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GEOMATICS BASED SOIL MAPPING OF THE EASTERN DESERT PART OF SOHAG GOVERNORATE, EGYPT

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ABSTRACT

The aim of this study is to apply the powerful capabilities of advanced remote sensing and GIS techniques to identify and characterize the main physiographic units of some soils of the Eastern Desert Part of Sohag Governorate. A physiographic analysis using visual interpretation of false colour composite (FCC) of Landsat ETM images was carried out to delineate the different physiographic units of the studied area which accurately defined by the Digital Elevation Model (DEM) which generated from the Shuttle Radar Topographic Mission (SRTM). Twelve soil profiles were collected and examined to represent the soils of the studied area. The soils of the studied area are slightly to highly saline (EC values ranged from 3.83 to 10.67 dS/m). Soil texture is mostly sandy to loamy sand. Soil pH values ranged from 7.83 to 8.45. Organic carbon content is very low with a maximum value of 0.35%. Regarding the CEC, it varied from 2.68 to 4.76 cmole$^+$/kg and the $CaCO_3$ ranged from 3.81 to 17.68 %. The soils were classified as Typic Haplocalcids, Typic Torripsamment and Typic Torriorthents. The major landforms of the studied area were described as Wadi Bottom (WB), Bajada (B), Alluvial Fans (AF), Tableland (T), Gently Undulating Sand Sheet (GUS) and Undulating Sand Sheet (US).The data revealed that current capability of soils is moderately suitable (S2), marginally suitable (S3) and temporary not suitable (N1). The major limiting factors were texture, topography and salinity. With the application of some scientific and technical improvements, the limiting factors could be mitigated to attain the potential capability of the soils of the study area.

Keywords: GIS, DEM, Physiographic unit, capability classification, soil mapping

INTRODUCTION

Till now, there is only one small-scale soil map with global coverage, the Soil Map of the World, at a scale of 1:5,000,000. FAO and UNESCO produced this map between 1960 and 1980 (FAO, 1988). The map contains polygons representing soil associations attributes provided for each mapping unit which include the soil information *viz.* dominant soil type, list of associated soils, the textural class and the slope class of the soil association. FAO prepared a map of World Soil Resources at a scale of 1:25,000,000 and also created a generalized version at a scale of 1:100,000,000 (FAO,1993). Both the Soil Map of the World and the World Soil Resources maps are available from the FAO in digital format (Dobos and Montanarella, 2007). In addition, many efforts has been made by different agencies using various satellites and sensors such as Landsat-MSS / TM , SPOT and IRS - LISS-I / II /III for mapping soils at different scales ranging from 1:250,000 to 1:50,000 (NRSA, 2002).

Nowadays, there is a great demand for accurate soil information over large areas from environmental modellers and land use planners as well as more traditional agricultural users of soil resource inventories. The generated information was interpreted for various purposes like land capability classification, land irrigability assessment, crop suitability studies, management of watersheds, prioritization of watersheds (Rossiter, 2005). Recently, thematic mapping has undergone a revolution as the result of advances in geographic information science and remote sensing. For soil mapping archived data is often sufficient and this is available at low cost. Green (1992) stated that integration of Remote Sensing within a GIS database can decrease the cost, reduce the time and increase the detailed information gathered for soil survey.

The Digital Elevation Model (DEM) has been used to derive landscape attributes that are utilized in land forms characterization (Dobos *et al*., 2000). The DEM is an electronic model of the Earth's surface that can be stored and manipulated in a computer (Brough, 1986). It provides greater functionalities than the qualitative and nominal characterization of topography. A DEM can be manipulated to provide many kinds of data that can assist the soil surveyor in mapping and giving a quantitative description of landforms and of soil variabilities. Information derived from a DEM, such as elevation, slope and aspect maps can also be used with the images to improve their capabilities for soil mapping (Lee *et al*., 1988). Hammer *et al.* (1995) indicated that slope class maps produced from 10 m DEM appear to have great potential use for soil survey and land use planning. Also, the integration of information derived from DEM, geology and surface deposits could be used to predict soil types (Moore *et al*., 1992). Mora-Vallejo *et al*. (2008) applied digital soil mapping to create a reconnaissance soil map to assess clay and soil organic carbon contents in terraced maize fields. Soil spatial variability prediction was based on environmental correlation using the concepts of the soil forming factors equation.

Dobos and Montanarella (2007) stated that the use of digital data sources, such as digital elevation models (DEMs) and satellite data can speed up the completion of digital soil databases and improve the overall quality, consistency and reliability of the database. Soil information is needed for a wide range of environmental and agricultural applications.

Knowledge of soils, combined with climatic and ecological data, is essential for understanding recent and future changes in ecosystems. Similary, McBratney *at al*. (2003) reported that the principal manifestation is soil resource assessment using GIS, i.e., the production of digital soil property and class maps with the constraint of limited relatively expensive fieldwork and subsequent laboratory analysis. Morsy (2015) identified sex physiographic units in a part of Wadi Qena viz, Low elevated sand sheet (LSS) with an area of 30.07 Km^2, High elevated sand sheet (HSS) with an area of 31.05 Km^2, Bajada (B) with an area of 27.47 Km^2, Piedmont (P) with in area of 27.45 km^2 and Tableland (TL) with in area of 26.39km^2.

The objective of this study is to apply remote sensing and GIS techniques to identify and characterize the main physiographic units of some soils of the Eastern Desert Part of Sohag Governorate and to assess its capability.

MATERIALS AND METHODS

1.Study area

The study area is a part of the Eastern Desert of Sohag, Egypt and located between geo-coordinates 26° 25′ to 26° 45′ latitudes (N) and 32° 40′, 33° 00′ longitudes (E) covering about 121.316 feddan. It is situated between the Nile Valley in the West and the Red Sea mountains in the East. The location map of the studied area is shown in figure (1).

