PEDOLOGICAL STUDIES ON SOME SOILS WEST OF GREAT BITTER LAKE, ISMAILIA GOVERNORATE- EGYPT.

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ABESTRACT

Sixteen soil profiles were chosen representing the identified physiographic units of the studied area west to The Great Bitter Lake to study its characteristic features, classify its soils and evaluate its ability for cultivation. The studied physiographic units are Old river terraces, Recent river terraces, Wadi bottoms, Soils of fans and outwash plains, Miscellaneous land types (which has two subunits namely faulted ridges and plateaus of sandstone and limestone and End of high land slopes) and Rock land.

The study indicated that the soils have generally almost flat to gently undulating relief except some soils of end of high land slopes and old river terraces, and varied in some surface features like land cover and elevation. Soils are generally deep except end of high land slopes with texture from sand to sandy clay loam mainly have reddish color with dominance of coarse texture and high gravel content in most of studied soil profiles layers, with some rocks in soils of fans and outwash plains and end of high land slopes. All studied soils have low gypsum content and moderate calcium carbonate content with relatively high lime accumulation in some soils of old river terraces and fans makes diagnostic calcic horizon. Values of pH ranges between slightly to mildly alkaline with varied salinity levels from non to highly saline. Soil profiles are classified by using soil taxonomy to a number of families under Orthents as Entisols and Calcids as Aridisols orders.

According to the degree of soil limitations in the studied profiles, the suitability indices for irrigated agriculture were calculated in its present condition and after specified major improvements. The soils of river terraces, fans and outwash plains, and wadi bottoms (about 24994 feddans) are considered as promising soil units for cultivation and the potential land characteristics of these units can be more adapted by chose the suitable land utilization types.

Key words: Ismailia Governorate**,** GIS, Land Evaluation, Soil Classification, Geomorphic Units.

INTRODUCTION

Due to high population increase in Egypt we have lack of all agriculture needs, so both vertical and horizontal agricultural expansions have a great importance in all agriculture studies. We had a great jump in crop productivity so here we focus on studying the ability of horizontal expansion. One of the suggested areas for soil reclamation is southern part of Ismailia Governorate.

Location of study area:

The studied area located at the west of Great Bitter Lake with latitudes 30^{o} $11^{'}$ $00^{"}$ to 30^{o} $28^{'}$ $00^{"}$ N and longitudes 31^{o} $42^{'}$ $00^{"}$ to 32^{o} $18^{'}$ $00^{"}$ E, Map (1) and Fig (1). Total space of studied area is 1450 km^2 (about 345240 feddans).

Geology:

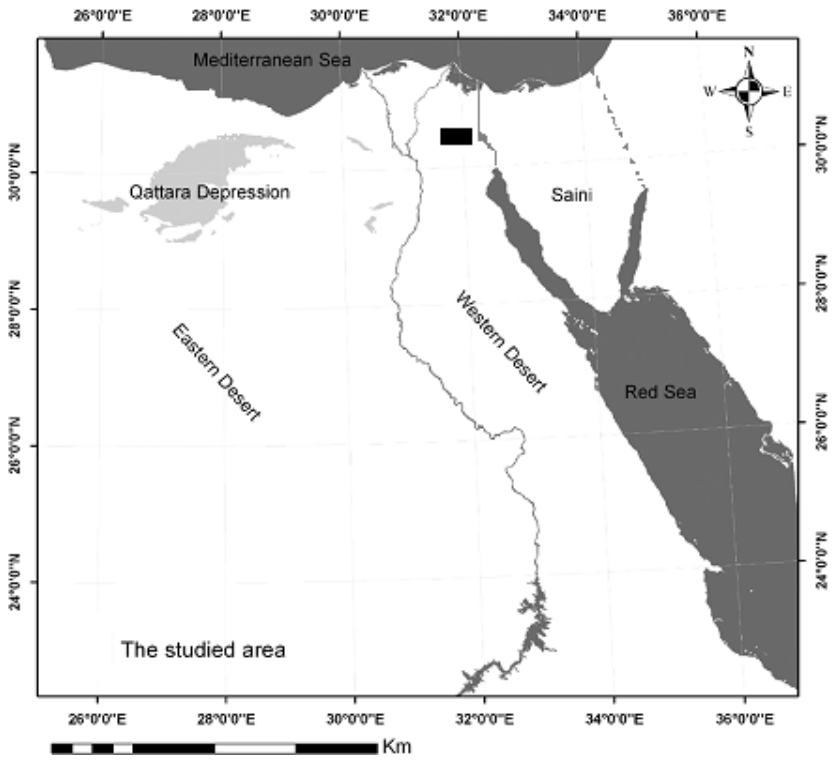
geology of the northern part of Eastern Desert had been studied by many workers such as El-Fayoumy (1968), Said (1962, 2000) and Abo Al-Izz (2000). Using geological Map of Egypt, the studied area is covered by Tertiary and Holocene sedimentary rocks. Holocene sediments formed in recent wadis which found in dry wadis basins. These sediments may be loose to slightly hard and composed mainly from sand and lime sandy loam with some gravel. Tertiary age sediments are divided into the following: a- Miocenes which found mainly east of Nile Delta and composed of limestones and sandy marl formed under shallow marine conditions. b- Oligocenes which found between Cairo and Suiz and composed of sand and gravel with volcanic basalt. C- Pliocenes which found around Suiz Gulf, Red Sea coast and dry wadi mouths and mainly of limestones, sand, gravel and clay with marine and lacustrine origins.

