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CHARACTERISTICS, CLASSIFICATION AND EVALUATION OF WADI EL NAGRA SOILS, UPPER EGYPT

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ABSTRACT: *Wadi El Nagra (Aswan governorate) is the most protective area for agriculture expansion in the Eastern Desert. The aim of this investigation is to study the morphological, physical, and chemical properties of representative area soils. Soil classification, land suitability for cultivation and the crop water requirements are also performed. Landsat ETM (Path 174/Row 43) images (2012) and digital elevation model (DEM) were used in ERDAS Imagine 8.7 software to produce the physiographic map of the study area.The main physiographic units of the area are sedimentary plain, low Wadi plain, dissected erosion plain, terraces and Wadi bottom. Ten soil profiles were selected to represent these physiographic units. Morphological description was done and soil samples have been collected for physical and chemical analysis. The studied soils are classified according to USDA (2010) up to family level under Entisols or Aridisols orders. The current suitability of the studied soils could be categorized into three suitability classes. These classes are highly suitable, S1 (5981.3 feddans); moderately suitable, S2 (35165.84 feddans) and marginally suitable, S3 (6184.6 feddans). Further land improvement could be executed to correct the severity of soil limitations. In consequence of this the highly suitable, (S1) area could be increased to about 26275.5 feddans, and the moderately suitable, (S2) could be rise to about 21056.8 feddans. The main land qualities of the different physiographic units and the crop requirements were rated and matched to obtain the current and potential land suitability according to Sys, et.al. (1993). The crop water requirements for some selective crops were calculated using the climate data and crop WAT program.*

Key words: *Physiographic unit, GIS, land suitability, Crop water requirements.*

INTRODUCTION

Nowadays, sustainability through improving land properties as natural resources has become a key concept to describe its successful management for agriculture development to satisfy incrementing human need. On the same time, the agriculture utilization projects of the virgin lands at the Egyptian Deserts should be executed by using newly approach techniques in order to improve as well as to sustain their potentialities. This technique depends on the economical aspects of land use during the reclamation steps, declining soil reclamation period, increasing soil supplying power for plant nutrients and minimizing the possible adverse fears of environment risks, maximizing profitability and threats to human health.

Through the use of remote sensing and GIS techniques, the identification of the most suitable zones of the new areas for the horizontal expansion is accomplished. Therefore, Wadi El Nagra area that having potential for program special consideration has been focused one of the projects of soil reclamation. The main problems, which are facing the land reclamation policy, is coarse textured, salt affected soil and the sustainability of the land resources in the reclaimed areas. Wadi El Nagra which is located at the fringe of the East Nile Valley is one of these areas. The study area is mainly irrigated by Wadi El Nagra Canal.

The aim of this investigation is to study the morphological, physical and chemical characteristics of the soils representing this area. Soil classifacation, land evaluation and crop water requirements are also performed.

Description of the studied area

Location:

Wadi El Nagra area is located in the South Eastern part of the Nile valley. It extended from longitudes 33^{o}, 18^{-} , $11^{=}$ to 33^{o} , 26^{-}, $11^{=}$ East and latitudes 24^{o} , 23^{-}, $30^{=}$ to 24^{o} , 39^{-}, $10^{=}$ North. It covers part of Aswan governorate with a total area of 47331.8 feddans, Fig. (1).

Climate:

According to the Central Laboratory for Agriculture Climate (CLAC, 2012), the averages of climate data (temperature, humidity, wind speed and Precipitation) during the period between the years (2000 to 2012) are presented in Table (1). Data in Table (1) indicated that, the highest maximum temperature in Aswan area is 42.9 0C in July, while the minimum is 7.8 0C in January. The highest rate of relative humidity is 40.80 % in December and the lowest is 16.6 % in May. The highest wind speed is 24.20 km / h in July and the lowest is 17.20 km / h in January, The Precipitation is 1.78 mm, in October .

Geology:

According to Said (2000), and Abo El-Ezz (2000), Wadi El Nagra area has the following formations.

1- **Precambrian formations**, these are represented mainly by crystalline rocks of the basement complex.

2- **Mesozoic formations**, these are represented by a series of varicolored sandstone that is weathered into a brown color Nubian sandstone and formed either under shallow conditions or under fluvio – marine conditions.

3- **Cenozoic formations**, these are composed mainly of nummulitic rocks interpenetrated with marl and clay. The Oligocene formations are mainly sand and gravel deposits of fluvial origin. Miocene strata are mainly composed of sand and mainly limestones.

4- **Quaternary formations**, the Pleistocene deposits are formed from the great amounts of river silt, sand and gravels.

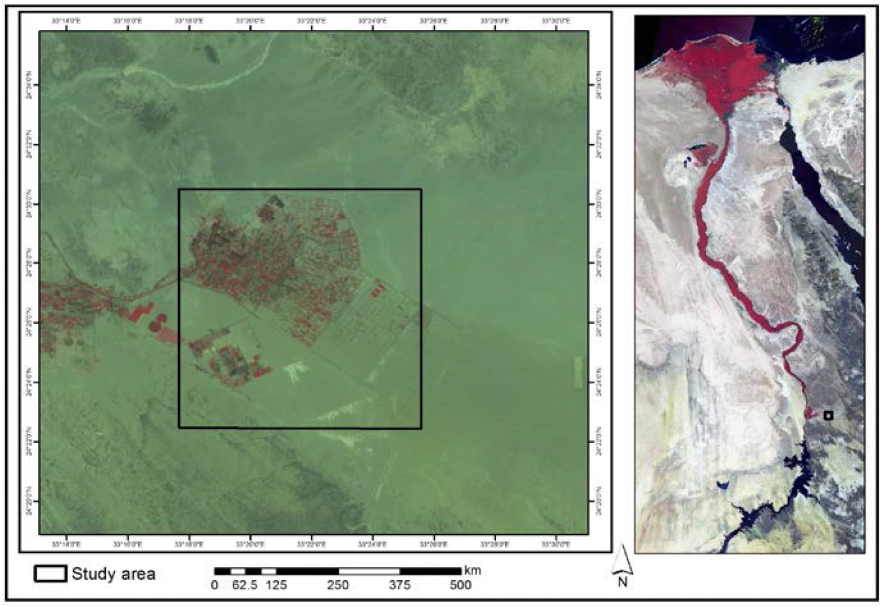

Fig. (1): Landsat ETM Multispectral Image (Bands 4, 3, 2) of the studied area.

Table (1): Averages for climate data (temperature, humidity, wind speed and Precipitation) during (2000 to 2012)

Month	Precipitation mm	Temperature 0C			Relative Humidity%	Wind speed (m/sec)
		Max.	Min.	Aver		max
Jan	0	21.2	7.8	15.5	38.5	17.5
Feb	0	26.5	12.1	19.2	28.2	21.8
Mar	0	28.6	13.1	21	25.2	20.9
Apr	0	36.5	20.7	28.9	16.8	21.9
May	0	40.3	25.1	33.2	16.6	22.3
Jun	0	42.4	28	35.5	17	23.7
Jul	0	42.9	28.9	36.3	18.4	24.2
Aug	0	41.9	27.8	35.1	19.7	24.1
Sep	0	39.7	25.6	32.7	23	20.7
Oct	1.78	37.5	23.2	30.3	25.9	18.8
Nov	0	31.3	24.6	18.3	36.4	18.5
Dec	0	24.7	11.8	18.6	40.8	18.1

Source: - Central Laboratory for Agriculture Climate (CLAC, 2012)

MATERIALS AND METHODS

Physiographic mapping of the study area:

Topographic maps of the investigated area (scale 1:100000) and landsat ETM image (Path 174/ Row 43) taken during the year (2012) were used for physiographic mapping. The extracted data form topographic maps are contour lines, roads , urban areas, drains and canals where as the land use were extracted from the landsat image. The physiographic of the study area was defined throughout the following steps.

1- Digital Elevation Model (DEM) of the study area have been generated from the vector contour lines. The elevation points which recorded during the field survey by (GPS) were also used to enhance the digital elevation model. ARC - GIS 9.3 software is used for this function.
2- Landsat ETM (Path 174/Row43) images (2012) and digital elevation model (DEM) was used in ERDS Imagine 8.7 software to produce the physiographic map of the study area (Dobos *et.al,* 2002). Also, the main purpose for using such tool is to use the capability of the system for data input; analysis data output and prepare the data base for the study area.

Ten soil profiles were chosen representing the different physiographic units (Fig.2). The soil profiles were dug to a depth of 150 cm or to lithic contact (bedrock). Morphological description was carried out following the guidelines of FAO (2006) and abbreviated as presented in Table (2). Disturbed soil samples were collected for laboratory analyses.

Laboratory analyses:

1. Soil color in dry and moist by Munsell color Charts (2009).
2. Particle size distribution using the international pipette method (USDA, 2004).
3. Calcium carbonate content using Collin's Calcimeter method (USDA, 2004).
4. Soil pH in the soil past as well as ECe and soluble cations and anions in saturation soil paste extract (Jackson, 1973).