2.Climate:

The area under study is characterized by hot dry sub-humid to semi-arid transition with intense hot summer, cold winter and general dryness throughout the year except during July and September.

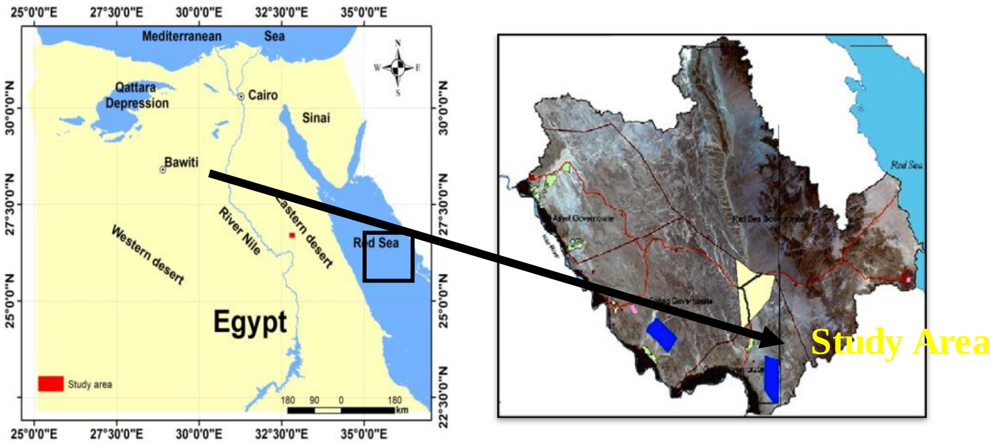

Figure.1. Location map of the studied area (Awad, 2008 and EGMA, 2004).

3.Geology and Geomorphology:

The Eastern Desert areas are covered by the Red Sea Mountains consisting of igneous and metamorphic rocks. Surface Quaternary deposits exist in the form of alluvial hills and alluvial terraces consisting of gravels, sands and cemented by fine clay materials (El-Shamy, 1988). Wadi Qena anticline represents one of the oldest systems in the stable shelf of Egypt .It has a great amplitude, gentle dip, and plunges southward (Said, 1990).

The geomorphologic characterize of Wadi Qena basin have been extracted and classified into the main landforms: Limestone Plateau, Nubian Sandstone Plateau, Tors, Fault Scarps, Alluvial Fans and Flood Plain landform (Said,1990).

Methodology

1.Remote Sensing data and processing:

In the present study the Landsat ETM+ satellite data of 2010 was used. The study area is covered by one image (172Path /42 Row). The false color composite (FCC) of the study area is presented in figure (2). The digital data of geo-coded cloud free of three image was downloaded from http://glcf.umd.edu/data/landsat/ (GLCF, 2014). Table 1 presents the principle specifications of the sensor used in the investigation. The Shuttle Radar Topographic Mission (SRTM) images of 30 pixel size resolution have been used to generate the DEM for the study area and its surrounding were consulted to represent the area landscape. The study area was extracted from the whole image (Fig.2) of through on screen digitization of the area of interest (AOI) and masking out using subset module of ENVI software (ver.4.8).

Table. 1 Satellite and sensor specifications

Bands		Spatial resolution (m)	Spectral resolution (µm)
1	Blue	30	0.414 – 0.514
2	Green	30	0.519 - 0.601
3	Red	30	0.631 – 0.692
4	NIR	30	0.772 – 0.898
5	SWIR-1	30	1.547 – 1.749
6	TIR	60	10.31 – 12.36
7	SWIR-2	30	2.064 – 2.345
8	Pan	15	0.515 – 0.896

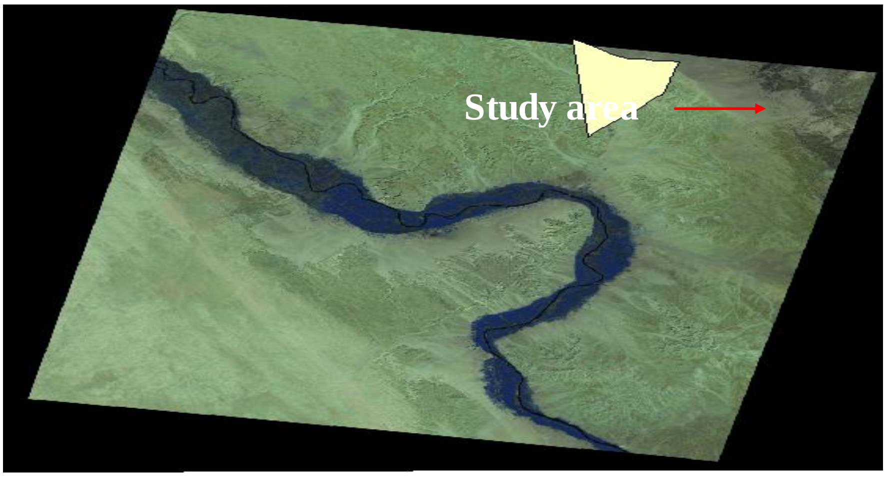

Figure.2. FCC of Landsat image of the studied area

2.Delineation of different landforms:

The delineation of the landform units from the satellite data needs a high spatial resolution images; therefore the spatial resolution of the used Landsat ETM+ was enhanced through the data merge process. This process is commonly used to enhance the spatial resolution of multi-spectral datasets using higher spatial resolution panchromatic data or single band (band 8). In this study merged data were performed using multi-spectral bands (30 m) as a low spatial resolution with panchromatic band 8 of ETM+ satellite image as a high spatial resolution (15 m) resulting in multi-spectral data with high spatial resolution (15 m). The landforms map has been generated from the SRTM (30 m) and enhanced Landsat ETM+ images using the ENVI 4.8 software (Dobos et al., 2002).

