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GEOMORPHOLOGY AND PEDOLOGY OF SOUTH WESTERN AREA OF TOSHKA, EGYPT, USING RS AND GIS TECHNIQUES

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ABSTRACT: *The aim of this research is to identify the geomorphological features and study the soil characteristics and classification of the south western area of Toshka, Egypt. For these purposes and for producing the maps of the study area, the remote sensing (RS) and GIS techniques were used.*

According to the RS and GIS works, five main geomorphic unites with different subunits are recognized. These units are 1) Plain sandstone terraces (with three subunits i.e. low, medium and high terraces); 2) Depression (with three subunits i.e. plain sandstone, deposited hill and eroded karstified hill depressions); 3) Residual hills (with six subunits i.e. deposited back-slopes and foot slopes as well as eroded karstified top, summit, back-slopes and foot-slopes hills); 4) Sand sheets (with three subunits i.e. low, medium and high); and 5) Rock mesas (with four subunits i.e. plain sandstone, deposited hills, eroded karstified hills and sand sheet mesas).

Thirteen selected soil profiles representing the geomorphic unites were morphologically described and soil samples were collected according to the vertical variations. These samples were analyzed for their physical and chemical characteristics. The elevation of the studied area is between 194 and 256 m above sea level. The study area has different topography (i.e. almost flat, nearly level and undulated to sloping). The soil profiles are moderately deep to deep with well drainage status. They have mainly sandy texture with common fine to coarse gravels and/or fragments. The main soil structure is weak fine granular to medium sub angular blocky. The consistence is soft to hard when dry and friable when moist. The main hue notation of the soils has reddish color mainly between 2.5YR to 10YR. The soils are slightly to moderately saline having weak alkaline reaction. The soils have almost low to medium calcium carbonate contents. Organic matter content (OM) is very low and decreased generally with depth. The cation exchange capacity (CEC) is mainly correlated with the fine fractions and organic matter contents. The exchangeable sodium percentage (ESP) is very high making sodicity effect in the most of profile layers.

The studied soils haven't any diagnostic horizons and therefore, they are classified under Entisols order up to sub-great group's level according to Soil Survey Staff (2010). GIS works were performed to produce base, geomorphologic and soil classification maps of the studied area.

Key words: *Toshka, geomorphology, Pedology, characteristics, RS, GIS, classification.*

INTRODUCTION

Over the past 20 years, the population of Egypt has risen from 20 to nearly 90 million and it has been predicted that this trend will continue, reaching an anticipated 120 million in the next 20 years. The distribution of this population within Egypt is fairly estimated as 60% live in urban areas - in cities which are growing faster than infrastructure to support them. Increasing population increased demands for food and water. Due to increasing population and reduction of cultivated land in the valley and Delta the government of Egypt decided to get out from the narrow Valley and search for other areas for food production.

Recently, Egyptian government has lunched several ambitious land development projects aiming to increase the inhabited area from 5% to 25% of the total area of Egypt over next 20 years. Intensive works have been directed to the western desert which is about 65% of Egypt's total area and considered to be the most important phase of the ambitious projects. It is considered to be suitable of agriculture land resources for

future expansion and development in Egypt. The susceptible lands occur mainly in the fringes of the Nile valley and Delta, northwest coast, desert Oases and the southern valley of western desert.

Toshka project aims to develop and extend agricultural production and create new jobs and population centers away from the narrow confines of the Nile Valley. The project entails transferring water from Lake Nasser behind the Aswan dam, to the western desert. The main pumping station has already been completed. The proposed area to be cultivated is about 540,000 feddans using the water received from Lake Nasser as well as area of about 135,000 feddans could be irrigated using water extracted from proposed 300 wells.

The aim of the current study is to identify the geomorphological features and study the representative soil characteristics and classification of area around the 4^{th} branch of Sheikh Zaied Canal at south western Toshka. This study could serve proper planning of reclamation and amelioration of these soils.

MATERIALS AND METHODS

The studied area is located at the south western desert of Egypt around Toshka – El Owinat - Darb El-Arabian road, between latitudes 22° 33' 24" N and 22° 51' 46" N, and longitudes 31° 00' 07" E and 31° 15' 25" E (Figures 1 and 2).

The geomorphologic map of the area was produced using digital image processing of recent (2013) US Landsat Enhanced Thematic Mapper plus (ETM^{+}), scale (1: 100,000) as well as topographic maps scale 1:25000. Arc.GIS 9.2, ERDAS imagine 9.1 and ILWIS 3.7 software's were used for data gathering, input, storage, manipulation, analysis, and output by integrating conventional GIS according to Lillesand and Kiefer (2007). The geo-statistical analysis was carried out according to Stein (1998). The geological map of Egypt, scale 1:500,000 (EGPC, 1988) was also used in this study. The study area covers an area of about 196,148 Feddan.

Thirteen soil profiles in three transects were chosen for this investigation from thirty profiles representing the main landform units of the studied area. Dynamic GPS system was used to located the soil Profiles in the field. The location of studied profiles is presented in Fig. (4).

The soils and profiles were morphologically described according FAO (2006). Samples were collected from profiles according to the vertical variations. The soil samples were air dried, crushed and sieved to get the fine earth fractions (< 2 mm). These fine earth fractions were analyzed to determine their physical and chemical characteristics.

