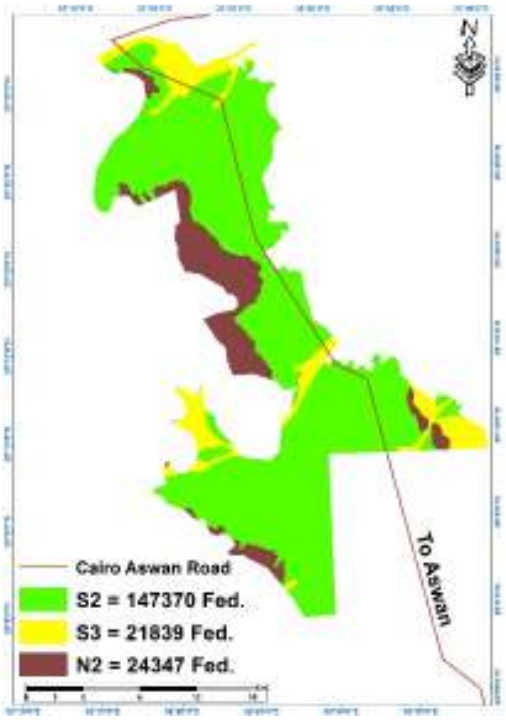

Figure 10. Current land suitability of tomato in the studied area.

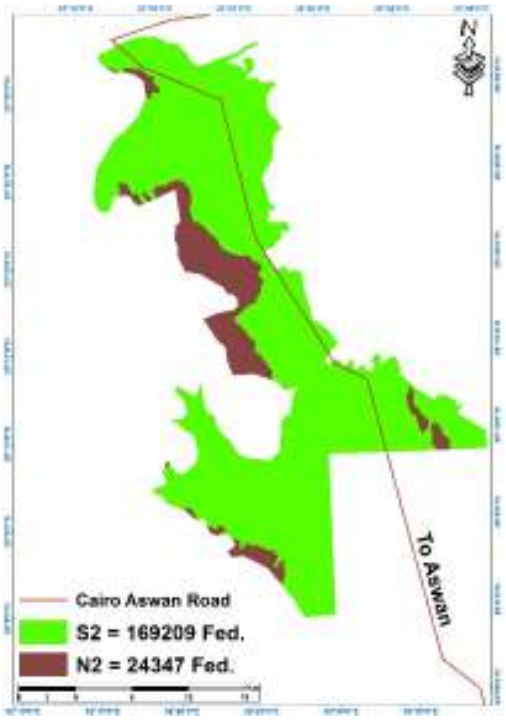

Figure 11. Potential land suitability of tomato in the studied area.

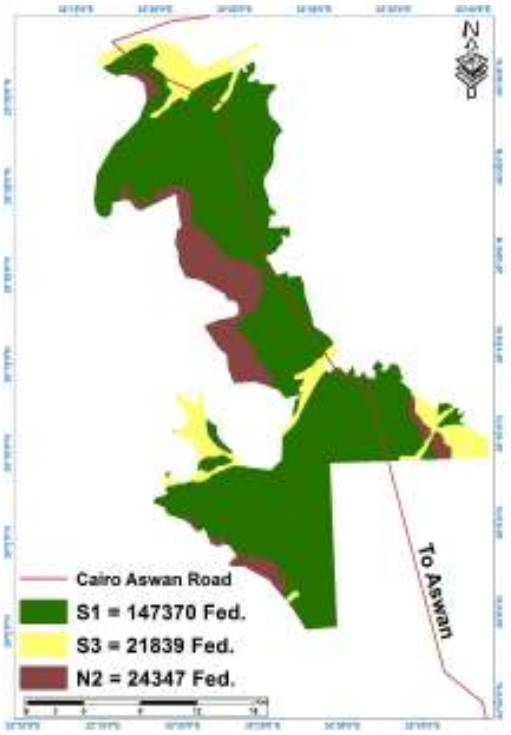

Figure 12. Current and potential land suitability of olive in the studied area.

