SOIL TAXONOMY AND EVALUATION MODEL FOR SPECIFIC AGRICULTURE LAND USE OF PHYSIOGRAPHIC UNITS IN THE DESERT ZONE LOCATED ON THE EAST-NORTHERN RIM OF QARUN LAKE, FAYOUM DEPRESSION, EGYPT

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ABSTRACT:

The desert zone located on the east-northern rim of Qarun lake represents one of the promising desert outskirt of El Fayoum Governorate whether be under demand for agriculture use or to be future planned projects for later on use. That is true, since it is considered a good model for representing many of the landscape features in El Fayoum depression. So, it selected to be identified within the context of physiography, soil classification and land evaluation for specific agriculture land use. This area includes both the continental alluvium of the Nile and desert sediments that were derived from local parent rocks. The physiographic features were identified, using visual interpretation of Landsat data ETM7 (Enhanced Thematic Mapper 7), according the applied physiographic approach, and found to be as the Nile alluvial terraces, desert alluvial terraces, dissected slopes, aeolian plain, pediplain, bajada, cuesta fronts, cuesta summits and wadis. The later landforms whether are almost flat or gently slopping. The relatively high tableland structures were delineated as dissected cuesta of summits and fronts. Forty-five mini pits were located and studied for setting up a characteristic map legend. The differences were represented by nine soil profiles to be fully described and soil samples were selected for laboratory analyses.

Soil taxa were categorized according to the **Key of Soil Taxonomy (USDA, 2006)** till the soil family level into:

i) The *Aridisols*, soil families are a) Typic Haplocalcids, coarse loamy, mixed, hyperthermic in pediplain unit b) *Typic Haplogypsids, coarse loamy, mixed, hyperthermic* in bajada unit; c) Soils of wadis unit are found in a complex pattern of *Typic Haplogypsids, fine loamy, mixed, hyperthermic* and d) *Typic Calcigypsids, fine loamy, mixed, hyperthermic* in the desert alluvial terraces unit.

ii) The *Vertisols* include a) *Chromic Gypsitorrets, fine clayey, semectitic, hyperthermic* in the Nile alluvial terraces unit.

iii) *Entisols* include a) *Lithic Torriorthents, fine loamy, mixed, hyperthermic* in cuesta summits unit; *b) Typic Torriorthents, coarse loamy, mixed, hyperthermic* in cuesta fronts units; c) *Typic Torripsamments, siliceous, hyperthermic* in aeolian plain unit and *d) Lithic Torripsamments, siliceous, hyperthermic* in dissected slopes unit.

The supreme and subsequent prior potential suitability of sixteen specific corps, *i.e.*, field crops (wheat, barley, maize, cotton and onion), oil crops (sesame and sunflower), fodder crops (alfalfa and sorghum), vegetables (tomato) and fruit trees (banana, citrus, guava, mango, oil palm and olive) to be cultivated in the studied physiographic-soil units was carried out by matching between the parametric approach of land evaluation classes and their crop-physiography adaptations. The obtained data show that the potential suitability classes differed according to the satisfaction conditions between different properties of soils developed on the studied physiographic-soil units and plant requirements. These adaptations can be promising for rather higher output as the major land improvements that are considered for the land qualities of drainage, salinity and sodicity to be achieved when the land considering free of those limitations.

Key words: Physiographic-soil units, land evaluation, soil taxa, El Fayoum region.

INTRODUCTION:

The progressive increase of human pressure on limited cultivated areas in El-Fayoum Governorate requires to a pay an attention towards two main aspects, *i.e.,* conserving the productivity status of cultivated soils and the horizontal expansion for the desert outskirts of El Fayoum depression. The later soils have less productive desert siliceous or calcareous in nature. The desert soils under study at both north and east rims of Qarun lake are considered ones of the promising areas for agricultural utilization and developing the economical activities of El Fayoum Governorate. According to **High Dam Soil Survey Project (1963)**, the studied area are identified into four soil units for the northern-east rim of Qarun lake, *i.e.*, saline loose sand soils, foot slopes, partly shale and soft sand stone. **Shendi (1984)** classified the soils adjacent to Qarun lake from the eastern and southern rims as Typic Calcigypsids, Typic Haplogypsids and Typic Torripsamments.

The scientific benefits of the current work should be created to update and support the local knowledge, concerning the best use of land whether be under demand for agriculture use or be planned for later on use. The objectives were to identify the physiographic-soil units of a unique area in El Fayoum depression by mapping them to be a digital model in a harmony of physiography and soil data set, serving the extrapolation approach when other areas will be under study.

It is also to find the best adaptation between certain land units with specific crop to give the maximum output. For this purpose, the harmony of descriptive and processing systems, established by **Sys (1991) and Sys *et al.* (1993)** were considered, being highly required in this study. The collective findings of this study create and document copy data sets, using visual interpretation of Landsat image, basic and topographic maps to obtain a physiographic-soil map, soil taxa and land suitability classes. The result is a comprehensive land evaluation database for a certain area in Egypt. These data can be matched with the other products, produced as the same global standard.

MATERIAL AND METHODS:

Image interpretation:

Landsat images interpretation performed using the physiographic analysis as proposed by **Burnigh (1960) and Gossen (1967)**. Generally, Landsat image composite of Enhanced Thematic Mapper (ETM7) with bands 2,3 and 4 was used to add an extra landscape assessment to the photo-interpretation map. The image was helpful for getting a collective overall view of the studied area as well as using the spectral signatures of the used bands in detecting the cultivated areas and drainage conditions.

Visual analysis of Landsat TM5:

Images of Landsat 5 Thematic Mapper (TM) were used for the purpose of visual analysis. The overall view for delineating the promising areas in East desert soils of Menya characterized by the spectral signatures of an

Orthorectified Land sat Thematic Mapper (TM 5) Mosaic. It is a composite of the bands 4, 3 and 2. The pixel size is a mixture of 28.5 and 30.0 meters. The composite output was of benefit, especially when focusing on the infrared bands that permit the detection and discrimination of broad combinations of different vegetation cover types and identification of water bodies, active drainage, drainage conditions, cultivated areas, and rock types.

The image of Land sat 5 was used for the detailed physiographic analysis for modeling the study areas. This Land sat 5 was acquired during the year 2004 (path 175 rows 42, resolution 28.5 to 30 m). The Thematic Mapper of this Land sat is operating in eight spectral bands. The images are considered as a source of recent information that can be aimed at transferring the recent or modified infrastructures to the maps during the phase of cartography.

