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SOIL MAPPING AND LAND EVALUATION OF THE AREA AROUND LAKE IDKO, EGYPT BY MEANS OF REMOTE SENSING AND GIS

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ABSTRACT: *The studied area is located between longitudes 29° 58′ 33".72 to 30° 25′ 38".04 East and latitudes 31° 06′ 04".74 to 31° 21′ 50".83 North and covers about 147,307 fed.*

A physiographic analysis using visual interpretation on Misrsat satellite image was carried out to delineate the different physiographic units of the studied area. The image have false color composite of bands 3,2,1 with scale 1:50000. Physiographic units were accurate defined by the Digital Elevation Model of the area around Lake Idko. Thirty eight soil profiles and fourty minipits were examined to represent the soils of the studied area. The physiographic units were incorporated with soil taxonomic units of sub great group level and field data to represent digital physiographic soil map of the studied area.

The soils of studied area are slightly to very highly saline (EC values range from 1.0 to 17.7 dS/m). Soil texture is sandy to sandy clay. pH values range from 7.1 to 8.1. The soils are classified as Typic Torrifluvents, Vertic Torrifluvents, Typic Torripsamments, Typic Torriorthents, Typic Endoaquents and Oxyaquic Torripsamments.

According to current land capability, studied soils are moderately suitable (S_2) and marginally suitable for agriculture (S_3). The soils of class S_2 form 35.06% of the studied area (~ 51644 fed.). It includes two subclass S_2 x, and S_2xn in which the texture and salinity are the limiting factors, respectively. The soils of class S_3 cover an area of about 73279 fed. (49.74 %) and it contains four subclasses namely S_3xn (with texture and salinity as limiting factors), S_3xd (with texture and water table as limiting factors), S_3tx (with topography and texture as limiting factors) and S_3txn (with topography, texture and salinity as limiting factors). Potential capability reveals that the soils of class S_3 could be improved to class S_2.

Four crops were selected to assess their convenience for cultivation in the studied area: wheat, barley, sugar beet and citrus. Sugar beet is the most suitable crop in the studied area followed by wheat, barley and citrus.

Key words: *Remote sensing, GIS, soil mapping, land evaluation, Lake Idko*

INTRODUCTION

The area around Lake Idko is suffering from some problems for agricultural development. Land suitability is essential for the studied area in order to provide the planners with the necessary information they needed. However, sometimes the survey data are difficult to be understood by them. When, the variables are translated into productivity terms, they become more relevant and supporting. Land capability systems are the tools to convert the figures and specialized expression of soil characteristics into meaningful language for decision makers and non specialized users.

Sadek (1993) used Landsat Multispectral Scanners (MSS) and Thematic Mapper data for the potential of agricultural expansion of the west Nile Delta. He found that the land suitability classification of west Nile Delta using FAO (1976) are marginally suitable land (S_3). These soils include part of Wadi El-Natrun, Wadi El-Ralat, and Wadi El-Fargh terrace have limitations due to texture, moisture deficiencies, low fertility and physical soil deficiencies.

The combination of remote sensing data with geographic information system (GIS) has been used in several fields such as land management, monitoring soil salinity with very good results (Cisse et al., 1984; De Vries, 1985; Abdel-Hamid, 1990 and Abdel-Hamid et al., 1992).

The main objective of this study is to define the optimum land use and to evaluate the potentiality of the soils of the studied area. Land evaluation was performed using adapted system to fit the conditions of the area under investigation. Four crops were selected to assess their convenience for cultivation in the studied area. Suitability maps for soil and selected crops are included.

MATERIALS AND METHODS

The area under investigation is located between longitudes 29° 58′ 33".72 to 30° 25′ 38".04 East and latitudes 31° 06′ 04".74 to 31° 21′ 50".83 North and covers about 147,307 fed. including the area of Lake Idko (Fig. 1). Misrsat data acquired on July the 25th 2010 and topographic maps of the area (scale 1:50,000) have been used for the visual interpretation (Zinck, 1988) and Digital Elevation Model (DEM) (Stein, 1998). The interpretation was done on a false color composite of bands 3, 2 and 1 with scale 1:50,000. A physiographic map was produced using the DEM classes, then the result were intersected with the geological units.

Thirty eight soil profiles and fourty minipits were collected (Fig. 2) and subjected for the following analyses: Particle size distribution according to Piper (1950), calcium carbonate was determined volumetrically using Collin's Calcimeter according to Black (1982). Total soluble salts were determined in the soil paste extract by means of Electrical Conductivity (ECe), soluble cations and anions, and soil pH (using pH meter) according to Jackson (1976).