Geomorphology:

Abo Al-Izz (1999) studied the geomorphological units of Egyptian Eastern Desert as hole and divided it into six units: 1- Red Sea Mountains, 2- The Sandstone Plateau, (Al-Abadla) 3- The Eocene plateau (Al-Maaza), 4- The region between sandstone and limestone plateaus, 5- Wadi Qina, 6-Red Sea coastal plain. (DRC, 2005) studied geomorphology of Eastern Desert and mentioned that the main landform of the Eastern Desert wadis are plateaus, rubble terraces, wadi bottom, out wash plains, alluvial fans and sand sheets and dunes. The same geomorphic units were established by Said (1962) and HDSS (1965).

Climate:

The climatic data of Ismailia Governorate show a very low annual precipitations (about 22 mm/y). The main annual temperature is about 22.6^{o}C (16.2^{o} main minimum and 28.9^{o} main maximum temp.). Minimum temperature is recorded in January, while maximum temperature is recorded in August, (CLAC, 2010). According to Soil Survey Staff(2010) the studied area has hyperthermic temperature regime with torric soil moisture regime.



Map (1) Location of the studied area

Water resources:

The main water source for the studies area is Ismailia Canal (Nile water) which has level (+10 m above sea level) lower than the studied area. The second water resource is ground water which has salinity level from non to slightly saline (El-Fayoumy, 1968).

The aim of this investigation is to identify the main physiographic units of the studied area using land forms Map and satellite images with GIS techniques which simplify studying the ability to have sustainable agriculture in the study area by evaluate land resources for irrigated agriculture.

MATERIAL AND METHODS

Remote sensing work:

1-Spatial data used in the study:

Satellite data (ETM) of Path 176 Row 39 and acquisition date 2012 as shown in Fig. (1).