Field work:

The physiographic units of space images were checked in the field to confirm the boundaries of the physiographic units or to revise what were shifted. Soil profiles representing the predominant characteristics of the identified physiographic units of the studied area were taken, however, eleven soil profiles were dug to a depth of 150 cm or lithic contact, their locations are shown in Fig. (1).

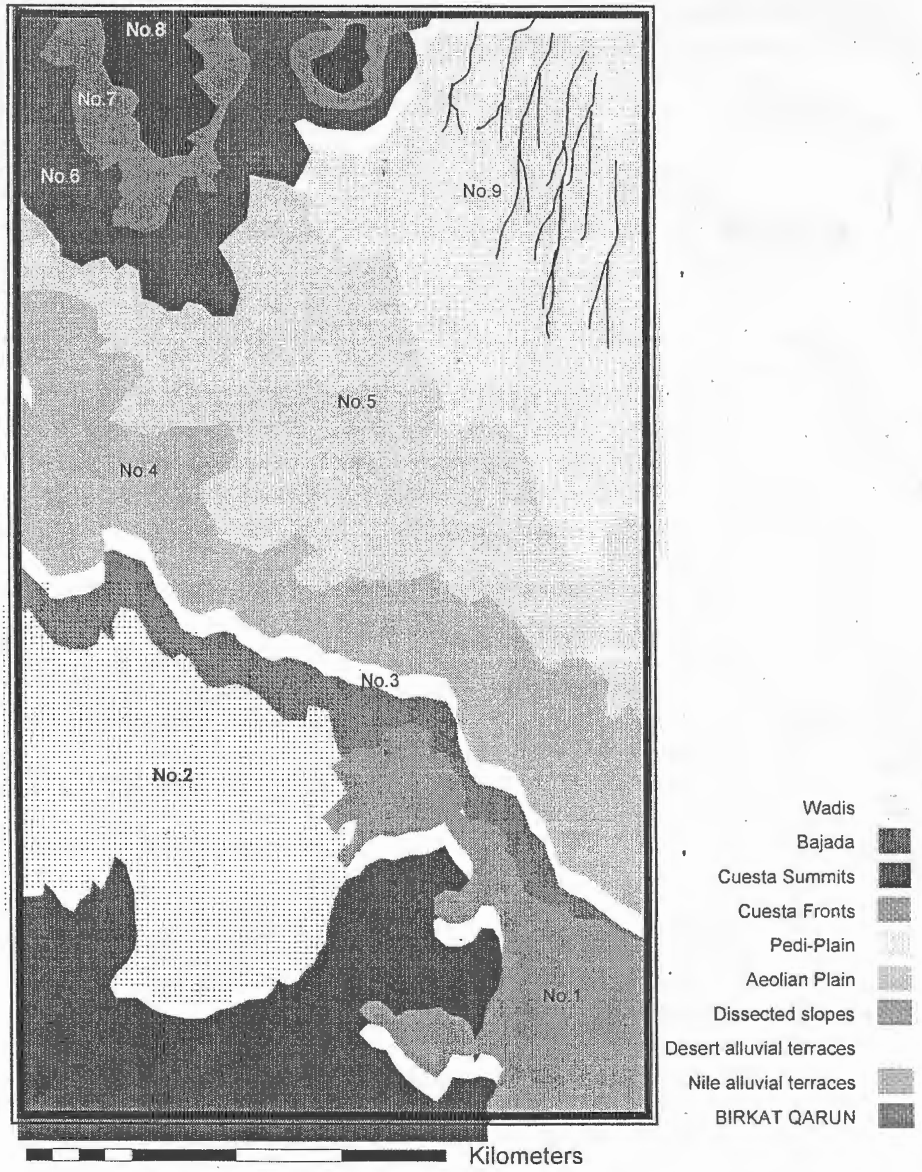
Soil profiles were described, using the nomenclature of the **Soil Survey Division Staff Manual (USDA, 2003)**. The described soil characteristics included land surface configuration, soil slope, vegetation, parent material, soil depth, master horizons, texture, rock fragments, soil matrix color, soil structure, consistence, roots, pores, secondary formation of calcium carbonate and gypsum and boundaries of horizons and layers. Soil samples were air dried, crushed, with wooden hammer, sieved through a 2 mm sieve to obtain the fine earth used for physical and chemical analysis. The elements of soil color description, *i.e.*, the colour name and notations were determined using the **Munsell Soil Colour Chart (1975)**.

Laboratory analyses:

Particle size distribution was determined using the International Pipette method **(Piper, 1950)** and sodium hexametaphosphate as dispersing agent **(Baruah and Barthakur, 1997)**. Calcium carbonate content was measured using the Collin's Calcimeter method **(Wright, 1939)**. Gypsum was determined by the acetone method **(Bower and Huss, 1948)**. Saturation soil paste extract analysis, and soil pH in the soil water suspension of 1:2.5 were determined according to the methods describe by **Jackson (1973)**. Cation exchange capacity and the exchangeable sodium were determined according to the methods describe by **Richards (1954)**.

Soil classification and evaluation:

Soils under study were classified into taxonomic units starting from the level of soil order down to the soil family level according to Soil Taxonomy System **(USDA, 1975)** and using the keys to Soil Taxonomy **(USDA, 2006)**. Soils under investigation were evaluated using the parametric system for land evaluation undertaken by **Sys and Verheye (1978)**. Land suitability classification for specific crops was done according to **Sys *et al.* (1991) and Sys *et al.* (1993)**. Matching the land characteristics with the crop requirements was undertaken by limitation approach.



Map (1) Physiographic-Soil units of the studied area.

RESULTS AND DISCUSSION:

A general view on the physiographic-soil units and their taxonomic classes:

Physiographic-soil legend has been set up as shown in Fig. (1), associated with the morphological description of the representative soil profiles in Table (1). The identified physiographic-soil units were Landsat imagery delineated in two main formations, *i.e.*, 1) The Nile deposits (flat or almost flat Nile alluvial terraces) and 2) The desert formations (cuesta summits, cuesta fronts, bajada, wadis, pediplain, aeolian plain, dissected slopes, desert alluvial terraces). Soil taxa after soil physical and chemical analyses are presented in Tables (2, 3 and 4).