5. Gypsum contents using acetone method (Page *et.al,* 1982).
6. Cation exchange capacity and exchangeable sodium percentage (ESP) using the method described by Robert (2008).
7. Organic matter content using Walkly and Black method (USDA, 2004).
8. SAR was calculated using the formula

$$SAR = \frac{\mathrm{Na}}{\sqrt{\mathrm{Ca} + \mathrm{Mg}/2}}$$

- Soils under study were classified according to (USDA, 1975 and 2010).
- Land capability evaluation and its suitability for certain crops were obtained by using the parametric systems of Sys (1991) and Sys *et.al.*(1993).
- The crop water requirements are calculated by using the climatic data of Aswan area (CLAC, 2012) and the Crop WAT program to calculate ETo according to Pennon – Monteith method, (Allen, 1998).

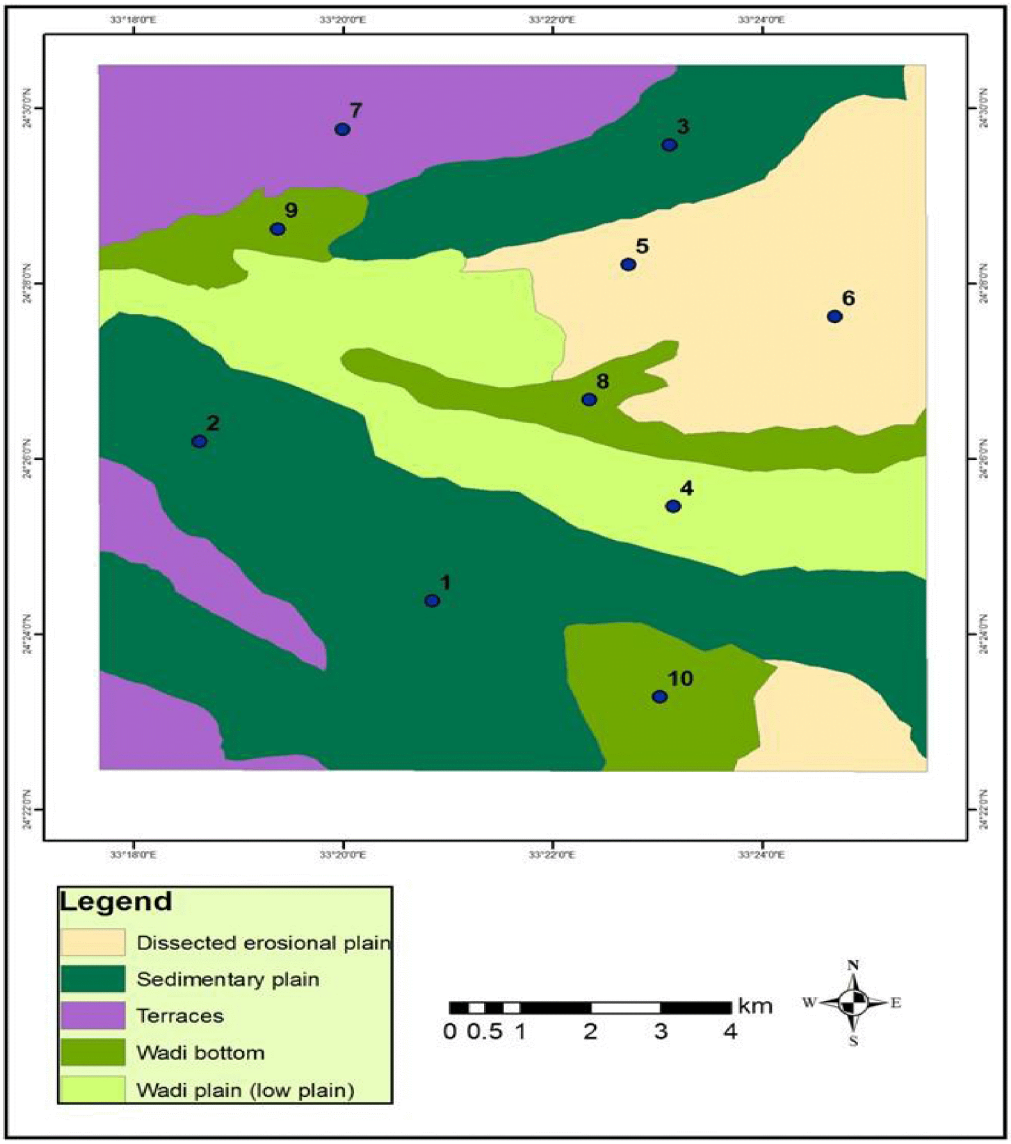

Fig. (2): Location of soil profiles representing the physiographic units of the study area.

Table (2): Morphological features of the studied soil profiles

Profile No.	Depth (cm)	Color		Texture	Stracture	Consistance			Efferves-cence	Lower bowndary	Gavel %
		Dry	Moist			Dry	Wet	Moi st			
Sedimentary plain											
1	0-20	7.5YR 4/6	7.5YR 4/4	LS	s.g	Lo	n.pl n.st	vfr	sl	cs	

	20-50	5YR 4/6	5YR 3/4	LS	s.g	Lo	"	"	sl	cw	
	50-100	5YR 4/6	5YR 4/4	SL	ma	so	sl.pl. sl.st.	fr	Mod.	cs	
	100-150	5YR 4/6	5YR 4/4	SL	ma	sh	sl.pl. sl.st.	fr	Mod.		
2	0-30	5YR 4/4	5YR 4/4	SL	s.g	Lo	sl.pl. sl.st.	fr	sl	cs	sl.gravel 2%
	30-60	5YR 4/4	5YR 4/4	SL	ma	so	sl.pl. sl.st.	fr	sl.	cs	"
	60-150	5YR 3/4	5YR 3/4	SL	ma	h	sl.pl. sl.st.	fr	Mod.		
3	0-30	7.5YR 5/4	7.5YR 4/4	L	ma	h	Pl & st	fr	Mod.	cs	
	30-60	5YR 5/4	5YR 4/4	L	ma	h	Pl & st	fr	Mod.	ds	
	60-150	5YR 5/4	5YR 4/6	SL	ma	sh	sl.pl. sl.st.	vfr	strong		
Wadi plain (low plain)											
4	0-30	7.5YR 5/6	7.5YR 4/6	LS	sg	Lo	n.pl& n.st	vfr	Mod.	cs	
	30-60	7.5YR 4/6	7.5YR 4/6	SL	ma	so	sl.st sl.pl	vfr	Strong	ds	
	60-150	7.5YR 4/6	7.5YR 4.6	L	ma	sh	pl&st	fr	Strong	-	
Dissected erosional plain											
5	0-20	5YR 5/4	5YR 4/6	SC L	s.g	Lo	sl.st sl.pl	fr	Strong	cs	Sl.gravel 20%
	20-60	5YR 5/4	5YR 4/4	L	ma	h	pl&st	fr	Strong	cs	
	60-120	5YR 5/4	5YR 4/4	L	ma	h	sl&st	fr	Strong	-	
6	0-10	7.5YR 6/4	7.5YR 5/4	CL	ma	so	pl&st	fr	Strong	cs	
	10-40	7.5YR 6/4	7.5YR 5/4	C	w.f.sub ang. b	so	vpl& vst	fr	Strong	gs	
	40-80	10YR 6/3	10YR 5/4	C	w.f.sub ang. b	sh		fr	Strong	gs	
	80-120	10YR 6/4	10YR 5/4	SL	ma	so	n.pl n. st		Strong		Few fine
Terraces											
7	0-10	5YR 5/4	5YR 4/6	SL	s.g	Lo	sl.st sl.pl	fr	Strong	cs	
	10-20	5YR 4/6	5YR 4/6	SL	ma	so	sl.st sl.pl	fr	Mod.	cs	Sl.gravel 15%
	20-60	5YR 5/6	2.5YR 3/6	SL	ma	sh	sl.st sl.pl	fr	Strong	cs	Sl.gravel 10%
	60-150	5YR 5/6	2.5YR 3/6	SL	m.a	ha	sl.st sl.pl	fr	Strong		Sl.gravel 15%

Table (2):Cont

Profile No.	Depth (cm)	Color		Texture	Stracture	Consistance			Efferves-cence	Lower bowndary	Gavel %
		Dry	Moist			Dry	Wet	Moist			
Wadi bottom											
8	0-15	10YR 6/4	10YR 4/3	CL	ma	so	sl&st	fr	Strong	cs	
	15-50	10YR 6/4	10YR 4/3	CL	ma	so	pl&st	fr	Strong	gs	
	50-90	10YR 6/4	10YR 4/4	CL	w.f.sub	sl.h	pl&st	fr		cs	

					ang. b						
	90-150	10YR 6/4	10YR 4/4	SiC L	ma	sl.h	Pl&st				
9	0-15	10YR 6/3	10YR 4/4	SCL	ma	so	sl.st sl.pl		Strong	cs	
	15-40	10YR 7/3	10YR 4/4	CL	w.f.sub ang. b	sl.h	pl&st	fr	Strong	gs	
	40-90	10YR 6/3	10YR 5/4	CL	ma	sl.h	sl.st sl.pl	fr	Strong	gs	
	90-150	10YR 6/3	10YR 4/4	SiC L	ma	sl.h	sl.st sl.pl	fr	Strong		
10	0-15	5YR 6/4	5YR 4/6	SCL	s.g	Lo	sl.st sl.pl	fr	Strong	ds	Sl.gravel 10%
	15-50	5YR 5/6	2.5YR 3/6	SL	ma	so	sl.st sl.pl	fr	Mod.	cs	Sl.gravel 15%
	50-80	5YR 6/4	5YR 4/6	SCL	ma	sh	l.st sl.pl	fr	Mod.		Sl.gravel 20%