By using the image elements such as texture, parcelling, pattern, shape, size, color, site and situation, many information about the terrain have been extracted from enhanced ETM+ image. Moreover, The SRTM data has been used in conjunction with enhanced ETM+ to provide a better visualization of the topographic features, namely surface elevation, slope, aspect, shaded relief and convexity). The topographic features have extracted using ENVI 4.8 software. Afterwards, the landform units were defined and classified and the map legend was established. DEM of the study area has been generated from the SRTM image (Fig. 3) using ArcGIS 9.3 software. The extracted data generates a preliminary geomorphologic map which was checked and completed through field observation.

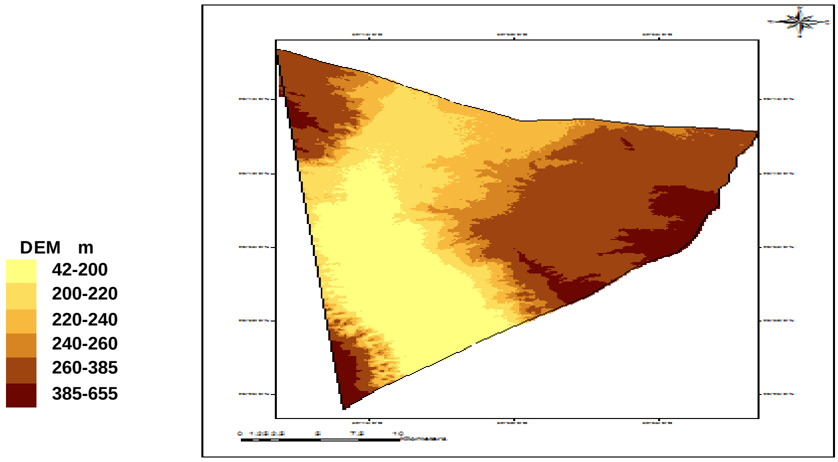

Figure.3. DEM of of the studied area

3.Ground truth verification:

A rapid reconnaissance survey of the area under study was conducted in order to achieve more detailed information of the soil patterns, land forms and characteristic of the landscape and landforms occurring in the study area.

4.Samples collection

Twelve soil profiles were selected representing various types of landforms occurring in the study area. The morphological examination of soil profiles was carried out in the field as per procedures laid out in the Soil Survey Manual (FAO,2006). Horizon wise disturbed soil samples (1 Kg) as well as core samples (diameter 2.5 cm and length 6 cm) were collected from each profile and kept separately in polyethylene bags for further analysis. Location coordinates were recorded with hand held GPS under WGS 84 (Lat-Lon) coordinate system (Fig.4).

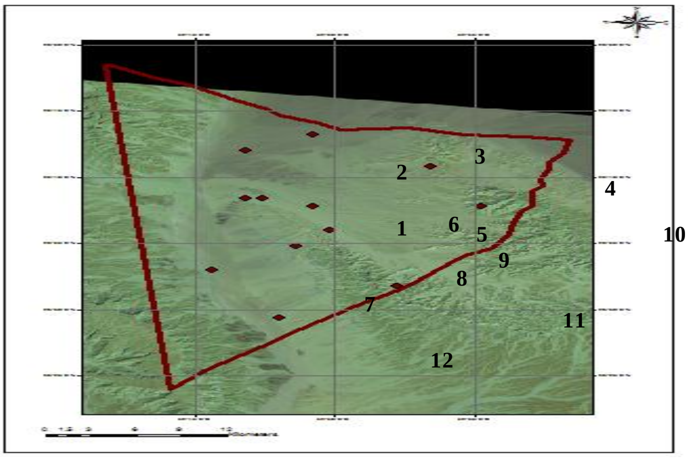

Figure.4 Location of the representative soil profiles laid on studied area

5. Soil samples analysis

The collected soil samples were subjected for the following analyses: Particle size distribution (Piper, 1950); using the sodium hexametaphosphate for dispersion in calcareous soils (USSL Staff, 1954), calcium carbonate, electric conductivity (ECe) in the soil paste extract, soluble cations and anions, soil pH, organic matter content (Jackson, 1973); cation exchange capacity and exchangeable sodium (Black, 1982).

6.Soil classification:

The American Soil taxonomy (USDA, 2010) was followed to classify the different soils of the studied area up to the family level. Then the correlation between the physiographic and taxonomic units, were identified (Elbersen and catalan, 1987)

7.Generation of thematic maps

Inverse Distance Weighted (IDW) interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance. IDW lets the user control the significance of known points on the interpolated values, based on their distance from the output point. Thematic maps were generated for each of the soil physical and chemical parameters using IDW interpolation provided in Arc GIS 9.3 software.

Land suitability techniques were done using the rating tables suggested by Sys and Verheye (1978); FAO (1976 and 1983) and Sys *et al*.(1991) according to the equation:

$$Ci = t \times \frac{W}{100} \times \frac{S1}{100} \times \frac{S2}{100}\frac{S3}{100} \times \frac{n}{100}$$

Where:
Ci = Capability index (%)
t = Slope (t)
w = Drainage conditions (w)
s1 = Texture (x)
s2 = Soil depth (d)
s3 = $CaCO_3$ content (k)
n = Salinity and alkalinity (n)

RESULTS AND DISCUSSION

1. Characterization of map units:

The visual interpretation of the Landsat data and DEM integrated with Soil Taxonomy and soil field data using GIS have been used to generate the slope map and physiographic soil map (Fig. 5 and 6). The studied soils are classified according to USDA (2010) as Typic Haplocalcids, Typic Torripsamment and Typic Torriorthents (Table 2).The main soil characteristics of the mapping units are shown in Tables (3 and 4).