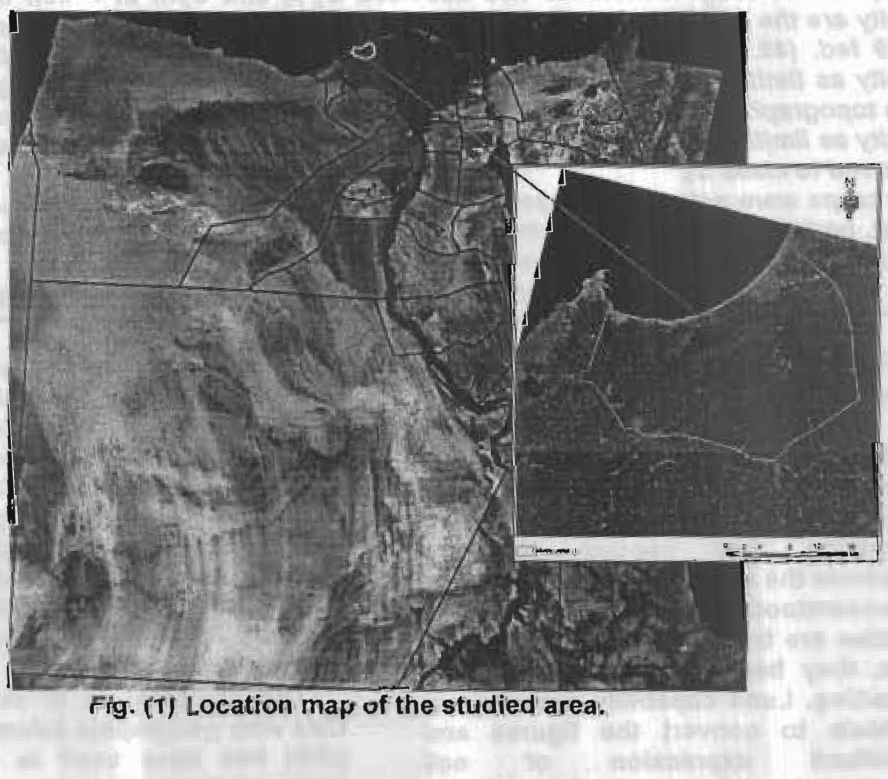

Fig. (1) Location map of the studied area.

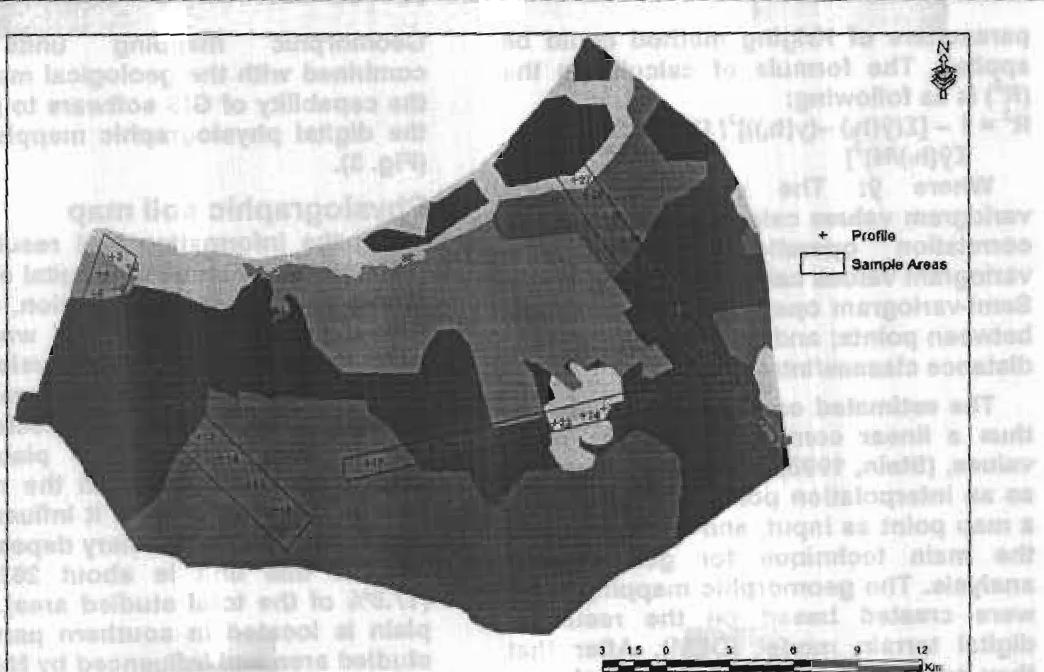

Fig. (2) Location of the studied soil profiles.

The results obtained from the visual interpretation, digital elevation model and information from field data was incorporated using the capability of GIS software in order to produce soil map of the studied area.

Land suitability techniques were done using the rating tables suggested by Sys and Verheye (1978); FAO (1976 and 1983), Sys (1985) and Sys *et al.* (1991) according to the equation:

$$Ci = \frac{t}{100} \times \frac{w}{100} \times \frac{x}{100} \times \frac{d}{100} \times \frac{k}{100} \times \frac{n}{100} \times 100$$

Where:

Ci = Capability index (%)

t = Slope

w = Drainage conditions

x = Texture

d = Soil depth

k = $CaCO_3$ content

n = Salinity and alkalinity

Four crops were selected to assess their convenience for cultivation in the studied area. The selected crops are: wheat, barley, sugar beet and citrus. Soil characteristics of the different mapping units were compared and matched with the requirements of each crop. The matching led to the current and potential suitability for each land use using the parametric approach and land index mentioned by Sys et *al.* (1993).

