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Soil Classification of Different Physiographic Units in South East Egypt Using Remote Sensing Data

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ABSTRACT

The study area was situated in South East Egypt, which includes soils of different parent rocks and different parent materials. These soils were either regionally derived from sandstone parent rock or continentally from basement complex parent rocks forming River Nile alluvium. Remote sensed data were manipulated from the satellite TM8 2020 for delineating the physiographic units on the base of reflected spectral signatures of different landscape elements, which cover 386,171.04 hectares. Two groups of physiographic units were identified as having different genesis. One of these groups includes dissected rock land of sandstone, pediplain of residuum, bajada and wadis of alluvium. Another group includes River Nile alluvium as levees, point bares, bow bars and alluvial plain. Soil taxa of those physiographic units were categorized as three soil orders to the level of soil family. These soil taxonomic units are: *Aridisols* including a) *Lithic Calcigypsids, coarse loamy, mixed, hyperthermic* in pediplain with inclusion of *Lithic Calcigypsids, sandy, mixed, hyperthermic;* and b) *Typic Haplogypsids, coarse loamy, mixed, hyperthermic* in bajada. *Vertisols* include *Typic Haplotorrerts, fine, hyperthermic* in River Nile alluvial plain. *Entisols* including: a) *Typic Torrifluvents, fine loamy, mixed (calcareous), hyperthermic*in wadis with inclusion of *Typic Torrifluvents, fine loamy over sandy, mixed (calcareous), hyperthermic.;* b) *Typic Torriorthents, fine loamy, mixed, hyperthermic* occurred in levees.; c) *Typic Torriorthents, fine loamy over sandy, mixed, hyperthermic* in point bars; and d) *Typic Torriorthents, coarse loamy, mixed, hyperthermic* in bow bar.

Keywords: Physiography, Soil classification, South East Egypt, Remote sensed data.

INTRODUCTION

The study area was selected to be investigated and introduced as a promising area for the agricultural development. This area in south-east of Egypt, is a unique landscape, which has soils of wide variations in their genesis where they were either derived by River Nile from continental basement complex parent rocks or formed locally from sandstone parent rock. This area requires to be harmonized for maximizing the use of its water and land resources. River Nile alluvium is considered the most important base of Egypt's economy in a unique agrobiodiversity. It is a profound part of Land-River Nile natural adaptation in Egypt of a very high economical value. Accordingly, this area needs for setting up the engineering constructions for the best use of soils and maximizing the use of irrigation water. On the other hand, for programming any reclamation plan in this area, the information of landscape features and soil classification are required for tracing an extra area to be under agricultural land use. Complementary data for serving this purpose is tracing the watershed areas in the high land that are supporting the seasonal flash flooding to the promising areas in the low land via the drainage system. In this case, rather engineering constructions are required for water harvesting to be converted to the specified areas for agricultural land use. According to Magaly *et al.* (2012), this study area and its outskirts occasionally receive a significant amount of surface runoff during the rainy season from the eastern Red Sea mountain range. Zhu and Abdelkareem (2021) reported that, the desert fringes of the Kom Ombo area are promising areas for land cultivation and population growth. They are distinguished by excessive water claim and pressure on existing water stores. The nature of the stream-networks and catchment area control the harvesting of the precipitation

on the highly elevated areas. Catchments that capture excessive amounts of rainfall have the capability to infiltrate and recharge the groundwater aquifers. Such areas constitute good potential drilling sites for groundwater abstraction. Fracture system seems to be particularly promising in terms of bringing groundwater from the Nubian aquifer. In addition, deep seated fractures trending in NWSE, N-S and E-W directions seem to control much of the Kom Ombo graben structure. These fracture sets have been investigated in detail in the Kom Ombo graben east of the Nile (El Bastawesy *et al.*, 2010). The aim of this study is to identify the physiographic features and their highly correlated soil taxa as data base for an extra study that realize the best land utilization types. This data base also can be used for extrapolating further physiographic features in other scanned areas. This aim of study was realized by careful understanding of remote

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sensing application and using the Geographic Information System (GIS) producing physiographic-soil data. The findings were based on systematic and uniform cartographic and mapping specifications

MATERIALS AND METHODS

Location of study area

The study area is located at the south-east of Egypt. It includes a part of River Nile alluvium with its eastern desert outskirts. Its total area is about 386,171.04 hectares. The coordinates of this area are latitude of 24^{o} 16^{-} $43.52^{=}$ N and longitude of 32^{o} 53^{-} $24.01^{=}$ E in the lower left corner, while in the upper left corner are latitude of 24^{o} 38^{-} $11.48^{=}$ N and longitude of 32^{o} 55^{-} $26.40^{=}$ E. In the upper right corner, the latitude is 24^{o} 44^{-} $12.33^{=}$ N and the longitude is 33^{o} 43^{-} $13.15^{=}$ E, while in the lower right corner, the latitude is 24^{o} 16^{-} $42.66^{=}$ N and the longitude is 33 ^{o} 43^{-} $05.82^{=}$ E (Figure 1).

