Minufiya J. Agric. Res. Vol.40 No. 4(2): 1055 –1064 (2015) **"http://www.mujar.net"**

IDENTIFICATION OF GEOMORPHIC AND PEDOLOGICAL CHARACTERISTICS AT EAST OWEINAT AREA (EGYPT) USING REMOTE SENSING AND GIS TECHNIQUES

A.H. El-Nahry[(1)], M. S.Amira[(2)], F.E. Abu-Agwa[(2)] and M. E. Fadl[(1)]

[(1)] National Authority for Remote Sensing and Space Sciences.

[(2)] Soil Sciences Dept., Faculty of Agriculture, Menofiya University.

(Received: May 3 , 2015)

ABSTRACT: *The aim of this investigation is to identify the geomorphic and pedological characteristics of the East Oweinat area.The investigated area is locatedin the south of Egypt with an area of 95809.46 km^2 representing 10. 43% of Egypt. The Remote Sensing technique was used to identify the geomorphological features (landscape) of the area. A reconnaissance survey followed by semi detailed one was done to verify the information resulted from satellite images. The prevailing deposits of the area could be expressed in three types namelythe Nubian sandstone, the Quaternary sediments and the sand-dunes belt. Seven main geomorphic unites were recognized namely sand sheets (with four sub-main landforms i.e. high, moderately high, moderate and low), depressions (with four sub-main landforms i.e. high, moderately high, moderate and low), dry valleys, peniplains, footslopes, barchans, and tablelands. Eleven soil profiles were chosen representing these main and sub-main landforms except Barchans and Tableland. Representative soil profiles were described in the field and samples were collected and analytically studied. Studied soils could be classified as Typic Torripsamments, Typic Haplocalcids, Typic Torrifluvents and Typic Haplodurids. GIS works were performed to produce base, geomorphologic and soil classification maps of the studied area.*

Key words: *Remote sensing, GIS, geology, geomorphology, soil characteristics, soil classification, East Owinat.*

INTRODUCTION

Agriculture is the backbone of the Egyptian economy. The two main components of the agricultural system are soil and water. These two resources have to be used in more sustainable manner in order to produce food for increasing population. Knowledge about theseresources is important for any project planning in order to satisfy the environmental conditions. Soil data are spatial in nature and they can be easily handled and analyzed using RS and GIS. Sharing and dissemination of information is easier when the information is stored in digital form. Hence advantages in use of RS&GIS in handling soil data are demonstrated in the current work belonging the East Oweinat and West Tushka basin in the heart of Sahara south Egypt. The investigated area is the natural extension of the New Valley area. Surveying resources of this promising area may lead to the evolution of their potentiality for development and sustainable planning. Earlier, a reconnaissance surveyswere conducted by some researchers, leading to the common patterns of soil associations. However, these surveys were unsatisfactory owing tolack of information. Therefore, it was decided to re-survey the area on a semi detailed level complementary use of satellite images.

Geology and geomorphology of the area:

Soil geomorphology is basically an assessment of the genetic relationship of soils and landforms (Gerrard, 1993). Regarding lithological, stratigraphic and structural conditions of the area, the majority of the surface area is occupied by an over whelming Mesozoic sandstone body attributed to the Nubian sandstone. However, this section is masked, at considerable parts of the area by the overlying Quaternary deposits. It is also hidden in the eastern part of the area under

a tongue of younger sediments. The basement rocks are outcropping at some localities. Smaller basement occurrences are scattered in the areas, Klitzsch and List (1978)and Klitzsch *et al* (1984). The prevailing deposits could be expressed as follows:

- *The Nubian sandstone section overlies uncomfortably the basement complex throughout the studied area. It is uncomfortably overlain at considerable parts of the area by Quaternary deposits and is uncomfortably overlain by shale in a limited stretch in the East. The Nubian sandstone is composed lithological of a succession of sandstone beds, mostly fine to medium grained sometimes to coarse grained having different color gradations of white, yellow and brown. Its cementation ranges from friable to highly consolidate. The succession contains interbeds of sandy clay, siltstone and clay- However, the Nubian succession in the southern parts of the area is almost devoid of significant clay intercalations, yet clay beds develop and increase in number and thickness toward the North.*
- *The Quaternary sediments are found, to a considerable extent, in the area, topping the Nubian sandstone. They are represented by Aeolian sand and sand accumulations, sand-dunes, salt crusts and lake deposits. Aeolian sands are composed of loose, mostly fine, wind-blown sand, found either in the form of thin sheets covering the flat tracts as accumulations filling the topographic lows.*
- *The sand-dunes are either forming continuous belts or isolated crescent sand-dunes.*

The current investigationaims at identifying the geomorphological features, soilcharacteristics and classification. This could be useful for the agricultural development of the area.