RESULTS AND DISCUSSION

Visual interpretation

Visual interpretation was done on false colour composite of bands 3, 2,1 scale 1:50,000 to produce a base map for the field work activities and other purposes related to the present study.

The visual analysis was based on the physiographic analysis methods according to Zinck (1988).

Digital Elevation Model (DEM)

The DEM was created using the geostatistical analysis. Geostatistical analysis was carried out at a two step procedure:

(a) The calculation of the experimental semi-variogram and fitting a model.

(b) Interpolation through ordinary Kriging, which uses the semi-variogram parameters (Stein, 1998). From the semi-variogram operation, it could be possible to define which models fit the experimental semi-variogram values. By calculating the Goodness of fit (R^2), and choice of most fitted model, the model parameters of Kriging method could be applied. The formula of calculating the (R^2) is as following:

$$R^2 = 1 - [\Sigma(\hat{y}(h_i) - (y(h_i))]^2 / [\Sigma(\hat{y}(h_i) - \Sigma\hat{y}(h_i)/N)^2]$$

Where $\hat{y}$: The experimental semi-variogram values calculated by the spatial correlation operation; y: the semi-variogram values calculated by the column Semi-variogram operation; h: the distance between points; and N: the total number of distance classes/intervals.

The estimated or predicted values are thus a linear combination of the input values, (Stein, 1998). Kriging can be seen as an interpolation point, which requires a map point as input, and it was used as the main technique for geostatistical analysis. The geomorphic mapping units were created based on the result of digital terrain model (DEM). After that they combined with the geological map to create the physiographic mapping units (Zinck, 1988).

The DEM value map was used to delineate the boundaries of the geomorphic mapping units. The Geomorphic mapping units were combined with the geological map using the capability of GIS software to produce the digital physiographic mapping units (Fig. 3).

Physiographic soil map

All the information and results from the different procedures, digital elevation model and visual interpretation, coupled with the results of the field work were used to produce the final physiographic soil map of the studied area. Two landscape units were delineated, (i.e. Coastal plain and Flood plain). The coastal plain is located in the northern part of the studied area. It influenced by undifferentiated quaternary deposits. The area of this unit is about 26228 fed. (17.8% of the total studied area). Flood plain is located in southern part of the studied area and influenced by Nile silt. It represents an area of about 98695 fed. (67.0 % of the total studied area). The area of lake is about 22384 fed. (15.2 % of the total studied area) (Table 1 and Fig. 3).

Table (1): The legend of physiographic mapping units.

Landscape	Relief	Lithology	Landform	Symbol	Area		Soil classification
					fed.	%	
Coastal Plain	Sand Beach	Undifferentiated Quaternary Deposits	Beach	CP111	9795	6.65	Typic Torrifluvents Typic Torripsamments
	Bar		Bar	CP211	7706	5.23	Typic Endoaquents
	Lagoon		Shore	CP311	1185	0.80	Typic Torrifluvents Typic Endoaquents
	Pyramid Sand Dune		Pyramid Sand Dune	CP411	7542	5.12	Oxyaquic Torripsamments
Flood Plain	Flat Area	Nile Silt	Relatively Very Low Terraces	FP111	50986	34.61	Typic Torrifluvents
			Relatively Low Terraces	FP112	43938	29.83	Vertic Torrifluvents
	Dune		Dune	FP211	3771	2.56	Typic Torriorthents
Lake					22384	15.20	___