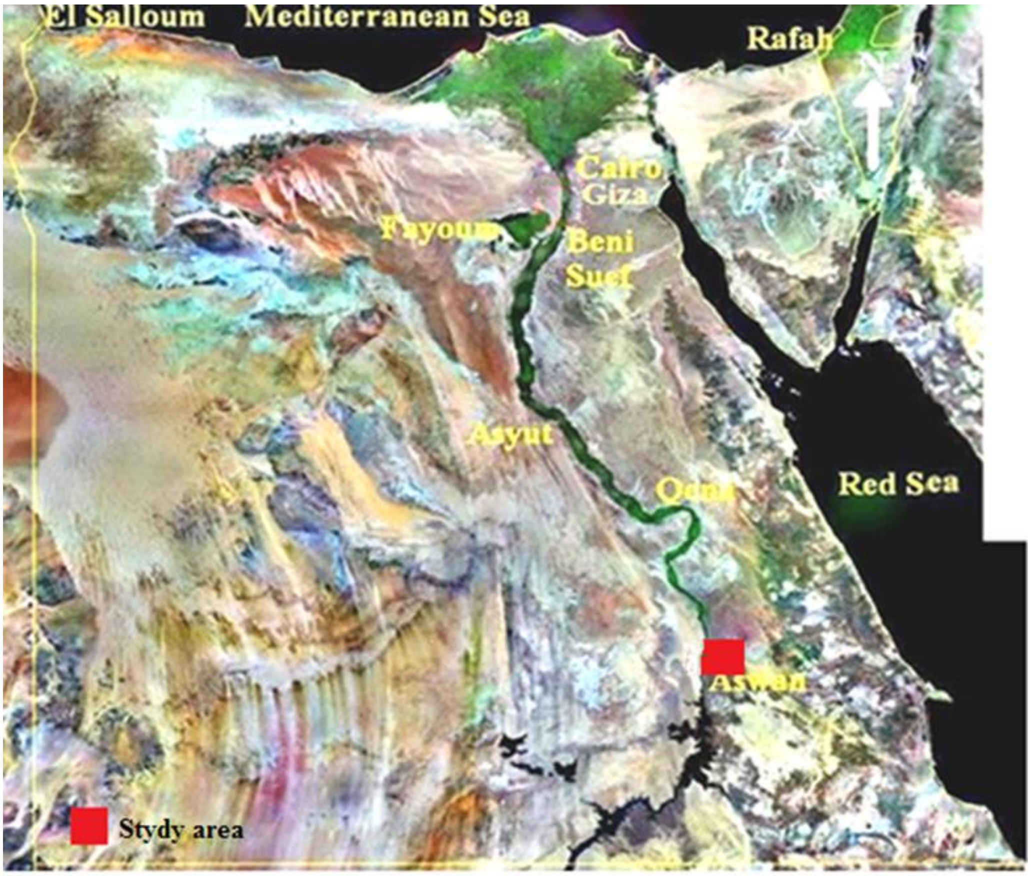

Figure 1. Location map of the study area

The attributes of remote sensing data

Remote sensed data were manipulated from the Operational Land Imager (OLI) of the satellite TM8 2020 within the path 176 and row 39. The spectral bands are green (530 - 590 nm), red (640 - 670 nm), and near-infrared (850 - 880 nm). These data were merged with panchromatic band of 15meter spatial resolution with spectral resolution of 500-680 nm.

Remote sensing data processing

1- Geometric correction

Remote sensing data were geometrically corrected according to Universal Transverse Mercator (UTM) as a projection of zone 36 Spheroid and Datum are WGS 84. The landscape features were geometrically named from the coincided geographic maps (scale 1:50000) published by the Land Survey Authority of Egypt (1990).

2- Data sub-setting

Data that were fitting the located study area were breached out to reduce the data space using the cartographic software of ERDAS Inc. (2010). Mask function in this software was used for clipping the full scene to be a sub-set.

3- Visual interpretation

The physiographic units were visually delineated on the base of reflected spectral signatures of different landscape elements. A manipulated layer including suitable combined bands in suitable channels results in more reliable interpretation. The physiographic features were delineated applying the approach of Zinck and Valenzuela (1990). The main roads, railways and water flowing canals in this step were traced as lines and then were buffered as polygons to be calculated as areas.

Field work

Afield work was performed to test the borders of the physiographic units using Global Positioning System (GPS). Fifteen sites representing the different physiographic units were coordinated for soil profile description and sampling. The profiles were dug to the depth of 150 cm from the surfaces or to the bed rock. The soil morphological features were described according to the nomenclature of Soil Survey Manual (USDA 2017).

Laboratory analyses

Particle size distribution was determined using the Pipette International method as outlined by Klute (1986). Calcium carbonate contents were measured by the calciminer while gypsum content was determined by precipitation with acetone (Nelson, 1982). Salinity expressed as electrical conductivity (EC) was measured in soil paste extract (Carter and Gregrich, 2007). Soil pH was determined in the soil paste using a pH meter. The exchangeable sodium percentage (ESP) was determined according to Page *et al.* (1982)

Soil classification

Soil taxa were categorized according to the basis of the keys of Soil Taxonomy (USDA, 2014) till the level of soil family.

Terminology and etymology contemplation

Terminology and etymology contemplation were traced using the Dictionary of Earth Science (Allaby, 2008) and the Latin English Dictionary (Smith and Lockwood, l996).

RESULTS AND DISCUSSION

Landscape identification of the study area.

Landscape features of the study area were spatially traced as physiographic units each of them is associated with certain soil attributes. Other landscape features are crossing and upgrading those physiographic units as a resultant of manmade activity such as linear infra structures or nonlinear ones like settlements

Physiographic unit's delineation.