Particle size distribution was achieved according to Arnold (1986). Chemical characteristics such as EC, pH, organic matter (OM), total carbonate ($CaCO_3$), cation exchange capacity (CEC), gypsum and exchangeable sodium percentage (ESP) were determined according to Page (1982).

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

RESULTS AND DISCUSSION

Geology and Geomorphology of the study area

According to the geological map (EGPC, 1988), the parent material of the study has four main sources namely Sabaya, KurKur, Lake Nasser, and Abu Simbil formations as well as gneiss, magmatic gneiss and sand sheets, Fig. (3). The geomorphic mapping units were created on the bases of the result of digital elevation model using the histogram of the DEM value map. The Geopedological soil map (Zink 1989) was created to obtain the most purveyed geomorphic mapping units and then was combined with the geologic map to create the physiographic mapping units.

The physiographic mapping interpretation indicated that the investigated area includes five main geomorphic unites with different subunits. These units are: 1) Plain sandstone terraces (with three subunits i.e. low,

medium and high terraces); 2) Depression (with three subunits i.e. plain sandstone, deposited hill and eroded karstified hill depressions); 3) Residual hills (with six subunits i.e. deposited back-slope and foot slope as well as eroded karstified top, summit, back-slope and foot-slope hills); 4) Sand sheets (with three subunits i.e. low, medium and high); and 5) Rocky mesa (with four subunits i.e. plain sandstone, deposited hills, eroded karstified hills and sand sheet mesa). The geomorphologic unites and subunits are represented in Fig. (4). The description, legend, represented profiles and area of these landforms are presented in Table (1).

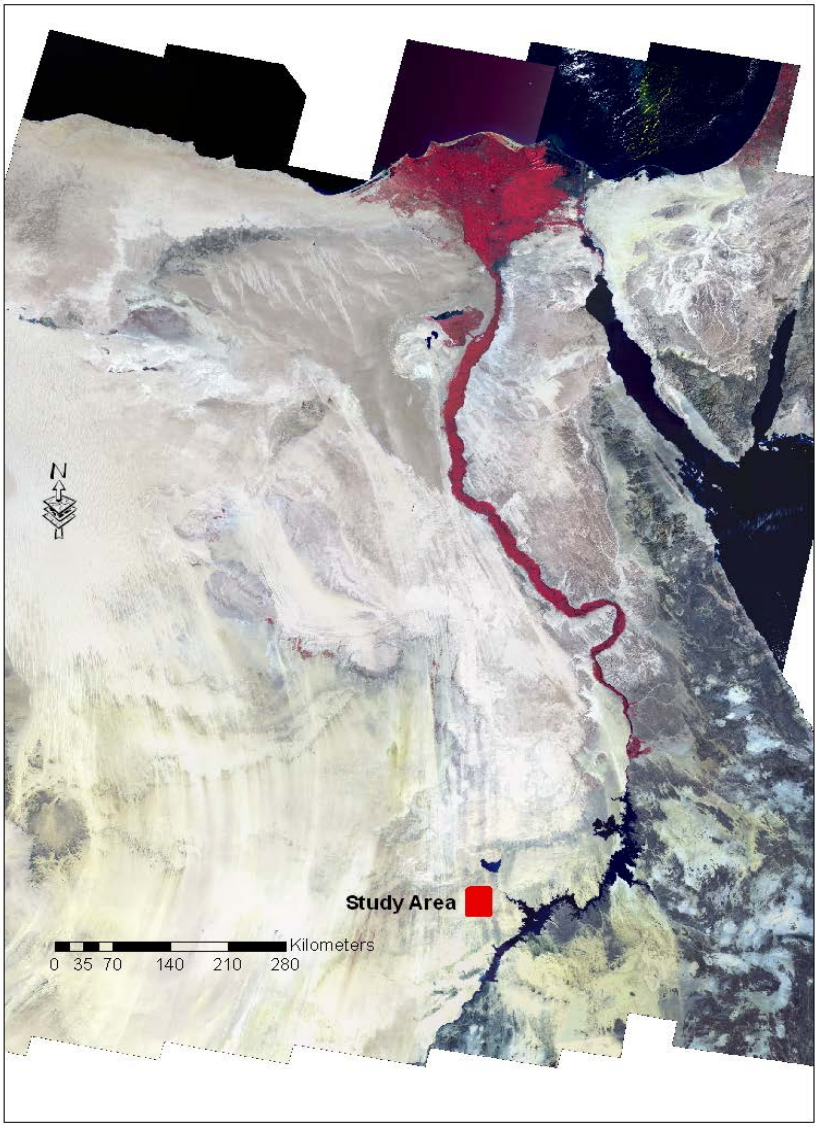

Fig. (1): General location of the Studied Area at Egypt.