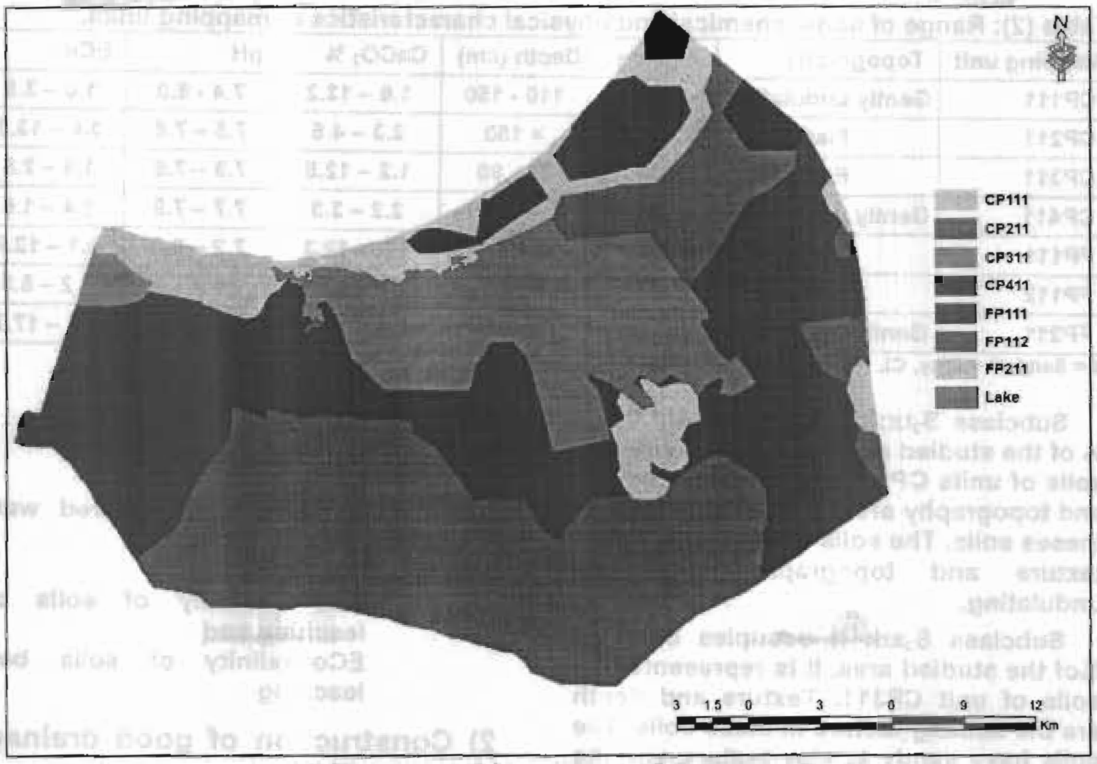

Fig. (3) Physiographic soil map of the studied area.

The studied soils are classified according to USDA (2006) as Typic Torrifluvents, Vertic Torrifluvents, Typic Torripsamments, Typic Torriorthents, Typic Endoaquents and Oxyaquic Torripsamments (Table 1). Some physical and chemical properties of the mapping units are shown in Table (2).

Current land capability

The studied area could be classified into two capability classes and six sub classes reflect the kind of their limitations (Fig. 4a).

Current class S_2

This class includes the soils which are moderately suitable. Two subclass S_2x and S_2xn were found in this class. The subclass S_2x includes the moderately suitable soils which occupies an area of ~ 43938 fed. (29.83% of the total area). The soils of this subclass are affected by moderate limitations. Texture is the limiting factor for these soils which it is ranging from clay loam to clay (Table 2). It includes one mapping unit i.e. FP112. The soils of other subclass S_2xn are affected by moderate limitations of texture and salinity. Their texture is ranging from clay loam to clay and ECe varies between 3.6 and 13.0 dS/m. This subclass includes one mapping unit (CP211) with area about 5.23% of the total area.

Current class S_3

This class includes the soils which are marginally suitable. The soils have moderate limitations. It forms about 49.74 % of the studied area (73279 fed.). Four subclasses were recognized in this class as follows:

Subclass S_3xn: It covers 50986 fed. (34.61 % of the studied area). It includes the soils of FP111. Texture and salinity are the limiting factors for these soils. Texture is sandy Loam to clay and EC values vary between 1.1 to 12.9 dS/m (Table 2).

Table (2): Range of some chemical and physical characteristics of mapping units.

Mapping unit	Topography	Texture	Depth (cm)	$CaCO_3$ %	pH	ECe
CP111	Gently undulating	S - C	110 - 150	1.6 – 12.2	7.4 - 8.0	1.0 – 3.5
CP211	Flat	CL – C	> 150	2.3 – 4.5	7.5 – 7.8	3.6 – 13.0
CP311	Flat	S - C	75 - 90	1.2 – 12.5	7.3 – 7.6	1.6 – 2.8
CP411	Gently undulating	S	> 150	2.2 – 3.3	7.7 – 7.9	1.4 – 1.6
FP111	Flat	SL - C	> 150	1.2 – 12.3	7.2 – 8.4	4.1 – 12.9
FP112	Flat	CL - C	> 150	2.2 – 13.9	7.1 – 8.1	1.2 – 6.5
FP211	Gently undulating	SL - C	>110	5.4 – 10.2	7.2 – 7.5	4.5 – 17.7

S = Sand, C = Clay, CL = Clay Loam, and SL = Sandy Loam

Subclass S_3tx: It occupies only 11.77 % of the studied area. It is represented by soils of units CP111 and CP411. Texture and topography are the limiting factors in theses soils. The soils have sandy to clay texture and topography is gently undulating.

Subclass S_3xd: It occupies only 0.8 %of the studied area. It is represented by soils of unit CP311. Texture and depth are the limiting factors in these soils. The soils have sandy to clay texture and the soils are affected by moderate water table depth (75-90 cm).

Subclass S_3txn: It covers ~ 2.56 % of total studied area (3771 fed.). It includes one mapping unit FP211. Slope, texture and salinity are the limiting factors for the soils of this subclass. The soils have gently undulating surface with slope ranges from 3 to 4 %. The soil texture ranges from sandy loam to clay. These soils are moderately to very highly saline (EC values range from 4.5 to 17.7 dS/m).

