Middle East Journal of Agriculture Research, 3(3): 670-676, 2014
ISSN 2077-4605

Landform Classification and Soil Distribution of Sidi Barrani Area, North-Western Coast of Egypt

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ABSTRACT

This study presents a classification of landform elements and examines the relationship between these landform elements and selected soil characteristics. The study was carried out on "Sidi Barrani" locate in the north-western coast of Egypt lies between Marsa Matruh and El Salloum cities. It extends from the coast of Mediterranean Sea to the El Dabha El Salloum main road at south. Based on remote sensing data, DEM and GIS, five landform elements are recognized: plateau , coastal plain, sabkhas, dry valley and depression. All of the elements are easily identified in the field. Fourteen soil profiles have been selected to represent the main landform units in the study area. The obtained results showed that the investigated soils of the study area are belong to Typic torriorthents, Typic Torripsamments, Typic Haplocalcids and Typic Haplosalids . In general more than 30% of the study area is deep soils while 44% is moderately deep soils. Fine to average soil texture is covers about 68 % (1934 km^2) of the studied area. These soils can be easily cultivated. Soil survey and classification are very essential and important for investing any virgin area for agricultural development and rural rehabilitation as in the case of Sidi Barrani.

Key words: landform, Soils classification, GIS, Sidi Barrani, North Western Coast, Egypt.

Introduction

Afifi *et al.* (2010) illustrated that, the soil of the north coast is characterized mainly by high sensitive areas for desertification. The geology of the Mediterranean coastal zone is intensively studied by Hume (1925), Ball (1939), Shukri *et al.* (1956), Shata (1957) and El-Shazly (1964). Generally, the sedimentary rocks found in this area are dated back to Late Tertiary and Quaternary ages; their stratigraphic sequence was given by Shata (1957), Abd El-Samie (1960), Conoco (1989). The coastal landforms including coastal ridge, elevated plains, flood plains, drainage channels and lagoons. The shoreline is sculptured a series of destructive and/or constructive regional activities. These are mainly of marine, water streams, wind and even tectonic origins (Shata, 1957). According to Shata (1957), Abdel Samie (1960), El-Kady (1961), Abdel Salam (1962), El-Shazly (1964), Hammad (1964) and Metwally (1969); the geomorphologic features encountered can be summarized as follows: the structural plateau, the coastal plain, foreshore plain (coastal belt) and sand sheets. Abdel Rahman, *et al.* (1987) concluded that the soils of the study area are the most promising soil for agricultural expansion beyond the Nile Valley. Soils are distinguished into orders Entisols and Aridisols. The soils are mainly Torripsamments, Torriorthents and Calci/Paleorthids (FAO, 1970). Hegazi and El Bagouri (2002) mentioned that soil types and properties are highly influenced by geomorphic and pedogenic factors. The depressions that are close to the shore is salt affected generally. Soil in the beaches – that is affected by salt – is unsuitable for cultivation; opposite to the soils in the wadies and highways, (Abdel Rady, 2011). Abou Yuossef *et al.* (2005) estimated soil erosion risk by using CORINE model and erosion risk index in the Northern Coast of Egypt. Kotb (2013) mentioned that water erosion is recognized by different degrees of severity; some of them occur in the north coastal shore areas due to the relatively heavy short rain shower. The eroded materials are loaded away to low areas. The objective of this study is to present classification of landform elements and examines the relationship between these landform elements and selected soil characteristics

Materials and Methods

Study area is located in the north western coast of Egypt between Marsa Matruh and Salloum cities which is lied between Latitudes 31º 15' to 31º 44' N and Longitudes 25º 18' to 26º 20' E, with an area about 2853 km2.This study is based on the multi concept of remote sensing, thematic maps and land surveying data. Thus, materials related to these data sources are used as the following details: Landsat ETM+ images acquired during the year 2012 were employed in this study (i.e. ETM+ path 180 row 038 and ETM+ path 181 row 038). Digital elevation model (DEM) of the study area was extracted from the Shuttle Radar Topography Mission (SRTM). DEM could be used in conjunction with controlled imagery sources to provide better visualization of the terrain. The Landsat ETM+ image and SRTM data are processed in ENVI 4.7 software to identify the