Physiographic analysis is a good approach as considering the parent rock and the inherited parent material realizing the relationship between physiography and soils. Parent material can be identified by tracing the drainage patterns from highlands to the lowlands for interpreting the geomorphic processes (Afify *et al.*, 2010). With the guide of landscape spectral signatures that associated with remote sensing data, two groups of physiographic units were categorized. They have different parent materials from different parent rocks. One group was locally formed as dissected rock land, pediplain of residuum, bajada and wadis of alluvium. Other units were continentally derived from the basement complex parent rocks forming River Nile alluvium either in the meandering belt or in the basin. The spatial distributions of these physiographic units are shown in Table 1 and Figure 2 and are described as follows:

1-Physiographic units of sandstone parent rock

A-Dissected rock land

These dissected rock land in the study area are distributed in the most elevated areas as platuex and isolated outcropping of sandstone rock. They are rugged landscapes with rough surfaces, which are dissected by sub dendritic drainage pattern having different slope gradients covering 98120.447 ha as 25.41 % of the total area.

B-Pediplain

Pediplain in the study area is mostly formed on sandstone parent rock including residual parent material overlying a consolidated pan of sandstone parent rock. This residuum is a resultant of physical weathering process that acts on the parent rock in the regions of arid climate. Pediplain in the study area is distributed in relatively high elevations compared to most of the other physiographic units. The units have slopping gravelly and stony surfaces covering 59552.04 ha as 15.43 % of the total area, which are locally including rock outcrops. This physiographic unit has developed thin layers of parent material.

C-Bajada

Bajada was described by Chorley *et al.* (1985) as alluvial fans, coalesce laterally to produce a depositional belt along the piedmont zone. In this study, bajada was characterized by descent slopes including alluvial parent material that formed during erosion process by seasonal flash flooding from the highlands of more slope gradients. During moving over surfaces of less slope gradients the runoff activity decreased and the loaded materials deposited. Accordingly, a lateral coalescing alluvial fans formed as depositional broad gently slop gravelly surfaces, which are named as bajadas. They are covering 67201.57 hectares (17.4% of the total area) aligning the side of the dissected rock land and the pediplain.

D- Wadi

These wadis were traced as reflecting the slope directions from high elevations to lower ones. They are linked with the watershed in higher areas by shorter and narrower channels but on surfaces of descending slopes, they feed the wider channels in a relatively lowlands with the seasonal flash flooding. Via lower areas in the open landscape, the main channel collects the flowing harvested water. They are dry chanells in most seasons reflecting former water flow in the paleo drainage during the fluvial periods over sandstone parent rock. These wadis are confined drainage system within the dessicted rock land but somewhat opened within the bajada. The land of these wadis are subjected to seasonal erosion hazards as a result of annual flush flooding along dentritic and sub-dentritic drainage patterns. They have gently slop gravelly surfaces that cover 123533.56 ha. (31.99 % of the study area).

2-Physiographic units of basement complex parent rocks

A-Meandering River Nile belt

These physiographic units were delineated aligning with the meandering course of River Nile as affected by water flow that activates undercutting sediments from banks in the outside of bends to deposit them on the areas inside these bends. According to Huggett (2007), the resultant is an alteration in the course through cut offs and channel diversion. In the study area, the meandering belt includes levees, point bars and bow bars that have sediments of relatively coarser parent material compared with the river alluvial plain. They are described as follows:

Levee

Afify *et al.* (2020) traced the levee, which were delineated aligning with the River Nile course in relatively higher surfaces. These surfaces are of Nile alluvium that includes relatively coarser fractions, which were previously deposited at the side of the channel. This certain case probably occurred during an active discharge when the area was previously inundated. These levees have flat surfaces covering1387.83 hectares representing about 0.36 % of the total area.

Point bar

According to Afify *et al.* (2020), these point bars occurred on the side bend of the meandering river, while the outside bend was eroded. They are delineated inside the accurate bends of the River Nile. These point bars have flat surfaces covering 1608.82hectares representing about 0.42% of the total area.

Bow bar

These bars have somewhat elongated islands as a result of the deposition action inside the River Nile course. The deposition occurred within the meandering belt during the periods of more active flow. Within the straight part of the river course, these bars were delineated as surrounded by water in the middle of the water course. When the river course become bend, these bars are surrounded by narrow channel in a side and a wide one in the other side. They have flat surfaces covering 718.89 hectares representing 0.19 % of the total area.

B- River Nile alluvial plain

This physiographic unit occurred during the former periodic flooding as a flat plain aligning with the physiographic unit of the meandering belt. Its alluvium occurred in relatively low surfaces as compared to those in the meandering belt covering 23938.29 hectares (6.2 % of the total area).

Other landscape features

Other landscape features are affected by man-made action as nonlinear structures like settlements that cover 5403.59 hectares representing 1.40 % of the total area and also as linear infra structures of roads, railways, and irrigation and drainage canals. They are covering together 1937.93 hectares as 0.50 % of the total area. The natural water course of River Nile is partly covering 2785.92 hectares as 0.72 % of the total area.

Table 1. The delineated areas of the different physiographic units in the study area.