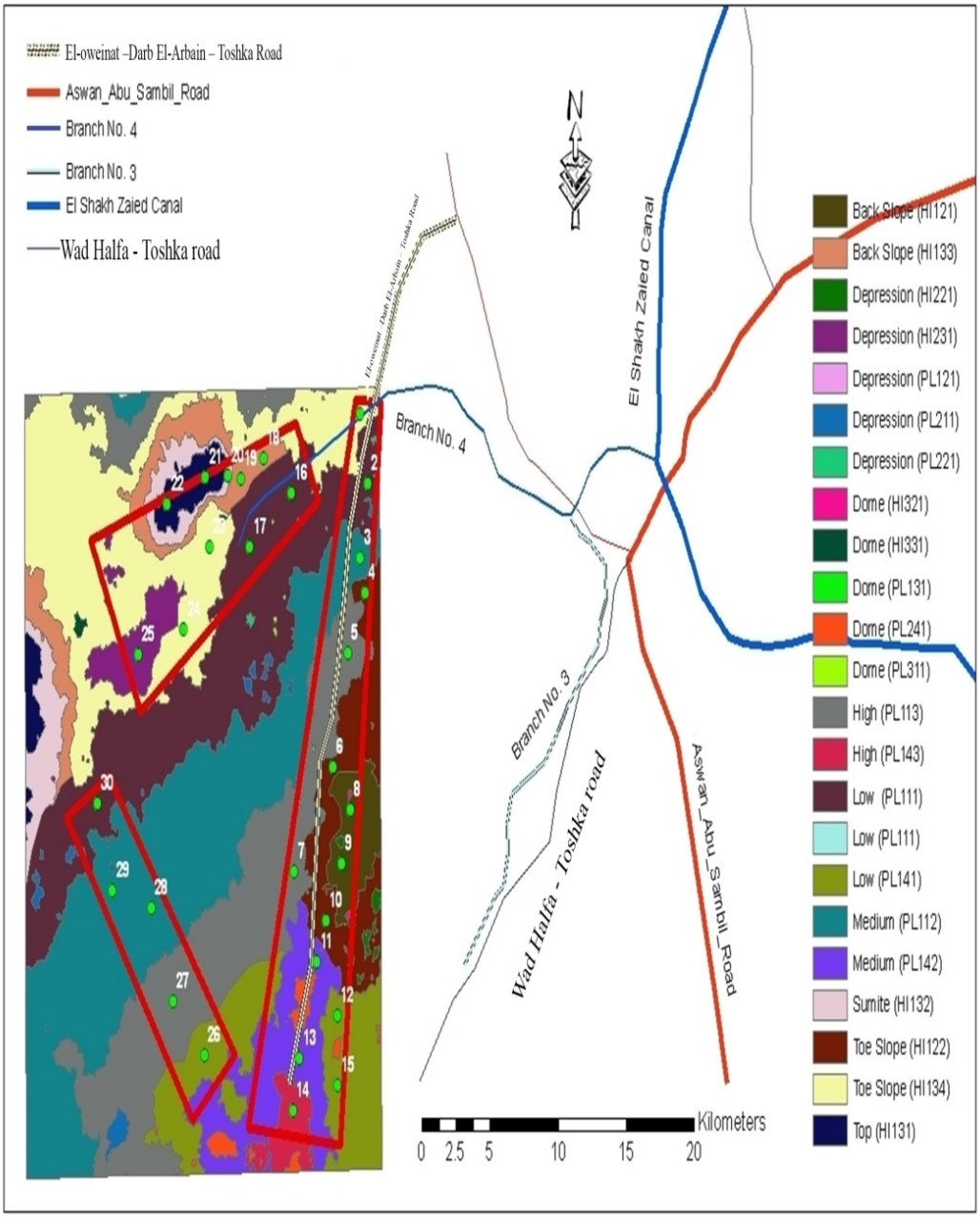

Fig. (2): Location of the studied area at Toshka.