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different landforms and establish the soil database of the studied areas using the methodology described by Zink and Valenzuala (1990) and Dobos *et al.*, (2002

The thematic maps used in this study includes the soils and geology, these maps were collected from different sources and converted to digital form by using Arc-GIS 9.2 software. Digital soil map of the study area was extracted and modified after the Soil Map of Egypt (ASRT, 1982). The geological map of Egypt at scale 1:1000000 after CONOCO (1989) was used for extracting the geology of the study area. Fourteen soil profiles and fifty two observation points were collected to ensure the different preliminary information, Fig.(1). About 46 representative soil samples from different depth were collected for laboratorial analyses. The representative soil samples were chemically and physically analyzed according to USDA (2004) as soil texture class; calcium carbonate content; oganic matter; electric conductivity (EC); soil reaction (pH); and cation exchange capacity(CEC).Using profile description and laboratory analyses data, the soils were classified to the great group level on the basis of soil taxonomy (USDA, 2010).

Arc GIS 9.2 software was used in data analysis, the first step in analysis began with locating the field observation sites on the thematic layers with their attributes. Using the 3D module of Arc-GIS 9.2 the interpolation of the spatial distribution of the land use classes was performed. Spatial analyst of Arc GIS was used to classify the soil parameter ranges on the map and deduct the relation between the soil conditions and the land features. Also, the 3D analyst was used for generating digital Elevation Model (DEM) from the contour lines and spot heights the DEM creation depends on the nearest neighboring function. Statistical parameters and presentations were used to find out the relation between ground truth and image classification. Landsat satellite images dated 2012 were used in this study to obtain an up-to-date landuse and landcover map. The satellite images were geometrically corrected to the UTM grid system (Zone: 36 N, datum: WGS84).

Results and Discussion

The landforms of the investigated areas were identified by using the Digital Elevation Model (DEM) satellite images and land surveying data of both Sidi Barrani and Darnah areas. The obtained data illustrated that the studied area is divided into two main landscapes units as plateau and coastal plain that includes several landform units as the following: The coastal plain in the investigated areas includes the landform units such as coastal sand sheets, dry valleys, depressions, sabkhas and playas. The coastal sand sheets are large and deep sheets of wind-blown sand and silt that were found very close to the Mediterranean coast, presented with profile no. (1). Soils are or have been subject to the influence of brackish or salt sea water. The obtained data show its soluble salts content is ranges from 15 to 50 dS/m and it is slightly alkaline to alkaline. Total calcium carbonate is ranged from 25 to 30%. Soil present coastal sand sheets are classified to the great group level on the basis of soil taxonomy (USDA, 2010) as *Typic Torriorthents* .Sabkhas are supratidal, forming along arid coastlines and are characterized by evaporite-carbonate deposits with some siliciclastics. Sabkhas form sub-aerial, pro-grad and shallow-upward sequences that have an average thickness of a meter or less. It was found near to the coastal line. It is dominates large areas especially near to El Salloum city. Dry valleys may be developed on many kinds of permeable rocks, such as limestone and chalk, or sandy terrains that do not regularly sustain surface water flow. Such valleys do not hold surface water because it sinks into the permeable bedrock. Several dry valleys were found as their direction from south to north. These valleys in general are small and shallow in depth. Depression is a landform sunken or depressed below the surrounding area. Depressions may be formed by various mechanisms. In the investigated area the depressions are erosion, sedimentary and tectonic related. Soils of depression are presented with profiles no. (5, 6,9,10,11,12 and 13). The obtained data show its soluble salts content is ranges from 2-20 dS/m and it is slightly alkaline to alkaline. Total calcium carbonate is ranged from 3to 67%. Soils present depressions are classified as *Typic Haplocalcid*. In general the plateau surface ranges from 75 to 250 meter above sea level in the study area. The main landforms in the plateau surface comprise rock outcrops, sand sheets, depression and playas. Sand sheets are flat, gently undulating plots of sand surfaced by grains that may be too large for saltation. They form approximately 40 percent of aeolian depositional surfaces. Sand sheets exist where grain size is too large, or wind velocities too low, for dunes to form. Soils of aeolian and alluvial plains presented with profiles no. (2,3,7 and 8). The obtained data show its soluble salts content is ranges from 3-18 dS/m and it is slightly alkaline to alkaline. Total calcium carbonate is ranged from 5- 27%. Soil present aeolian and alluvial plains are classified as *Typic Torripsamments*. Playa could be identified as a nearly level area at the bottom of an un-drained desert basin, sometimes temporarily covered with water and it is presented with profile no(14) and the obtained data show its soluble salts content is very high (reach 62 dS/m) and it is slightly alkaline. Total calcium carbonate is ranged from 33 to 35% in most profile layers. Soil is classified as *Typic Haplosalids*. Rock outcrop is the part of a rock formation that appears above the surface of the surrounding land. It is presented with profile no. (4). The obtained data show its soluble salts content is up to 15 dS/m and it is slightly alkaline. While total calcium carbonate is reach 31%. Soil present rock outcrop is classified as *Typic Taplocalcids.* Bedrock and superficial deposits may also be exposed at the Earth's surface due to human excavations such as quarrying and building of transport routes.