MATERIALS AND METHODS

Location and description of the area:

The East Oweinat is located in the southern part of the Western Desert of Egypt between latitudes 22º 00' 00'' to 25º 00' 00'' N and longitudes 28º 00' 00'' to 31º 00' 00'' E with an area of 103971.39 km^2 representing 10.34% of the total area of Egypt. Topographically, the elevation of the area varies from 200 to 300 m above sea level. The general slope of land decreases from south to north and from western and eastern borders toward the center. The micro relief varies considerably from almost flat to undulating with scattered escarpments and isolated mounds located in north eastern and western directions of the region. Moreover, two chains of discontinuous sand dunes covering the surface The study area is characterized by extreme aridity, virgin soils and huge storage of water resources, "Fig. (1)".

Remote sensing and GIS works:

Geomorphologic map was carried out using digital image processing of Land Sat 8.0 ETM+ image (Path/Row 176-177/43-45) dated February 2015, executed using ENVI software 5.1 (ITT, 2014). Landsat 8 images have data recorded in 11 spectral bands of the electromagnetic spectrum. It has a swath width of 170 km * 185 km; with a spatial resolution of 30 m (high spatial resolution with improved radiometric sensitivity).Image was stretched, smoothly filtered, and its histograms were matched for its rectification and restoration according to Lillesand and Kiefer (2007). GIS works were performed to produce base, geomorphologic and soil classification maps of the studied area using Arc GIS software 10.2.2 (ESRI, 2014).

Fieldwork:

Eleven soil profiles were chosen representing the main and sub-main geomorphologic units except Barchans and Tableland. These profiles were morphologically described according to FAO (2006). Samples were collected from these profiles according to their vertical morphological variations. The soil samples were air dried, crushed and sieved to get the fine earth fraction (< 2 mm) then used for different physical and chemical analysis.