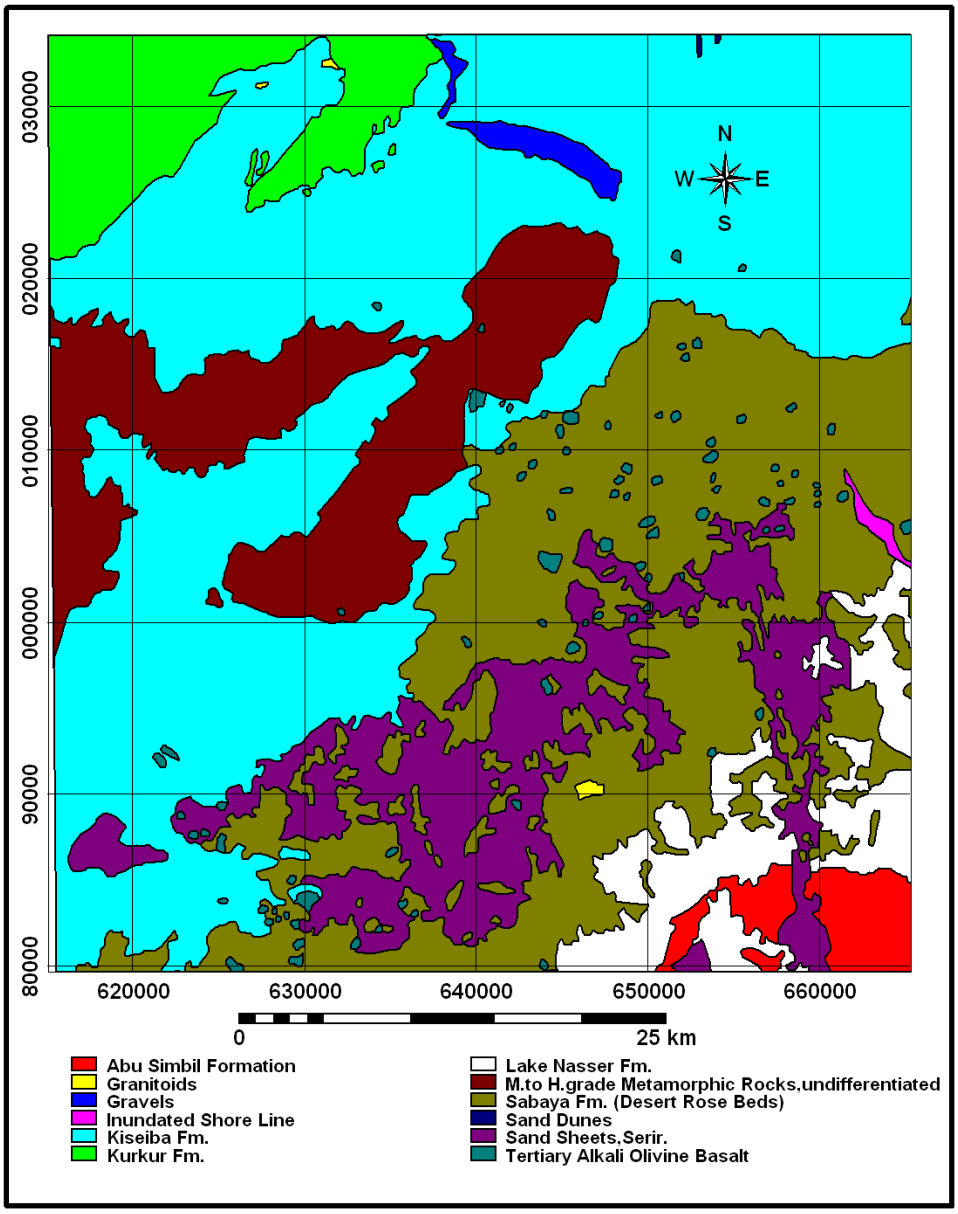

Fig. (3): The Geological formation of the study area.

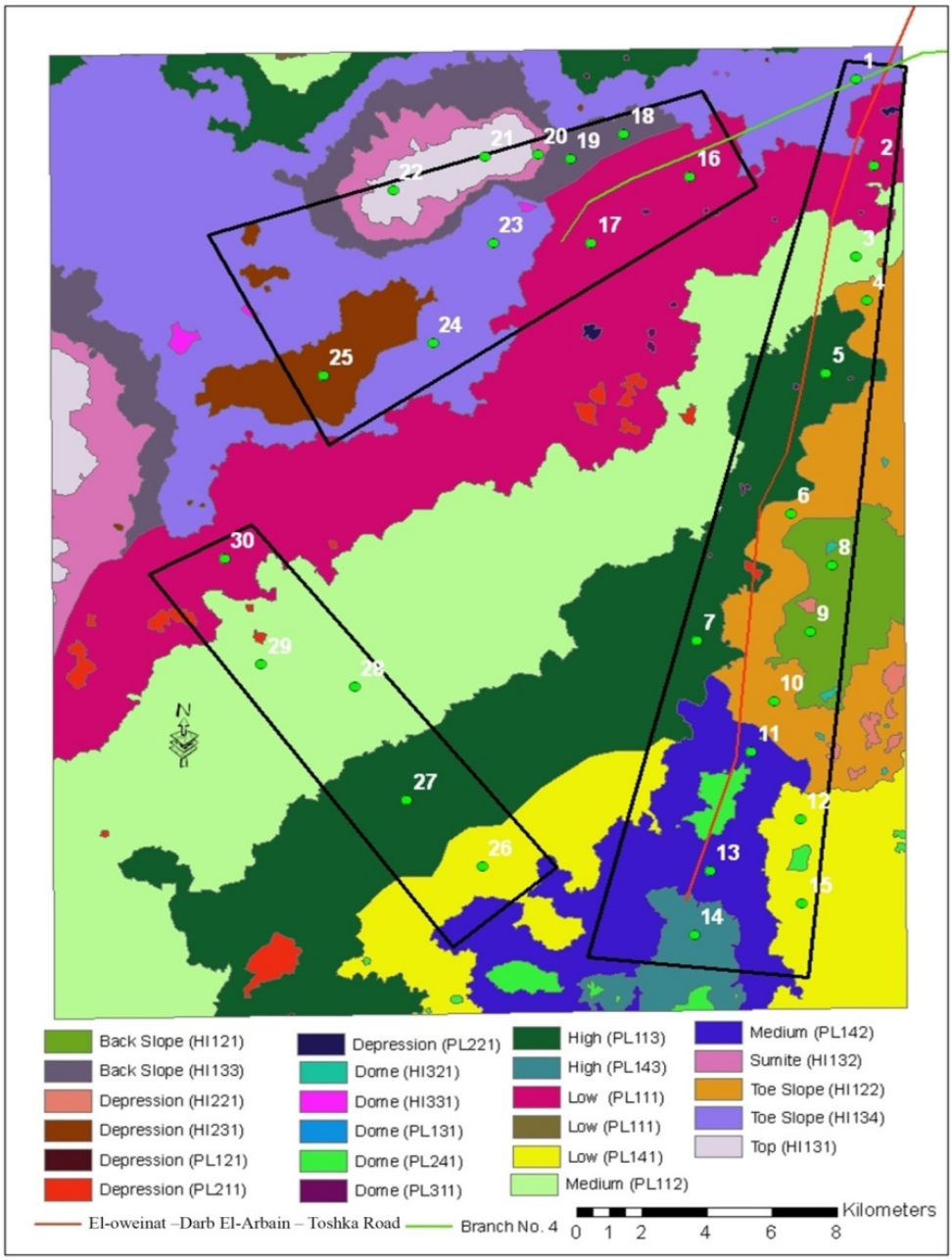

FIg. (4): Geomorphology and location of selected profiles in three transects of the study area.