As a general Table (1) and Figure (1) represents the soils classifications and landforms of Sidi Barrani area.

Table 1: Soil classification and landforms of the investigated area.

Profile No.	Soil classification	Landform unit
1	*Typic Torriorthents*	Depression
2	*Typic Torripsamments*	Aeolian Plain
3	*Typic Torripsamments*	Rock outcrops
4	*Typic Taplocalcids*	Rock outcrops
5	*Typic Haplocalcids*	Hilly
6	*Typic Haplocalcids*	Depression
7	*Typic Torripsamments*	Alluvial plain
8	*Typic Torripsamments*	Alluvial plain
9	*Typic Haplocalcids*	Alluvial plain
10	*Typic Haplocalcids*	Alluvial plain
11	*Typic Haplocalcids*	Alluvial plain
12	*Typic Haplocalcids*	Depression
13	*Typic Haplocalcids*	Depression
14	*Typic Haplosalids*	Alluvial plain

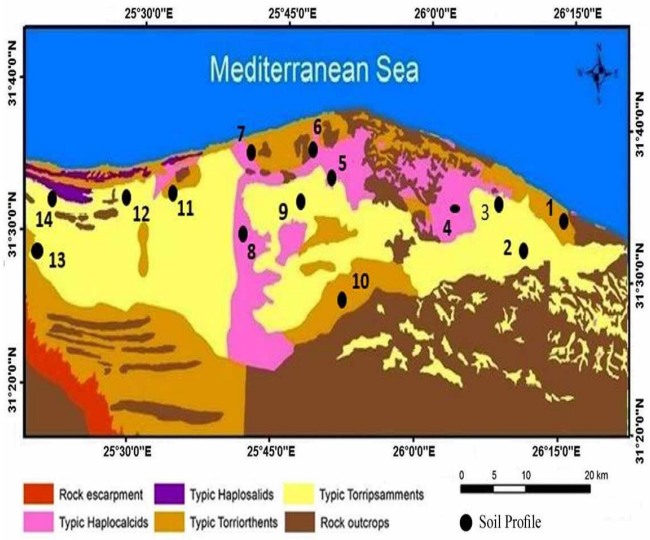

Figure 1: Soil classification of Sidi Barrani area, Egypt.

The area of different soil classification units in the study area is illustrated in Tables (2). The classification units are *Typic Haplocalcids, Typic Haplosalids, Typic Torriorthents,* and *Typic Torripsamments*. These soil units represent 9.03, 0.99, 19.13 and 31.91% of the total area, respectively. The rest of the area includes other features i.e. rock outcrops (36.94%) and rock escarpment (2.00%). It is found that the rock outcrops in Sidi Barrani area are concentrated in the southern parts. Some chemical analyses of the investigated soils in Sidi Barrani are illustrated in Tables (3).