Table 1: Morphological description of the studied soil profiles.

Physiographic unit	Profile No.	Slope gradient	Horizon	Depth (cm)	Soil colour	Modified texture class	Soil structure	Soil consistency	Boundary	Pedological features
The Nile alluvial terraces	1	Almost flat	A	0-10	10YR 3/4	C	Medium sub-angular blocky	Hard	--	--
			By	10-30	10YR 3/3			Very hard	--	sfg
			Byz	30-80	10YR 3/3			Very hard	Diffuse	sfg
			By	80-150	10YR 3/2			Very hard		sfg
The desert alluvial terraces	2	Gently undulating	A	0-25	10YR 7/6	Sl	Massive	Slightly hard	--	sfcg
			Bky	25-70	10YR 6/4		Sub-angular blocky		Diffuse	sfCa
			By	70-150	10YR 7/6					sfg
Dissected slopes	3	Gently slopping	A	0-10	10YR 7/6	LS	Massive	Slightly hard	--	--
			Lithic contact							
Aeolian plain	4	Almost flat	A	0-30	10YR 7/5	S	Single grain	Loose	--	--
			C	30-75	10YR 6/6				Diffuse	
			C_2	75-150	10YR 6/6					
Pediplain	5	Gently undulating	A	0-25	10YR 7/4	LS	Single grain	Slightly hard	--	--
			C	25-80	10YR 6/3				Clear	sfCa
			C_2	80-150	10YR 6/5					--
Bajada	6	Gently slopping	A	0-30	10YR 7/5	SCL	Massive	Slightly hard	--	sfCa
			By	30-100	10YR 8/6		Sub-blocky	Hard	Clear	sfg
			C	100-150	10YR 6/4		Platy	Hard	Clear	--
Cuesta fronts	7	Very gently sloping	A	0-30	10YR 7/6	LS	Single grain	Slightly hard	--	--
			C	30-60	10YR 7/5				Diffuse	
			C_2	60-150	10YR 6/6					
Cuesta summits	8	Gently undulating	A	0-25	10YR 7/5	GSL	Massive	Loose	--	--
			C	25-40	10YR 6/6	SCL		Hard	Clear	
Wadis	9	Almost flat	A	0-25	10YR 6/7	SCL	Massive	Slightly hard	--	sfCa
			C	25-80	10YR 5/5		Platy	Hard	Clear	sfg
			C_2	80-150	10YR 5/6		Platy	Hard	Diffuse	--

Soil texture: S=Sand, LS=Loamy sand, SL=Sandy loam, GSL=Gravely sandy loam, SCL=Sandy clay loam, C=Clay.

Pedological features: sfg= secondary formations of gypsum, sfCa=secondary formations of lime

A brief note about each of the identified physiographic-soil units, which are belonging the previous two formations in the studied area, was carried out as follows:

1. The Nile alluvial deposits:

The Nile alluvium occurred under a specific depositional action of the ancient lake of Fayoum depression "Lake Moeris" with the Nile fresh-water in the Pliestocene period resulting in different physiographic-soil units, particularly the Nile alluvial low terraces adjacent to Birkat Qarun. Thus, an injection was occurred between fluvial deposits and local lacustrine ones, which were richer in secondary formations of $CaCO_3$ and gypsum. **Said (1990)** stated that, in the case of Lake Moeris, where the Fayoum depression fell completely with the fresh Nile water, that reaches inundate its floodbasin. Due to the depositional processes rather than erosional processes, hence the Nile suspended matter was deposited in different physiographic-soil units from the seasonal and periodic flooding. Discharge that is fully confined to El Fayoum basin maintains high competence, and when discharge exceeds basin capacity, there is a dramatic increase in cross-sectional area associated with expansion into the floodbasin.

Table 2: Particales size distribution %, calcium carbonate %, gypsum %, CEC and ESP of the studied profiles.

Physiographic units	Profile No.	Depth (cm)	Gravel %	Particle size distribution %				Modified texture class	$CaCO_3$ %	$CaSO_4.2H_2O$ %	CEC ($C\ mol_c\ kg^{-1}$)	ESP
				C. sand	F. sand	Silt	Clay					
The Nile alluvial terraces	1	0-10	--	15.0	7.9	33.8	43.3	C.	9.10	1.50	38.55	7.58
		10-30	--	14.3	8.2	33.3	44.2		10.50	9.30	33.67	6.58
		30-80	--	15.7	6.8	34.6	42.9		8.10	11.30	34.08	5.65
		80-150	--	16.8	9.7	29.9	43.6		11.30	10.10	35.78	9.67
The desert alluvial terraces	2	0-30	--	56.4	20.0	8.9	14.7	SL	3.50	11.30	11.87	6.15
		30-70	--	60.1	16.1	10.2	13.6		17.30	11.70	10.43	7.84
		70-150	--	65.2	14.4	8.3	12.1		5.10	13.10	8.68	9.76
Dissected slopes	3	0-10	--	69.4	15.3	7.1	8.2	LS	2.44	1.12	5.35	11.47
		Lithic contact										
Aeolian plain	4	0-30	--	79.3	15.0	3.5	2.5	S	2.48	1.37	2.76	4.95
		360-75	--	77.5	17.4	2.8	2.3		1.97	0.84	1.89	5.84
		75-150	--	76.5	16.7	3.3	3.5		2.06	0.75	2.12	7.03
Pediplain	5	0-25	--	65.4	19.1	8.2	7.3	LS	14.97	3.75	5.96	9.74
		25-80	--	59.5	18.7	7.3	14.5	SL	27.50	4.02	6.87	12.35
		80-150	--	67.7	17.5	5.3	9.5	LS	21.34	3.44	8.39	13.89
Bajada	6	0-30	--	47.5	15.0	12.5	25.0	SCL	9.15	2.50	16.11	8.36
		30-100	--	50.2	15.5	11.3	23.0		3.10	13.30	14.97	9.15
		100-150	--	35.0	14.4	22.4	28.2		2.30	3.70	18.53	11.74
Cuesta fronts	7	0-30	--	63.7	20.0	6.8	9.5	LS	2.54	3.94	7.47	12.87
		30-60	--	67.3	16.0	6.0	10.7		2.88	2.58	8.95	14.35
		60-150	--	62.9	21.7	7.0	8.4		3.66	1.24	7.15	14.86
Cuesta summits	8	0-20	41.3	55.8	21.4	8.3	14.5	G SL	2.10	1.24	11.01	10.60
		20-40	5.1	34.4	26.2	15.3	24.1	SCL	7.30	1.97	19.54	13.42
Wadis	9	0-30	--	43.5	13.3	13.7	23.5	SCL	10.95	3.12	17.85	7.99
		30-80	--	45.4	16.6	12.8	25.2		4.55	11.84	18.40	8.87
		80-150	--	37.9	15.3	19.7	27.1		2.79	2.50	21.61	9.45

Soil texture: S=Sand, LS=Loamy sand, SL=Sandy loam, GSL=Gravely sandy loam, SCL=Sandy clay loam, C=Clay.