Soil texture
Ls= loamy sand
Sl= sandy loam
L = loamy
Scl= sandy clay loam

Soil structure
ma= massive
S.g.= single grian
weak fine sub angular blocky

Consistence (moist)
Pl&st= plastic & sticky
vpl &vst=very plastic & very sti
n pl & nst=non plastic &non sticky

Dry Lo: Loose **(wit)** fr: firm
so: soft vfr: very firm
sh: slightly hard hard: hard

boundary ----cs= clear smooth cw= clear wavy ds= diffuse smooth

RESULTS AND DISCUSSION

Photo-interpretation and physiographic map:

The element analysis in photo-interpretation is based on the fact that most of the features on the earth's surface are in some way connected with soil conditions. In the present study, the pre-interpretation reconnaissance procedure was done according to Zinck (1990). Preliminary study of the general soil condition for the whole area and some detailed soil mapping of small sample areas, was followed by aerial photo-interpretation of all photos. Physiographic units are shown in Fig. (2) and could be categorized as follows:

1- Sedimentary plain (profiles 1,2 and 3).
2- Wadi plain (low) (profile 4).
3- Dissected erosional plain (profiles 5 and 6).
4- Terraces (profile 7).
5- Wadi botton (profiles 8, 9 and 10).

Characteristics and classification of studied soils:

Data of studied soil characteristics are presented in Tables (2, 3 and 4). Soil characteristics and meteorological data of the area are used for classifying the studied soils according to USDA (2010). The results are discussed in the following.

Table (3): Particle size distribution and calcium carbonate content of the studied soil profiles

			C.S	F.S	Silt	Clay		
Sedimentary plain								
	0-20	-	67.76	16.19	6.52	9.53	Ls	2.20
	20-50	-	59.00	21.83	12.48	6.69	Ls	3.14
	50-100	-	60.68	19.09	8.21	12.02	Sl	5.32
	100-150	-	57.49	21.57	6.57	14.37	Sl	6.10

	0-30	-	61.17	14.86	6.76	17.21	Sl	3.44
	30-60	-	58.32	18.87	8.81	14.00	Sl	3.00
	60-150	-	51.96	20.11	19.46	8.47	Sl	6.45
	0-30	-	36.70	13.62	30.34	19.34	L	6.05
	30-60	-	34.96	13.73	34.24	17.07	L	5.10
	60-150	-	37.97	17.62	30.00	14.416	Sl	11.35
Wadi plain (low plain)								
	0-30	-	65.04	16.38	8.09	10.49	Ls	7.05
	30-60	-	51.47	17.89	31.32	14.32	Sl	9.20
	60-150	-	36.06	12.90	29.22	20.82	L	10.00
Dissected erosional plain								
	0-20	20	43.97	23.95	9.24	22.84	Scl	8.45
	20-60	-	30.01	20.35	31.42	18.22	L	9.21
	60-120	-	32.22	15.88	32.40	19.50	L	9.32
	0-10	-	5.35	22.37	35.57	36.71	Cl	8.84
	10-40	-	0.94	24.94	33.00	41.12	C	9.24
	40-80	-	1.22	27.79	32.50	38.49	C	8.64
	80-120	11	41.83	36.32	8.49	13.36	Sl	15.87
Terraces								
	0-10	-	40.85	17.57	16.59	24.99	Sl	10.10
	10-20	15	49.83	25.99	8.99	15.19	Sl	5.24
	20-60	10	41.25	26.30	20.34	12.11	Sl	6.20
	60-150	15	50.75	19.18	15.42	14.65	Sl	6.30
Wadi bottom								
	0-15	-	4.99	23.48	40.25	31.28	Cl	10.05
	15-50	-	0.52	23.88	47.50	28.10	Cl	11.25
	50-90	-	0.69	23.81	40.32	35.18	Cl	11.25
	90-150	-	1.02	17.01	48.10	33.87	Sicl	10.85
	0-15	-	3.02	43.72	28.26	25.00	Scl	10.65
	15-40	-	1.49	25.99	40.93	31.59	Cl	11.05
	40-90	-	2.61	16.89	52.30	28.20	Cl	13.86
	90-150	-	2.74	15.46	46.49	35.31	Sicl	11.23
	0-15	10	42.01	16.94	18.80	22.25	Scl	10..40
	15-50	15	45.11	31.69	9.90	13.99	Sl	4.10
	50-80	20	37.59	23.57	7.65	25.87	Scl	5.70

C.S: Coarse Sand LS: Loamy sand Scl: Sandy clay loam
F.S: Fine Sand SL: Sandy Loam Sicl: Silty clay loam
C: Clay Cl: Clay loam

Table 4 (1

Table 4 (2

1- Soils of sedimentary plain:

This landform is located in the north western part and south of the studied area, covering an area of about 18493.4 feddans (39.1% of the total area). The morphological description and soil properties (profiles 1,2 and 3 in Tables 2,3 and 4) reveals that, the soil depth is very deep. The surface of these soils are flat to slightly undulating. the texture of these soils are sandy Loam to Loam (Table, 2). Calcium carbonate content ranges between 3.2 to 11.35% and tends to increase with depth. Data in Table (3) reveal that the soils are slightly to moderately alkaline where pH values varied from 7.18 to 7.82. These soils are non to slightly saline, which their ECe values range between 0.52 and 5.73 dsm^{-1} . Na^{+}, Ca^{++} and Mg^{++} are the dominated soluble cations, while $SO^{=}_{4}$ and Cl^{-} are the

dominated soluble anions. Accordingly the dominated salts are sodium, calcium and magnesium chlorides and sulphates. Cation exchange capacity ranges between 7.23 and 11.27 meq\100g soil. The soils are non sodic soils as indicated by ESP which varied from 1.49 to 6.55% and SAR, that is less than 13. Organic matter content is very low not exceeds 1.2%. Gypsum content ranged from 0.12 to 3.20% and tends to decrease with depth.

These soils haven't any diagnostic horizon and could be classified up to family level as follows (Table 5).

1- The soils represented by profile 1 could be classified as : Typic Torriorthents, sand over coarse loamy, mixed, hyperthermic.
2- The soils represented by profile 2 are classified as Typic Torriorthents, coarse loamy, mixed, hyperthermic,
3- The soils represented by profile 3 are classified as Typic Torriorthents, loamy , mixed, hyperthermic.

2- Soils of wadi plain (low):

This landform is located in the middle of the studied area and adjacent Wadi bottom with an area of 7686.6 feddans (16.3% of the total area). The morphological features (profile No.4) show that, the topography is almost flat to undulating. Soil texture of these soils are loamy sand in the surface layer changed into loam in the deepest layer. The clay varies from 10.49 to 20.82%, while the silt fraction is from 8.09 to 31.32%. Calcium carbonate is 7.05% in the surface layer and increases to 10.0% in the deepest layer. The analytical data in Table (3) reveal that the soils of this mapping unit is slightly alkaline as indicated by pH values, which ranged from 7.5 to 7.8. These soils are non saline where ECe values ranged from 0.58 to 2.14 dsm^{-1}. Soluble cations are dominated by Na+ followed by Mg++ and Ca++, while $SO_4^{=}$ and Cl^- are the dominated soluble anions. CEC ranges between 3.3 and 10.23 meq/100g soil depending on clay content. These soils are non-sodic as indicated by ESP and SAR values which are ranged from 5.15 to 7.97%. and 3.10 to 3.99, respectively. Organic matter content is very low and ranged from 0.03 to 0.09%. Gypsum content is very low not exceeds 0.33%. These soils haven't any diagnostic horizons and could be classified as Typic Torriorthents, loamy, mixed, hyperthermic.