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تقييم التربة باستخدام الاستشعار عن بعد ونظم المعلومات الجغرافية في بعض المناطق الواعدة غرب مركز اسنا-مصر

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تقع منطقة الدراسة غرب مركز اسنا بمحافظة الوادى الجديد بمساحة تقدر بحوالي193557 فدان وتعتبر من المناطق الواعدة للتنمية الزراعية بهذه المنطقة. ويهدف هذا البحث الي دراسة خصائص أراضي تلك المنطقة وتقييم كفاءتها الإنتاجية وملائمتها لاستزراع المحاصيل الرئيسية وذلك بإستخدام تقنيات الاستشعار عن البعد ونظم المعلومات الجغرافية وتطبيق نموذج تقييم الاراضي الجافه Sysولهذا الغرض تم إختيار وحفر 18 قطاعا أرضيا ممثلا لأراضي المنطقة ، 82 حفرة صغيرة (Aguer) ، ولقد وصفت هذه القطاعات وصفا مورفولوجيا دقيقا وجمعت منها عينات تمثل الاختلافات الرأسيه لاجراء للتحليلات المعملية. ولقد تم عمل خريطة جيومورفولوجية باستخدام التفسير المرئي لصورة القمر الصناعي سينتنل 2 مع بيانات التركيب الجيولوجى ونموذج الارتفاعات الرقمي لمنطقة الدراسة. ودرست الصفات المميزة لوحدات خريطة التربة المنتجة وتم التعرف على الوحدات التصنيفية السائدة بها كالاتي: وحدة المصاطب القديمة Old terraces تمثل مساحة 45,07% من اجمالي منطقة الدراسة وتصنيف التربة بها Typic Torriorthentsمع Typic Haplosalids و Typic Hapocalcids ، وحدة المصاطب الحديثة Recent terraces وتبلغ مساحتها 10,97% من اجمالي منطقة الدراسة وتصنيف التربة بها Typic Torriorthentsمع Typic Hapocalcids و Typic Haplosalids، وحدة سهل الغسيل Outwash plain تمثل مساحة 20,09% من اجمالي مساحة منطقة الدراسة وتصنيف التربة بها Typic Torripsamments مع Typic Hapocalcids ، وحدة قاع الوادى Wadi bottom تمثل مساحة 6,71% من اجمالي مساحة منطقة الدراسة وتصنيف التربة بها Typic Torriorthents ، وحدة سهل الوادى Wadi plain تمثل مساحة 4,58% من اجمالي منطقة الدراسة وتصنيف التربة بها Typic Torriorthents ، اما الأراضي الصخرية Rocky Land تمثل مساحة 58, 12% من اجمالي منطقة الدراسة. وبتقييم صلاحية التربة طبقا لنموذج Sys أوضحت الدراسة أن أراضي المنطقة تقع في أقسام متوسطة الصلاحية (S2) وحدية الصلاحية (S3) وغير صالحة للزراعة بصفة دائمة (N2). وتبين النتائج أن حوالي 76,14 % من اجمالي منطقة الدراسة هي أراضي متوسطة الصلاحية (S2) وأن العامل المحدد هو قوام التربة. أما الأراضي حدية الصلاحية (S3) فهي تغطي مساحة 11,28% من اجمالي منطقة الدراسة وحدية الصلاحية فيها ترجع الى عمق القطاع الأرضي وقوام التربة. بينما كانت الأراضي غير الصالحة للزراعة (N2) تمثل مساحة 12,58%.وقد تم اختيار أربعة محاصيل لتقييم درجة صلاحيتها للزراعة طبقا لطريقة Sys وهي والقمح والشعير والطماطم والزيتون، وتبين من النتائج أن الزيتون هو أفضل هذه المحاصيل حيث تجود زراعته بدرجة أعلى من باقي المحاصيل