Table2. Legend of the physiographic map of the studied area

Landscape	Lithology	Relief	Landform	Land use	Map unit symbol	Sub group	Area	
							Feddan (1000)	%
Wadi Plain (WP)	Eocene Deposits (1)	Almost Flat (1)	Wadi Bottom (WB)	Barren	$WP11_{WB}$	Typic Haplocalcids	26.426	21.78
			Alluvial Fans (AF)	Barren	$WP11_{AF}$	Typic Torriorthents	33.457	27.58
			Bajada (B)	Barren	$WP11_{B}$	Typic Haplocalcids	15.785	13.02
			Tableland (T)	Barren	$WP11_{T}$	Typic Torriorthents	16.648	13.72
		Gently Undulating (2)	Gently Undulating sand sheet (GUS)	Barren	$WP12_{GUS}$	Typic Torripsamments	16.500	13.60
		Undulating (3)	Undulating sand sheet (US)	Barren	$WP13_{US}$	Typic Torripsamments	12,500	10.30
Total							121.316	100

The physiography of the studied area was identified based on the Landsat ETM+ images, the Digital Elevation Model (DEM), slope map and the field check,. The obtained results reveal that, the main physiographic unites in the studied area are; the Wadi Bottom (WB), Bajada (B), Alluvial Fans (AF), Tableland (T), Gently Undulating Sand Sheet (GUS) and Undulating Sand Sheet (US).

Wadi bottom (WB) is the lowest land in the valley and usually contains sediments resulted from water erosion of the bounded high areas and mountains. This mapping unit covered about 26,426 feddan and represented by two profiles (7, 12). The surface is almost flat, the parent material is Eocene deposits, the evidence of erosion is slightly and drainage is well. The dominant texture class is loamy sand with few gravels. Calcium carbonate content is high. Soil pH values ranged between 7. 7 and 8. 4. Soil organic carbon content varied from 0.02 to 0.35 %. Calcium carbonate content ranged between 11.4 and 14. 5%. Soil salinity (EC) ranged between 4. 3 and 6. 5 dS/m. Cation exchange capacity (CEC) ranged between 3.9 to 5.16 $cmol^+/kg$. Exchangeable sodium percentage (ESP %) is less than 15%.

Regarding to Alluvial Fan (AF) unit, it covered an area of 33,457 feddan and represented by two profiles (9,4). The surface is almost flat, the parent material is Eocene deposits, the evidence of erosion is slightly they are well drainage. The dominant texture class is loamy sand. There are a few gravels and high $CaCO_3$ content. The soil reaction was moderately alkaline (8.1 to 8.6) The organic carbon content is very low. The EC of soil ranged between 6.3 to 11.3 dS/m. Cation exchange capacity (CEC) varied from 2.48 to 4.32 $cmol^+$ /kg.

Bajada unit (B) which represents by profiles (5 and 8) and covered an area of 15,785 feddan.The surface is almost flat, the parent material is Eocene deposits, the evidence of erosion is slightly and they are well drainage. The dominant texture class is loamy sand. The $CaCO_3$ content ranged between 11.6 and 22.2 %. The soil reaction was moderately alkaline (7.8 to 8.5). The organic carbon content is varied from 0.04 to 0.21 %. The EC of soil is slightly saline. Cation exchange capacity (CEC) varied from 2.50 to 4.48 $cmol^+$ /kg.

Two profiles (10,11) represent Tableland unit (T) which occupied an area of 16,648 feddan.The surface is almost flat, the parent material is Eocene deposits, the evidence of erosion is slightly and they are well drainage. The dominant texture class varied from moderately gravely loamy sand and gravely loamy sand. The $CaCO_3$ content was medium. The soil reaction was moderately alkaline (8.2 to 8.5) The organic carbon content is very low. The EC of soil ranged between 6.3 to 7.5 dS/m. Cation exchange capacity (CEC) varied from 2.23 to 3.46 $cmol^+$ /kg.

Based on relief, Sand sheets can be divided into two units, namely gently undulating and undulating sand sheet covering an area of 16,500 and 12,500 feddan, respectively. Both having sandy texture and the pH varied from 7.8 to 8.6 while EC ranged between 2.4 and 6.4 dS/m. The organic carbon content is very low (0.01- 0.23%). Cation exchange capacity (CEC) varied from 2.21 to 4.74 cmol+ /kg.