3- Soils of Dissected erosional plain :

The soils of these mapping unit are represented by profiles 5 and 6 and covering an area of about 8799.6 fed. (18.6% of the studied area) . This unit is located in two parts, the first is north of Wadi bottom and the second is south eastern of the studied area. Topography is undulating and the land surface is covered with moderate fine to medium gravels. Texture of the soil representing by profile 5 is sandy clay loam in the top layer and loamy in its deepest one, while it is clay loam in surface layer, at profile 6 changed to sandy loam in its deepest layer. The soils have moderate $CaCO_3$ which ranged from 8.45% to 13.87% that tends to increase with soil depth. Also, data in Table (3) reveal that pH values ranged between 7.1 and 7.86. ECe values varied between 0.35 to 104.4 dsm^{-1} (non saline to very extremely saline). Sodium ions are the dominated soil cations followed by Ca^{++}, then Mg^{++}, while soluble anions are dominated by Cl^- followed by $SO_4^{=}$. CEC values ranged from 8.74 to 34.33 meq/100g soil, depending on caly content. ESP and SAR values ranged from 6.64 to 21.9%, and 1.82 to 24.9, respectively. The values of ESP and SAR indicating sodisty condition increases with depth in profile 6, while in profile 5 the soils are non sodic. Organic matter content is very low not exceeds 0.47%. Gypsum content ranged in narrow limit from 0.18 to 2.55%. According to the keys of Soil Toxonomy (2010), the soils of land type could be classified into the following:

The soils represented by profile 5 havn't any diagnostic horizons and therfore are classified as Typic Torriorthents, loamy , mixed, hyperthermic.

The soils of profile 6 have both sodic and salic sub horizons and classified as Typic Haplosalids, clay over coarse loamy , mixed hyperthermic.

4. Soils of terraces:

This soil mapping unit is represented by profile 7 and occupies about 7217.6 feddans (15.2% of the area). It is located in the north eastern part of the studied area. The surface is covered by desert pavement and few stones. Topography is undulating to sloping. the soils are deep. Soil texture is sandy loam throughout profile. CaCo3 content ranged between 5.24 and 10.10%. The soil reaction (pH) is slightly to moderately alkaline (7.4 to 7.95). Soluble salts are low in the surface layer and tend to increase with depth. Soluble cations are dominated by Na^{+} and/or Ca^{++} followed by Mg++, while soluble anions follow the order $SO4^{=}$>Cl^{-} >$HCO^{-}3$. CEC ranged between 8.01 and 15.49 meq/100g. soil, depending on clay content. ESP and SAR values varied from 9.48 to 25.7% and 5.84 to 18.8, respectively. Organic matter content is extremely low and not exceeds 0.08%. Gypsum content varied from 0.48 to 3.46%. Soils of this unit are classified as Typic Torriorthents, coarse loamy, mixed, hyperthermic.

5. Soils of Wadi bottom:

This unit is represented by profiles 8, 9 and 10 and located in three parts, namely, in the middle, the south east and the north west of the studied area. It occupies about 5134.5 feddans (10.8% of the studied area). The surface of Wadi bottom is almost flat to gently undulating. The depth of these soils is moderate to deep.Texture in the soil of profiles 8 and 9 is almost clay loam. while in profile 10, it is sandy clay loam over clay and silty clay loam in the deepest layer. Calcium carbonate content ranges between 4.10 to 13.86% with out regular distribution pattern with depth. Soil reaction is neutral to slightly alkaline (pH values are 7.0 – 7.65). Soluble salts content ranged between 0.67 to 15.8 dsm-1 (non saline to moderately saline). Soluble cations follow the order Na+ > Ca++> Mg++>K+, while soluble anions follow the order $SO^{=}_{4}$ > Cl^{-}>HCO^{-}_{3}. Cation exchange capacity varied between 19.38 to 29.31 meq/100g soil. depending on clay content. Exchangeable sodium percentage and sodium adsorption ratios indicating that these soils are non sodic, where ESP and SAR ranged from 1.04 to 16.8 % and 2.06 to 19.4 respectively. Organic matter is extremely low not exceed 0.49%. Gypsum content ranged between 0.09 to 1.30%.

These soils are classified as Typic Terriorthents, fine loamy, mixed, hyperthermic (profiles 8 and 9). The soils of profile 10 could be classified as Typic Terriorthents , coarse loamy over fine loamy, mixed, hyperthermic.

Land suitability evaluation:

Quantitative estimation of soil characteristics were used for evaluating land suitability for agriculture as well as for growing specific main crops according to Sys *et al.* (1991 and 1993). The suitability classes are defined according to the values of suitability index (Ci) as follows:

Suitability classes	Index (Ci)
Highly suitable (S1)	≥ 75%
Moderately suitable (S2)	50- < 75%
Marginally suitable (S3)	25- <50%
Not suitable (N2)	< 25%

The two evaluation systems are estimated for the current soil situation and expected situation in case of improving it is characteristics (limitations).

Land suitability for agriculture:

The ratings of soil characteristics, suitability indexes (Ci) and classes in the current and expected situations for the studied profiles representing the different physiographic units are presented in Table (5) and Figs.(3 and 4).

a- Current suitability:

The calculated suitability index (Ci) for the studied area in the current situation revealed that these soils can be classified into the following classes:

Highly suitable areas (S1), that have rates between 76.95 to 77.16% and cover about 5981.3 feddans (12.63% of the studied area). These include the sedimentary plain (profile 2) and Wadi bottom (profile 9).

Moderately suitable areas (S2), that have rats between 51.78 and 73.10% and cover about 35165.84 feddans (74.29% of the

studied area) These include the sedimentary plain (profiles 1&3), Wadi plain (profile 4), dissected erosional plain (profile 5); Terraces (profile 7); and Wadi bottom (profile 8). These areas have mainly slightly to moderately limitation intensity of texture and salinity and alkalinity.

Marginally suitable areas (S3), that have rates between 27.7 and 40.39% and cover about 6184.60 feddans (13.07% of the studied area).These include the soils of dissected erosional_plain (profile 6) and Wadi bottom (profile 10). These soils have severe to very severe intensity limitations, i.e. salinity and alkalinity, texture, soil depth and $CaCO_3$ content.

Table (5): Rating of studied soil characteristics for evaluating land suitability index in cases of current (C) and expected (E) situation.

Profile No.	Topography (t)		Wetness (w)		Physical soil characteristics				Salinity & Alkalinity (n)		Suitability index (Ci)		Suitability class (Si)	
	C	E	C	E	Texture	Depth	CaCO3	Gyp.	C	E	C	E	C	E
Sedimentary plain														
1	95	100	100	100	75	100	95	90	100	100	60.9	64.1	S2	S2
2	95	100	100	100	95	100	95	90	100	100	77.16	81.22	S1	S1
3	95	100	100	100	90	100	95	90	100	100	73.1	76.95	S2	S1
Wadi plain (low plain)														
4	95	100	100	100	90	100	95	90	100	100	73.1	76.95	S2	S1
Dissected erosional plain														
5	95	100	100	100	80	100	95	90	96	100	62.38	68.4	S2	S2
6	90	100	100	100	100	90	95	90	40	100	27.7	76.9	S3	S1
Terraces														
7	95	100	100	100	85	100	95	90	75	100	51.78	72.67	S2	S2
Wadi bottom														
8	95	100	100	100	100	100	100	90	80	100	64.8	90	S2	S1
9	95	100	100	100	100	100	100	90	90	100	76.9	100	S1	S1
10	95	100	100	100	65	90	95	90	85	100	40.38	50	S3	S2