Table 2: Areas of different soil classification units in Sidi Barrani, Egypt.

Soil classification	Area (km^2)	Area (Feddan)*	Area (%)
Typic Haplocalcids	257.7	61840.9	9. 03
Typic Haplosalids	28.4	6809.3	0.99
Typic Torriorthents	545.8	131000.8	19.13
Typic Torripsamments	910.5	218529.	31.91
Rock outcrops	1053.9	252924.586	36.94
Rock escarpment	56.93	13663.6	2.00
Total	2853.2	684768.5	100.0

** feddan = 4200 m^2= 0.42 hectar*

Table (4) and Figures (2) represent the types, and areas of the different soil depth of the studied area. The soil is divided to four classes according to its depth as: very deep soil which represents 30% (864km^2) of the total area. It mainly dominates in the western part of the study area .Deep soil is covers about 44. 9 % (i.e. 1281 km^2) of the study area. This class dominates middle of the study area. Moderately deep soil is more susceptible to desertification than very deep and deep soils. It covers only 1.6 % (45.9 km^2) of the study. It is

mainly located to the middle north part of the study area. Shallow soil covers about 23% (662 km^2) of the study. It is located mainly in southern parts of the study area.

Table 3: Some chemical characteristics of the studied soil samples.

Profile No.	Depth (cm)	pH (1:1 H_2O)	EC(dS/m) 1:1	$CaCO_3$%	OM%	CEC/100g soil
1	0-20	8.2	14.8	30.3	0.39	4.3
	20-40	8.5	49.8	24.9	0.25	3.5
	40-70	8.7	26.3	27.6	0.14	3.7
	70-100	8.5	12.1	26.7	0.14	2.4
	100-130	8.6	2.5	26.7	0.07	2.3
2	0-10	8.2	17.8	21.4	0.29	2.1
	10-40	8.2	12.7	23.1	0.50	1.8
	40-70	8.3	15.0	22.3	0.54	1.7
	70-110	8.3	12.3	24.9	0.21	1.7
3	0-5	8.3	13.0	26.7	0.07	1.6
	5-100	8.1	17.0	16.0	0.04	1.3
4	0-40	8.0	14.8	31.2	0.47	4.4
5	0-10	8.0	11.2	45.4	0.54	1.9
	10-30	8.2	12.0	43.6	0.43	2.3
	30-45	8.1	19.0	55.2	0.43	2.6
6	0-15	8.0	11.8	31.2	0.86	2.3
	15-45	8.1	11.2	16.0	0.72	2.8
	45-110	8.2	8.8	13.4	0.82	3.2
7	0-20	8.0	2.9	9.8	0.68	3.4
	20-60	8.3	8.5	5.3	0.75	2.8
8	0-15	8.1	9.9	5.3	0.79	2.9
	15-55	8.1	12.3	6.2	0.61	1.7
	55-150	8.0	8.0	6.2	0.68	1.4
9	0-10	7.9	19.9	7.1	0.86	2.7
	10-40	7.9	2.8	7.1	0.61	1.9
	40-100	8.0	3.5	8.0	0.43	3.0
10	0-10	7.9	4.3	31.2	0.68	4.6
	10-25	8.0	6.7	64.1	0.54	4.9
	25-40	8.0	7.9	66.8	0.39	9.3
	40-60	7.9	14.7	49.0	0.36	13.3
11	0-10	8.2	11.8	27.6	0.54	4.8
	10-45	8.2	2.3	51.6	0.47	8.3
	45-70	8.3	5.8	44.5	0.39	7.9
	70-100	8.3	10.7	35.6	0.36	8.2
12	0-15	7.6	10.1	7.1	0.90	4.0
	15-50	8.3	4.3	7.1	0.68	2.7
	50-90	8.3	17.8	8.0	0.68	2.3
	90-140	7.9	2.4	8.0	0.68	2.5
13	0-15	8.1	3.4	8.0	0.14	9.8
	15-40	7.9	8.3	18.7	0.11	8.8
	40-90	7.6	15.2	2.8	0.07	4.3
	90-150	8.1	3.0	7.1	0.72	5.6
14	0-10	7.7	33.8	35.6	0.21	8.8
	10-35	7.7	61.6	33.8	0.14	7.9
	35-60	7.7	64.3	32.9	0.32	7.2
	60-120	8.0	40.1	32.9	0.04	6.9