Physiographic unit	Area in hectare	Percent (%) of the total area
Dissected rock land	98102.59	25.4
Pediplain	59552.04	15.42
Bajada	67201.57	17.4
Wadi	123533.56	31.99
Levee	1387.83	0.36
Point bar	1608.82	0.42
Bow bar	718.89	0.19
Alluvial plain	23938.29	6.20
Other landscape features	Area per hectares	Percent (%)
Settlements	5403.59	1.40
Roads, railway and water canals	1937.93	0.50
River Nile	2785.92	0.72
Total area	386171.04	100

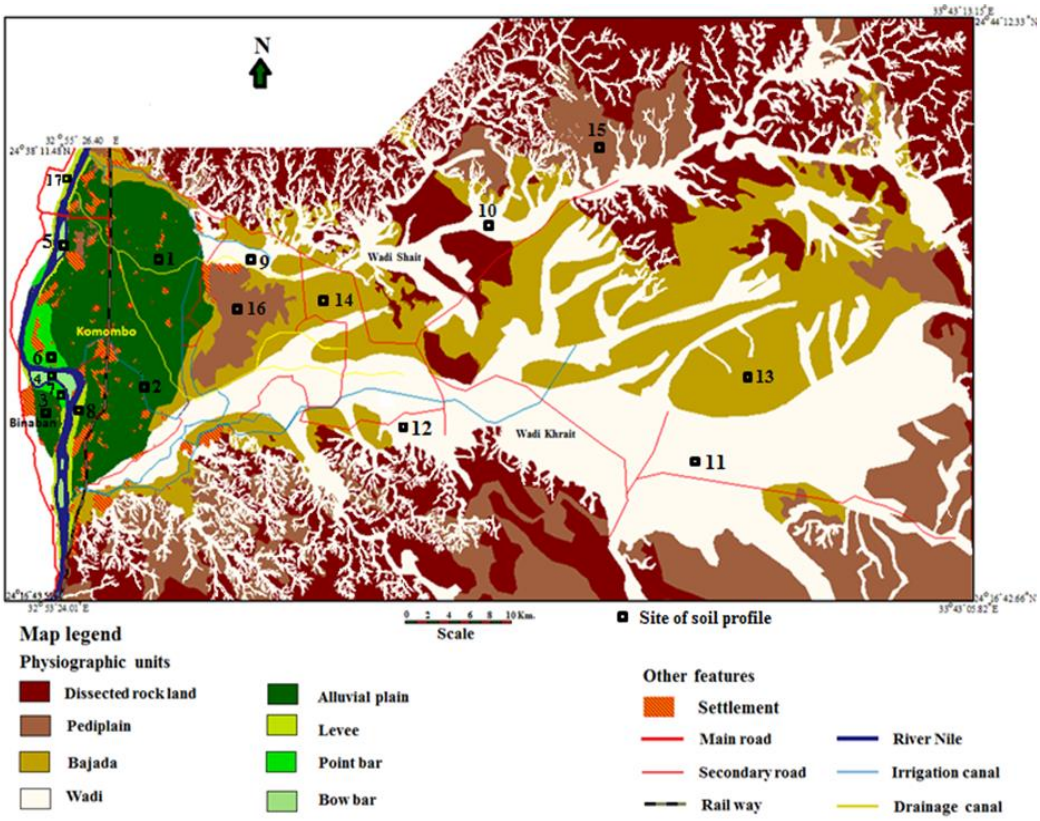

Figure 2. Spatial distribution of the physiographic units in the study area.

Soil taxonomic units

According to the Key of Soil Taxonomy (USDA 2014), the soils were classified considering soil moisture and temperature regimes. In the study area, soil moisture regime is aridic (*torric*) as the soils do not have available water to mesophytic plants for long periods unless be irrigated. Soil temperature regime is *hyperthermic* as the mean annual soil temperature at a depth of 50 cm or at a *lithic* contact is 22ºC or higher. Also, the difference between mean summer and mean winter soil temperatures is more than 6ºC. The soil attributes in Tables 2 and 3 were classified under three soil orders i,e. *Aridisols*, *Vertisols* and *Entisols* to the level of soil families, which express the levels of soil development in their inherited parent materials.

Table 2. Physical analysis (grain size distribution) of the soil layers.