C=Current Suitability
E= Exepected Suitability

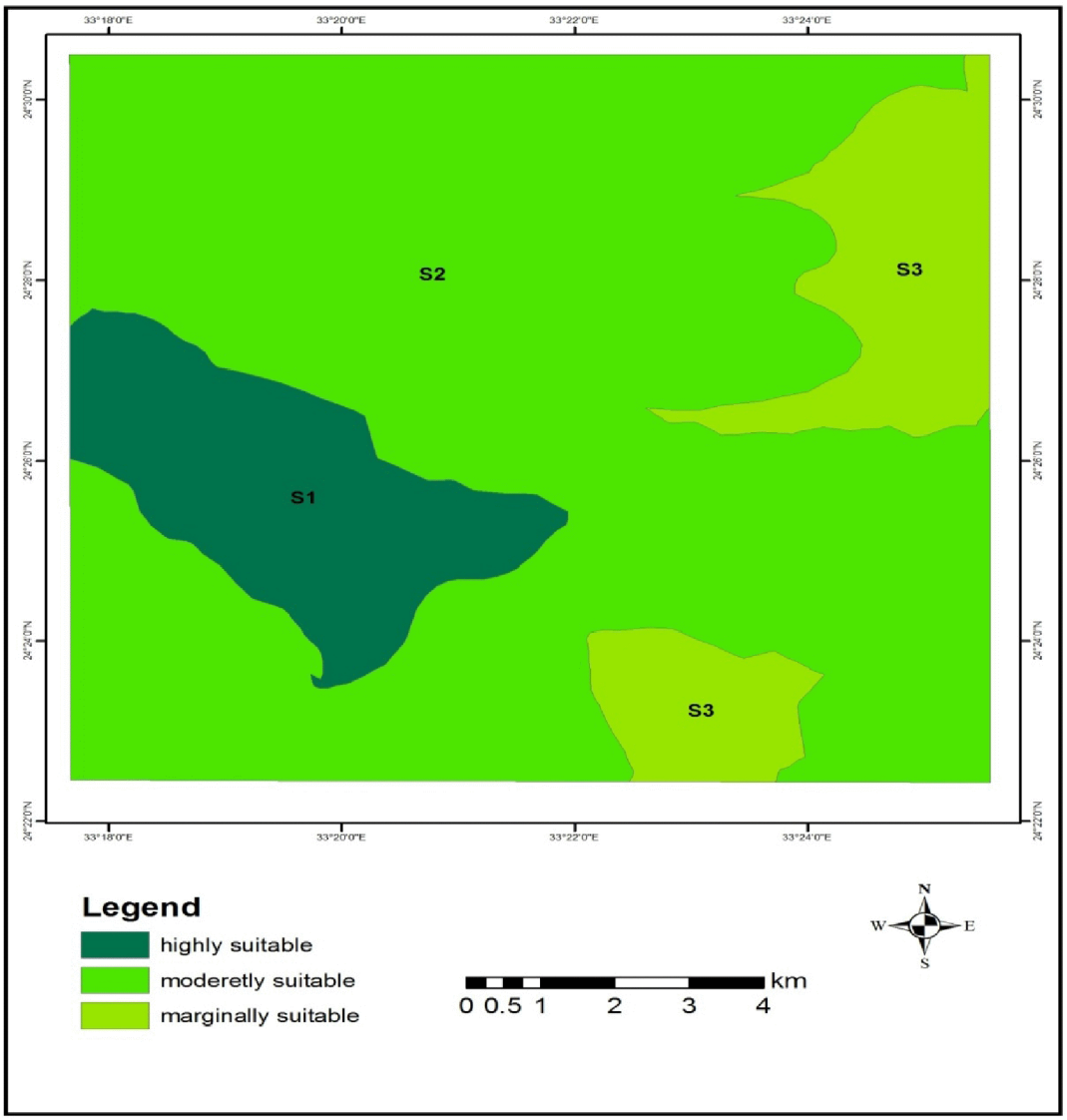

Fig (3): Current land suitability for agriculture of the study area.

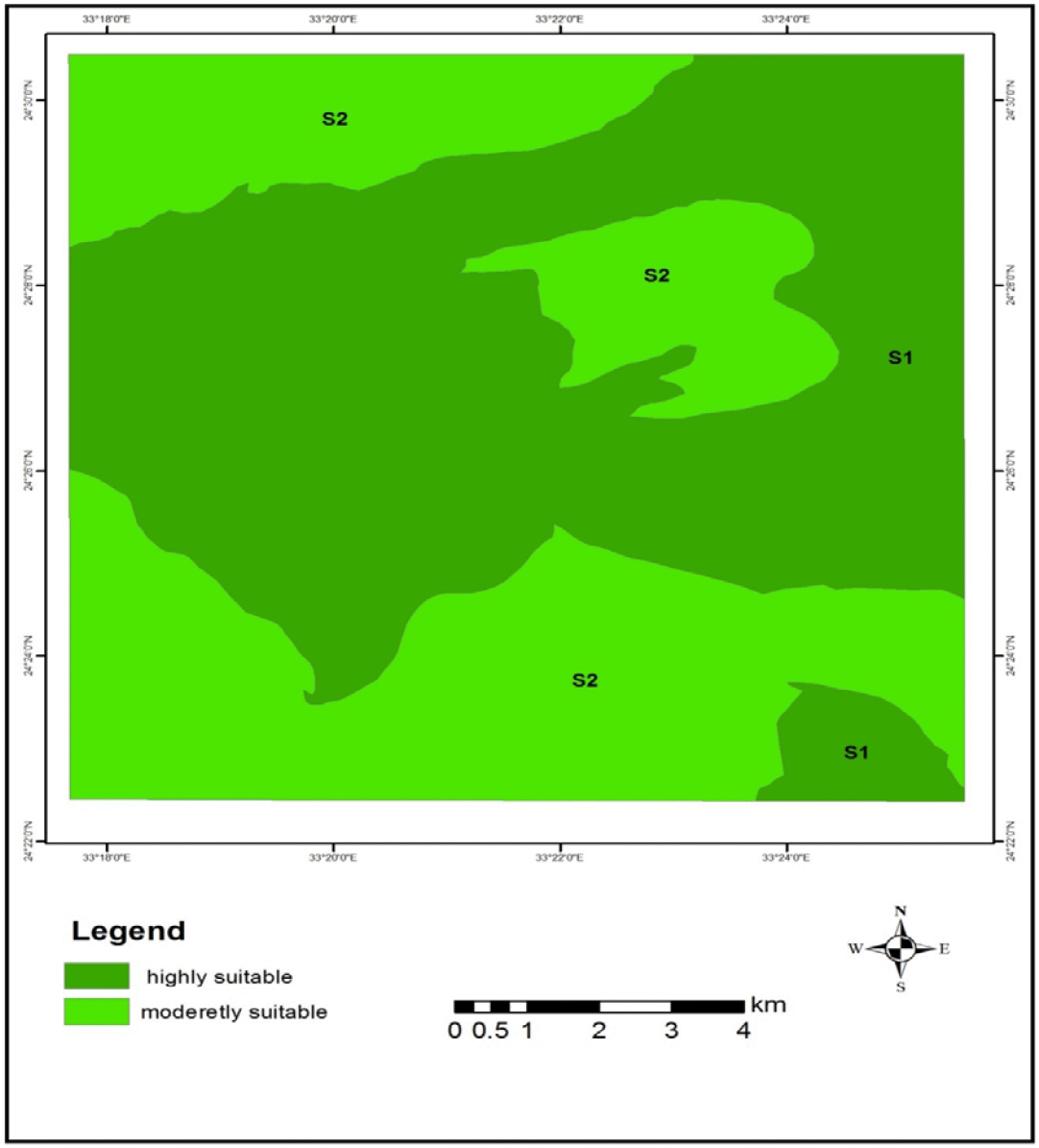

Fig (4): Exepected land suitability for agriculture of the study area.

b- Expected suitability

The expected ratings of soil characteristics, suitability indexes and classes in case of reclamation and improving the soil limitations are illustrated in Table (5) and map (4). The data calculated in this case are depended on improvement mainly the topography and salinity & alkalinity properties. The expected suitability index (E) for the studied area revealed following classes:

Highly suitable areas (S1), that have rates between 76.95 to 90.0% and cover about 26275.5 feddans (55.5% of the studied area). This include the soils of sedimentary plain (profiles 2 and 3), Wadi plain (profile 4), dissected erosional plain (profile 6) and Wadi bottom (profiles 8 and 9).

Moderately suitable areas (S2), that have rates between 50.0 and 68.84% and cover about 21056.8 feddans (44.5% of the studied area). This class include the soils of sedimentary plain (profile 1), dissected erosional plain (profile 5); terraces profile 7) and Wadi bottom (profile 10).

Land suitability for growing specific crops:

Studied profiles were evaluated to determined their soil suitability for growing 15 main field, vegetable and fruit crops in the current and expected situations according to Sys et.al.(1993). Ratings, suitability indexes and classes estimated for the soils of physiographic units in the studied area are presented in Table (6).

a- Current land suitability for growing crops:

1- Soils of sedimentary plain

These soils have moderately suitable (S2) for growing alfalfa, Sorghum, pea, maize, tomato, onion, cabbage, watermelon, grapes and Olives. These soils are marginal suitability (S3) for groundnut, green pepper, potato, citrus and palm.

2- Soils of low Wadi plain

The soils of this physiographic unit is moderately suitable (S2) for alfalfa, sorghum, groundnut , maize, potato, tomato, cabbage, watermelon, olives and grapes. These soils are marginally suitable (S3) for onion, and green pepper and Not suitable (N) for pea, citrus and palm.

3- Soils of dissected erosional plain

The dissected erosional plain soils are marginally suitable (S3) for alfalfa, sorghum, groundnut, maize , citrus and grapes. The other crops are Not suitable (N) for cultivation in this physiographic unit.

4- Soils of terraces

These soils are moderately suitable (S2) for alfalfa , Marginally suitable (S3) For tomato and olives and Not suitable (N) for the other crops.

5- Soils of Wadi bottom

Soils of Wadi bottom is moderately suitable (S2) for alfalfa, sorghum , groundnut , maize , potato, tomato, cabbage, olives and grapes. These soils are marginally suitable (S3) for onion, green pepper , and watermelon and Not suitable (N) for pea, citrus and palm.

b- Expected land suitability for growing crops:

1. Soils of sedimentary plain :

In case of reclamation improving some important soil properties, The studied soils could be suitable for growing crops as in the following:

These soils could be highly suitable (S1) for alfalfa, sorghum , pea, groundnut , maize , potato, tomato, onion, green pepper, cabbage, water melon, olives, grapes and citrus. Also, they could be marginally suitable (S3) for palm.

2. Soils of low Wadi plain :

These soils could be highly suitable (S1) for alfalfa, sorghum , pea, groundnut , maize , potato, tomato, cabbage and watermelon. Also, they could be moderately suitable (S2) for onion, green pepper, olives, and grapes, and not suitable (N) for citrus and palm .