Potential land capability

Potential capability refers to the capability of units for a defined use after necessary specified major improvements (FAO, 1976).

In the study area the major improvements needed to overcome the current (present) limitations are:

1) Leaching of salinity (up to EC < 4 dS/m).

The leaching requirements (LR) to maintain soil salinity at a minimum level (< 4 dS/m) are calculating using the equation proposed by Hoffman (1980).

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

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 < 2%).

In addition to recommended irrigation systems in coarse texture areas (drip and sprinkler), that save water and prevent rise of ground water table.

By applying these improvements, the potential capability class of the studied area could be developed to S_2 (Fig.4b).

Potential subclass S_2x: It covers an area of about 124932 fed. (about 84.8 % of the studied area). It includes the six subclasses in current land capability: S_2x (29.83%), S_2xn (5.23%), S_3 xn (34.61 %), S_3 tx (11.77 %), S_3 xd (0.8%) and S_3txn (2.56%).

These current subclasses could be improved by leaching salinity in S_2xn, S_3 xn and S_3txn, by leveling the slightly gently undulating in S_3txn and S_3 tx and by reducing water table level in S_3 xd. Texture is still the limiting factor for these soils.

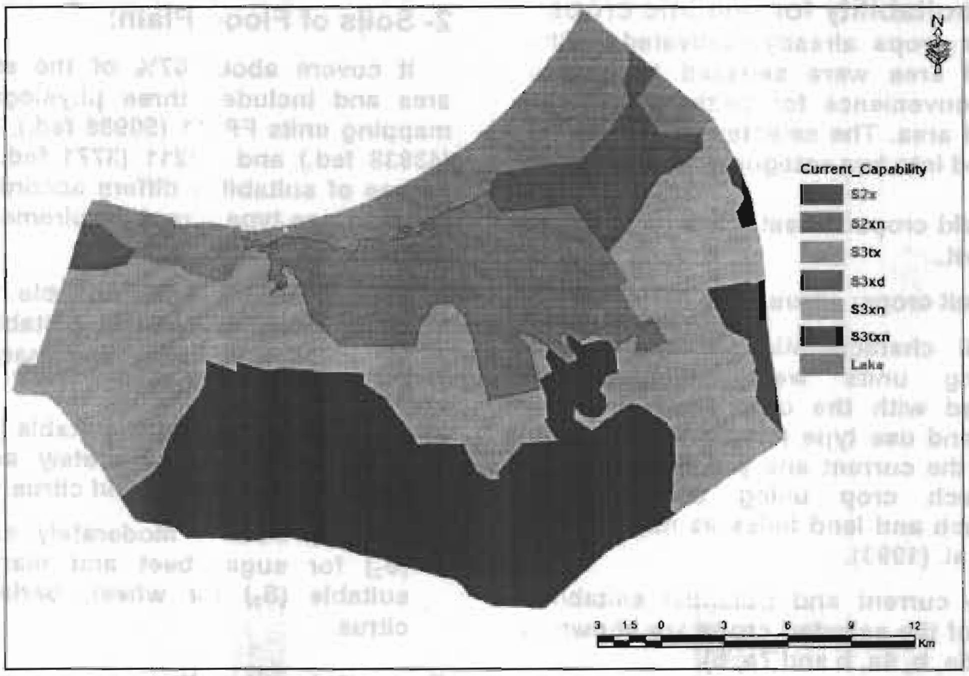

Fig. (4a) Current land capability map of the studied area.

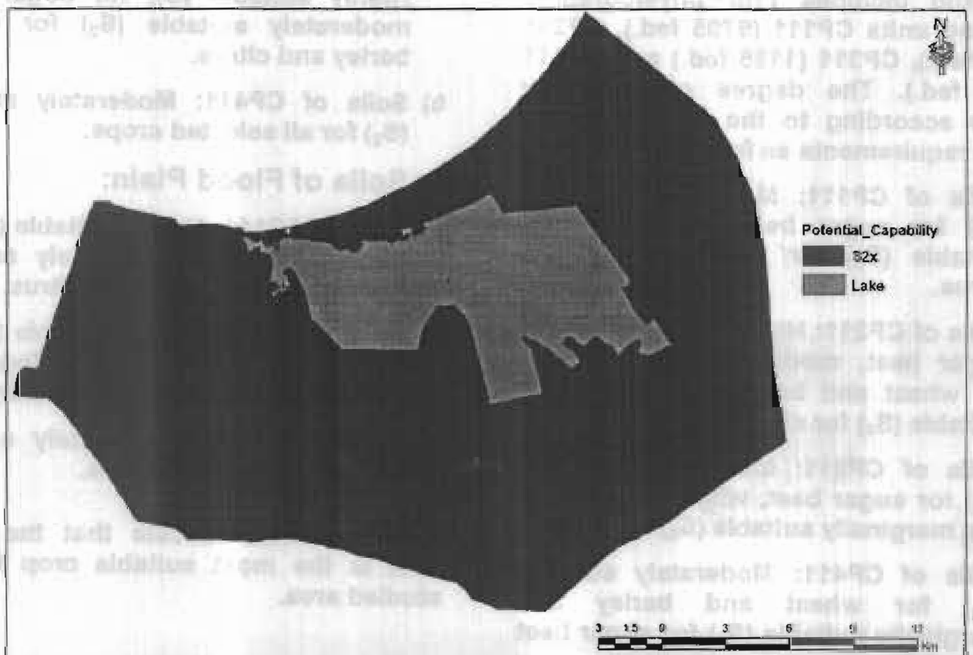

Fig. (4b) Potential land capability map of the studied area.