Table 4: Areas of soil depth categories in Sidi Barrani, Egypt.

Soil depth	Area (km^2)	Area (Feddan)*	Area %
Very deep	864.4	207444.3	30.3
Deep	45.9	11009.9	1.6
Moderately deep	1281	307418.4	44. 9
Shallow	662.1	158895.5	23.2
Total	2853.2	684768.1	100.00

** feddan = 4200 m^2= 0.42hectar*

Table (5 and 6) and Figure (3) represent the types, and areas of the soil texture in the investigated area. The soil could be divided into four classes according to its texture as follow: Average soil texture represents only 0.21 % (5.9 km^2) of the Sidi Barrani, Egypt area. It is found in very small patch in the southeast corner of the study area. Fine to average soil texture covers about 67. 8% (1934 km^2) of the studied area. It dominates the northeastern and southwest parts of the study area. Fine soil texture covers only 1.6 % (45.9 km^2) of the studied area. It is located in the middle north part of study area. Coarse soil texture covers 30 % (867 km^2) of the study area. It is mainly located in western parts of the study area.

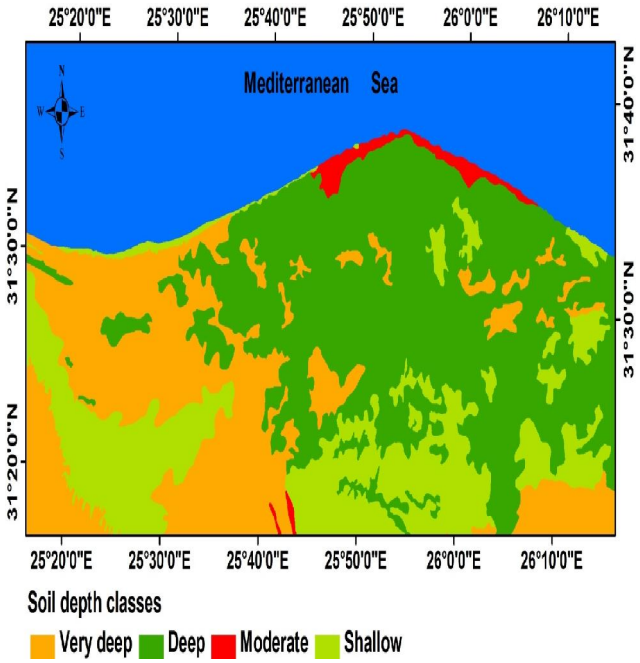

Figure 2: The soil depth of the Sidi Barrani, Egypt area.

Table 5: Areas of different classes of soil texture in Sidi Barrani, Egypt.

Type	Texture class	Area (km^2)	Area (Feddan)*	Area %
Coarse	Sandy	867.4	208179.8	30.4
Fine	Clayey, clay loam	45.9	11009.9	1.6
Fine to average	Loamy clay, clayey sand, candy clay	1934	464166.9	67.8
Average	Loamy sand, sandy loam	5.9	1411.4	0.2
Total		2853.20	684768	100.0