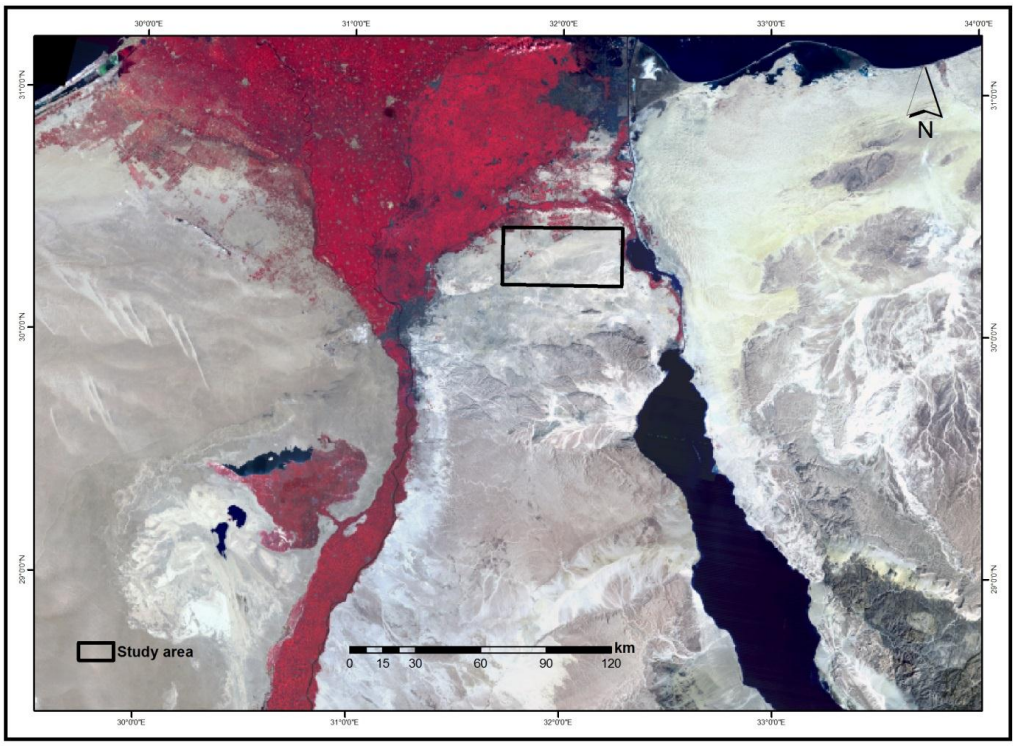


Fig (1) Satellite image of the studied area

2-GIS operations:

- On screen digitizing: screen digitizing was carried out to create vector layers (spots height, contour lines) extracted from the topographic Maps.
- Contour lines: contour and the spot height were analyzed in Arc GIS software. The TIN structure was produced and the profile graph as well as digital elevation model (DEM). The Digital Elevation Model (DEM) is created and analyzed to generate the degree of slope classes (Peterson et al, 1996).On the light of the DEM, TIN Maps and previous studies of (Zink and Valenzula, 1990), visual interpretation was carried out to delineate the physiographic Mapping units of the study area using the concepts of HDSS (1965).

Field work:

Sixteen soil profiles were chosen to represent the identified physiographic units were chosen. Soil profiles were dug to 150 cm unless hindered by bedrock

and morphologically described in the field according to FAO (2010). Soil samples were air dried, crushed, sieved and used for physical and chemical analysis. Soil color is defined according to the Munsel Color (2009).
Longitudes and latitudes of the studied profiles as well as their elevations were defined in the field using GPS.

Laboratory analysis:

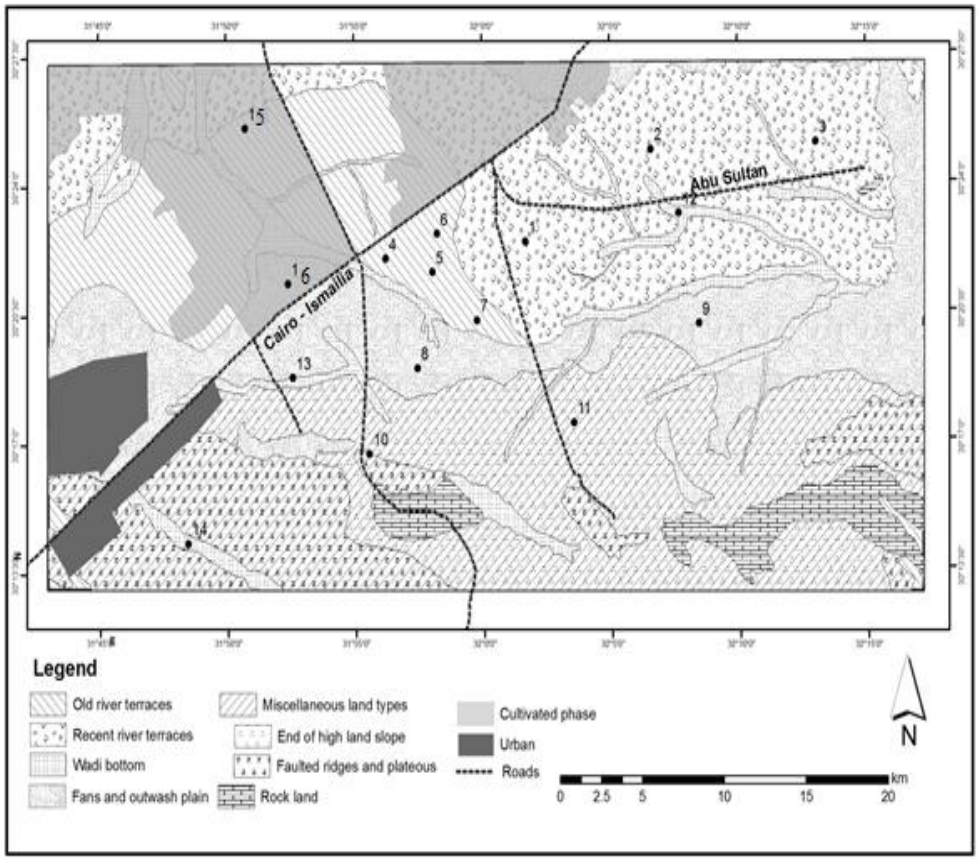
Chemical composition of the studied soil samples was determined according to (Soil Survey Staff, 2004).
Particle fractionation was carried out using pipette method for fine fraction, namely, Kohn method (Arnold, 1986).

Soil PH was determined in the soil paste, electrical conductivity and soluble ions in soil paste extract according to Soil Survey Staff (1993). Calcium carbonate and gypsum contents were determined according Page et al (1982).
Soil classification: according to the morphological and chemical properties, the soils under study were classified into taxonomic units according to soil taxonomy system (Soil Survey Staff, 1999) and using the keys of soil taxonomy (Soil Survey Staff, 2010).
The Land suitability evaluation was achieved according the system of Sys and Verheye (1978). The main soil parameters used in this system are climate, soil depth, texture, gravel percent, CaCO3 percent, gypsum content, Salinity (EC), alkalinity (ESP), slope pattern and drainage conditions.

RESULTS AND DISCUSSION

Using digital elevation model (DEM) with satellite images and HDSS (1965) Maps six physiographic units were identified (physiographic units of the studied area and location of studied profiles are listed in Map, 2). These units are Old river terraces, Recent river terraces, Wadi bottoms, Soils of fans and outwash plains, Miscellaneous land types (which has two subunits namely faulted ridges and plateaus of sandstone and limestone and End of high land slopes), and Rockland.

Areas of each physiographic unit are listed in Table (1). Morphological description of the studied profiles is listed in Table (2). All units have representative profiles except rock land and faulted ridges and sandstone and limestone plateaus which cannot be agriculture soils. The delineated physiographic units (Map, 2) are described as follows:



Map, 2 physiographic units and location of studied profiles

Soils of old river terraces:

The soils of river terraces pertaining to materials or processes associated with transportation or deposition by running water, and represent a step-like surface, bordering a valley floor that represents the former position of the alluvial plain. The old terraces has a total area about 322 km^2 (76570 feddans) which composes about 22.2 % of the studied area (Table, 1).

This unit is represented by profiles, 4, 5, 6 and 7and the cultivated area of this unit is presented by profile, 15. Description of soil profile, physical, chemical properties and location of unit under consideration are listed in Tables, 2 and 3 and Map, 2. Soils of this unit are found in the north-eastern portion of the studied area. Morpholo**g**ical description of the studied unit soils shows that soils are gently undulating to undulating relief with an elevation between 100 to 120 m a.s.l. and surface covered mainly by dark gravel. Soil color ranges from very pale

brown to strong brown in dry state and from yellowish brown to strong brown in moist state, soils have coarse texture range from sand to sandy loam with high gravel content from 28 to 56 % and clay content from4.18 to 9.2%. Lime content from 2.6 to 33.1% partly as secondary lime and gypsum content is few. Soils are non-saline to highly saline EC values range from 1.3 to 22.0 (dS/m). Soils are slightly alkaline pH ranges from 7.6 to 8.3.According to Soil Taxonomy (2010) Table (4), soils of previous unit are classified to the family level as**:**