Slope

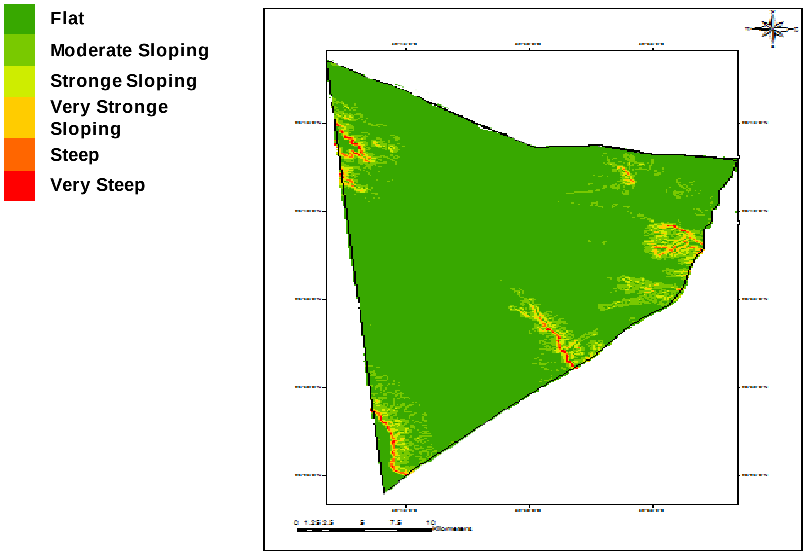

Fig. 5 Slope map of the study area

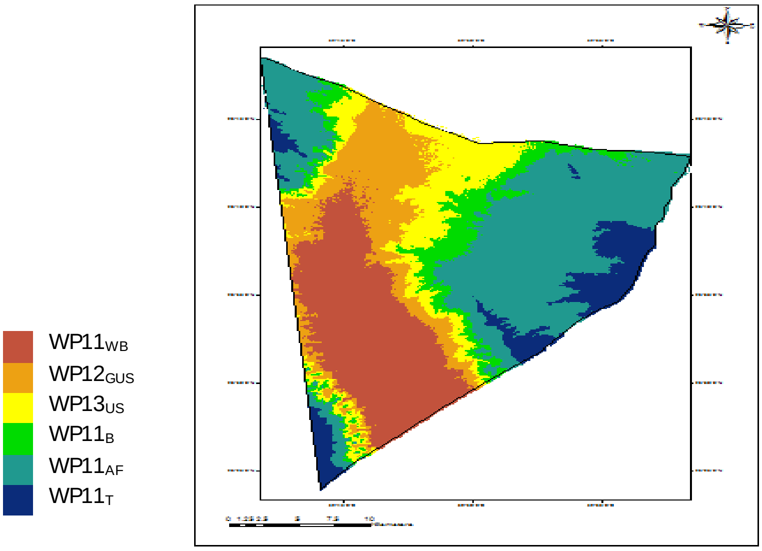

Fig. 6 physiographic units map of the study area

Table 4.The wheighted mean of soil characteristics of the Soil mapping units

Map units	Profile No.	Gravels	Coarse Sand	Fine Sand	Silt	Clay	Texture classe	CEC	ESP	O.C	EC	pH	CaCO3
$WP11_{WB}$	7	4.65	75.10	6.70	12.00	6.20	ls	4.26	9.67	0.16	5.69	8.09	12.36
	12	5.36	75.71	6.21	11.03	7.05	ls	4.76	7.76	0.15	5.41	7.83	13.41
$WP11_{AF}$	9	11.65	82.73	5.35	7.24	4.68	ls	3.38	7.33	0.08	10.67	8.16	17.08
	4	12.86	83.41	5.37	7.91	3.31	s	3.75	6.43	0.10	7.38	8.28	13.24
$WP11_{T}$	10	28.37	86.11	5.43	5.03	3.44	GS	2.68	10.35	0.08	5.38	8.39	8.59
	11	34.64	84.26	6.88	4.99	3.88	GS	3.46	6.76	0.08	5.85	8.36	9.19
$WP11_{B}$	5	5.79	75.73	9.25	10.61	4.42	ls	4.19	6.69	0.11	5.02	8.09	13.62
	8	5.59	76.74	8.91	10.31	4.04	ls	3.20	9.84	0.11	6.45	8.41	17.68
$WP12_{GUS}$	2	5.48	91.51	1.44	5.14	1.91	s	3.82	4.85	0.11	5.58	8.45	7.01
	1	6.37	91.21	1.83	4.86	2.10	s	2.81	7.94	0.08	3.83	8.37	3.81
$WP13_{US}$	6	6.06	91.47	1.90	4.61	2.02	s	3.19	9.18	0.13	4.28	8.24	8.65
	3	7.24	93.20	2.00	3.10	1.70	s	3.18	9.51	0.07	3.99	7.95	5.44

2.Current land capability:

The obtained results indicated that the soils of the studied area are considered as promising soils for agricultural projects. Evaluating their capability is an essential stage for future practical use. Current land capability refers to the capability for a defined use of land in its present condition, without major improvement (FAO, 1976 and FAO, 2007). The rating values (Sys et al., 1991) were calculated to express the capability of land characteristics. The rating values and the kind of limitations are presented in Table (5). Accordingly, the studied area could be classified into three current classes and four sub classes reflect the kind of limitations in the studied area (Fig. 7 & 8).

a.Current class S2 with capability index Ci varies between 69.04and 76.71 %. This class includes the soils which are moderately suitable. Only one subclass S2x was found in this class (Table 6). This subclass includes the moderately suitable soils which occupies an area of about 37195 fed. (30.66 % of the total area). The soils of this subclass are affected by moderate limitations.The loamy sand texture is the limiting factor for these soils. Two mapping units fall under this class i.e. WP11WB and WP11B

b.Current class S3: This class includes the soils which are marginally suitable. The soils have moderate limitations. It forms about 57.25 % of the studied area (69454 fed.). Two subclasses were recognized in this class as following:

Subclass S3x: It occupies the highest area of about 44608 fed. (36.77 %). It is represented by soils of units WP12GUS, WP13US and WP11AF which covered by sand sheet.

Subclass S3xn: It covers 24846 fed. (20.48 % of the studied area). Texture and salinity are the limiting factors for these soils as soil texture is sandy to loamy sand and EC values ranging from 3.83 to 10.67 dS/m. Only one profile falls under this subclass and WP11AF represents the map unit of this soil.