Table 6

Table 6(2

Table 6(3

3. Soils of dissected erosional plain:

These soils could be moderately suitable (S2) for alfalfa , sorghum , pea, groundnut , maize , potato, tomato, cabbage , water melon, olives, grapes and citrus. they could be marginally suitable (S3) for onion, green pepper and palm.

4. Soils of terraces :

These soils could be highly suitable (S1) for potato; moderately suitable (S2) for alfalfa, sorghum , pea, groundnut, maize, tomato, cabbage and watermelon. while they could be marginally suitable (S3) for onion, green pepper and citrus and not suitable (N) for palm.

5. Soils of Wadi bottom

These soils could be highly suitable (S1) for alfalfa, sorghum , pea, groundnut, maize , watermelon, olives and grapes. They could be moderately suitable (S2) for potato, tomato, onion, green pepper; cabbage and citrus; and marginally suitable (S3) for palm.

Crop water requirements of the studied area:

The crop water requirements of the studied area were calculated using crop wat program. The ETo was estimated according to (Penman- Monteith) method, after Allen (1998), and given presented in Table (7). Data in Table (7) revealed that, the crop water requirements of tomato (135 day), tomato (180 day), suger beet, sorghum, Egg plant, pepper, banana, maize, grain, Barley, citrus-1), citrus-2, pea, peanut, lentil, cucumber, sunflower, onion\dry, flay were (691.3, 1034.1, 613.2; 756.6, 653.7, 729.6, 2245.8, 749.4, 391.8, 1869.0, 1455.7, 363.0, 774.3, 526.8,678.3, 689.8, 570.9 and 690.3 mm\s), respectively.

REFERENCES

Abo El-Ezz, M.S. (2000). "Land forms of Eypt", 281 p. the Am. Univ., Cairo pesss, Cairo, Egypt.

Allen, R. (1998)."Crop evapotranspiration Guidelines " for computing crop water requirements, FAO Irrigation and Drainge paper No. 65.Rome

CLAC (2012) ,"Central Laboratory for Agriculture of Climate . Agic. Res. Center.

Dobos, E. , B. Norman, W. Bruee, M. Luca, J. Chris and M. Erika (2002). "The use of DEM and Satellite Images for Regional Scale Soil Database", 17th ed World Congress of Soil Science (WCSS), pp. 14-21 August 2002, Bangkok, Thailand .

FAO (2006). Guideline for Soil Description " 4th ed FAO, Rome.

Jackson, M.L. (1973). "Soil chemical Analysis" Pentice Hall of India Private LTD, New Delhi, Indian.

Munsell Color Charts (2009). Munsell Soil Color Charts 2009 "Edition by Munsell Colour 4300 44th street Grand Rapids, M149512-

Page, A.L., H. Miller and D.R. Keeney (1982). "Method of Soil Analysis" part 2 "Chemical and Microbiological properties", 2nd Edition Amer.Sc., of Agron; Modison, Winsconsin, USA.

Robert, W.D. (2008). "Soil Testing Manual Procedures Classification Data and Sampling Practices". Printed by press of Ohio.

Said, R. (2000). " The Earth Science , 814.p , Hurbe and Raw Publishers, New York and London.

Sys, C. (1991). "Land evaluation part I and II lecture Notes., Gent. Univ., Gent, Belgium.

Sys, C., E. Ranst, J. Van Debaveye and T.F. Beernaer (1993). Land evaluation part III " Crop requirements", Agric, Public 7, Gest Adm For Dev. Coop., Brussels, Belgium.

USDA (1975)."Soil Taxonomy" A Basic system of soil classification for making and interpreting soil Survey handbook 436. USA Giv. Print off, Washington, D.C. USA.

USDA (2004). "Soil Survey Laboratory Methods Manual , Soil Survey Investigation Report No. 42; version 4.0 November, 2004.

USDA (2010). Keys to soil taxonomy' 11th Edition, USA.

Zink, J.A. and Valenzuala (1990). Soil Geographic Database" Vol. 3 ITC. Ensched, Netherlands.

Table 7 (1

Table 7(2

Table 7(3

خصائص وتقسيم وتقييم أراضي وادى النقرة – مصر العليا

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الملخص العربى

أراضى وادى النقرة فى صحراء مصر الشرقية بمحافظة أسوان تعتبر من أكثر المناطق الواعده والملائمة للتوسع الزراعى ويهدف هذا البحث إلى دراسة الخواص الطبيعية والكيميائية وتقسيم وتقييم هذه الأراضى للإستخدام الزراعي وكذلك مدى ملائمتها لنمو بعض المحاصيل الرئيسية وكذا حساب الأحتياجات المائية لبعض المحاصيل. ولهذا الغرض تم تجميع البيانات المتاحة عن منطقة الدراسة وتشتمل على الخرائط الطبوغراقية والجيولوجية وكذلك الموارد الأرضية ونموذج الإرتفاع الرقمى (DEM) وصورة القمر الصناعى لاند سات ETM لمنطقة الدراسة، وقد إستخدمت الخرائط الطبوغراقية وصور القمر الصناعى (ETM (path 147/row 43" لمنطقة الدراسة والملتقطة فى عام (2012) وذلك لعمل الخريطة الفيزيوجرافية ، ونتيجه للتحليل الرقمي للخرائط أمكن تحديد الوحدات الفيزيوجرافية التالية: السهل الرسوبى ، سهل الوادى المنخفض ، السهل الرسوبي المجوي، والمصاطب ، قاع الوادى. وقد أختير عشرة قطاعات أرضية تمثل هذه الوحدات الفيزيوجرافية، ووصفت هذه القطاعات وصفاً مورفولوجياً وجمعت منها عينات التربة لإجراء عليها التحليلات الطبيعية والكيميائية ، وبإستخدام نظام التقسيم الامريكى الحديث تبين أن أراضى منطقة الدراسة تنتمي الى رتبتى الاراضى الحديثة Entisols والأراضى الجافة Aridisols وتحت رتبة الـ Orthents وال Salids وقد أجريت عملية التقسيم حتى مستوى العائلات.

ولقد قيمت مدي ملائمة تلك الأراضي بخصائصها الحاليه للإستخدام الزراعي ووجددت مساحة المناطق عالية الصلاحية (S1) منها تبلغ مساحتها حوالى ٥٩٨١,٣، أما المناطق متوسطة الصلاحية (S2) فتبلغ مساحتها ٣٥١٦٥,٨٤ فدان وتقدر الأراضى هامشية الصلاحية (S3) منها حوالي ٦١٨٤,٦ فدان، وبإجراء عمليات التحسين والإستصلاح لبعض خصائص هذه الأراضى فإن درجة الملائمه المتوقعة بعد التحسين يمكن أن تصل بمساحة الاراضى عالية الصلاحيه (S1) الي ٢٦٢٧٥,٥ فدان، والمناطق متوسطة الصلاحية (S2) الي ٢١٠٥٦,٨ فدان، كما قيمت تلك الاراضي لمدي ملائمتها لزراعة ١٥ محصولاً رئيسياً من محاصيل الحقل والخضر والفاكهه طبقاً لنظام Sys *et al.* (1993) في الحالتين الحاليه والمتوقعه بعد التحسين.

وبإستخدام البيانات المناخية المتوفرة عن المنطقة أمكن حساب الإحتياجات المائية لبعض المحاصيل بالإستعانة ببرنامج Crop Wat.

Table (4): Some chemical characteristics of the Studied Soil Profiles.