Typic Torriorthents, Sandy-skeletal, mixed, hyperthermic(profiles, 5 and 7)

Typic Haplocalcids, Sandy-skeletal, mixed, hyperthermic (profiles, 4 and 6)

Soils of old river terraces (cultivated phase) is presented by profile, 15 which is almost flat and has salinity levels (from 2.98 to 5.72 (dS/m)). According to Soil Taxonomy (2010) soils is classified as

Typic Haplocalcids, fine loamy, mixed, hyperthermic

Soils of recent river terraces:

This unit is the largest unit in the studied area. It covers area about 387 km^2 (92294 feddans) composes 26.7% of the studied area and covers the central part of the study area. This unit is presented by three soil profiles no, 1, 2 and 3.

Table (1) areas of studied physiographic units

Physiographic unit		Sum_area_km2	Sum_area_feddan
1	Old river terraces	322	76570
2	Recent river terraces	387	92294
3	Wadi bottom	69	16471
4	Fans and outwash plains	272	64659
5	Miscellaneous land types	347	82586
6	Rock land	53	12657
sum		1450	345240

Table (2)

Con table (2)

Table (3

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Table (4) Classification of the studied soils (USDA, 2010)

Prof. No.	Order	Suborder	Great group	Sub great group	Family
Old river terraces					
4,6	Aridisols	Calcids	Haplocalcids	Typic	Sandy skeletal, mixed, hyperthermic
5,7	Entisols	Orthents	Torriorthents	Typic	Sandy skeletal, mixed, hyperthermic
Old river terraces (Cultivated phase)					
15	Aridisols	Calcids	Haplocalcids	Typic	Fine loamy , mixed , hyperthermic
Recent river terraces					
3	Entisols	Orthents	Torriorthents	Typic	Sandy , mixed , hyperthermic
1	Aridisols	Calcids	Haplocalcids	Typic	Coarse loamy, mixed , hyperthermic
2	Entisols	Orthents	Torriorthents	Typic	Sandy skeletal , mixed , hyperthermic
Wadi bottom					
12	Entisols	Orthents	Torriorthents	Typic	Sandy , mixed , hyperthermic
13,14	Entisols	Orthents	Torriorthents	Typic	Sandy skeletal, mixed , hyperthermic
Soils of fans and outwash plains					
8	Entisols	Orthents	Torriorthents	Typic	loamy skeletal, mixed , hyperthermic
9	Aridisols	Calcids	Haplocalcids	Typic	loamy skeletal, mixed , hyperthermic
Soils of fans and outwash plains (cultivated phase)					
16	Aridisols	Calcids	Haplocalcids	Typic	Fine loamy , mixed , hyperthermic
Ends of slops highly dissected soils					
10	Aridisols	Calcids	Haplocalcids	Lithic	loamy skeletal, mixed, hyperthermic
11	Aridisols	Calcids	Haplocalcids	Lithic	Sandy skeletal, mixed, hyperthermic

The recent terraces soils have gently undulating to almost flat topography with elevation less than the old ones and the surface locally covered by sheets of wind-blown sand. Soil color of this unit varied from yellow to strong brown in dry state and from yellowish brown to strong brown in moist state. Soil pH values from 7.9 to 8.3. Soils are non- saline to slightly saline EC values from 2.0 to dS/m. Soils have texture classes varied from sand to sandy loam with gravel content from 2 to 57% and clay content range from 5.63 to 19.11%. All studies soils are structureless. Lime content from 5.0 to 22.0 %, partly as secondary accumulations with very few gypsum content. According to Soil Taxonomy (2010) soils of this unit are classified as follow:

Typic Haplocalcids, coarse loamy, mixed, hyperthermic profile, 1.
Typic Torriorthents loamy skeletal, mixed, hyperthermic, profile, 2.
Typic Torriorthents Sandy, mixed, hyperthermic, profile, 3.