Table 5 capability assessment of the soils of the study area

Map units	Profile No.	Slope	Drainage	Soil Characteristics (s) Texture (x)	Depth (d)	CaCO3 (k)	Salinity and Alkalinity (n)	Capability Index (CI) %	Class	Subclass	Area Fed. (1000)	%
WP11WB	7	100	100	85	90	95	95	69.04	S2	S2x	17.178	14.16
	12	100	100	85	90	95	95	69.04	S2	S2x	9.244	7.62
WP11AF	9	100	100	85	100	95	50	40.38	S3	S3xn	10.578	8.72
	4	100	100	65	100	95	95	58.66	S3	S3x	22.881	18.86
WP11T	10	50	100	50	100	95	95	22.56	N1	N1xt	1.965	1.62
	11	50	100	50	100	95	95	22.56	N1	N1xt	14.667	12.09
WP11B	5	100	100	85	100	95	95	76.71	S2	S2x	4.052	3.34
	8	100	100	85	100	95	95	76.71	S2	S2x	12.447	10.26
WP12GUS	2	100	100	65	100	95	95	58.66	S3	S3x	1.795	1.48
	1	100	100	65	90	95	95	52.80	S3	S3x	10.713	8.83
WP13US	6	100	100	65	100	95	95	58.66	S3	S3x	3.592	2.96
	3	100	100	65	100	95	95	58.66	S3	S3x	12.204	10.06
Total											121.316	100

Texture is the limiting factors in these soils. The soils are sandy to loamy sand and topography is ranging from gently undulating and undulating.

c.Class N1:

The soils have very severe limitations. topography and texture are the limiting factors for these soils. This class covers only 12.09 % of the studied area. The capability index Ci is < 25 %. It includes one mapping units which is WP11T (14667 fed.).

Table 6. capability classes and subclasses of the soils of the study area

Capability class	Capability class	Area Feddan (1000)	%
S2	S2x	37.195	30.66
S3	S3x	44.608	36.77
	S3xn	24.846	20.48
N1	N1xt	14.667	12.09
Total		121.316	100

%

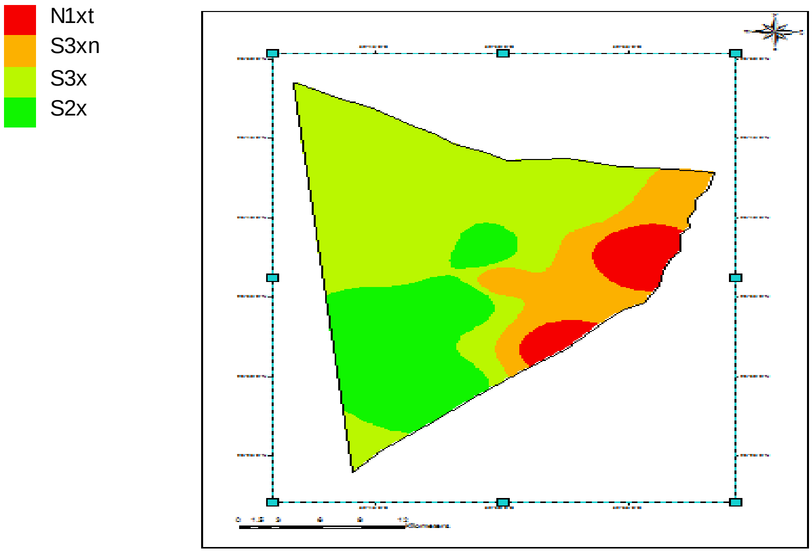

Fig. 7 Current land capability map of the study area

Map unit	Capability Subclasses
WP11WB	S2x
	S3x
WP11AF	S2x
	S3xn
WP11T	S3xn
	N1xt
WP11B	S2x
	S3x
WP12GUS	S2x
	S3x
WP13US	S2x
	S3x

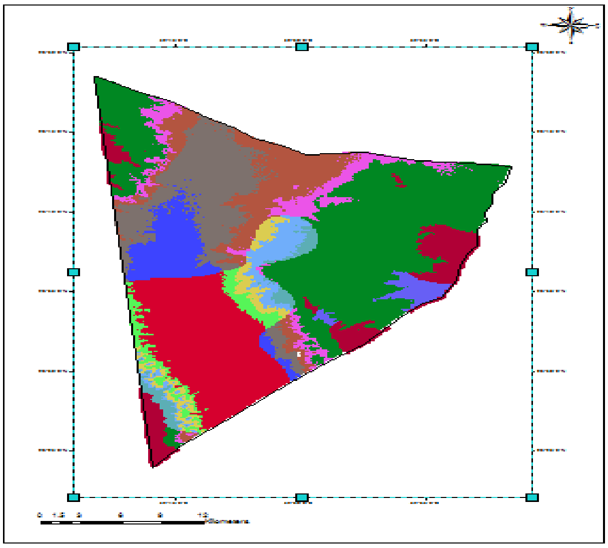

Fig. 8 Current land capability map overly on physiographic unit map

3.Potential land capability

Potential capability refers to the capability of units for a defined use, after specified major improvements have been completed where necessary (FAO, 1976). The major improvements needed to overcome the current limitations In the study area are:

1) Leaching of salinity (up to EC < 6 dS/m). The leaching requirements for reclamation (LRR) to maintain soil salinity at a minimum level (< 4 dS/m) are calculating using the equation proposed by Hoffman (1980).

$$\frac{Di}{Ds} \times \frac{ECs}{ECo} = 0.1$$

Where:

Di = Depth of required water irrigation,
Ds =Depth of soil,
ECs = salinity of soils after leaching and
Eco =salinity of soils before leaching

2) Construction of good drainage systems.
3)Leveling of undulating surface (up to slope < 4%). In addition to recommended irrigation systems in coarse texture areas (drip and sprinkler), that save water and keep ground water table under safe level. With the application of some scientific and technical improvements, the limiting factors could be mitigated to attain the Potential capability (Fig. 9) of the soils of the study area.
4) Application of organic matter such as farmyard manure, compost, filter and bagasse mud...etc to improve the soil physical , chemical and finally the productivity.