** feddan = 4200 m^2= 0.42 hectar*

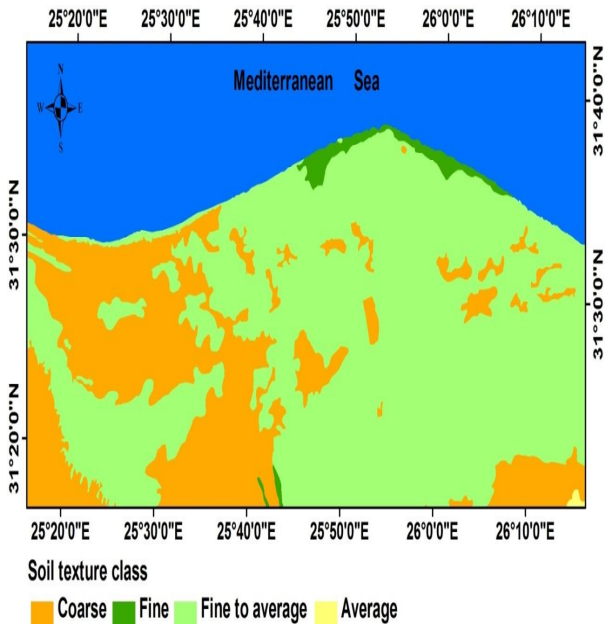

Fig. 3: Texture classes of Sidi Barrani, Egypt area.

Table 6: Texture class of the studied soil samples.

Profile No	Depth (cm)	Sand %	Silt %	Clay %	Texture class
1	0-20	70.9	19.9	9.2	SL
	20-40	71.4	20.9	7.6	SL
	40-70	73.5	20.0	6.5	SL
	70-100	68.2	13.4	18.3	SL
	100-130	60.5	17.0	22.5	SCL
2	0-10	81.2	7.9	10.9	LS
	10-40	76.8	4.3	18.9	SL
	40-70	71.3	18.6	10.2	SL
	70-110	60.2	9.0	30.8	SCL
3	0-5	95.1	2.9	2.0	S
	5-100	72.0	6.8	27.2	SCL
4	0-40	60.1	8.2	31.8	SCL
5	0-10	76.5	6.3	17.3	SL
	10-30	74.9	18.0	7.2	SL
	30-45	78.4	16.6	5.0	LS
6	0-15	72.9	17.2	10.	SL
	15-45	61.2	19.2	19.6	SL
	45-110	52.2	24.8	23.0	SCL
7	0-20	65.7	13.4	20.9	SCL
	20-60	62.2	16.3	21.3	SCL
8	0-15	75.2	18.9	6.0	SL
	15-55	76.5	17.2	6.4	LS
	55-150	63.7	13.2	23.1	SCL
9	0-10	83.9	10.7	5.5	LS
	10-40	76.8	13.7	9.7	SL
	40-100	51.5	24.2	24.3	SCL
10	0-10	69.2	11.0	19.7	SL
	10-25	75.0	13.9	11.1	SL
	25-40	51.6	24.3	24.1	SCL
	40-60	37.7	25.9	36.3	CL
11	0-10	57.5	13.5	29.0	SCL
	10-45	39.2	32.1	28.7	CL
	45-70	38.7	34.2	27.1	CL
	70-100	41.9	33.8	24.3	L
12	0-15	62.5	13.7	23.9	SCL
	15-50	67.8	6.9	25.3	SCL
	50-90	69.1	6.8	24.1	SCL
	90-140	73.0	14.0	13.0	SL
13	0-15	87.8	6.3	5.9	LS
	15-40	30.8	36.9	32.3	CL
	40-90	83.1	9.2	7.7	LS
	90-150	80.5	10.9	8.5	LS
14	0-10	44.8	23.8	31.4	CL
	10-35	48.4	19.8	31.8	SCL
	35-60	53.4	13.4	33.2	SCL
	60-120	52.4	14.7	33.0	SCL

Where S= sand; L= loam; C= clay

Conclusion

Calcium carbonate content mainly accumulated in depressions land by different factors such as water and or wind effects, and decreased gradually by depth in most locations. Plains as a general contain less calcium carbonate and salts in most of the studied sits. 68% of the total of the studied soils texture are fine to average. While hilly land is relatively shallow profiles with sand surface over basement rocks. As a general the results of the study highlight the need to consider land-surface morphology during the development of research designs for soil related studies.

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