Land suitability for specific crops:

Four crops already cultivated in the studied area were selected to assess their convenience for cultivation in the studied area. The selected crops can be grouped into two categories as follows:

1. Field crops: wheat, barley and sugar beet.
2. Fruit crops: citrus.

Soil characteristics of the different mapping units were compared and matched with the crop requirements of each land use type (crops). The matching led to the current and potential suitability for each crop using the parametric approach and land index as mentioned by Sys et al. (1993).

The current and potential suitability maps of the selected crops are shown in Figs. (5a, b, 6a, b and 7a, b).

Current suitability:

1- Soils of Coastal Plain:

It covers about 17.8% of the studied area and includes four physiographic mapping units CP111 (9795 fed.), CP211 (7706 fed.), CP311 (1185 fed.) and CP411 (7542 fed.). The degree of suitability differs according to the land use type (crop) requirements as follows:

a) Soils of CP111: Moderately suitable (S_2) for sugar beet and marginally suitable (S_3) for wheat, barley and citrus.

b) Soils of CP211: Highly suitable (S_1) for sugar beet, moderately suitable (S_2) for wheat and barley and marginally suitable (S_3) for citrus.

c) Soils of CP311: Moderately suitable (S_2) for sugar beet, wheat and barley; and marginally suitable (S_3) for citrus.

d) Soils of CP411: Moderately suitable (S_2) for wheat and barley and marginally suitable (S_3) for sugar beet and citrus.

2- Soils of Flood Plain:

It covers about 67% of the studied area and includes three physiographic mapping units FP111 (50986 fed.), FP112 (43938 fed.) and FP211 (3771 fed.). The degree of suitability differs according to the land use type (crop) requirements as follows:

a) Soils of FP111: Highly suitable (S_1) for sugar beet; moderately suitable (S_2) for wheat and barley and marginally suitable (S_3) for citrus.

b) Soils of FP112: Highly suitable (S_1) for sugar beet and moderately suitable (S_2) for wheat, barley and citrus.

c) Soils of FP211: Moderately suitable (S_2) for sugar beet and marginally suitable (S_3) for wheat, barley and citrus.

Potential suitability:

1- Soils of Coastal Plain:

a) Soils of CP111, CP211 and CP311: Highly suitable (S_1) for sugar beet; moderately suitable (S_2) for wheat, barley and citrus.

b) Soils of CP411: Moderately suitable (S_2) for all selected crops.

2- Soils of Flood Plain:

a) Soils of FP111: Highly suitable (S_1) for sugar beet and moderately suitable (S_2) for wheat, barley and citrus.

b) Soils of FP112: Highly suitable (S_1) for sugar beet and citrus. Moderately suitable (S_2) for wheat and barley.

c) Soils of FP211: Moderately suitable (S_2) for all selected crops.

The results indicate that the sugar beet is the most suitable crop for the studied area.

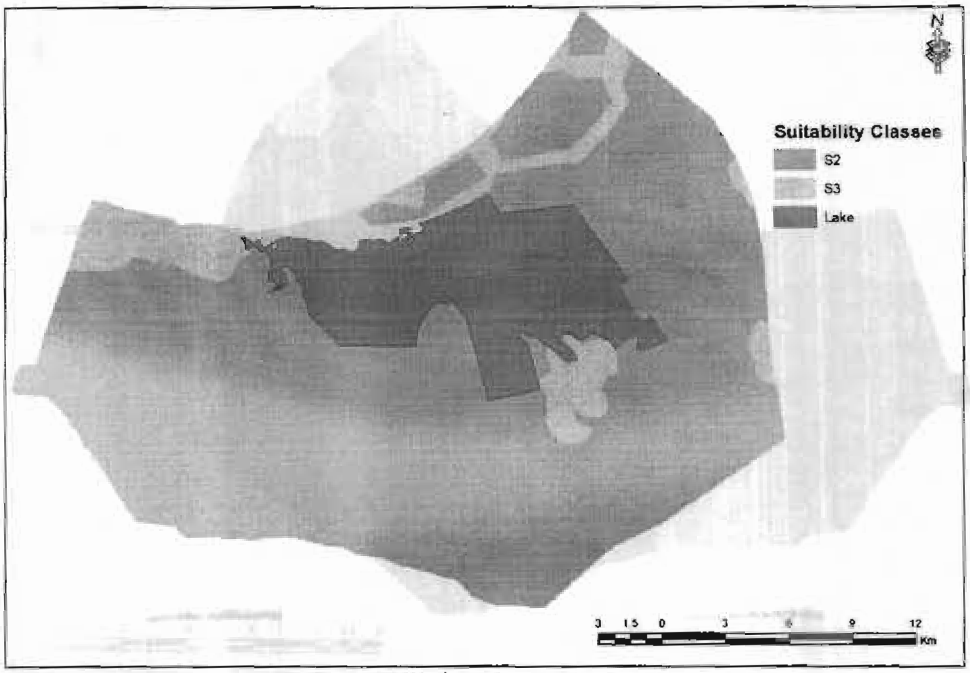

Fig. (5a) Current land suitability map of wheat and barley.