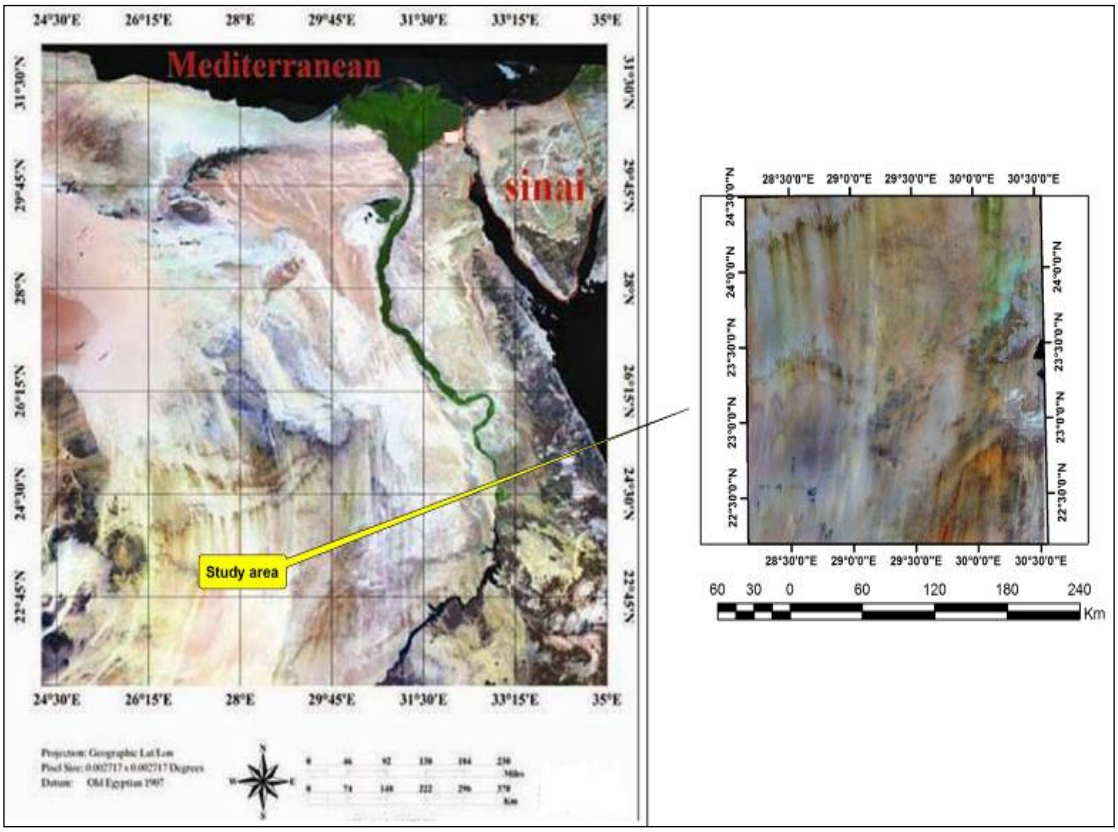

Fig. (1): Location of the study area.

Laboratory analyses:

Particle size distribution,EC,pH, O.M,CEC, exchangeable sodium percentage (ESP), $CaCO_3$, and gypsum were determined according to Bandyopadhyay (2007).

Soil classification:

Studied soils were classified up to the sub-great group level according to Soil Survey Staff (2010).

RESULTS AND DISCUSSION

Geomorphology and soil characteristics:

Satellite image interpretation indicated that the investigated area includes seven main geomorphologic units and eight subunits (thirteen landforms) namely: 1) Sand sheets (with four subunits i.e. high-, moderately high-, moderate-and low-sand sheets); 2) Depressions (with four subunits i.e. high-, moderate high-, moderately depression and low depression);3) Dry valleys;4) Peniplains;5) Footslopes; 6) Barchans; and 7) Tablelands. These geomorphologic unites are represented in Fig. (2). Characteristics of these landforms and their represented soils are shown in Table (1) and could be presented in the following**.**

1) Sand sheets:

This main geomorphic unitwas mainly derived from Nubian sandstone scattered over the whole area (Breed *et al* 1987). It could be subdivided into four subunits i.e. high (6581.75 km^2), moderately high (6412.78 km^2), moderate (7797.71 km^2) and low (5902.87 km^2). This landformhasflat or gently undulating broad floors with little rock exposure (tabular deposits ranging in thickness from a few centimeters to a few meters). Sand sheets are probably built from

successive deposits of sand left behind by the migration of ordinary small sand ripples, along with fine sediment (dust deposited from suspension, and gravel or granules moved by creep.). Sand sheet are protected by a lag, one grain thick, of the coarsest particles that can be shifted by the wind, ranging from coarse sand to pea-size gravel. The soils of this unit are characterized - mainly (Table, 1) by sandy texture, low to moderate salinity (EC>12), weak alkalinity reaction (pH<8), very low organic matter (OM) content (<1.6%)according to the aridity condition of the area, and low $CaCO_3$ content (<4.33 %).Cation exchange capacity (CEC) is lower than 14.00 meq/100g soil that mainly associated with the low fine particles and OM contents of the soils. Other propertiesand classification of the soils represented the subunits of sand sheets could be presented as follows:

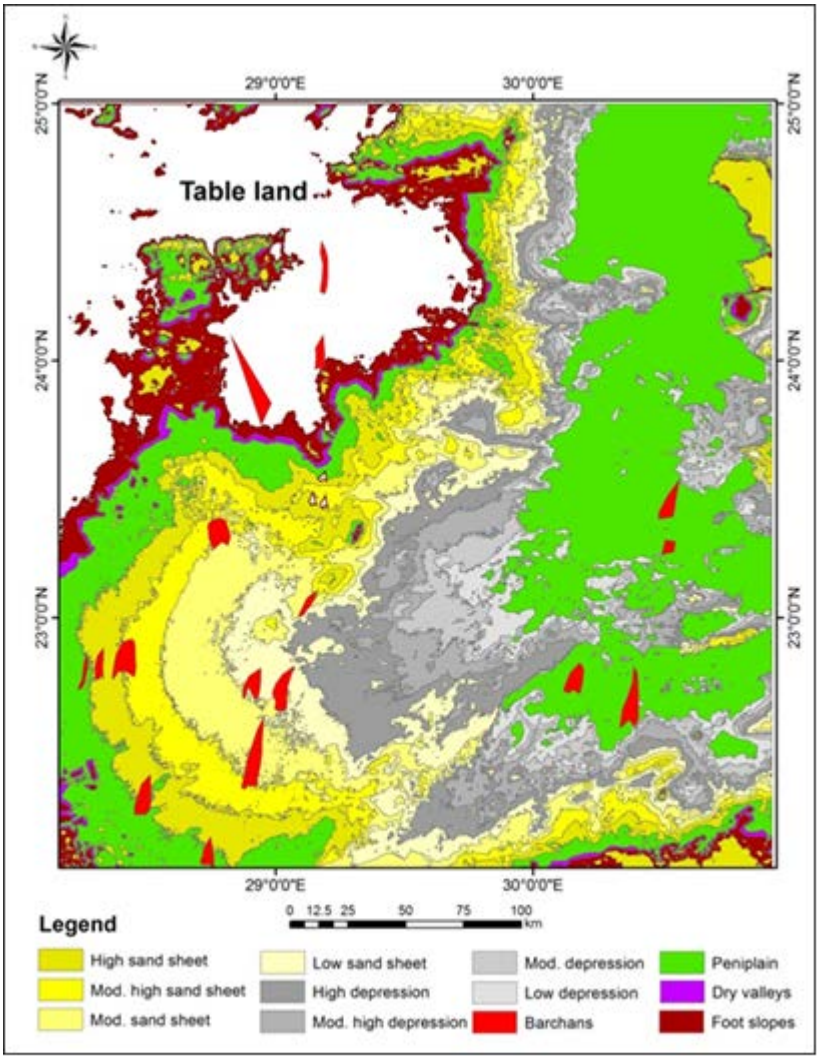

Fig. (2): Geomorphology of the studied area.

Table (1): Characteristics of soils represented the different landforms of the studied area.

Landform	Soil depth (cm)	EC (ds/m) (1:1)	PH (1:2.5) (S:W)	Particle size distribution %			Texture class	OM %	CEC meq/ 100g	$CaCO_3$ %	SAR	Gypsum %
				Sand	Silt	clay						
High sand sheets	0-30	0.83	7.14	98	1.3	0.7	Sand	1.3	6.04	3.9	1.68	1.2
	30-150	0.84	7.29	98.5	0.7	0.8	Sand	1.2	5.76	1.2	1.91	1.4
Moderate high sand sheets	0-20	2.13	7.12	95.1	4.6	0.3	Sand	0.3	1.56	1.8	0.91	0.3
	20-60	4.4	7.18	90.6	6.4	3.0	Sand	0.2	4.4	1.2	6.94	0.5
	60-120	4.12	7.21	91.9	4.1	4.0	Sand	0.1	5.2	1.0	7.63	0.4
Moderate sand sheets	0-45	8.0	7.11	94.9	4.1	1.0	Sand	0.2	2.0	1.4	10.50	0.6
	45-120	9.8	7.18	97.8	1.7	0.5	Sand	0.1	1.0	1.2	2.81	0.7
Low sand sheet	0-20	4.7	7.12	91.9	6.3	1.8	Sand	1.2	6.96	1.2	4.74	0.1
	20-48	3.4	7.30	92.5	6.3	1.2	Sand	0.2	2.24	4.1	2.70	0.3
High depressions	0-45	0.5	7.15	94.6	4.7	0.7	Sand	0.2	1.64	1.4	2.10	0.1
	45-120	0.6	7.21	95.6	4.2	0.2	Sand	0.1	0.64	1.7	1.20	0.2
Moderate high depressions	0-30	1.5	7.09	90.1	7.2	2.7	Sand	1.1	7.64	11.1	1.34	0.7
	30-48	1.5	7.08	91.3	5.2	3.5	Sand	1.3	11.0	15.4	2.80	0.3
	48-110	1.3	7.11	91.4	6.5	2.1	Sand	0.2	3.32	9.3	3.81	0.4
Moderately depressions	0-18	4.0	7.11	87.6	9.9	2.5	Sand	0.4	4.6	8.7	3.50	0.40
	18-40	1.2	7.29	98	1.3	0.7	Sand	0.3	4.04	15.3	4.00	0.40
	40-100	8.0	7.43	45.7	49.4	4.9	Silty loam	0.1	6.28	8.9	8.75	0.42
Low depressions	0-15	8.32	7.08	38.4	58	3.6	Silty loam	0.7	7.12	9.2	18.33	1.1
	15-35	8.0	7.13	85.6	10.8	3.6	Sand	0.4	5.92	15.6	2.48	1.4
	35-100	7.95	7.14	50.6	46.5	2.9	Loamy sand	0.1	3.88	10.5	2.00	0.5
Dry valleys	0-25	3.4	6.8	88.4	8.2	3.4	Sand	1.1	7.46	5.0	3.36	0.1
	25-90	3.1	7.0	30.3	34.4	34.3	Clay loam	1.4	35.07	2.7	4.24	0.3
	90-110	3.7	7.12	30.2	35.2	34.6	Clay loam	1.3	35.04	3.6	3.73	0.5
Peniplains	0-30	3.8	7.1	85.6	11.8	2.6	Sand	1.7	9.92	1.4	11.85	0.8
	30-50	1.8	7.3	96	1.3	2.7	Sand	2.9	14.84	2.1	2.89	0.7
	50-95	2.9	7.4	87.6	8.9	3.5	Sand	1.2	9.0	7.5	4.53	0.6
Footslopes	0-15	3.42	7.4	72	19.7	8.3	Loamy sand	0.51	9.51	9.8	3.59	0.1
	15-30	3.6	7.8	82.7	12.2	5.1	Loamy sand	0.4	6.19	16.5	3.27	0.1
	30-80	2.1	7.6	93.5	5.3	1.2	Sand	0.2	2.24	11.3	1.79	0.4