Table (1): Description and legend of the geomorphic units of the studied area.

Landscape	Relief	Lithology	Landform	Legend Code	Profiles No.	Area feddan	% OF total Area
Plains	Series of sandstone terraces	Kiseiba formation. Mainly clayey siltstone and fine-grained sand stone with shale intercalations. Locally phosphate beds. Lacustrine to coastal flood-plain and shallow marine low – energy environment. Replaces Quseir formation. And lower part of Dakhla formation.	Low	PL111	30	15063	7.68
			Medium	PL112	28	40372	20.58
			High	PL113	5	29473	15.02
	Depression		Depression	PL211	-	12060	6.15
	Mesa		Dome	PL311	Rock	112	0.06
Residual deposited Hills	Hills	Sabaya formation. Medium to coarse grained flood plain sandstone with interbedded channel deposits and soil horizons. May be transitional to Abu "Aggag" formation .	Back slope	HI121	8	9509	4.85
			Foot slope	HI122	4	4186	2.13
	Depression		Depression	HI221	-	2404	1.23
	Mesa		Dome	HI321	Rock	129	0.07
Residual eroded Karstified Hills	Hills	Gneiss and magmatic gneiss	Top	HI131	21	3484	1.78
			Summit	HI132	20	5378	2.74
			Back slope	HI 133	18	7172	3.66
			Foot slope	HI 134	1	31459	16.03
	Depression		Depression	PL231	25	5791	2.95
	Mesa		Dome	PL331	Rock	195	0.10
Sand sheet series	Flat areas	Sand sheet	Low	PL141	15	14463	7.37
			Medium	PL142	13	10857	5.54
			High	PL143	14	2764	1.41
	Mesa		Dome	PL241	Rock	1277	0.65
					Total	196148	100.00

Soil Characteristics

Morphological features

The morphological description of the studied soils (Table, 2) is characterized by high elevation ranging between +194.0 and +256.0 meters a.s.l, with almost flat and nearly level to gently sloping. The parent material of the soils belongs to the Nubian plain which is built up from Nubian sandstone beds. Sandstone formation is related to the upper Cretaceous which is covered by both aeolian and alluvial deposits from the Pleistocene and Recent Era. Soil surface and some layers of the studied sites contained common coarse gravels and fine or coarse fragments. Some sites are covered with desert pavement.

Most of the area has deep soil profiles with well drainage status. Slightly weathered bedrock was found under the solum of these profiles. Most of the studied soils have yellow to red color in dry state changed to brown or dark red when moisten, Table (2). Studied soils, generally, have slightly gravely to gravely sandy, sandy loam, and loamy sand texture. Soil structure of entire depth of studied profiles ranges from weak fine granular to weak or moderate fine to medium sub–angular blocky according to texture grade of each layer. The dry soil consistency varies from soft for most surface layers changing to very or extremely hard with depth. The reaction of these soils indicated that they are slightly to moderately calcareous.

Table 2

Table 2

Chemical properties

The chemical properties of the studied soils are given as weighted profiles mean in Table (3). The data in Table (3) indicate that these soils have low to moderate salinity with alkaline reaction. Most of soils have moderate carbonate content ($CaCO_3$) with narrow ranges in profile layers. Studied soils have very low gypsum content. Organic matter content (OM) is very low. The cation exchange capacity (CEC) is mainly correlated with the fine fractions and organic matter contents. The exchangeable Na^+ percentage (ESP) is very high (causing sodicity effect) in all studied sites.

Soil classification

The soils are classified according to Soil Survey Staff (2010). The dominant soil moisture regime of studied area is Aridic (Torric) with hyper-thermic soil temperature regime. Studied soils haven't any diagnostic sub-surface horizons, therefore they were classified under Entisols order up to sub-great group level as presented in Table (4). The taxonomy of the studied soils is illustrated as mapping units as shown Fig. (5). Relative areas of the taxonomic units found in the studied area are presented in Table (5).

The results show that, about 51.1% of the study area was classified as Typic Torriorthents with small area of Lithic Torriorthents. Also, the main taxonomic classes in geomorphic mapping units were classified as Typic Torriorthents. It could be concluded that, more than 70% of the study area is moderately to marginally suitable for agricultural use.

Acknowledgement

Authors express their gratitude and thanks to Prof. Dr. Rafaat Yakoub "Prof. of Soil Science, RS and GIS at RS and GIS Unit in Soils, Water and Environment Research Institute, Agricultural Research Center, Giza, Egypt for his help and efforts in applying RS and GIS technology in this investigation.

Table (3): Weighted profiles mean of some physical and chemical properties of the studied soils.