The velocity and depth of water flowing inside of the floodbasin declines rapidly with distance away from the water courses. The coarsest sediment (usually fine sand and silt) undergoes rapid deposition immediately adjacent to the entrance of the Nile water at Al-Lahun gap, while the finest sediment was deposited away from the gap at the lowest level of Birket Qarun, resulting in low-lying flat to almost flat (slightly depressed) Nile alluvial terraces with somewhat well drained soils of heavy-textured soil material. These soils are subjected to the swelling and shrinkage process fitting the main requirement to be *Vertisols*. Also, these soils have a control section is fully characterized by clayey layers, and are represented by soil profile No. 1. The soils are more developed due to the occurrence of gypsic horizon "By", and are classified as *Chromic Gypsitorrets, fine clayey, semectitic, hyperthermic.*

Table 3: Chemical analysis od soil paste extract of the studied soil profiles.

Physiographic units	Profile No.	Depth (cm)	pH	EC (dS/m)	Cations (meq / L)				Anions (meq / L)		
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	$SO4^{--}$
The Nile alluvial terraces	1	0-10	7.50	46.15	150.50	16.28	356.07	0.95	2.28	51.00	470.52
		10-30	7.10	41.14	247.30	75.72	163.60	0.89	2.23	380.00	105.28
		30-80	7.20	84.99	344.01	62.46	632.87	0.95	2.54	620.00	417.74
		80-150	7.30	20.12	53.70	19.28	145.26	0.67	2.11	110.00	106.80
The desert alluvial terraces	2	0-30	7.50	5.54	38.71	6.72	10.46	0.56	1.91	42.00	12.54
		30-70	7.70	13.58	40.99	11.28	90.60	0.67	2.41	95.00	46.13
		70-150	8.00	13.25	47.37	14.55	79.97	0.74	2.47	80.00	60.16
Dissected slopes	3	0-10	7.80	11.13	29.10	10.19	74.95	0.84	1.98	55.00	58.10
		Lithic contact									
Aeolian plain	4	0-30	7.25	17.10	21.69	11.94	143.12	0.24	1.81	75.60	99.58
		360-75	7.24	55.50	87.25	55.68	514.97	0.89	2.26	391.00	265.53
		75-150	7.18	21.37	28.62	15.54	187.90	0.45	1.89	108.00	122.62
Pediplain	5	0-25	7.90	13.16	19.15	7.36	108.30	0.47	1.89	69.00	64.39
		25-80	7.80	75.10	35.12	19.35	788.90	0.75	1.86	541.00	301.26
		80-150	7.70	15.30	17.33	7.93	132.46	0.64	1.58	83.00	73.78
Bajada	6	0-30	7.60	13.82	43.01	14.37	86.22	0.54	2.36	115.00	26.78
		30-100	7.70	12.60	37.64	9.36	84.31	0.49	2.27	105.00	24.53
		100-150	7.30	5.58	32.38	4.15	20.17	0.44	1.96	40.00	15.18
Cuesta fronts	7	0-30	7.90	14.77	18.25	9.40	125.77	0.48	2.18	65.00	86.72
		30-60	7.70	94.19	40.78	21.73	1065.81	0.93	2.51	672.00	454.83
		60-150	7.60	12.25	32.39	16.27	77.17	0.59	2.06	65.00	59.36
Cuesta summits	8	0-20	7.70	13.26	40.94	6.78	94.68	0.68	2.31	85.00	55.77
		20-40	7.30	7.18	12.38	12.69	49.47	0.71	1.99	45.00	28.26
Wadis	9	0-30	7.68	15.13	39.93	13.18	106.05	0.61	2.11	67.60	90.06
		30-80	7.24	17.34	48.99	16.83	118.61	0.59	2.00	101.50	81.52
		80-150	7.19	9.78	34.87	7.94	59.23	0.55	2.29	59.80	40.50

2. The desert formations:

2.1.Alluvial terraces:

These terraces are beginning from the northern shoreline of Qarun lake and extended towards the north direction. According to **Said (1990)**, they are remnants of formerly erosional processes. On this area, consequent streams, that follows the initial slope of the land (southwards) were rejuvenated, resuming down-cutting, thereby forming terraces, resulting in gullied surfaces of concave convex complex slopes (gently undulating topography). The soils are classified as *Typic Calcigypsids, fine loamy, mixed, hyperthermic.* This soil family is characterized by sandy loam in texture, and it is represented by soil profile No. 2.

2.2. Dissected slopes:

This physiographic unit represents the remnants of a structural plateau, subjected to severe dissection resulting in a rocky structure that be located on rocky slopes covered by talus and pediments with a complex pattern of steep and rolling concave convex surfaces. The soils are very shallow depth (10 cm depth) underlain lithic contact bed-rock, and they are classified as *Lithic Torripsamments, siliceous, hyperthermic*. This soil family is characterized by sand in texture, and it is represented by soil profile No. 3.

Table (4): Soil taxonomic units of the studied soil profiles.