-High sand sheets have very deep soil profile (>150 cm). Sodium Adsorption Ratio (SAR) is <10. The soils of this landform could be classified as *Typic Torripsamments.*

-Moderate high sand sheets have moderately deep soil profile (~120 cm). SARis < 10.2%.The soils of this landform could be classified as *Typic Torripsamments.*

-Moderate sand sheetshave deepsoil profile(~120 cm).SARis <14.7. The soils of this landform could be classified as *Typic Torripsamments.*

-Low sand sheethave moderately deep soil profile (~48 cm).SARis >15.Thesoils of this landform could be classified as *Lithic Torripsamments.*

2) Depressions:

Depressions are low lying deflated area, called also blowouts. They are similar to hollows formed by the removal of particles by wind. Blowouts are generally small, but may be up to several kilometers in diameter. Wind-driven grains abrade this landform. Grinding by particles carried by the wind creates grooves or small depressions. Some depressions in the studied area were formed by tectonic movements in the past and recently reshaped by deflation processes. This act as the removal of loose, fine-grained particles by the turbulent eddy action of the wind, and by abrasion and wearing down of surfaces by the grinding action and sand blasting of windborne particles. Depressions could be subdivided into four subunits i.e. high (5689.61 km^2), moderately high (4608.76 km^2), moderate (3837.04 km^2) and low (3532.56 km^2). The soils of this unit are characterized mainly (Table, 1) by sandy texture, slightto moderate salinity (EC between 0.5 to 8.32 dS/m), weak alkalinity reaction (pH<8), very low organic matter (OM) content (<1.4%), and different $CaCO_3$ content. CEC is lower than 11.50 meq/100g soil. Other properties and classification of the soils represented the subunits of sand sheets could be presented as follows:

- High depressions. have deep soil profile (120 cm) with non salinity (EC<1 dS/m)).$CaCO_3$ content is high(<4.33 %).SARis <10. Soils of this unit could be classified as *Typic Torripsamments.*

- Moderate high depressions. The main feature is parallel orientation of gravels and sand grains. Gravels cover is relatively lying on higher elevation, whereas active sand accumulation covers the low-lying areas. This landform is characterized by deep soil profile depth (~110 cm) having moderate salinity (EC<5 dS/m) and high$CaCO_3$ content (9.3to15.4 %). SAR is < 10. Calcic horizon was observedin these soils through the abundance of white rounded nodules of secondary $CaCO_3$. These soils could be classified as *Typic Haplocalcids.*

- Moderately depression. This landform is characterized by almost flat topography covered almost with desert pavement of different sizes dark gravels. It has deep soil depth (~100 cm) having moderate salinity(<10.12 dS/m). $CaCO_3$ content is high (8.7to15.3 %).SAR is <10. Calcic horizon was found in these soils through abundance of soft white segregation of $CaCO_3$.These soils could be classified as *Typic Haplocalcids.*

- Low depression. Has deep soil profile depth (~100 cm) with moderate salinity (7.95to8.32 dS/m). $CaCO_3$ content is high (9.2to 15.6%). SAR is >13.Calcic horizon was observed in these soils through abundance of hard concretions. These soils could be classified as *Typic Haplocalcids.*

3) Dry valleys:

Dry valleys encompass an area of 1427.621 km^2 .They are linear depressions that lack a permanent stream but shows signs of past water erosion. It is a common land-form in areas underlain by permeable rock (e.g. the chalk spread over the study area). The dry valley was eroded during an episode of surface drainage, to greater precipitation, or to a higher table. These are considered as the least abundant landform in the area. These valleys dissect the

highest elevated areas, filled up with fluvial material and having undulating surface. Some dry desert shrubs and bushes are apparent.