Prof. No.	Depth (Cm)	SP %	pH	ECe (ds/m)	Anions (meq/L)				Cations (meq/L)				CEC meq/100 g	ESP %	SAR	OM %	Gypsum %
					$CO^{=}_3$	HCO^{-}_3	Cl^-	SO^{--}_4	Ca^{2+}	Mg^{2+}	Na^+	K^+					
Sedimentary plain																	
1	0-20	23	7,18	2,52	0.0	1,6	7,0	15,82	7,35	1,22	15,5	0,35	7.23	2.21	7.48	0.10	1.25
	20-50	25	7,37	2,71	0.0	1,2	13,0	16,75	8,82	6,38	18,7	0,05	7.37	1.49	5.69	0.10	0.80
	50-100	30	7.30	4,11	0.0	1,0	21,0	23,68	15,9	10,4	19,3	0,08	9.65	3.32	3.63	0.06	0.32
	100-150	30	7,36	4,14	0.0	1,2	21,0	19,5	16,5	6,4	18,7	0,10	8.93	4.92	5.53	1.20	0.12
2	0-30	25	7,56	5,73	0.0	1,2	21,0	48,64	30,3	4,89	26,6	0,05	7.39	2.03	6.35	0.08	2.34
	30-60	25	7,61	0,97	0.0	1,8	4,0	4,05	2,45	1,35	6,0	0,05	9.79	4.39	4.38	0.06	1.44
	60-150	30	7,54	5,48	0.0	1,2	24,0	22,8	22,3	7,6	25,3	0,10	10.11	5.54	6.55	1.20	0.98
3	0-30	28	7,69	1,83	0.0	1,6	4,0	14,98	11,27	3,01	0,20	0,10	11.27	4.70	2.32	0.05	3.20
	30-60	35	7,74	0,52	0.0	1,8	3,0	1,21	1,92	0,84	3,17	0,08	11.24	5.25	2.71	0.03	1.19
	60-150	33	7,82	0,53	0.0	1,8	2,0	2,26	0,98	1,4	3,49	0,19	11.6	6.55	3.20	0.08	0.15
Wadi plain (low plain)																	
4	0-30	20	7,50	2,14	0.0	2,0	5,0	14,12	1,47	11,6	7,93	0,12	3.30	5.15	3.10	0.09	0.13
	30-60	30	7,78	0,77	0.0	3,0	3,0	1,68	1,45	1,36	4,71	0,16	10.23	5.67	3.99	0.07	0.33
	60-150	30	7,80	0,58	0.0	1,2	2,0	2,96	1,94	1,29	2,76	0,17	9.28	7.97	2.17	0.03	0.08
Dissected erosional plain																	
5	0-20	30	7,65	1,23	0.0	2,0	3,0	7,69	5,84	1,68	5,03	0,14	21.24	7.29	2.59	0.07	0.14
	20-60	30	7,85	0,48	0.0	2,0	2,0	1,18	1,96	0,89	2,17	0,16	10.39	6.64	1.82	0.05	0.18
	60-120	33	7,86	0,35	0.0	1,0	1,0	1,33	0,49	0,46	2,22	0,16	8.74	8.35	3.22	0.02	0.28
6	0-10	59	7.7	7.20	0.0	5.6.	42.0	28.40	15.83	2.44	55.23	2.5	29.97	15.52	18.3	0.47	2.55
	10-40	63	7.4	22.0	0.0	4.4	200.0	36.18	67.70	22.38	147.2	3.3	34.33	18.7	21.9	0.45	1.74
	40-80	41	7.1	104.4	0.0	4.0	1360.	295.8	875.0	197.9	577.0	10.0	32.61	15.1	24.9	0.41	1.04
	80-120	25	7.7	13.0	0.00	6.8	94.0	42.20	30.29	15.28	95.43	2.0	12.20	21.9	20.0	0.20	0.86

Table (4):Cont.

Profil No.	Depth Cm	SP %	pH	ECe (ds/m)	Anions (meq/L)				Cations (meq/L)				CEC meq/100 g	ESP %	SAR	OM %	Gypsum %
					$CO^{=}_3$	HCO^{-}_3	Cl^{-}	$SO^{=}_4$	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}					
Terraces																	
7	0-10	26	7,54	1,72	0.0	1,8	4,0	12,54	4,90	2,32	11,04	0,17	15.49	9.48	5.84	0.10	3.46
	10-20	26	7,95	20,7	0.0	1,6	180	161,3	152,9	12,8	171,3	5,89	14.66	14.6	18.8	0.08	1.90
	20-60	28	7,40	20,5	0.0	1,6	184	265,3	294,0	25,9	126,9	4,10	8.92	22.8	14.5	0.05	0.48
	60-150	28	7,44	20,5	0.0	1,6	160	250,6	250,9	50,0	107,9	3,39	8.01	25.7	8.80	0.03	0.74
Wadi bottom																	
8	0-15	57	7.0	0.77	0.0	2.5	3.0.	2.86	2.22	2.74	3.24	0.16	26.31	6.80	2.06	0.33	0.87
	15-50	58	7.3	2.01	0.0	1.6	4.0	16.31	5.56	3.81	12.40	0.14	23.92	7.85	5.73	0.26	0.12
	50-90	63	7.5	3.34	0.0	1.6	5.0	28.28	3.89	3.83	27.00	0.16	28.77	16.8	13.7	0.10	0.58
	90-150	55	7.6	3.00	0.0	2.7	3.0	25.32	2.22	1.64	27.00	0.16	27.52	15.2	19.4	0.10	0.15
9	0-15	45	7.1	0.67	0.0	3.2	2.0	2.00	2.22	0.54	4.16	0.28	21.11	3.50	3.54	0.49	1.30
	15-40	52	7.3	0.80	0.0	2.2	3.0	5.07	1.67	2.74	5.70	0.16	25.97	5.98	3.84	0.24	1.00
	40-90	50	7.6	0.96	0.0	3.8	2.0	6.59	1.67	0.54	10.00	0.18	23.65	9.61	9.51	0.12	0.50
	90-150	40	7.4	1.02	0.0	3.4	2.0	7.54	2.22	0.54	10.00	0.18	29.31	13.57	8.51	0.06	0.80
10	0-15	33	7,65	3,38	0.0	1,6	4,0	28,12	20,4	2,55	10,6	0,17	19.38	10.26	3.14	0.07	1.12
	15-50	35	7,45	15,8	0.0	3,2	128	140,2	14,31	9,28	114,2	4,82	25.60	15.15	13.08	0.07	0.42
	50-80	33	7,51	13,56	0.0	2,4	104	238,0	133,3	7,6	98,3	4,64	20.72	1 0.62	11.72	0.03	0.09

Table (6): Suitability indices of the studied soils for different crops.

Profile No.	Field crops					Vegetable crops					Fruit crops				
	Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class	
		C	E	C	E		C	E	C	E		C	E	C	E
Sedimentary plain															
1	Alfalfa	77.4	90.1	S1	S1	Potato	52.3	85.5	S2	S1	Olives	77.2	90.0	S1	S1
	S0rghum	46.3	57.0	S3	S2	Tomato	59.0	81.2	S2	S1	Graps	73.1	81.2	S2	S1
	Pea	58.3	72.0	S2	S2	Onion	58.6	81.2	S2	S1	Citrus	41.7	95.0	S3	S1
	Groundnut	54.1	79.1	S2	S1	G. pepper	55.7	100	S2	S1	Palm	31.0	48.0	S3	S3
	Maize	44.1	60.5	S3	S2	Cabbage	75.6	83.8	S1	S1					
						W. melon	76.9	100	S1	S1					
2	Alfalfa	96.8	90.0	S2	S1	Potato	30.4	100	S3	S1	Olives	68.6	95.0	S2	S1
	S0rghum	65.4	76.5	S2	S1	Tomato	44.3	81.2	S3	S1	Graps	54.2	95.0	S2	S1
	Pea	27.3	80.1	S3	S1	Onion	27.8	85.7	S3	S1	Citrus	21.7	80.4	N	S1
	Groundnut	47.4	83.8	S3	S1	G. pepper	32.6	81.0	S3	S1	Palm	6.78	30.0	N	S3
	Maize	51.3	79.1	S2	S1	Cabbage	50.9	88.4	S2	S1					
						W. melon	52.2	90.0	S2	S1					
3	Alfalfa	72.7	84.8	S2	S1	Potato	30.4	100	S3	S1	Olives	76.0	100	S1	S1
	S0rghum	74.6	87.3	S2	S1	Tomato	61.4	90.3	S2	S1	Graps	68.2	95.0	S2	S1
	Pea	52.6	79.5	S2	S1	Onion	55.2	76.0	S2	S1	Citrus	29.2	64.8	S3	S2
	Groundnut	48.3	83.1	S3	S1	G. pepper	46.9	64.8	S3	S2	Palm	33.7	46.7	S3	S3
	Maize	58.4	76.o	S2	S1	Cabbage	96.0	90.3	S2	S1					
						W. melon	56.7	98.0	S2	S1					
Wadi plain (low plain)															
4	Alfalfa	69.6	81.2	S2	S1	Potato	51.6	85.0	S2	S1	Olives	57.5	95.0	S2	S1
	S0rghum	70.9	86.4	S2	S1	Tomato	65.2	90.3	S2	S1	Graps	50.2	95.0	S2	S1
	Pea	23.5	82.0	N	S1	Onion	40.0	61.7	S3	S2	Citrus	21.8	59.8	N	S2
	Groundnut	63.6	82.9	S2	S1	G. pepper	40.4	53.6	S3	S2	Palm	22.6	42.5	N	S3
	Maize	55.9	72.6	S2	S1	Cabbage	70.9	85.5	S2	S1					
						W. melon	69.5	98.0	S2	S1					

Table (6): Cont.