Order	Sub-order	Great group	Sub-group	Family	Representative soil profiles and physiographic units
Vertisols	Torrerts	Gypsi-torrerts	Chromic Gypsi-torrerts	Chromic Gypsitorrerts, fine clayey, smectitic, hyperthermic	1 (The Nile alluvial terraces)
Aridisols	Gypsids	Calci-gypsids	Typic Calci-gypsids	Typic Calcigypsids, fine loamy, mixed, hyperthermic	2 (The desert alluvial terraces)
		Haplo-gypsids	Typic Haplo-gypsids	Typic Haplogypsids, coarse loamy, mixed, hyperthermic	6 (Bajada)
	Calcids	Haplo-calcids	Typic Haplo-calcids	Typic Haplocalcids, coarse loamy, mixed, hyperthermic	5 (Pediplain)
				Typic Haplogypsids, fine loamy, mixed, hyperthermic	9 (Wadis)
Entisols	Psamments	Torri-psamments	Lithic Torri-psamments	Lithic Torripsamments, siliceous, hyperthermic	3 (Dissected slopes)
			Typic Torri-psamments	Typic Torripsamments, siliceous, hyperthermic	4 (Aeolian plain)
	Orthents	Torri-orthents	Typic Torri-orthents	Typic Torriorthents, coarse loamy, mixed, hyperthermic	7 (Cuesta fronts)
			Lihic Torri-orthents	Lithic Torriorthents, fine loamy, mixed, hyperthermic	8 (Cuesta summits)

2.3. Aeolian plain:

This unit is found in areas of the Earth where erosion and deposition by wind are the dominant geomorphic forces, particularly under the dry climates that are classified as arid deserts and semi-arid steppe. Different processes are responsible for the transport of sediment by wind, like this rolling motion, which called traction and suspension, this type of transport is called also saltation. This plain is located on the margins of the plateau remnant, immediately bordering the dissected slopes in the southern side. It is most probably that, these aeolian deposits are covering an old bed-rock that was naturally excavated. The plain is locally occupied by sinuous clustered low-dunes, which are currently retreated as subjected to the natural vegetation. This plain includes excessively well-drained coarse textured soils, that are classified as *Typic Torripsamment, siliceous, hyperthermic*, and its soils are represented by profile No. 4.

2.4. Pediplain:

This physiographic unit was formed under the prevailing aridic conditions through an action of physical weathering processes on the limestone parent rock. This unit has very gently slopping to gently undulating and including somewhat well drained soils. Its polygons are the remnants of weathered limestone rock, including residual parent material over limestone lithic contact at the depth of 90-150 from soil surface. This parent material developed to *Aridisols*, being with diagnostic calcic horizon (BK). The representative soils are with control sections dominated by loam sandy texture grade. The soils were classified as *Typic Haplocalcids, coarse loamy, mixed, hyperthermic;* and these soils are represented by soil profile No. 5.

2.5. Bajada:

This unit is a depositional belt in the studied area along the elevated structures of cuesta fronts when the fans coalesce laterally to form that bajada. It is somewhat relatively broad and gently inclined, alluvial piedmont slope extending from the base of cuesta range out into relatively low basin southern-eastwards. Bajada surface is gullied and gently slopping. The soils are well drained, classified as *Typic Haplogypsids, coarse loamy, mixed, hyperthermic.* These soils are more developed than those the pediplain, being with gypsic "By" horizon, and they are represented by soil profile No. 6.

2.6. Cuesta:

This physiographic unit represents the remnants of a structural plateau, subjected to severe dissection resulting in a rocky structure, that be divided into two sub units as:

a. Cuesta fronts:

These fronts are located on gently slopping area covered by talus deposits and with a complex pattern of relatively rolling concave convex surfaces. These soils are classified as *Typic Torriorthents, coarse loamy, mixed, hyperthermic.* Also, this soil family is characterized by loamy sand in texture, and it is represented by soil profile No. 7.

b. Cuesta summits:

These summits represent the original elevation of the limestone body before the dissection processes. The soils are very shallow depth (40 cm depth) underlain lithic contact bed-rock, This unit has gently undulating to gently sloping, gravely and stony surfaces including somewhat well drained soils. and they are classified as *Lithic Torriorthents, fine loamy, mixed, hyperthermic.* This soil family is characterized by sandy loam to sandy clay loam in texture, and it is represented by soil profile No. 8.

2.7. Wadis:

The surface of this physiographic unit is almost flat to gently undulating, partly natural vegetated on well drained soils. Also, this unit is the resultant of dissection action of the surrounding landscape as the interaction of erosional and depositional processes in the fluvial period. They appear as dry wadis, that seasonally receive flush flooding, running from west to east or southeast, draining into the relatively low areas. The soils of these wadis occur in a complex pattern and dominated by one taxonomic unit of *Typic Haplogypsids, fine loamy, mixed, hyperthermic.* These soils have a relatively fine texture class within the control section (sandy clay loam) as compared to the other studied desertic formations. This soil family is represented by soil profile No. 9.

It is noteworthy to mention that, based on the detected soil morphological features and physico-chemical properties, the soils under investigation could be classified up to the family level into nine taxonomic classes according to **Keys to Soil Taxonomy (USDA, 2006)**, as shown in Table (4). It is most probably due to the studied soils are developed on different parent materials differ in their mineralogical compositions, which are more related to the physiographic positions. Also, the investigated area lies within the climatic conditions characterized by a long hot rainless summer and short mild winter with a rare rainfall. The majority of the studied soil profiles are rich in secondary $CaCO_3$ and gypsum accumulations, which satisfy the requirement of calcic and gypsic horizons in some soil profile layers such as Nos. 1, 2, 5, 6 and 9.

Soil limitations for productivity and land evaluation:

The physical parametric land evaluation system undertaken by **Sys and Verheye (1978)**, which is considered a favourable system under the conditions prevailing in the soils of Egypt **(Moussa, 1991)**, was applied to determine the soil limitations and their intensities as well as land suitability classes according to the current suitability ratings. Since it is valid for irrigation purposes in arid and semi arid regions. By this approach, the classification was processed according to the **FAO Framework (1976)**, at the level of sub-classes.

The obtained data in Table (5) reveal that all the studied soils have no limitations for their topography (except profile Nos. 1 and 3), wetness (w), the effective soil depth (except profile Nos. 3 and 8) and gypsum content (except profile No. 2). On the other hand, most of the representative soil profiles are suffering from soil texture (s_1), $CaCO_3$ (s_3) content and salinity/alkalinity (n) as limitations for soil productivity, which are put into variable intensity degrees of (40-95, very severe-slight), (95, slight) and (50-85, severe-moderate), respectively.