This land form is characterized by deep soil profile (~110 cm) with sand and clay loamtexture. The soils have slight salinity indicated from EC values (<4dS/m). Soil reaction is weak alkaline (pH <8). Organic matter content is low (<1.5%). $CaCO_3$ content is low (<6%). CECis high(7.46to 35.07meq/100g soils). SAR is <8. These soils could be classified as *Typic Torrifluvents.*

4) Peniplains:

Peniplains occupy an area of 25917.51 km^2. This landform has low and gently undulating land surface of considerable area. It has been produced by the processes of long-continued sub aerial erosion, primarily mass-wasting and sheet wash on inter-stream areas of a mature landscape, assisted by stream erosion, almost to base level in the penultimate stage of a humid, fluvial geomorphic cycle.

The soil of this landform is characterized by moderate deep profile depth (95 cm) with sand texture. Salinity is low (1.8–3.8 dS/m). Soil reaction is weak alkaline (pH <8.01). Organic matter content is high (>2%). $CaCO_3$ content is low (<8 %). CEC is <15 meq/100g soils. Saris moderate (1.4-7.5). A duripan horizon is diagnosed within 30 to 50 cm of the soil surface. Soils of this land form could be classified as *Typic Haplodurids.*

5) Footslopes:

This landform has eroded surfaces with colluvial materials. It is mainly found at the marginal portion of slopes, where it is covered by weathered fragmented flakes of rocks dominated by Nubian sandstone and even granites. It constitutes about 5500.09 km^2 area that have moderate soil depth (<90 cm) with sand and loamy sand texture. These soils have low salinity which its profile weighted mean EC is 3 dS/m. Soil reaction is weak alkaline (pH <7.9). Organic matter content is very low (<0.60%). $CaCO_3$ content is high (9.8–16.5 %). CEC is < 12.45 meq/100g soil). SARis lowthat it is <4. Calcic horizon was observed in these soils through abundance of hard concretions of $CaCO_3$. Soils of this unit could be classified as *Typic Haplocalcids.*

6) Barchans:

The word barchans comes from the Turkish language and means “active dune”. It was preserved in the scientific literature to name the isolated crescent-shaped mobile dune. This type of dune possesses two "horns" that face downwind, with the slip face (the downwind slope) at the angle of repose, or approximately 32 degrees. The upwind side is packed by the wind, and stands at about 15 degrees. Simple barchans dunes may stretch from meters to a hundred meters or so between the tips of the horns. (Schwämmle & Herrmann, 2003 and 2005; Elbelrhiti *et a.l,* 2005). Sand dunes occupies an area of 301.56 km^2 and has arc-shaped sand ridge and comprising well-sorted sand.

7) Tableland:

This landform has flat topped lands occupying area of 17490.37km^2 called also Plateau. It is ahighland area, usually consisting of relatively flat terrain with steep edges. These are structural remnants having a nearly smooth surface. A dark shiny stain called desert varnish or rock varnish.It is often found on surfaces of some rocks on this plateau especially those exposed at the surface for a long period of time. Manganese, iron oxides, hydroxides, and clay minerals form most varnishes.

Soil mapping

Examinations of East Owienat soils provide the bases for placing them into taxonomic and mapping units. Each mapping unit is identified on the map by a symbol according to the system suggested by Zinck (1989). Each must has an identifying name within the general system of soil classification. Consistent nomenclature is essential for understanding the relationships and differences among the mapping units and for correlating the soil units with those found elsewhere. Mapping

units are therefore named in taxonomic classification terms.

The main physiographic units, kind of the mapping units and soil taxonomy of the main mapping units of the studied soils are illustrated in Tables (2) and Fig. (3). Also, the relative areasof the taxonomic units found in the studied area could be listed in Table (3).

Table (2): Landforms and soil mapping units of East Owienat.