Physiogra-phic unit	Profile No.	Master and diagnostic horison	Depth (cm)	Gravel % (vv)	Grain size distribution Sand	Silt	Clay	Modified texture class
Pediplain	15	ABky	0-15	15	82.8	9.0	8.2	GLS
		BCy	15-45	15	76.8	12.3	10.9	GSL
		R	45--		Bed rock of sandstone			
	16	ABky	0-20	10	84.3	8.5	7.2	SGLS
		C	20-45	25	82.9	7.6	9.5	GLS
		R	45--		Bed rock of sandstone			
Bjada	13	A	0-20	15	58.2	21.3	20.5	GSCL
		By	20-45	25	67.9	17.7	14.4	GSL
		C	45-85	20	71.9	11.7	16.4	GSL
		C	85-150	30	81.6	9.6	8.8	GLS
	14	A	0-25	15	70.3	13.4	16.3	GSL
		By	25-50	10	67.2	17.3	15.5	SGSL
		C	50-85	10	46.1	29.6	24.3	SGSCL
Wadi	9	C1	0-25	5	77.1	10.8	12.1	SG SL
		C2	25-80	5	63.9	14.2	21.9	SG CL
		C3	80-100	10	82.7	9.6	7.7	SG LS
		C4	100-150	5	73.1	12.4	14.5	SG SL
	10	C1	0-20	10	70.0	14.3	15.7	SG SL
		C2	20-75	10	47.1	28.9	24.0	SG SCL
		C3	75-120	15	81.8	9.5	8.7	G LS
	11	C1	0-30	10	72.2	14.3	13.5	SG SL
		C2	30-85	5	48.1	27.6	24.3	SG SCL
		C3	85-100	10	57.2	21.2	21.6	SG SCL
	12	C1	0-25	10	43.1	32.4	24.5	SG L
		C2	25-75	5	44.9	26.1	29	SG SCL
		C3	80-100	10	42.1	27.1	30.8	SG SCL
		C4	100-150	5	71.1	13.1	15.8	SG SL
Levee	8	Ap	0 – 20	-	39.2	20.7	40.1	C
		C	20 – 65	-	42.0	31.2	26.8	L
		C	65 – 120	-	46.7	30.1	23.2	L
		C	120 – 150	-	28.7	35.2	36.1	C L
	17	Ap	0 – 25	-	30.7	34.2	35.1	C L
		C	25 – 65	-	47.9	29.5	22.6	L
		C	65 – 85	-	63.9	20.3	15.8	S L
		C	85 – 150	-	33.9	31.1	35.0	L
Point bar	6	Ap	0 – 30	-	50.8	27.6	21.6	L
		C	30 – 75	-	31.1	33.4	35.5	C L
		C	75- 100	-	84.3	7.3	8.4	LS
		C	100- 150	-	82.1	8.2	9.7	LS
	7	Ap	0 - 30	-	74.9	9.9	15.2	S L
		C1	30 - 85	-	49.9	26.7	23.4	L
		C2	85 - 150	-	86.7	6.2	7.1	LS
Bow bar	4	Ap	0 - 30	-	38.3	19.8	41.9	C
		C1	30 – 60	-	45.1	30.5	24.4	L
		C2	60 - 100	-	69.9	14.7	15.4	S L
		C3	100- 150	-	65.8	16.5	17.7	S L
	5	A	0 - 30	-	36.9	31.1	32.0	C L
		C1	30 – 80	-	39.8	29.9	30.3	C L
		C2	80 - 100	-	74.9	11.3	13.8	S L
		C3	100- 150	-	37.9	30.6	31.5	C L
Alluvial Plain	1	Ap	0 - 25	-	38.3	20.8	40.9	C
		Css	25 - 50	-	30.2	20.2	49.6	C
		Css	50 - 70	-	16.2	40.9	42.9	C
		C	70-150	-	40.2	19.6	40.2	C
	2	Ap	0 - 20	-	36.7	18.2	45.1	C
		Css	20 - 50	-	29.5	19.4	51.1	C
		Css	50 - 80	-	33.2	18.3	48.5	C
		C	80 - 150	-	34.8	17.8	47.4	C
	3	Ap	0 - 20	-	39.5	16.3	44.2	C
		Css	25 - 70	-	36.2	19.7	44.1	C
		C1	70 - 85	-	28.1	34.5	37.4	CL
		C2	85- 150	-	39.5	16.3	44.2	C

A, B and C = master horizons, ss=presence of slickensides, p =disturbed mineral horizon by mechanical mean
C= clay, C L = clay loam, L = loam, SL = sandy loam LS = loamy sand and vv = volume of void-space.

Table 3. Chemical analyses of the soil layers.