Wadi bottoms:

This unit is extended from East and from West and North West to the middle of the studied area. Total area of this unit is 174 km^2 (16471 feddans) composes 4.8 % of the studied area. This unit is presented by three soil profiles, 12, 13and 14.

It occupies a long relatively narrow area. The surface is locally covered with sand hummocks. Soils of this unit are almost flat, soil color varied widely from very pale brown to light reddish brown in dry state and from yellowish brown to pale red in moist state. Soils have sand to loamy sand texture with gravel content varied widely from 17 to 57% and clay content 5.01 to 15.13%. Soil reaction is slightly alkaline to alkaline pH values from7.6 to 8.3. Lime content ranges from 2.7 to 8.8% with very few gypsum content. Soils of this unit haven't any diagnostic horizons.

According to Soil Taxonomy (2010), soils of this unit are classified as follow**:**

Typic Torriorthents Sandy, mixed, hyperthermic, profile, 12.
Typic Torriorthents Sandy skeletal, mixed, hyperthermic, profiles, 13 and 14.

Soils of fans and outwash plains

This unit considers a body of alluvium, with or without debris flow deposits, whose surface forms a segment of cone that radiates downslope from the point where the stream emerges from a narrow valley onto a less sloping surface. It consists a broad, gently-inclined, piedmont slop formed by lateral coalescence of series of alluvial fans. These soils are found in the middle portions of study area at the transition between the high land and the river terraces soils with an elevation ranges between 120 to 130m. a.s.l.. The total area is 272 km^2 (64659

feddans) composes about 18.8% of the study area. This unit is presented by two soil profiles, 8 and 9.

Morphological examination of the studied soils show that soils are almost flat, and the surface covered with angular gravel and some stones, soil color varied from very pale brown to reddish yellow in dry state and from brownish yellow to brown in moist state. Soils have wide range of texture classes from loamy sand to sandy clay loam with high gravel and stones content from 27 to 55% and clay content from 6.80 to 30.12. Soil reaction is slightly alkaline pH values from7.5 to 8.1.

Soils EC values varied from 3.0 to 12.8 dS/m. Lime content from 3.1 to 27.9 % partly as secondary accumulations with very few gypsum content.
According to Soil Taxonomy (2010), soils of this unit are classified as follow:

Typic Torriorthents, loamy-skeletal, mixed, hyperthermic, (profile, 8).
Typic Haplocalcids, loamy-skeletal, mixed, hyperthermic, (profile, 9).
Soils of fans and outwash plains (cultivated phase) presented by profile, 16 which has nearly the same soil characteristics of uncultivated parts of the unit with dark soil color so it classified as
Typic Haplocalcids, coarse loamy, mixed, hyperthermic Ends of high land slops

This unit is found in the southern portions of study area and occupies a part of the Miscellaneous land types. The total area is about 173 km2 (41165 feddans) composes about 11.9 % of the study area. This unit is presented by two soil profiles, 10 and 11.

The surface is mainly in undulating relief with elevation of more than 130m., moderately dissected and stony surface. These soils are characterized by shallow soil profile depth with coarse texture and very high gravel content so it has very low ability for cultivation. Soils of this unit are classified as follow
Lithic Haplocalcids, loamy-skeletal, mixed, hyperthermic (profile, 10).
Lithic Haplocalcids, sandy-skeletal, mixed, hyperthermic (profile, 11).

LAND suitability evaluation

Under the structure of the framework for Land Evaluation (FAO, 1976), the rating system suggested by Sys and verheye (1978) was used to identify the suitability classification of the studied area. The rating values of this system refer to the limitation factors, i.e, texture (s1), soil depth (s2), calcium carbonate content (s3), gypsum status (s4), salinity & alkalinity (n), topography (t), and wetness (w).accordingly, the degree of soil limitation were identified for each soil profile (table, 5). The obtained results indicated that all soils, except the end of high land slop soils have no limitation for both wetness and soil depth factors, the availability of foothold for roots as land quality seems to be favorable. Also, all