Land-scape	Relief / molding	Lithology / Origin	Landform unit	Mapping units	Soil set
Sand sheets (SS)	Flat to Almost flat	Aeolian sand deposit and Wind deposition	High sand sheets Mod. high sand Sheets Mod. sand Sheets Low sand sheets	SS1 SS2 SS3 SS4	*Typic Torripsamments* *Typic Torripsamments* *Typic Torripsamments* *Lithic Torripsamments*
Depressions (D)	Nearly Flat	Aeolian sand deposit and Wind deposition	High depression Mod. high depression Mod. depression Low depression	D1 D2 D3 D4	*Typic Torripsamments* *Typic Haplocalcids* *Typic Haplocalcids* *Typic Haplocalcids*
Peniplain (P)	Almost flat	Wind deposition	Peniplain	P	*Typic Haplodurids*
Dry Valleys (DV)	Nearly flat	Wind deposition	Dry Valleys	DV	*Typic Torrifluvents*
Hill Footslopes (HF)	Undulating	Aeolian / colluvial deposits	Concave Footslopes	HF	*Typic Haplocalcids*

Table (3): Area of each soil taxonomic unit at East Owienat.

Study area	Taxonomic unit	Area (Km^2)	Area (Feddan)	Area (%)
East Owienat	*Typic Torripsamments*	28198.25	6713870.26	35.68
	Lithic Torripsamments	5902.88	1405446.78	7.47
	Typic Haplocalcids	17475.15	4160751.12	22.12
	Typic Hapldurids	26007.64	6192293.67	32.92
	Typic Torrifluvents	1427.63	339909.76	1.81
Total Area		79011.55	18812271.59	100%

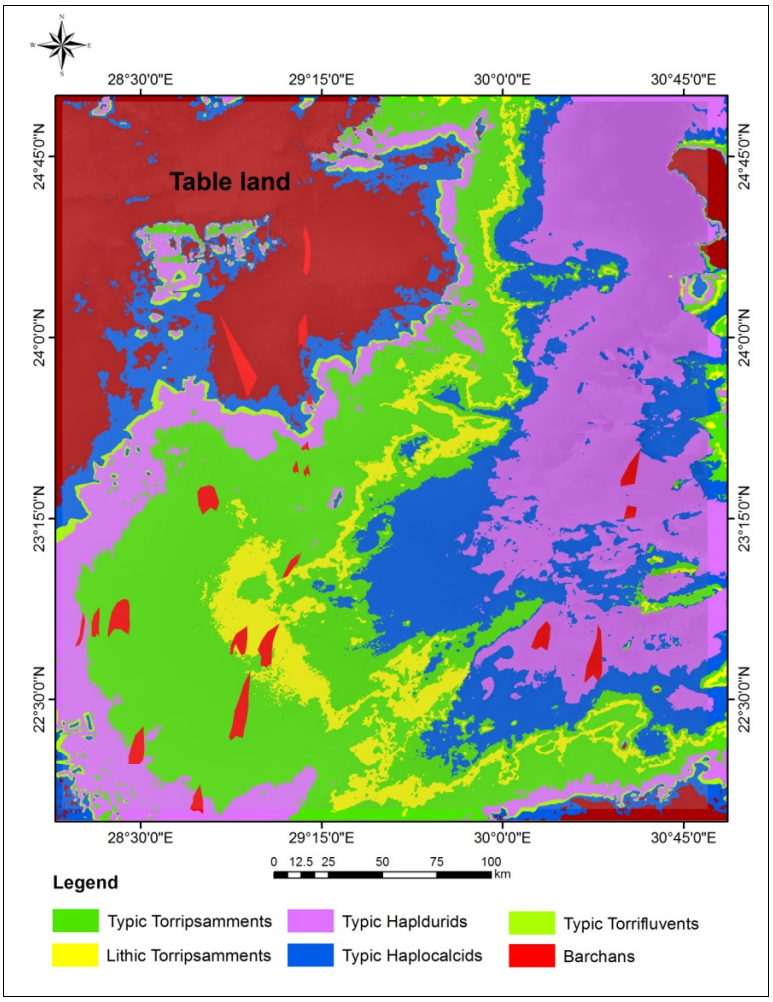

Fig. (3): Soil map of East Owienat area.

REFERENCES

Bandyopadhyay, P. (2007). Soil Analysis. 286 p, Hardcover, ISBN-13: 9788189729691, 978-8189729691.

Breed, CS, J.F. McCauley and P.A. Davis (1987). Sand sheets of the eastern Sahara and ripple blankets on Mars. In Desert sediments: ancient and modern, edited by L. Frostick and I. Reid. Geological Society of London Special Publication, no. 35, pp. 337-359.

Elbelrhiti, H., P. Claudin and B. Andreotti (2005). Field evidence for surface-wave-induced instability of sand dunes. Nature 437: 720–723.