According to the same parametric system and the estimated data of soil criteria, the suitability indices (Ci) for the studied nine profiles for current and potential suitability classes are also assessed and recorded in Table (5). The obtained results show that the estimated current ratings of the studied soil profiles ranged between 11.99 and 76.61, indicate that the soils of the studied areas could be categorized into four classes, as follows.

a. Not suitable soils (N):

The rating of this class is < 25, and represented by soil profile Nos. 3 and 4.

b. Marginally suitable soils (S3):

The rating of this class is 25-<50, and represented by profile Nos. 1, 2, 5, 7 and 8.

c. Moderately suitable soils (S2):

The rating of this class is 50-<75, and represented by soil profile No. 9.

d. Highly suitable soils (S2):

The rating of this class is 75 or more, and represented by soil profile No. 6.

Table (5): Soil limitations and rating indices for the evaluation of the studied soil profiles.

Physiographic units	Profile No.	Suitability condition	Topography (t)	Wetness (w)	s				Soil salinity/ Alkalinity (n)	Rating (Ci)	Suitability class	Suitability subclass
					Soil texture (s1)	Soil depth (s2)	$CaCO_3$ (s3)	Gypsum (s4)				
Nile alluvial terraces	1	Current	90	100	85	100	95	100	50	36.33	S3	S3n
		Potential	100	100	85	100	95	100	100	80.75	S1	S1
Desert alluvial terraces	2	Current	100	100	75	100	95	80	85	48.45	S3	S3s1s4
		Potential	100	100	75	100	95	80	100	57.00	S2	S1s1s4
Dissected slopes	3	Current	90	100	55	30	95	100	85	11.99	N2	N2s1s2
		Potential	100	100	55	30	95	100	100	15.67	N2	N2s1s2
Aeolian plain	4	Current	100	100	40	100	95	100	58	22.04	N1	N1s1n
		Potential	100	100	40	100	95	100	100	38.00	S3	S3s1
Pediplain	5	Current	100	100	55	100	100	100	58	31.90	S3	S2s1n
		Potential	100	100	55	100	100	100	100	55.00	S2	S2s1
Bajada	6	Current	100	100	95	100	95	100	85	76.71	S1	S1
		Potential	100	100	95	100	95	100	100	90.25	S1	S1
Cuesta fronts	7	Current	100	100	55	100	95	100	58	30.30	S3	S2s1n
		Potential	100	100	55	100	95	100	100	52.25	S2	S2s1
Cuesta summits	8	Current	100	100	85	55	95	100	85	40.34	S3	S3s2
		Potential	100	100	85	55	95	100	100	44.41	S3	S3s2
Wadis	9	Current	100	100	95	100	95	100	80	72.20	S2	S2n
		Potential	100	100	95	100	95	100	100	90.25	S1	S1

For ameliorating the suitability of these soils, major improvement practices should be carried out such as removing the excess of soluble salts and sodicity through applying the gypsum and leaching requirements under an efficient drainage ditches, in addition to organic fertilization and other soil and water managements. Such agro-management practices will correct the ratings of soil potential suitability classes to be ranged 15.67-90.25, and potential soil suitability becomes as follows.

a. Not suitable soils (N):

The rating of this class is < 25, and represented by soil profile No. 3.

b. Marginally suitable soils (S3):

The rating of this class is 25-<50, and represented by soil profile Nos. 4 and 8.

c. Moderately suitable soils (S2):

The rating of this class is 50-<75, and represented by soil profile Nos. 2,5 and 7.

b. Highly suitable soils (S1):

The rating of this class is 75<, and represented by soil profile Nos. 1, 6, and 9.

Land suitability for certain crops:

The physiographic-soil map was used as a base for presenting land suitability classes. The simple approach that proposed by **Sys (1991)** was selected for land suitability evaluation of the studied area, since it is valid for irrigation purposes in arid and semi arid regions. By this approach, the classification was processed according to the framework of **FAO (1976)**, at the level of subclasses. Ratings, attributed to land qualities, were matched with each crop requirements. The land qualities are drainage (d), soil texture (x), stoniness (g, gravel %), soil depth (p), calcium carbonate % (c), salinity (s, ECe), sodicity (n, ESP) and fertility (f). Fertility ratings attributed to soil reaction (pH), cation exchange capacity (CEC) and sum of basic cations (exchangeable Ca, Mg and K). Suitability subclasses in Tables (6 and 7) reflect the kind of limitations as indicated in symbols, using lower-case letters synonymous with those limitations when any of them is moderate.

Land suitability for agricultural irrigated soils is the appraisal of specific areas of land from a general point of view without mentioning the specific kind of use. So, some soils may be suitable for a specific crop and unsuitable for another. The ideal approach for land evaluation is based on evaluating the land for utilization types which used as guides for the most beneficial use for a specific productivity by replacing a less adapted land utilization type by another promising one, and was applied in this study according to **Sys (1991)**. The evaluation indices of land characteristics are done by rating them and specifying their limitations for certain crops by matching the calculated rating with the crop requirements in different suitability levels as proposed by **Sys *et al.* (1993)**.

a. Current land suitability classification (Cs):

In the studied area, without major land improvements, the crop requirements were matched with the present land qualities for processing the current land suitability of the different land units. This approach enables management of different alternatives for specific utilizations that are adapted to the existing limitations to give maximum output. The current land suitability classification of different physiographic units for the different specific utilizations is shown in Tables (6 and 7).

b. Potential land suitability classification (Ps):

As for this purpose, the land utilization is applicable after executing specified major land improvements as proposed in the current study according to their necessity. Potential land suitability classification can be established if the main improvements for the studied area are considered regarding land qualities of drainage, salinity and sodicity. The potential land suitability classification of different physiographic units for the different specific utilizations is shown in Tables (6 and 7) for the studied area. The obtained potential land suitability subclasses were sorted in two productive levels. These two levels were designed to be guide charts for the best land utilization alternatives giving a possible maximum output. The two potential land suitability levels are as follows:

1. Supreme potential suitability for specific utilizations:

Matching charts of the supreme potential suitability for specific utilizations with the different physiographic-soil units of the studied area shown in Tables (6 and 7).

Table (6): Current and potential suitability of the soils developed on the identified physiographic units for field, oil and fodder crops.