Land scape	Code	Profile No	Gravels %	Texture class	pH 1:2.5	EC dSm^{-1}	CEC meq/100 g soil	*ESP* %	$CaCO_3$ %	Gypsum %	O.M %
Plain sandstone terraces	PL111	30	5.96	LS	7.69	5.15	10.38	35.61	7.59	0.99	0.12
	PL112	28	4.40	SL	7.90	6.25	11.27	30.61	7.03	0.69	0.07
	PL113	5	4.72	SL	7.90	7.50	13.55	35.48	2.89	0.83	0.11
Deposited Hills	HI121	8	5.38	SL	7.79	9.50	11.97	37.59	28.27	4.63	0.09
	HI122	4	3.03	SL	7.01	5.60	10.01	28.59	6.73	0.57	0.12
Eroded karstified Hills	HI 131	21	1.31	SL	7.47	4.17	11.12	46.07	7.47	0.78	0.17
	HI 132	20	2.04	LS	7.78	4.02	10.13	32.30	2.12	1.07	0.09
	HI 133	18	5.62	LS	7.84	4.68	6.80	40.29	7.96	0.32	0.08
	HI 134	1	4.29	SL	7.57	7.79	13.15	43.11	10.34	0.59	0.08
	PL 231	25	1.06	SL	7.69	3.53	5.26	29.37	1.84	0.39	0.07
Sand sheets	PL 141	15	3.07	LS	7.67	5.21	6.27	47.22	11.71	0.38	0.09
	PL 142	13	4.34	LS	8.46	3.68	10.97	40.25	4.54	0.30	0.05
	PL 143	14	6.42	LS	7.85	6.27	10.14	46.35	8.27	0.65	0.09

Table (4): Classification of the studied soil profiles.

Land scape	Code	Profile No	classification
Plain sandstone terraces	PL111	30	Typic Torriorthents
	PL112	28	Typic Torriorthents
	PL113	5	Typic Torripsamments
Deposited Hills	HI121	8	Typic Torriorthents
	HI122	4	Typic Torriorthents
Eroded karstified Hills	HI 131	21	Typic Torripsamments
	HI 132	20	Typic Torripsamments
	HI 133	18	Typic Torriorthents
	HI 134	1	Typic Torriorthents
	PL 231	25	Typic Torriorthents
Sand sheets	PL 141	15	Typic Torriorthents
	PL 142	13	Typic Torriorthents
	PL 143	14	Typic Torriorthents

Table (5): Relative areas of the taxonomic units of the studied area.

Soil classification	Area in	
	Feddan	%
Lithic Torriorthents	1255.07	0.64
Lithic Torripsamments	2604.86	1.33
Typic Torriorthents	5045.79	2.57
Typic Torriorthents with Lithic Torriorthents	100505.6	51.24
Typic Torriorthents with Lithic Torriorthents and Typic Torripsamments	30138.64	15.37
Typic Torriorthents with Lithic Torripsamments	23365.07	11.91
Typic Torripsamments	3276.64	1.67
Typic Torripsamments and Lithic Torriorthents	29480.79	15.03
Rocks	470.36	0.24
Total	196142.79	100.00