ESRI (2014). Arc Map version 10.2.2 User Manual. ESRI, 380 New York Street, Redlands, California, 92373-8100, USA.

FAO (2006). Guidelines for soil profile description. 4th Edition, FAO, Rome.

Gerrard, A. J. (1993**).** Soil Geomorphology, 288 p., Soft cover ISBN: 978-0-412-44180-6.

ITT (2014). ITT corporation ENVI 5.1 software, 1133 Westchester Avenue, White Plains, NY 10604, USA

Klitzsch, E. and F.K. List (eds.) (1978). Geological Interpretation Map Egypt /Sudan 1: 500.000,Sheets2523 Gilf Kebir, 2521 Gebel Uwinat. TFH, Berlin.

Klitzsch, E., R.Said and E.Schrank (eds.) (1984). Research in Egypt and Sudan, Special study No. 69: Results of the Special Research Project. Arid Areas (period 1981-1984), Berliner Geowiss. Abh. (A) 50,457 PP.

Lillesand. T.M. and R.W. Kiefer (2007). Remote sensing and image interpretation, 5th ed. Paperback, JohnWiley, New York, pp. 820.

Schwämmle, V. and H.J. Herrmann (2003). Budding and solitary wave behavior of dunes, Nature 426: 619-620.

Schwämmle, V. and H.J. Herrmann (2005). A model of Barchan dunes including lateral shear stress, EPJE 16: 57-65.

Soil Survey Staff (2010). Keys to Soil Taxonomy, United States Department of Agriculture, Tenth Edition, USA.

Zinck, J. A. (1989). Physiography and soils, Soil survey course, ITC lecture note, K6 (SOL41), Enschede, The Netherlands.

التعرف على الخصائص الجيومورفولوجية والبيدولوجية لمنطقة شرق العوينات (بمصر) باستخدام الاستشعار من البعد ونظم المعلومات الجغرافية

علاء الدين حسن النهري[1] ، محمد سمير عراقي عميرة[2] ، فوزي الشاذلي أبوعجوة[2] ، محمد الأدهم مهدي فضل[1]

[1] الهيئة القومية للاستشعار من البعد وعلوم الفضاء بالقاهرة.

[2] قسم علوم الأراضي – كلية الزراعة – جامعة المنوفية.

الملخص العربي:

أجري هذا البحث بهدف التعرف على الخصائص الجيومورفولوجية والأرضية لمنطقة شرق العوينات الوقعة في جنوب غرب جمهورية مصر العربية ، والتي تبلغ مساحتها حوالي 95809.46 كم^2 (10.43%) من مساحة مصر.

ولقد استخدمت تكنولوجيا الاستشعار من البعد بواسطة الأقمار الصناعية للتعرف على الخصائص الجيومورفولوجية للمنطقة ، أعقبها عمل حصر تفصيلي لها لتأكيد معلومات الخرائط الناتجة من الأقمار الصناعية.

ولقد اتضح أن الرواسب السائدة في هذا المنطقة تنحصر في ثلاثة أنواع هي: الحجر الرملي النوبي ، رواسب العصر الرباعي ، والكثبان الرملية.

كما تم التعرف على سبعة وحدات جيومورفولوجية رئيسية تميز أشكال سطح أرض المنطقة هي: الأشرطة الرمليةSand sheets (تحتها 4 أشكال أرضية عالية ومتوسطة ومنخفضة) ، المنخفضات Depressions (تحتها 4 أشكال عالية ومتوسطة ومنخفضة) ، الأودية الجافة Dry valleys ، Peniplains ، أسفل المرتفعات Foot–slopes ، الكثبان الرملية Barchans ، والسهول المتفعة Tablelands.

ولقد تم اختيار وفتح ووصف إحدى عشر قطاعاً يمثل كل منها أراضي أحد الأشكال السابقة فيما عدا الكثبان الرملية والسهول المرتفعة ، وجمعت عينات تمثل آفاقها المختلفة لتحليلها للتعرف على الخصائصها الكيماوية والطبيعية لأراضي المنطقة ، وبالتالي تم تقسيم هذه الأراضي حيث اتضح أنها تنتمي إما إلى رتبة Entisols و Aridisols طبقاً للتقسيم الأمريكي الحديث.

ولقد استخدمت برامج نظم المعلومات الجغرافية لإنتاج الخرائط الأساسية والجيومورفولوجية والأرضية للمنطقة.