Physiographic unit	Profile No.	Field crops								Oil crops				Fodder crops			
		Wheat		Barley		Maize		Cotton		Sesame		Sunflower		Alfalfa		Sorghum	
		CS	PS	CS	PS	CS	PS	CS	PS	CS	PS	CS	PS	CS	PS	CS	PS
The Nile alluvial terraces	1	N2s	S2xy	N2s	S2xy	N2s	S2xy	N2s	S2xy	N2s	S2x	N2s	S2xy	N2s	S2xy	N2s	S2xy
The desert alluvial terraces	2	N2s	S3xy	N1s	S3xy	N1s	S3xy	N1s	S3xy	N2s	S1m	S3s	S3y	S3s	S1m	S2sxy	S2xy
Dissected slopes	3	N2s	S3p	S3p	S3p	N2p	N2p	N2p	N2p	N2p	N2p	N2p	N2p	N2p	N2p	S3p	S3p
Aeolian plain	4	N2s	N2x	N2s	N2x	N2sx	N2x	N2s	S3x	N2s	S3x	N2s	S3x	N2s	S3x	N2s	S3x
Pediplain	5	N2s	S3x	N2s	S3x	N2s	S2xc	N2s	S3x	N2s	S2x	N2s	S2xc	N2s	S2xc	N2s	S3x
Bajada	6	N2s	S2x	S3x	S2x	N1s	S1m	S2sxy	S2xy	N2s	S1m	S3s	S1m	S3s	S2y	S3y	S3y
Cuesta fronts	7	N2s	S3x	N2s	S3x	N2s	S2x	N2s	S3x	N2s	S3x	N2s	S2x	N2s	S2x	N2s	S3x
Cuesta summits	8	N2s	S3pg	S2pg	S2pg	N1s	S3pg	S3spg	S3pg	N2s	S3pg	N2p	N2p	S3pg	S3pg	S2sxg	S2xg
Wadis	9	N2s	S2x	N2sx	S2x	N2s	S2y	S3s	S2x	N2s	S1m	N2s	S2y	N2s	S2y	S3s	S1m

Table (7): Current and potential suitability of soils developed on the identified physiographic units for vegetable crops and fruit trees.

Physiographic unit	Profile No.	Vegetable crops				Fruit trees											
		Onion		Tomato		Banana		Citrus		Guava		Mango		Oil palm		Olive	
		CS	PS	CS	PS	CS	PS	CS	PS	CS	PS	CS	PS	CS	PS	CS	PS
The Nile alluvial terraces	1	N2sy	N2y	N2sy	N2y	N2s	S3y	N2sy	N2y	N2s	S2m	N2sy	N2y	N2sy	N2y	N2s	S2x
The desert alluvial terraces	2	N2sy	N2y	N2sy	N2y	N2s	S3y	N2sy	N2y	N2s	S2x	N2sy	N2y	N2sy	N2y	S1s	S1m
Dissected slopes	3	N2p	N2p	N2p	N2p	N2p	N2p	N2p	N2p	N2s	S3xp	N2sp	N2p	N2sp	N2p	N2p	N2p
Aeolian plain	4	N2s	S3x	N2s	S3x	N2sx	N2x	N2s	S3xy	N2s	S3x	N2s	S3xy	N2sy	N2y	N2s	S3x
Pediplain	5	N2s	S3yc	N2s	S3yc	N2sc	N2c	N2s	S3yc	N2s	S3x	N2s	S3y	N2syc	N2yc	N2s	S2x
Bajada	6	N2y	N2y	N2y	N2y	N2s	S3y	N2sy	N2y	N2s	S2x	N2sy	N2y	N2sy	N2y	S1s	S1
Cuesta fronts	7	N2s	S2y	N2s	S2xy	N2s	S3x	N2s	S2y	N2s	S3x	N2s	S2xy	N2s	S3xy	N2s	S1m
Cuesta summits	8	N2s	S2g	N2sp	N2p	N2s	S3pg	N2sp	N2p	N2s	S2xg	N2sp	N2p	N2s	S3pg	N2p	N2p
Wadis	9	N2s	S3y	N2s	S3y	N2s	S3y	N2s	S3y	N2s	S2x	N2s	S3y	N2sy	N2y	S2s	S1

CS=Current suitability, PS=Potential suitability, S1=Highly suitable, S2=Moderately suitable, S3=Marginally suitable, N1=Currently not suitable, N2=Potentially not suitable
[Soil limitations: d=drainage, x=texture, g=gravel%, p=soil depth, c=calcium carbonate %, y=gypsum %, s=salinity (EC), n=ESP, m= accumulation of minor limitations]

The resultant adaptations are as follows:

** Highly suitable (S1) adaptations:*

a. Some soil sites of the desert alluvial terraces unit are suitable for sesame, alfalfa and olives.
b. Some soil sites of bajada unit are suitable for maize, sesame, sunflower and olives.
c. Some soil sites of cuesta fronts unit are suitable for olive.
d. Some soil sites of wadis unit are suitable for sesame, sorghum and olives.

** Moderately suitable (S2) adaptations:*

a. Some soil sites of the Nile alluvial terraces unit are suitable for wheat, barley, maize, cotton, sesame, sunflower, alfalfa, sorghum, guava and olives.
b. Some soil sites of pediplain unit are suitable for maize, sesame, sunflower and alfalfa.
c. Some soil sites of cuesta summits unit are suitable for barley, sorghum and guava.

** Marginally suitable (S3) adaptations:*

a. Some soil sites of dissected slopes unit are suitable for wheat, barley, sorghum and guava.
b. Some soil sites of aeolian plain unit are suitable for cotton, sesame, sunflower, alfalfa, sorghum, onion, tomato, citrus, guava, mango and olives.

2. Subsequent prior potential suitability for specific utilizations:

** Moderately suitable (S2) adaptations:*

a. Some soil sites of the desert alluvial terraces unit are suitable for sorghum and guava.
b. Some soil sites of bajada unit are suitable for wheat, barley, cotton, alfalfa and guava.
c. Some soil sites of cuesta fronts unit are suitable for maize, sunflower, alfalfa, onion, tomato, citrus, and mango.
d. Some soil sites of wadis unit are suitable for wheat, barley, maize, cotton, sunflower, alfalfa and guava.

** Marginally suitable (S3) adaptations:*

a. Some soil sites of the Nile alluvial terraces unit are suitable for banana.
b. Some soil sites of pediplain unit are suitable for wheat, barley, cotton, sorghum, onion, tomato, citrus, guava and mango.
c. Some soil sites of cuesta summits unit are suitable for wheat, maize, cotton, sesame, alfalfa, banana and oil palm.