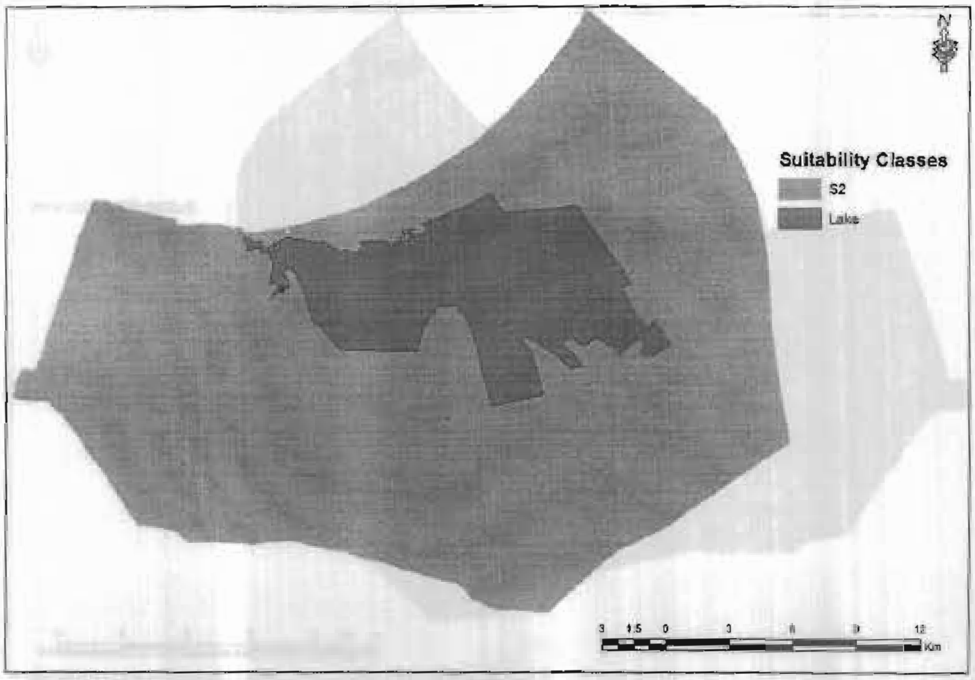

Fig. (5b) Potential land suitability map of wheat and barley.

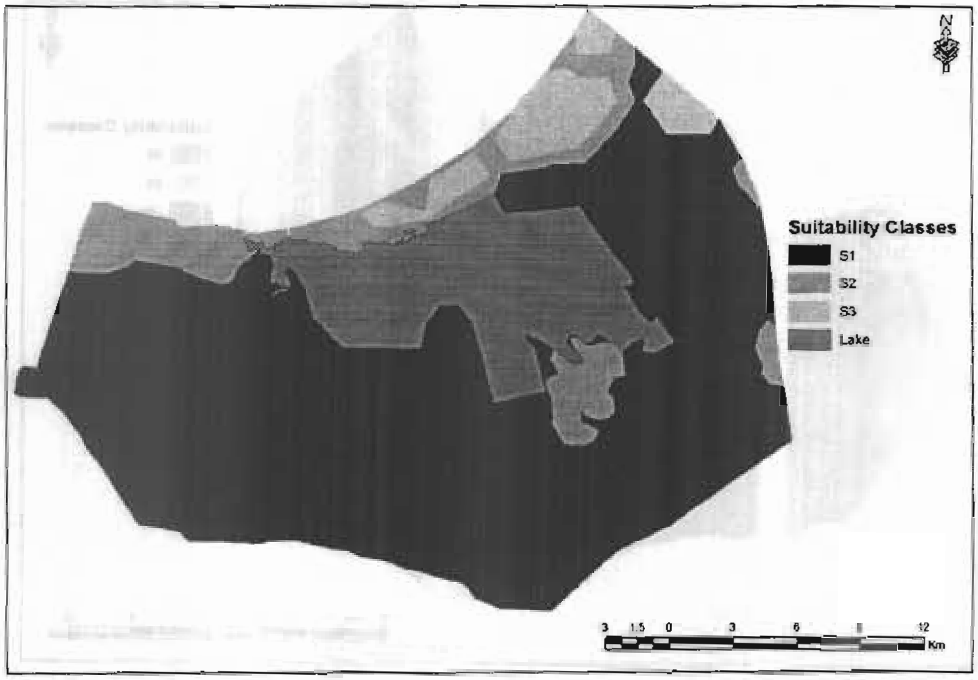

Fig. (6a) Current land suitability map of sugar beet.