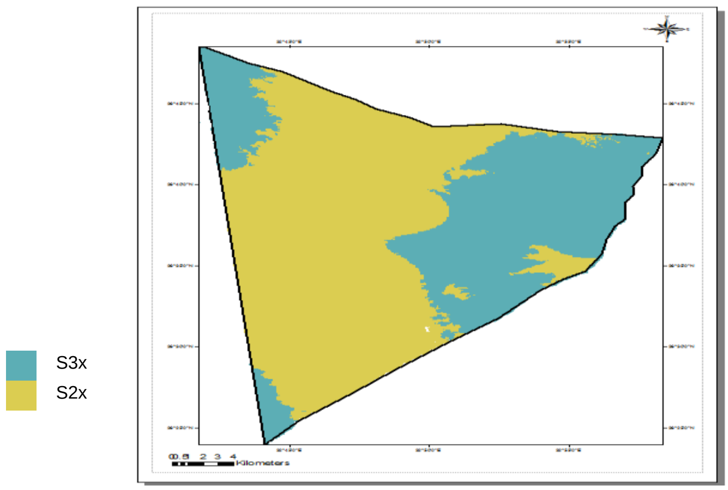

Fig. 9 Potential land capability map of the study area

CONCLUSION

The current investigation was done to apply utilize the capability of remote sensing and GIS techniques for identifying and characterizing the main physiographic units of soils of the Eastern Desert Part of Sohag Governorate. The obtained results revealed that the EC values ranged from

3.83 to 10.67 dS/m. Soil pH values varied from 7.83 to 8.45. The maximum value of organic carbon is 0.٣٥%. In addition, CEC has a range value of 2.68 and 4.76 $cmole^+/kg$ and the $CaCO_3$ content from 3.81 to 17.68 %. The main greatgroups found in the studied area were Typic Haplocalcids, Typic Torripsamment and Typic Torriorthents. Sex landforms occured in the d area under study and were described as Wadi Bottom (WB), Bajada (B), Alluvial Fans (AF), Tableland (T), Gently Undulating Sand Sheet (GUS) and Undulating Sand Sheet (US). Regarding to soil capability, the soil of the study area were classified as moderately suitable (S2), marginally suitable (S3) and temporary not suitable (N1). It could be recommended that scientific and technical management could be improved the capability of the soil.

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تطبيقات نظم االجيومعلوماتية لعمل خرائط التربة لمنطقة شرق سوهاج الصحراوية بمصر

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أجريت هذة الدراسة بهدف التعرف علي الوحدات الفيسيوجرافية لأراضي المنطقة الصحراوية الواقعة غرب محافظة سوهاج وذلك بإستخدام تقنية الإستشعار عن بعد ونظم المعلومات الجغرافية. حيث تم تحليل بيانات كلا من القمر الصناعي Landsat ETM+ وكذلك نموذج الإرتفعات الرقمية الذي تم الحصول عليه من بيانات SRTM وذلك لتحديد أهم المظاهر الفسيوجرافية في المنطقة المدروسة. تم تحديد مواقع ١٢ قطاع تمثل الإختلافات في أراضي منطقة الدراسة. وأوضحت النتائج أن الأراضي المدروسة قليلة إلي عالية الملوحة من (٣.٨٣ الي ١٠.٦٧ ds/m) وتراوحت درجة الحموضة من (7.83 to 8.45) . وكانت الأراضي رملية إلي لومية وذات محتوي منخفض من المادة العضوية . وترواحت قيم السعة التبادلية الكاتيونية من (2.68 – 4.76 cmole+/kg) بينما تراوحت قيم الكربونات الكلية من (3.81 – 17.68%) .

وأوضحت النتائج أن الأراضى محل الدراسة تقع تحت المجموعات العظمي Typic Haplocalcids, Typic Torripsamment and Typic Torriorthents . وأحتوت منطقة الدراسة علي ٦ وحدات فسيوجرافية وهي Wadi Bottom (WB), Bajada (B), Alluvial Fans (AF), Tableland (T), Gently Undulating Sand Sheet (GUS) and Undulating Sand Sheet (US).

وأوضحت نتائج دراسة القدرة الإنتاجية كانت درجتها من محدودة إلي قابلة للإنتاجية. ومع إستخدام بعض تقنيات الإستصلاح الحديثة والمعاملات الزراعية يمكن رفع إنتاجيتها إلي مستوي أعلي.