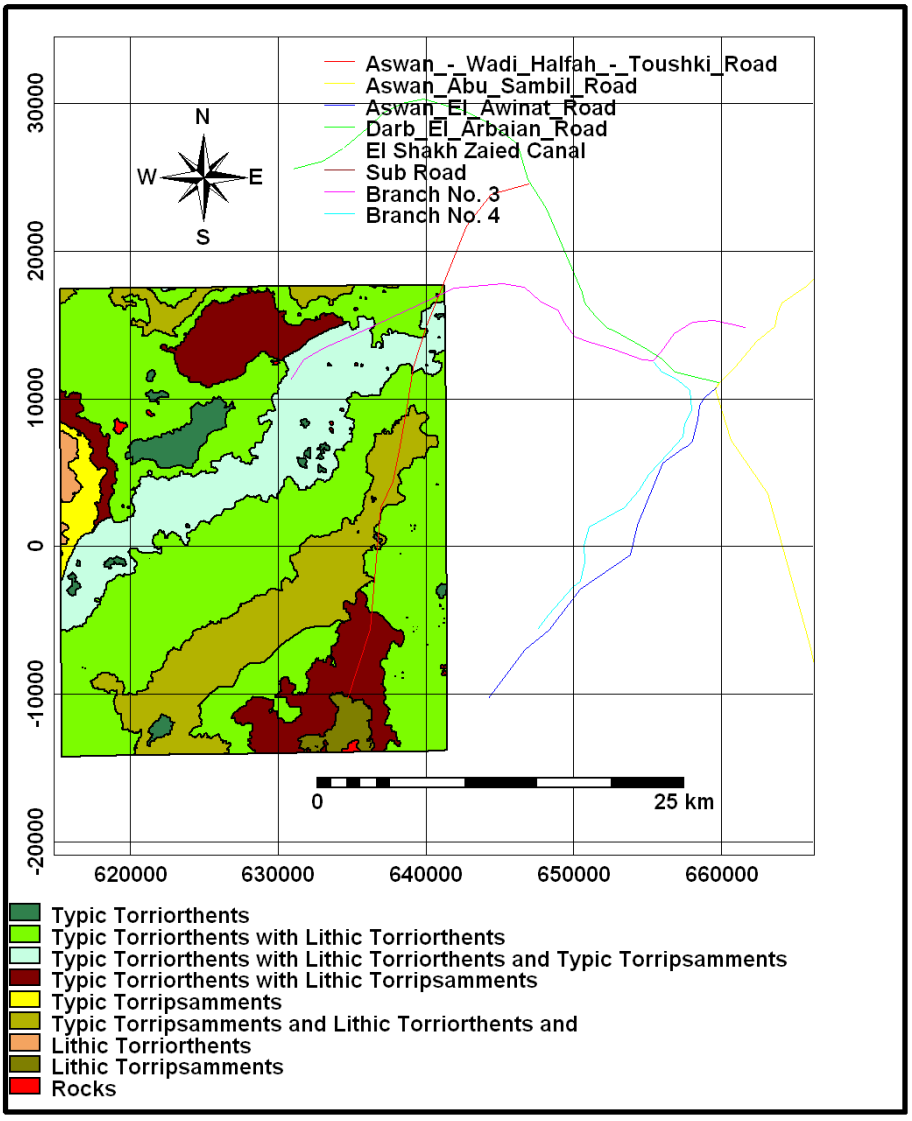

Fig. (5): Soil taxonomy mapping unites of the studied area.

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الخصائص الجيومورفولوجية والبيدولوجية للمنطقة الجنوبية الغربية لتوشكى ، مصر باستخدام تكنولوجيا الاستشعار من البعد ونظم المعلومات الجغرافية

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الملخص العربي:

يهدف هذا البحث إلى التعرف على الخصائص الجيومورفولوجية ودراسة خواص التربة وتقسيمها للمنطقة الجنوبية الغربية من توشكى بمصر ، ولهذا الغرض ولانتاج الخرائط الموضحة لمنطقة الدراسة تم الاستعانة بتكنولوجيا الاستشعار من البعد ونظم المعلومات الجغرافية.

ولقد أوضح تفسير نظم الاستشعار من البعد والمعلومات الجغرافية لصور القمر الصناعي الامريكى لأند سات (TM) ودراسة كلاً من الخرائط الجيومورفولوجية والجيولوجية للمنطقة تميز منطقة الدراسة المقدرة مساحتها بحوالي 196148 فدان بوجود خمس وحدات جيومورفولوجية رئيسية يندرج تحتها عدة أشكال أرضية هي:

1-سهول الشرفات المتكونة على الصخر الرملي الطميي وتشمل ثلاثة أشكال أرضية هي سهول الشرفات المنخفضة ، والمتوسطة و والمرتفعة.

2-المنخفضات وتشمل ثلاثة أشكال أرضية هي منخفضات سهول الصخر الرملي ، ومنخفضات التلال الرسوبية ، ومنخفضات التلال الكارستية المعراه.

3-التلال المتبقية وتشمل ستة أشكال أرضية هي الرواسب الخلفية والأمامية للمنحدرات ، قمة وأعالي وسفوح التلال الكارستية.

4-الأشرطة الرملية وتشمل ثلاثة أشكال أرضية (المنخفضة والمتوسطة والمرتفعة).

5-القمم الصخرية وتشمل أربعة أشكال هي سهول الحجر الرملي ، التلال الرسوبية ، التلال الكارستية المعراة ، وقمم الأشرطة الرملية الصلبة.

وتم أختيار ثلاثة عشر قطاعاً أرضياً لتمثل معظم هذه الأشكال الأرضية ، وتم وصفها مورفولوجياً ، وجمعت منها عينات أرضية تبعاً للاختلافات الرأسية فيها وذلك لاجراء التحليلات المعملية للخواص الطبيعية والكيميائية لهذه الأراضي.

ولقد أوضحت النتائج أن منسوب هذه الأراضي يتراوح بين 194 – 256 متراً فوق سطح البحر ، وطبوغرافية سطح الأرض تختلف من شبه الاستواء إلى المتموجة والمائلة ، وقطاع هذه الأراضي متوسط العمق إلى عميق ، والأراضي جيدة الصرف ، ذات قوام رملي إلى رملي طميي مع وجود بعض الحصى والقطع الصخرية ، بناؤها ضعيف حبيبي إلى كتلي ، ذات صلابة متغيرة من هشة إلى قوية ، ترواح لونها الأصفر المحمر إلى البني الفاتح ، والأراضي قليلة إلى متوسطة الملوحة ، قلوية التأثير ، ذات محتوى قليل إلى متوسط من الكربونات الكلية ، منخفضة في محتواها من المادة العضوية ، السعة التبادلية تتوقف على محتوى الأرض من الحبيبات الدقيقة والمادة العضوية وغالباً ما يسود الصوديوم المتبادل المعقد الغروي الضئيل مما يسبب التأثير الصودي.

لم يتضح وجود أي نوع من الآفاق الوراثية في هذه الأراضي ولذلك قسمت الأراضي طبقاً للنظام الأمريكي (2010) تبعاً لرتبة الأراضي غير المتطورة Entisols حتى مستوى تحت المجموعات ، ولقد استخدمت البرامج الالكترونية الحديثة لنظم المعلومات الجغرافية لإنتاج خرائط الوحدات الجيومورفولوجية والأصول الجيولوجية وخرائط التقسيم لأراضي منطقة الدراسة.

Table (2): Morphological description of the studied soil profiles.