Physiographic unit	Profile No.	Depth (cm)	Master & diagnostic horizon	$CaCO_3$		$CaSO_4$		pH	EC (dSm^{-1})	ESP	OM ($g\ kg^{-1}$)
				$g\ kg^{-1}$	% (vv)	$g\ kg^{-1}$	% (vv)				
Pediplain	15	0-15	ABky	99.0	6.0	104.1	6.0	7.9	11.3	10.6	0.2
		15-45	BCy	40.2	4.0	106.3	7.0	8.1	13.7	15.7	0.8
		45--	R	Bed rock of sandstone							
	16	0-20	ABky	117.8	8.0	99.1	5.0	7.8	14.7	9.1	0.1
		20-45	C	64.2	5.0	42.1	4.0	8.1	15.9	16.4	0.5
		45--	R	Bed rock of sandstone							
Bjada	13	0-20	A	42.0	3.0	45.8	2.0	7.8	3.3	5.4	1.0
		20-45	By	59.4	6.0	98.5	6.0	7.6	4.7	6.7	0.9
		45-85	C1	18.1	4.0	48.6	3.0	8.1	3.9	11.6	0.9
		85-150	C2	15.0	5.0	80.0	2.0	7.6	5.1	6.9	0.6
	14	0-25	A	39.4	4.0	45.1	3.0	7.4	2.7	5.1	0.8
		25-50	By	22.0	4.0	102.4	6.0	7.6	2.4	3.5	0.9
		50-85	C1	50.5	2.0	43.5	3.0	7.3	3.6	3.9	0.3
		85-120	C2	10.2	3.0	73.5	4.0	7.7	4.1	4.8	0.09
Wadi	9	0-25	C1	12.3	1.0	33.8	1.0	7.4	1.1	2.9	0.8
		25-80	C2	15.4	1.0	49.3	1.0	7.5	2.3	4.1	0.7
		80-100	C3	13.2	2.0	37.8	2.0	7.3	2.6	2.4	0.4
		100-150	C4	14.0	2.0	54.2	3.0	7.7	1.9	11.5	0.2
	10	0-20	C1	13.4	1.0	30.7	2.0	7.4	1.8	5.4	0.9
		20-75	C2	14.6	1.0	45.1	1.0	7.5	2.5	5.2	0.8.
		75-120	C3	12.5	2.0	36.9	1.0	7.3	2.3	6.1	0.2
	11	0-30	C1	15.7	2.0	40.7	3.0	7.4	1.9	5.3	0.9
		30-85	C2	16.2	3.0	42.5	2.0	7.7	3.1	4.3	0.5
		85-100	C3	13.7	3.0	55.9	2.0	7.6	2.1	5.1	0.4
	12	0-25	C1	12.6	3.0	43.8	1.0	7.4	2.2	4.7	0.7
		25-75	C2	10.0	2.0	44.3	2.0	7.5	1.8	9.7	0.4
		80-100	C3	11.0	3.0	47.8	1.0	7.4	3.7	3.9	0.3
		100-150	C4	13.1	2.0	39.8	2.0	7.5	1.1	4.5	0.2
Levee	8	0- 20	Ap	13.2	--	8.4	--	7.4	0.9	2.9	1.0
		20-65	C1	14.2	--	9.4	--	7.8	1.0	4.8	1.1
		65-120	C2	17.5	--	8.8	--	7.5	0.8	3.9	0.3
		120-150	C3	11.6	--	7.9	--	7.9	1.0	5.1	0.4
	17	0-25	Ap	12.2	--	8.9	--	7.5	0.7	3.9	0.9
		25-65	C1	14.3	--	7.4	--	7.8	0.8	2.8	1.1
		65-85	C2	19.5	--	8.3	--	7.9	0.9	2.9	0.6
		85-150	C3	17.6	--	5.9	--	8.0	1.0	4.7	0.3
Point bar	6	0-30	Ap	19.4	--	3.4	--	7.8	1.1	4.9	0.9
		30–75	C1	17.5	--	9.4	--	7.7	1.0	3.4	0.8
		75-100	C2	16.7	--	4.8	--	7.5	0.8	3.8	0.7
		100-150	C3	18.6	--	5.9	--	7.8	0.9	2.9	0.3
	7	0-30	Ap	21.2	--	8.4	--	7.7	0.8	4.1	1.6
		30-85	C1	26.1	--	9.8	--	7.8	0.9	4.1	0.8
		85-150	C2	12.5	--	8.1	--	7.6	0.7	4.2	0.4
Bow bar	4	0 - 30	Ap	18.8	--	5.9	--	7.5	1.0	3.8	1.2
		30 – 60	C1	17.4	--	6.8	--	7.8	1.1	4.3	1.1
		60 - 100	C2	20.4	--	7.3	--	7.9	0.8	3.1	0.6
		100- 150	C3	21.5	--	8.5	--	8.0	1.0	6. 2	0.2
	5	0 - 30	Ap	14.9	--	9. 4	--	7.8	0.8	6.8	0.9
		30 – 80	C1	16.8	--	6.4	--	7.7	0.9	6.7	1.0
		80 - 100	C2	30.8	--	7.3	--	7.5	0.8	5.9	0.6
		100- 150	C3	24.2	--	4.7	--	7.8	1.0	5.8	0.4
Alluvial Plain	1	0 - 25	Ap	11.8	--	3.8	--	7.3	1.1	3.8	2.1
		25 - 50	Css	19.4	--	10.3	--	7.4	1.3	3.9	1.7
		50 - 70	Css	30.8	--	7.2	--	7.7	0.8	6.1	0.8
		70-150	C	22.2	--	9. 3	--	7.7	1.4	5.6	0.5
	2	0 - 20	Ap	18.8	--	6.8	--	7.4	1.0	6.9	1.8
		20 - 50	Css	19.9	--	7.6	--	7.8	0.9	8.6	1.1
		50 - 80	C1	32.8	--	6.5	--	7.8	0.8	7.9	0.6
		80 - 150	C2	20.2	--	8. 7	--	7.5	1.1	5.8	0.3
	3	0 - 20	Ap	28.8	--	8. 7	--	7.4	7.1	1.5	2.3
		25 - 70	Css	29.9	--	9.8	--	7.5	7.9	1.1	2.1
		70 - 85	C1	12.8	--	8.5	--	7.3	7.2	0.9	0.5
		85- 150	C2	21.7	--	6.9	--	7.7	7.1	0.9	0.4

vv = volume of void-space (secondary formations), pH = soil reaction, EC ($dS\ m^{-1}$) Electrical conductivity, ESP = exchangeable sodium percentage.

The soil taxonomic units as associated with the delineated physiographic units are described as follow:

1- Aridisols

[Arid; etymology: Latin "*aridus*" = dry]. In the study area, *Aridisols* developed under an aridic moisture regime having calcic or gypsic diagnostic horizons with upper boundary within 100 cm of the surface. This *Aridisols* order is categorized into the following soil families:

A- *Lithic Calcigypsids, coarse loamy, mixed, hyperthermic.*

These *Calcigypsids* occurred in pediplain of residual parent material having layers of calcic horizon "ABk", with $CaCO_3$ contents ranging from 99.0 to 117.8 g kg^{-1} and layers of gypsic horizons "ABy and BCy" with gypsum contents ranging from 99.1 to 106.3 g kg^{-1}. These calcic and gypsic horizons were realized according to the identified secondary carbonates by volume and calcium carbonate by weight following Soil Classification System of USDA (2014). The soils are lithic being shallow on a coherent underlying material of sandstone parent rock to a depth of less 50 cm from the soil surface. The soils are coarse loamy since the soil control section is dominated by gravelly sandy loams, (profile 15). This Lithic Calcigypsids has a soil inclusion of *Lithic Calcigypsids, sandy, mixed, hyperthermic* since the soil control section is dominated by gravelly loamy sands (profile 16).