Table 3.The main soil characteristics of the mapping unit

Mappng unit	Profile No.	Depth cm	Gravels	Coarse Sand	Fine Sand	Silt	Clay	Texture Class	Exchangeable Cations				CEC cmole+ /kg	ESP	BS	O.C	EC dS/m	pH	$CaCO_3$ %
			%	%					cmole+/kg					%		%			
									Na	K	Ca	Mg							
$WP11_{WB}$	7	0-20	5.3	77.3	5.9	11.4	6.5	Ls	0.43	0.19	2.63	1.73	5.16	8.3	96.5	0.31	6.2	8.4	11.4
		20-45	4.2	75.2	9.6	10.5	5.7	Ls	0.35	0.21	2.11	1.12	3.96	8.8	95.7	0.15	6.7	8.2	12.6
		45-75	4.6	73.6	5.5	13.7	6.5	Ls	0.44	0.18	1.65	1.54	3.90	11.3	97.7	0.08	4.5	7.8	12.8
	12	0-25	6.3	73.7	5.9	13.7	6.7	Ls	0.31	0.15	2.42	1.71	4.77	6.5	96.2	0.35	4.3	7.7	14.5
		25-40	6.1	77.5	8.6	7.2	6.7	ls	0.36	0.17	2.71	1.68	5.06	7.1	97.2	0.16	6.5	8.1	13.5
		40-80	4.5	76.3	5.5	10.8	7.4	Ls	0.41	0.12	2.82	1.23	4.65	8.8	98.5	0.02	5.7	7.8	12.7
$WP11_{AF}$	9	0-30	12.3	76.3	8.6	9.7	5.4	Ls	0.35	0.18	2.21	0.76	3.65	9.6	96.0	0.17	9.3	8.3	15.7
		30-60	11.2	85.2	3.5	6.7	4.6	S	0.22	0.17	2.3	1.42	4.32	5.1	95.1	0.06	11.2	8.1	17.5
		60-100	11.5	85.7	4.3	5.8	4.2	S	0.18	0.21	1.43	0.55	2.48	7.3	95.6	0.03	11.3	8.1	17.8
	4	0-25	15.4	78.4	6.5	10.6	4.5	Ls	0.31	0.14	2.35	1.16	4.13	7.5	95.9	0.19	8.2	8.6	14.6
		25-50	13.3	84.3	5.8	7.4	2.5	S	0.29	0.12	2.34	0.42	3.21	9.0	98.8	0.08	8.5	8.3	11.4
		50-95	11.2	85.7	4.5	6.7	3.1	S	0.17	0.23	2.71	0.61	3.84	4.4	96.1	0.06	6.3	8.1	13.5
$WP11_{T}$	10	0-20	25.1	88.1	3.1	5.2	3.6	S	0.31	0.14	2.11	0.70	3.41	9.1	95.6	0.20	6.3	8.4	7.55
		20-55	27.5	87.3	2.8	4.7	5.2	S	0.25	0.12	1.50	0.90	2.83	8.8	98.0	0.07	5.2	8.5	8.23
		55-100	30.5	84.3	8.5	5.2	2.0	s	0.27	0.11	1.30	0.51	2.23	12.1	98.2	0.04	5.1	8.3	9.34
	11	0-25	35.6	83.0	9.2	5.0	2.8	S	0.37	0.18	1.84	1.10	3.62	10.1	96.4	0.17	7.5	8.3	8.11
		25-55	33.6	89.0	4.0	4.5	2.5	S	0.24	0.16	2.23	0.62	3.34	7.2	97.3	0.06	6.2	8.2	8.56
		55-100	34.8	81.8	7.5	5.3	5.4	S	0.16	0.15	2.51	0.51	3.46	4.6	96.2	0.04	4.7	8.5	10.2
$WP11_{B}$	5	0-25	6.7	71.4	9.4	13.5	5.7	Ls	0.25	0.16	2.74	0.72	3.90	6.4	99.2	0.21	6.4	8.5	13.7
		25-55	6.3	79.6	8.6	8.2	3.6	Ls	0.17	0.20	3.17	0.81	4.48	4.0	97.1	0.11	4.7	8.1	11.6
		55 -90	4.7	75.5	9.7	10.6	4.2	Ls	0.37	0.19	2.71	0.75	4.16	9.2	96.6	0.04	4.3	7.8	15.3
	8	0-30	7.8	71.5	9.8	12.5	6.2	Ls	0.23	0.12	1.50	0.90	2.81	8.4	97.9	0.18	7.3	8.2	22.2
		30-50	4.5	80.2	8.1	7.3	4.4	ls	0.28	0.13	1.35	0.65	2.50	11.6	96.4	0.13	5.8	8.5	18.6
		50-100	4.7	78.5	8.7	10.2	2.6	lS	0.36	0.21	1.80	1.23	3.72	10.0	96.8	0.05	6.2	8.5	14.6
$WP12_{GUS}$	2	0-25	6.3	91.3	1.1	5.3	2.3	S	0.31	0.15	2.27	1.91	4.77	6.5	97.2	0.21	5.3	8.5	11.3
		25-50	4.5	89.5	1.4	7.0	2.1	S	0.15	0.10	1.20	1.44	3.01	4.9	96.01	0.11	6.4	8.6	5.1
		50-85	5.6	93.1	1.7	3.7	1.5	S	0.18	0.12	1.72	1.62	3.72	3.64	97.85	0.05	5.2	8.3	5.3
	1	0-20	7.8	87.3	2.7	7.2	2.8	S	0.17	0.13	2.11	1.64	4.13	4.8	98.06	0.24	5.2	8.1	3.5
		20-45	6.3	92.4	1.6	3.9	2.1	S	0.22	0.13	1.35	0.65	2.41	9.1	97.51	0.04	3.2	8.4	4.2
		45-90	5.6	92.6	1.5	4.2	1.7	s	0.21	0.13	1.30	0.65	2.35	8.9	97.45	0.01	3.5	8.5	3.7
$WP13_{US}$	6	0-20	7.5	88.3	3.1	5.3	3.3	S	0.27	0.11	1.30	0.51	2.23	12.1	98.2	0.23	6.3	8.3	10.7
		20-50	7.3	89.5	1.4	6.7	2.4	S	0.37	0.18	1.84	1.10	3.62	10.2	96.4	0.17	4.7	8.4	9.3
		50-95	4.6	94.2	1.7	2.9	1.2	S	0.24	0.16	2.23	0.62	3.34	7.2	97.3	0.06	3.1	8.1	7.3
	3	0-20	8.4	87.5	2.9	6.1	3.5	s	0.16	0.15	2.51	0.51	3.40	4.6	97.9	0.22	7.2	7.8	8.4
		20-45	7.3	95.4	2.5	3.1	2.1	S	0.27	0.11	1.30	0.51	2.21	12.2	99.1	0.05	4.3	7.8	6.4
		45-90	6.7	94.6	1.5	2.8	1.1	S	0.37	0.18	1.84	1.10	3.62	10.2	96.4	0.02	2.4	8.1	3.6