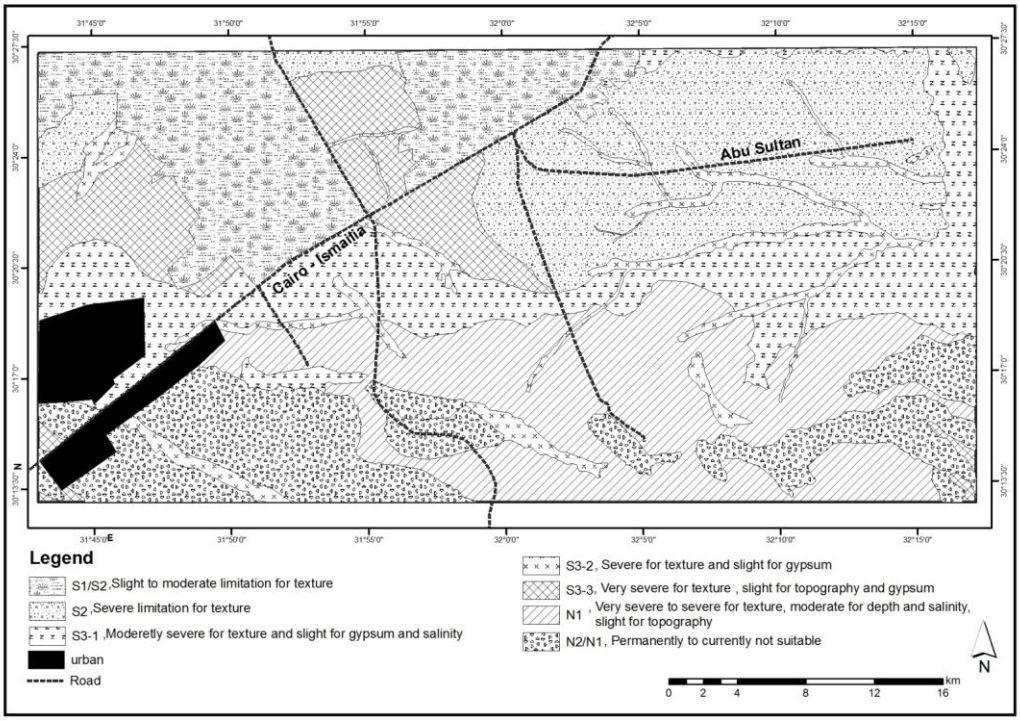
soils have no to light intensity of limitations for topography, calcium carbonate, gypsum and salinity contents. The most effective factor in all profiles is soil texture including gravel which ranged from moderately severe to very severe intensity of limitations. Soil texture has a direct influence on the permeability and available water content and can therefore be considered as a good indicator for water holding capacity of the profile.

According to the degree of soil limitations, the capability index (Ci) for each profile is calculated and then the suitability classes can be distinguished (Table, 5). The (Ci) is measured form the previous formula:

$$Ci = t \times \frac{w}{100} \times \frac{51}{100} \times \frac{52}{100} \times \frac{53}{100} \times \frac{54}{100} \times \frac{n}{100}$$

With an exception of the cultivated land phase, the current Ci values ranged from 9.3 to 59.9 that indicated currently suitability classes varied from currently not suitable (N1) to moderately suitable (S2). The currently suitability refers to its present condition without major land improvements and under surface irrigation system. The soil profiles represent the recent river terraces indicate the relatively high Ci values that ranged from 46.6 to 59.9 with a mean value of 51.3 (moderately suitable , S2), followed by fans and out wash plains soils with a main value of 48.5 (marginally suitable, S3). The lowest Ci values (9.3 to 20.9) were obtained in the end of high land slope soils that indicated currently not suitable (N1). The soil profiles of both wadi bottom and old river terraces units seem to be more heterogeneous and have Ci values range from 22.4 to 55.6 with a mean value of 39.4 (S3) and 31.7 (S3), respectively. The obtained currently suitability categories are represented in the form of land suitability Map with explanatory legend in summary form (Map, 3).

Table5



Map, 3 Land suitability classes of the studied area

Data in Table, 5 indicate also the potential suitability of the studied soil profiles. It refers to suitability of units after specified major improvements have been completed were necessary (FAO, 1976). The required land improvements to correct the severity of limitations exiting in the studied area are as rectification of undulating topography, leaching the excess of soluble salts, application of drip and sprinkler irrigation systems, as well as application of chemical and organic fertilizers. The modifications were made by using the criteria suggested by Sys (1980).