B- Typic Haplogypsids, coarse loamy, mixed, hyperthermic

These *Haplogypsids* occurred in the bajada of alluvial parent material having layers of gypsic horizons "By" with gypsum contents ranging from 98.5 to 102.4 g kg^{-1}. The soil control section is dominated by gravelly sandy loams to be coarse loamy (profiles 13 and 14).

2- Vertisols.

Vertisols [Vert.; etymology: Latin "verto" = to turn]. According to Afify *et al.* (2016), the soils in River Nile alluvial plain are dominated by a clay textural class, which turns the upside soils to be down as a result of shrinkage during the phase of dryness resulting in cracks to be filled with soil from the surface. When the soils become wet, soil matrix swells causing pressure on the dropped materials resulting in *slickensides.* Accordingly, soil volume increases, and the surface somewhat goes up shaping soil *gilgai*. In the study area, the presence of *slickensides* fits the requirements to classify the soils in this alluvial plain as the following taxonomic unit:

Typic Haplotorrerts, fine, hyperthermic.

These soils occurred in River Nile alluvial plain having clayey soils with less than 60 percent as 40.2 to 51.2 % by weight to be clayey (fine). These soils have pedogenic *slickensides* (Css) as a result of swelling and dryness by clay minerals. They are indicators for the *vertic* characteristics, such as wedge-shaped peds and surface cracks, may be present. These soils are non to very slightly saline where their EC values range from 0.8 to 1.4 dS m-1, while their ESP values range from 3.8 to 8.6. CaCO3 contents range from 3.8 to 10.3 g kg-1, while gypsum contents range from 11.8 to 32.8 g kg-1 (profiles 1, 2 and 3).

3- Entisols

[Ent. Implying recent, the last 3 letters of the word "recent"]. According to Smith (1986), *Entisols* as either losing material rapidly through truncation or receiving additions rapidly for horizons to form. The suborder level is first sorted out according to the reasons as why they had no subsurface diagnostic horizon. These recent soils were classified to two suborders till the family level as follow:

A- Typic Torrifluvents, fine loamy, mixed, hyperthermic.

These soils occurred in wadis and were defined under the suborder *Fluvents* where they were formed under the deposition and erosion processes.They have stratified layers of C horizon. As these soils formed under a *torric moisture regime,* they are *Torrifluvents*. According to Afify *et al.* (2016), these soils were formed in wadis and are the most recent ones under the order *Entisols* that still affected by seasonal flooding agent. Accordingly, in this study, the soils in wadis were classified as *Fluvents as* having stratified layers of C horizons with an irregular decrease in organic matter within a depth of 25 cm to 125 cm. The case is expressing the status of frequent erosion and deposition.

These recent soils have no A horizon as their epi-pedons are mostly reworked by seasonal water runoff. Accordingly, *Fluvents* require certain land management to be protected. The soil control section is dominated by slightly gravelly sandy clay loams, therefore these soils are fine loamy. They are non to very slightly saline as they have EC ranging from 1.1 to 3.7 dS/m and slightly alkaline since their pH values ranged from 7.4 to 7.7. Soil ESP ranged from 3.8 to 9.7 and CaCO3 contents range from 10.0 to 15.7 g kg-1, while gypsum contents ranged from 39.8 33.8 to 54.2 g kg-1 (profiles 11 and 12). Within these soils, there are inclusions that have layers of slightly gravelly loamy sands below the layer of slightly gravelly clay loams to be classified as *Typic Torrifluvents, fine loamy over sandy, mixed, hyperthermic* (profiles 9 and 10).

B- Typic Torriorthents, fine loamy, mixed), hyperthermic.

These soils occurred in levees and were defined under the suborder *Orthents* since they were formed under the deposition processes having stratified layers of C horizon but lack erosion action so the master horizon "A" characterizes the soil surfaces. As these soils formed under a *torric moisture regime*, they are *Torriorthents.* The soil control section is dominated by the texture classes of loams and clay loams, therefore they are fine loamy. These soils are non-saline where they have EC ranging from 0.7 to 1.0 dS/m and slightly to moderately alkaline since they have pH values ranged from 7.4 to 8.0. Soil ESP ranged from 2.8 to 5.1. $CaCO_3$ contents ranged from 11.6 to 19.5 g kg^{-1}, while gypsum contents ranged from 5.9 to 9.4 g kg^{-1} (profiles 8 and 17).

C- Typic Torriorthents, fine loamy over sandy

These *Orthents* were formed under the deposition processes within the meandering belt as point bars having master horizons of Ap and C. The soil control sections have two contrasting textural classes i.e. clay loams and loams (fine loamy) underlaid by loamy sands (sandy) to be classified as fine loamy over sandy. The soils are non-saline as having EC from 0.7 to 1.1 dS/m and slightly alkaline as having pH from 7.5 to 7.8. Soil ESP ranged from 2.9 to 4.9. $CaCO_3$ contents ranged from 12.5 to 26.1 g kg^{-1}, while gypsum contents ranged from 3.4 to 9.8 g kg^{-1} (profiles 6 and 7).

D- Typic Torriorthents, coarse loamy, mixed, hyperthermic.