Landform	Profile No.	Elevation M ASL	Drainage	Depth, cm	Color		Texture[1]	Structure[2]	Consistence[3]		Boundary[4]
					Dry	Moist			Dry	Moist	
Low plain sandstone terraces	30	+200	Well drained	0- 25 25-70 70-110	10YR 7/6 7.5YR 6/4 7.5YR 6/4	5/6 5/4 5/4	LS SL LS	1m gr 2 F sbk 2 F sbk	soft S.hard hard	friable friable friable	clear Gr. smooth
Medium plain sandstone terraces	28	+ 217	Well drained	0- 15 15-30 30-50 50-100	7.5YR 6/6 7.5YR 7/6 7.5YR 6/6 2.5YR 6/6	5/6 4/6 4/6 4/6	LS SL SL SL	1 F gr 1 F gr 2 F sbk 1 F gr	soft soft hard soft	friable friable friable friable	clear Gr. smooth Abrupt
High plain sandstone terraces	5	+216	Well drained	0-15 15-60 60-120	7.5YR 7/4 7.5YR 6/6 7.5YR 8/4	5/4 5/6 6/4	SL SL LS	1 F gr 1 F sbk 2 m sbk	soft soft s. hard	v friable friable friable	clear Gr. smooth
Deposited back slope hills	8	+ 233	Well drained	0- 15 15-40 40-70 70-120	10YR 7/6 2.5YR 5/6 2.5YR 5/6 2.5YR 5/6	5/6 4/6 4/6 4/6	LS SL SL LS	1 F sbk 1 M. gr 1 M. gr 1 M. gr	soft s .hard hard v .hard	friable friable friable friable	Abrupt diffuse diffuse
Deposited foot slope hills	4	+212	Well drained	0-10 10-45 45-120	10YR 8/6 7.5YR 5/6 7.5YR 6/4	5/6 4/6 4/6	LS SL SL	1 F gr 2 . F. sbk 1 F sbk	soft soft soft	v friable v friable v friable	Abrupt Gr. smooth
Eroded karstified top hills	21	+194	Well drained	0- 25 25 - 60 60 - 130	10YR 7/6 7.5YR 6/6 7.5YR 6/4	5/6 5/6 5/6	SL SL SL	1 F gr 1 F sbk 1 F sbk	soft S .hard v .hard	friable friable friable	clear clear
Eroded karstified summit hills	20	+194	Well drained	0- 20 20- 65 65 - 120	10YR 7/6 10YR 6/6 10YR 6/4	5/6 6/4 5/4	SL SL SL	1 F gr 1 F sbk 1 F sbk	V. soft S .hard S .hard	v friable friable friable	clear diffuse
Eroded karstified back slope hills	18	+ 195	Moderately well drained	0- 15 15-45 45-75	10YR 7/6 7.5YR 7/6 10YR 8/4	6/6 6/6 6/4	S SL LS	1F gr 1 F gr 1 F gr	Loose Soft hard	Loose friable friable	clear clear

Abbreviations: Texture[1]: LS=loamy sand, SL= sandy loam, Structure[2]: 1=weak, 2=moderate, F= fine, m=medium, co=coarse, gr=granular, sbk = sub angular blocky; Consistence[3]: S = slightly, v = very, x =extremely; Boundary[4]: Gr= gradual.

Table (2): Continued.

Landform	Profile No.	Elevation M ASL	Drainage	Depth cm	Color		Texture	Structure	Consistence[2]		Boundary[3]
					Dry	Moist			Dry	Moist	
Eroded karstified foot slope hills	1	+ 202	Well drained	0- 20 20- 100 100 - 130	10YR 7/6 10YR 7/6 10YR 7/2	5/6 6/6 6/2	LS SL SL	1 F gr 2 .F- .SbK 2. M blaty	soft s .hard s .hard	v friable friable friable	clear Abrupt
Eroded karstified depression	25	+200	Well drained	0- 20 20- 65 65-120	10YR 7/6 10YR 6/6 10YR 6/4	5/4 5/6 5/4	LS SL SL	1 F gr 2 m sbk 2 m Sbk	Loose S. hard hard	Loose friable friable	Abrupt Gr. Smooth
Low sand sheets	15	+256	Moderately well drained	0- 25 25- 50 50- 90	10YR 7/4 5YR 6/6 2. 5YR 6/6	5/6 5/6 4/6	LS SL SL	1 F sbk 1 F Sbk 1 F sbk	Soft S. hard hard	friable friable friable	clear clear
Medium sand sheets	13	+250	Well drained	0-15 15-65 65-130	7.5YR 7/6 2.5YR 4/8 2.5YR 4/8	5/6 3/6 3/6	L.S L.S SL	1 F sbk 1 m gr 1 m gr	Soft hard ex. hard	friable friable friable	Abrupt diffuse
High sand sheets	14	+252	Well drained	0- 15 15- 45 45- 100	10YR 7/4 7.5YR 7/6 5YR 5/8	6/4 5/6 5/6	LS SL SL	1 F gr 1 F sbk 1 F gr	Soft Soft Soft	V.friable friable friable	Gr. smooth Abrupt

Abbreviations: Texture[1]: LS=loamy sand, SL= sandy loam, Structure[2]: 1=weak, 2=moderate, F= fine, m=medium, co=coarse, gr=granular, sbk = sub angular blocky; Consistence[3]: S = slightly, v = very, x =extremely; Boundary[4]: Gr= gradual.