Profile No.	Field crops					Vegetable crops					Fruit crops				
	Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class	
		C	E	C	E		C	E	C	E		C	E	C	E
Dissected erosional plain															
5	Alfalfa	52.8	64.9	S2	S2	Potato	38.0	72.3	S3	S2	Olives	14.5	30.6	N	S3
	S0rghum	59.7	69.8	S2	S2	Tomato	39.9	58.6	S3	S2	Graps	52.3	72.6	S2	S2
	Pea	9.87	70.0	N	S2	Onion	34.4	42.5	S3	S3	Citrus	49.7	72.7	S2	S2
	Groundnut	49.2	68.4	S3	S2	G. pepper	28.9	42.1	S3	S3	Palm	12.5	27.4	N3	S3
	Maize	44.4	61.6	S3	S2	Cabbage	44.2	54.5	S1	S2					
						W. melon	40.6	57.6	S3	S2					
6	Alfalfa	5.52	72.7	N	S2	Potato	3.75	68.0	N	S2	Olives	6.05	79.1	N	S1
	S0rghum	4.02	72.7	N	S2	Tomato	2.89	48.7	N	S3	Graps	4.84	76.0	N	S1
	Pea	4.36	72.7	N	S2	Onion	4.04	55.9	N	S2	Citrus	1.34	52.8	N	S2
	Groundnut	3.26	76.7	N	S1	G. pepper	3.00	58.9	N	S3	Palm	1.27	49.9	N	S3
	Maize	4.94	72.6	N	S2	Cabbage	3.81	81.2	N	S1					
						W. melon	5.51	81.0	N	S1					
Terraces															
7	Alfalfa	55.2	72.6	S2	S2	Potato	11.6	80.7	N	S1	Olives	49.7	81.2	S3	S1
	S0rghum	11.7	72.6	N	S2	Tomato	38.9	57.0	S3	S2	Graps	87.7	81.2	N	S1
	Pea	2.29	6.7	N	S2	Onion	2.89	48.5	N	S3	Citrus	0.98	46.2	N	S3
	Groundnut	2.34	69.3	N	S2	G. pepper	3.12	45.9	N	S3	Palm	1.21	2.6	N	N2
	Maize	2.10	61.7	N	S2	Cabbage	2.35	65.4	N	S2					
						W. melon	13.5	72.3	N	S2					

Table (6): Cont.

Profile No.	Field crops					Vegetable crops					Fruit crops				
	Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class	
		C	E	C	E		C	E	C	E		C	E	C	E
Wadi bottom															
8	Alfalfa	65.8	81.2	S2	S1	Potato	43.9	72.3	S3	S2	Olives	79.6	88.2	S1	S1
	S0rghum	62.5	81.2	S2	S1	Tomato	39.7	52.3	S3	S2	Graps	61.4	80.7	S2	S1
	Pea	52.6	81.2	S2	S1	Onion	35.3	51.3	S3	S2	Citrus	16.2	54.2	N	S2
	Groundnut	39.2	80.7	S3	S1	G. pepper	36.4	51.3	S3	S2	Palm	14.5	48.5	N	S3
	Maize	55.5	81.2	S2	S1	Cabbage	51.3	72.6	S3	S2					
						W. melon	64.8	90.0	S2	S1					
9	Alfalfa	74.8	87.5	S2	S1	Potato	64.4	80.7	S2	S1	Olives	83.8	88.2	S1	S1
	S0rghum	75.6	88.4	S1	S1	Tomato	72.6	80.7	S2	S1	Graps	81.2	90.3	S1	S1
	Pea	73.3	85.7	S2	S1	Onion	69.4	76.9	S2	S1	Citrus	58.3	76.7	S2	S1
	Groundnut	72.8	90.3	S2	S1	G. pepper	62.1	72.6	S2	S1	Palm	55.2	72.7	S2	S2
	Maize	73.3	85.7	S2	S1	Cabbage	58.7	68.6	S2	S2					
						W. melon	76.9	90.0	S1	S1					
10	Alfalfa	26.6	69.3	S3	S2	Potato	10.4	72.2	N	S2	Olives	49,9	76.9	S3	S1
	S0rghum	14.7	28.1	N	S3	Tomato	10.9	46.2	N	S3	Graps	22.5	65.4	N	S2
	Pea	3.88	59.9	N	S2	Onion	3.69	44.6	N	S3	Citrus	4.04	36.7	N	S3
	Groundnut	12.5	58.1	N	S2	G. pepper	7.02	48.6	N	S3	Palm	5.15	17.3	N1	N2
	Maize	12.6	50.0	N	S2	Cabbage	21.4	75.5	N	S1					
						W. melon	12.3	80.7	N	S1					

C=Current Suitability E= Expected Suitability

Table (7): Crop water requirements for suitable crops in the studied area

Months	Jan.	Fep.	Mar	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	W per/S
ETo (mm/day)	4.10	4.23	5.35	6.24	7.08	7.80	7.39	7.07	6.31	5.57	4.44	3.63	
Tomato (135 day)													
KC per month		0.45	0.75	1.02	1.05	0.43							
ET crop mm/day		1.90	4.01	6.36	7.43	3.35							
ET crop per month		57.0	120.1	190.8	222.9	100.5							691.3
Tomato (180 day)													
KC per month		0.43	0.69	0.88	1.15	1.15	0.85						
ET crop mm/day		1.90	3.69	5.49	8.14	8.97	6.28						
ET crop per month		57.0	110.7	164.7	244.2	269.1	188.4						1034.1
Sugar beet													
KC per month	0.98	0.67							0.23	0.65	0.98	1.15	
ET crop mm/day	4.02	2.83							1.45	3.62	4.35	4.17	
ET crop per month	120.6	84.9							43.5	106.6	130.5	125.1	613.2
Sorghum													
KC per month				0.48	0.81	1.15	0.81	0.22					
ET crop mm/day				2.99	5.73	8.97	5.98	1.55					
ET crop per month				89.7	171.9	269.1	179.4	46.5					756.6
Egg plant													
KC per month		0.45	0.75	1.02	1.04	0.27							
ET crop mm/day		1.95	4.01	6.36	7.36	2.11							
ET crop per month		58.5	120.3	190.8	220.8	63.3							653.7
pepper													
KC per month			0.50	0.80	1.15	1.08							
ET crop mm/day			2.67	4.99	8.14	8.42							
ET crop per month			80.1	149.7	244.2	255.6							729.6

Table (7): Cont.

Months	Jan.	Fep.	Mar	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	W per/S
ETo (mm/day)7	4.10	4.23	5.35	6.24	7.08	7.80	7.39	7.07	6.31	5.57	4.44	3.63	
Banana													
KC per month	0.70	0.75	0.80	0.85	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	
ET crop mm/day	2.87	3.17	4.28	5.30	6.37	7.80	8.13	8.48	8.20	7.79	6.66	5.81	
ET crop per month	86.1	95.1	128.4	159.0	191.1	234.0	243.9	254.4	246.0	233.7	199.8	174.3	2245.8
Maize grain													
KC per month				0.54	o.86	1.15	o.77	o.12					
ET crop mm/day				3.37	6.10	8.97	5.69	0.85					
ET crop per month				101.1	183.0	269.1	170.	25.5					749.4
Barley													
KC per month	o.81	o.23								0.18	0.81	1.15	
ET crop mm/day	3.32	0.97								1.00	3.60	4.17	
ET crop per month	99.6	29.1								30.0	108.0	125.1	391.8
Citrus - 1													
KC per month	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
ET crop mm/day	3.69	3.81	4.82	5.62	6.37	7.02	6.65	6.36	5.68	5.01	3.99	3.28	
ET crop per month	110.7	114.3	144.6	168.6	191.1	210.6	199.9	190.8	170.4	150.3	119.7	98.4	1869.0
Citrus - 2													
KC per month	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
ET crop mm/day	2.87	2.96	3.75	4.37	4.96	5.46	5.17	4.95	4.42	3.90	3.18	2.54	
ET crop per month	86.1	88.8	112.5	131.1	148.8	163.6	155.1	148.5	132.6	117.0	95.4	76.2	1455.7
Pea													
KC per month										0.63	1.04	1.10	
ET crop mm/day										3.51	4.62	4.00	
ET crop per month										105.3	138.6	120.0	363.0

Table (7): Cont.

Months	Jan.	Fep.	Mar	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	W per/S
ETo (mm/day)7	4.10	4.23	5.35	6.24	7.08	7.80	7.39	7.07	6.31	5.57	4.44	3.63	
Peanut													
KC per month				0.23	0.75	0.91	1.05	0.58					
ET crop mm/day				1.44	5.41	7.10	7.76	4.10					
ET crop per month				43.2	162.3	213.0	232.8	123.0					774.3
Lentil													
KC per month	1.1	0.6	0.25							0.23	0.92	1.05	
ET crop mm/day	4.51	2.54	1.34							1.28	4.08	3.81	
ET crop per month	135.3	76.2	40.2							38.4	122.4	114.3	526.8
Cucumber													
KC per month	0.49	0.75	1.15	1.04	0.27								
ET crop mm/day	2.07	4.01	7.30	7.36	1.87								
ET crop per month	62.1	120.3	219.0	220.8	56.1								678.3
Sunflower													
KC per month						0.29	0.75	1.08	0.95	0.28			
ET crop mm/day						2.26	5.54	7.64	5.99	1.56			
ET crop per month						67.8	166.3	229.2	179.7	46.8			689.8
Onion/dray													
KC per month	1.05	0.88	0.43							1.05	0.88	0.43	
ET crop mm/day	4.31	3.71	2.30							1.39	3.51	3.81	
ET crop per month	129.3	111.3	69.0							41.7	105.3	114.3	570.9
Flax													
KC per month	0.88	1.15	0.96	0.75							0.45	0.75	
ET crop mm/day	3.61	4.86	5.14	4.68							2.00	2.75	
ET crop per month	108.3	145.8	154.2	140.4							60.0	81.6	690.3