Accordingly, the relatively high Ci values were obtained in the most promising soil units (total area about 249994 feddans) that ranged from 32.5to 70. The mean Ci values of the recent river terraces, fans and outwash plains, wadi bottoms and old river terraces were 60.8, 55, 48.5 and 46.6, respectively. The soil profiles representing the cultivated phase as examples of some of these soils indicated Ci values ranged from 70 to 85 with mean value of 77.5 (highly suitable, S1). Therefore, it could be concluded that the potential land characteristics of the promising units can be more adapted by chose the suitable land utilization types. The choosing of the suitable crops, holders of high capital-intensity and large-scale land tenures will be highly recommended for the proper agriculture land use.

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دراسات بيدولوجية لبعض الاراضي غرب البحيرة المرة الكبرى- محافظة الإسماعيلية- مصر

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معهد بحوث الاراضي والمياه والبيئة- مركز البحوث الزراعية

تم اختيار سته عشر قطاع ارضي يمثل الوحدات الفيزيوجغرافية المختلفة التي تم التعرف عليها في منطقة الدراسة (حوالي ٣٥٤٢٤٠ فدان) الواقعة غرب البحيرة المرة الكبرى محافظة الإسماعيلية لدراسة الصفات المميزة لها وتصنيف تربتها وتقييم صلاحيتها للزراعة. وقد اشتملت الوحدات الفيزيوجرافية علي أراضي الشرفات النهرية القديمة، أراضي الشرفات النهرية الحديثة، أراضي المروحيات والسهول المتكونة من جرف السيول، أراضي قيعان الوديان، الاراضي المختلفة الانواع والتي تقسم الي تحت وحدتين أراضي نهايات المنحدرات المرتفعة و الاراضي المرتفعة ذات الطبيعة الصخرية.

وقد بينت الدراسة ان تلك الاراضي ذات طبوغرافية شبه مستوية الي خفيفة التموج باستثناء اراضي نهايات المنحدرات المرتفعة وبعض اراضي الشرفات النهرية القديمة، كما اظهرت تباين في بعض المظاهر السطحية مثل المنسوب وغطاء سطح الارض.

وبينت الصفات المميزة لتلك الوحدات ان قطاع التربة عميق- باستثناء نهايات المنحدرات المرتفعة- وذات قوام يختلف من الرملي الي التمي الرملي مع لون يميل غالبا الي الاحمرار مع سيادة نسبيه للقوام الخشن وارتفاع نسبة الحصي في معظم طبقات القطاع الارضي مع ظهور بعض الاحجار في اراضي المروحيات ونهاية المنحدرات المرتفعة.

وجميع اراضي المنطقة ذات نسب منخفضة من الجبس بينما اظهرت نسب متوسطة غالبا من كربونات الكالسيوم مه وجود تراكم بنسبة مرتفعة نسبيا في بعض اراضي الشرفات النهرية القديمة واراضي المروحيات ظهرت علي هيئة افاق جيرية تشخيصية .

وتراوحت قيم تفاعل التربة (pH) غالبا بين التأثير القلوي الخفيف الي المتوسط مع تباين مستويات الملوحة من غير الملحية الي المرتفعة في بعض طبقات القطاع الارضي. وصنفت قطاعات التربة تبعا للنظام الامريكي الي عائلات متباينة تابعه لتحت رتبة Orthents كأراضي حديثة التكوين وتحت رتبة Calsids التي تطورت تحت ظروف الجفاف.

وتم تقييم صالحية تلك الاراضي للزراعة المروية بعد تحديد درجة محددات التربة ومدي تأثيرها علي درجة الصالحية سواء في حالتها الراهنة او بعد عمليات التحسين الرئيسية الواجب اجرائها، واسفرت عن وجود مساحات واعده (٢٤٩٩٩٤فدان) يمكن استخدامها زراعيا بنجاح باتباع الاساليب المناسبة.