These *Orthents* were formed within the meandering belt as bow bars having master horizons of Ap and C. The soil control sections are dominated by textural classes of sandy loams (coarse loamy). They are non-saline (EC from 0.8 to 1.1 dS/m) and slightly to moderately alkaline (pH from 7.5 to 8.0). Soil ESP ranged from 3.1 to 6.8 and $CaCO_3$ contents ranged from 14.9 to 30.8 g kg^{-1}, while gypsum contents ranged from 4.7 to 9.4 g kg^{-1} (profiles 4 and 5). These soil taxonomic units are included in Table 4 as fitting to the associated physiographic units.

Thus, it can be concluded that, Soil taxa of those physiographic units are categorized as three soil orders to the level of soil family. These soil taxonomic units are: *Aridisols* including a) *Lithic Calcigypsids, coarse loamy, mixed, hyperthermic* in pediplain with inclusion of *Lithic Calcigypsids, sandy, mixed, hyperthermic;* and b) *Typic Haplogypsids, coarse loamy, mixed, hyperthermic* in bajada. *Vertisols* include *Typic Haplotorrerts, fine, hyperthermic* in

River Nile alluvial plain. *Entisols* including: a) *Typic Torrifluvents, fine loamy, mixed (calcareous), hyperthermic*in wadis with inclusion of *Typic Torrifluvents, fine loamy over sandy, mixed (calcareous), hyperthermic.;* b) *Typic Torriorthents, fine loamy, mixed, hyperthermic* occurred in levees.; c) *Typic Torriorthents, fine loamy over sandy, mixed, hyperthermic* in point bars; and d) *Typic Torriorthents, coarse loamy, mixed, hyperthermic* in bow bar. Those data will be essential for any reclamation plan for agricultural land use.

Table 4. The taxonomic units in each associated physiographic unit

Physiographic unit	Soil taxonomic unit
Dissected rock land	—
Pediplain	**Lithic Calcigypsids, coarse loamy, mixed, hyperthermic* *Lithic Calcigypsids, sandy, mixed, hyperthermic*
Bajada	*Typic Haplogypsids, coarse loamy, mixed, hyperthermic.*
Wadi	**Typic Torrifluvents, fine loamy, mixed, hyperthermic.* *Typic Torrifluvents, fine loamy over sandy, mixed, hyperthermic.*
Levee	*Typic Torriorthents, fine loamy, mixed, hyperthermic.*
Point bar	*Typic Torriorthents, fine loamy over sandy), hyperthermic*
Bow bar	*Typic Torriorthents, coarse loamy, mixed, hyperthermic*
Alluvial plain	*Typic Haplotorrerts, fine, hyperthermic*

*** = Dominant soils**

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تصنيف التربة للوحدات الفيزيوجرافية المختلفة فى جنوب شرق مصر باستخدام بيانات الاستشعار من البعد

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أختيرت منطقة الدراسة فى جنوب شرق مصر، والتى تشتمل على أراضى ذات صخور ومواد أصل مختلفة وقد إشتقت هذه الأراضى إقليميا من الحجر الرملى أو قاريا من صخور القاعدة المركبة مكونة لترسيبيات نهر النيل. تم إستخدام بيانات الإستشعار من البعد للقمر الصناعي TM8 لعام ٢٠٢٠ لتحديد الوحدات الفيزيوجرافية تأسيسا على البصمات الكهرومغناطيسية المنعكسة للعناصر الأرضية المختلفة والتي تغطي 386,171.04 هكتار. تم تحديد مجموعتين من الوحدات الفيزيوجرافية تختلف فى منشئها وقد ضمت أحدهما أراضي صخرية متقطعة فى الحجر الرملي، سهل التجوية ذات مادة أصل متبقية، الباجادا والوديان ذات مادة أصل رسوبية كما إشتملت المجموعة الأخرى على ترسيات نهر النيل مثل أكتاف النهر قواطع منحنيات النهر، القواطع المحدبة داخل النهر والسهل الرسوبى. صنفت خواص التربة لهذه الوحدات الفيزيوجرافية تحت ثلاث رتب للتربة حتى مستوى عائلات التربة حيث إشتملت هذه الوحدات التصنيفية للتربة على: رتبة الأضى الجافة (*Aridisols*) **و**تشمل الوحدات التصنيفية التالية: أ) *Lithic Calcigypsids, coarse loamy, mixed, hyperthermiac* والتى توجد فى سهل التجوية يتخللها الوحدة التصنيفية *Lithic Calcigypsids, sandy, mixed, hyperthermic* ب) *Typic Haplogypsids, coarse loamy, mixed, hyperthermic* فى الباجادا. رتبة أراضى الفرتيسول (*Vertisols*) **و**تشمل الوحدة التصنيفية التالية: *Typic Haplotorrerts, fine, hyperthermic* وتوجد فى السهل الرسوبى لنهر النيل رتبة الأراضى الحديثة (*Entisols*) **و**تشمل الوحدات التصنيفية التالية: أ) *Typic Torrifluvents, fine loamy, mixed (calcareous), hyperthermic* وتوجد فى الوديان حيث يتخللها الوحدة التصنيفية *Typic Torrifluvents, fine loamy over sandy, mixed (calcareous), hyperthermic* ب) *Typic Torriorthents, fine loamy, mixed, hyperthermic.* والتى توجد فى أكتاف النهر ج) *Typic Torriorthents, fine loamy over sandy, mixed* والتى توجد فى قواطع منحنيات النهر. د) *Typic Torriorthents, coarse loamy, mixed, hyperthermic* وتوجد فى القواطع المحدبة داخل النهر.