From the aforementioned discussion, it could be concluded that the results of the current work are created a local knowledge should be supported the future projects of agricultural utilization in El Fayoum area. Also, the obtained can be use as a guide to explain and correct the problems facing the future agricultural utilization projects in the area under investigation, and in turn the best use of land whether be under demand for agriculture use or be planned for later on use. That means the obtained results represent the best adaptation between certain land units with specific land use in agricultural purposes as well as to give the maximum outputs from the agricultural utilization projects.

Moreover, identifying the physiographic-soil features of a unique area in the adjacent desert outskirts of El Fayoum depression by mapping them to be a model is in a harmony of physiographic and soil data set, serving the extrapolation approach when other areas will be under study. In addition, this work was carried out by using physiographic-soil units map obtained from the visual analysis of Enhanced Images of Landsat Thermatic Mapper 7 of the studied area. These soil criteria represent a base for making a proper agricultural utilization and could be considered as promising items in soil potentiality and its sustainable agriculture on the long-term.

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نموذج تصنيفى وتقييمى لأراضى الوحدات الفيزيوجرافية لاستخدام زراعي معين في النطاق الصحراوى الواقع شمال-شرق حافة بحيرة قارون – منخفض الفيوم – مصر

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تمثل أراضى النطاق الصحراوى الواقع شمال-شرق حافة بحيرة قارون أحد المناطق الواعدة فى الظهير الصحراوى لمحافظة الفيوم تحت الطلب للإستخدام فى الأغراض الزراعية أو فى التخطيط المستقبلى لمشاريع التنمية الزراعية. هذا حقيقى، لأنها تعتبر نموذجا ممثلا لمعظم ملامح الوحدات الارضية فى منخفض الفيوم، قد اختيرت هذه المنطقة لتعريفها من خلال المفهوم الفيزيوجرافي وتصنيف التربة وتقييمها بغرض استخدامات زراعية معينة. وتضم هذة المنطقة الترسيبات القارية لنهر النيل وأيضا الترسيبات الصحراوية المتاخمة لها والتي اشتقت من صخور الأم المحلية. ولقد تم تعريف الوحدات الفيزيوجرافية عن طريق التحليل المرئى لصور القمر الاستطناعي (ETM 7) مع تطبيق المنهج الفيزيوجرافى. ومن خلال هذا التحليل وجد ان منطقة الدراسة تتكون من المصاطب النهرية الرسوبية The Nile alluvial terraces، المصاطب الصحراوية الرسوبية Desert alluvial terraces، سلسلة من الميول المتقطعة Dissected slopes، سهل الترسيبات الهوائية Aeolian plain، سهل تجوية والذي يحتوي على مادة اصل متبقية Pediplain، الباجادا Bajada، من كويستا وبروزات Cuesta summit and fronts، الوديان Wadis. والملامح الأرضية تضم أجزاءا مستوية وأخرى ذات ميول بسيطة. والأجزاء ذات المناسيب المرتفعة تضم تتواجد فى شكل بقايا مادة اصل هضبية الشكل Plateau تعرضت لعمليات تجوية شديدة حتى أصبحت فى شكل كويستا وبروزات. ولقد حددت خمسة وأربعون موقعا لحفر نقاط ملاحظة أرضية صغيرة من اجل تصميم مصطلحات الخريطة حيث تم تمثيل تبايناتها بدراسة تفصيلية لتسعة قطاعات لأرضية اخذت منها عينات للتربة للتحليلات المعملية.

وقد تم تصنفت خواص التربة حسب دليل نظام التصنيف الأمريكي لعام (٢٠٠٦) حتي مستوي عائلات التربة، حيث وجد ان الأراضي المتكونة تتبع ثلاثة رتب تشتمل على العائلات التالية:

i) The *Aridisols*, soil families are a) Typic Haplocalcids, coarse loamy, mixed, hyperthermic in pediplain unit b) *Typic Haplogypsids, coarse loamy, mixed, hyperthermic* in bajada unit; c) Soils of wadis unit are found in a complex pattern of *Typic Haplogypsids, fine loamy, mixed, hyperthermic* and d) *Typic Calcigypsids, fine loamy, mixed, hyperthermic* in the desert alluvial terraces unit.

ii) The *Vertisols* include a) *Chromic Gypsitorrets, fine clayey, semectitic, hyperthermic* in the Nile alluvial terraces unit.

iii) *Entisols* include a) *Lithic Torriorthents, fine loamy, mixed, hyperthermic* in cuesta summits unit; *b) Typic Torriorthents, coarse loamy, mixed, hyperthermic* in cuesta fronts units; c) *Typic Torripsamments, siliceous, hyperthermic* in aeolian plain unit and *d) Lithic Torripsamments, siliceous, hyperthermic* in dissected slopes unit.

وقد تم تقييم أراضى الوحدات الفيزيوجرافية – سواء بالنسبة لصفات التربة الحالية أو بعد تحسينها – بغرض تحديد الأفضلية الأعلى لحاصلات زراعية معينة بلغت فى جملتها ستة عشر محصول ممثلة فى حاصلات الحقل (القمح، الشعير، الأذرة، القطن، البصل)، حاصلات زيتية (السمسم، عباد الشمس)، حاصلات عاف (البرسيم، السورجم)، خضر (الطماطم)، أشجار فاكهة (الموز، الموالح، الجوافة، المانجو، نخيل الزيت، نخيل البلح) والتى يمكن زراعتها فى أراضى الوحدات الفيزيوجرافية تحت الدراسة، وذلك من خلال عمل توافق بين التقييم الكمى للتربة وإحتياجات تلك الحاصلات. وتشير النتائج المتحصل عليها إلى أن القدرة الكامنة لمدى صلاحية الأراضى تختلف تبعا لمدى توفر خصائص التربة الملائمة المتكونة على كل من الوحدات الفيزيوجرافية تحت الدراسة. وأن هذه الموائمات بين أراضى الوحدات الفيزيوجرافية والمحاصيل المختلفة تتوقف على مدى التأقلم المستقبلى ما بين خصائص التربة وإحتياجات الحاصلات المختارة. وهذا التأقلم المستقبلى واعدا بلا شك لتعظيم العائد من خلال تحسين حالة التربة خاصة فيما يتعلق بالصرف، مستويات الملوحة والصودية لتعزيز القدرة الكامنة للأراضى بعد خلوها من تلك العوامل المعوقة للإنتاجية.