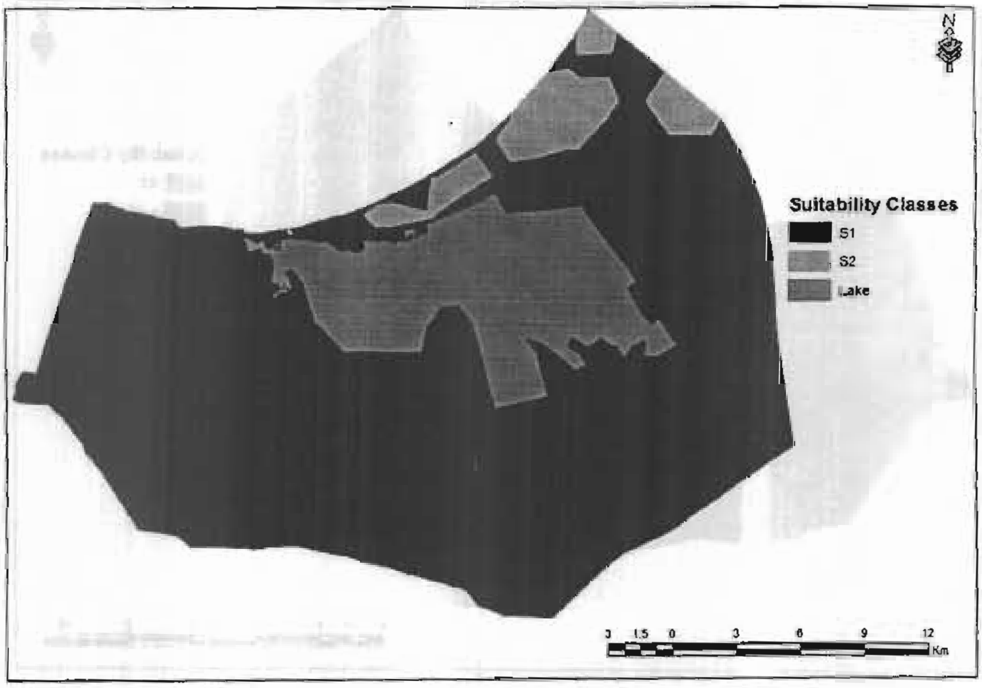

Fig. (6 b) Potential land suitability map of sugar beet.

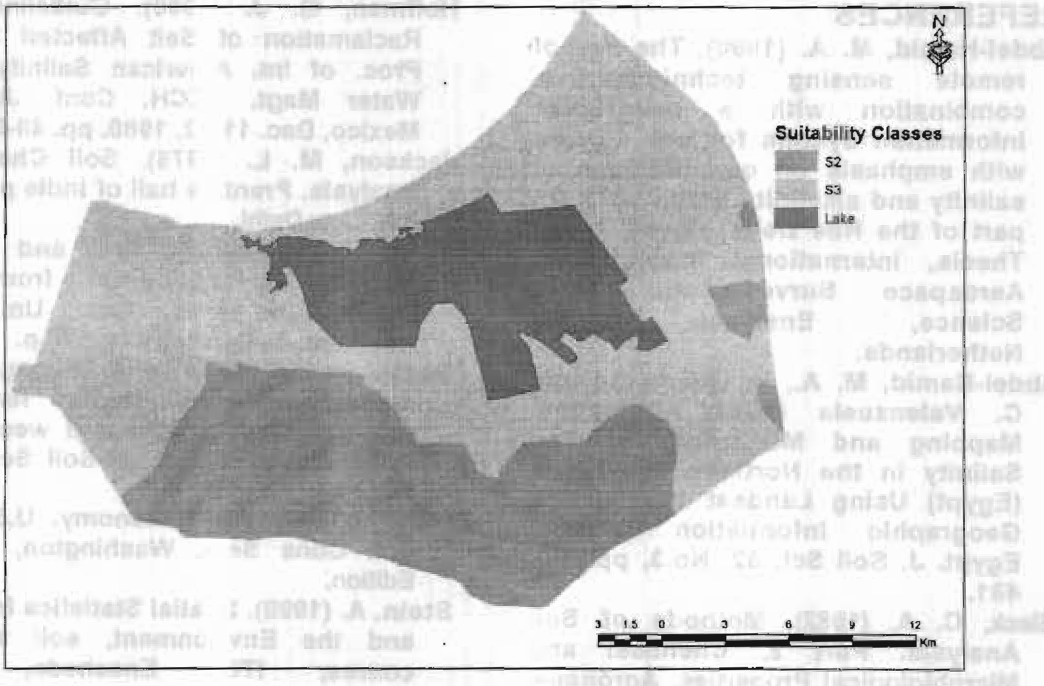

Fig. (7a) Current land suitability map of citrus.

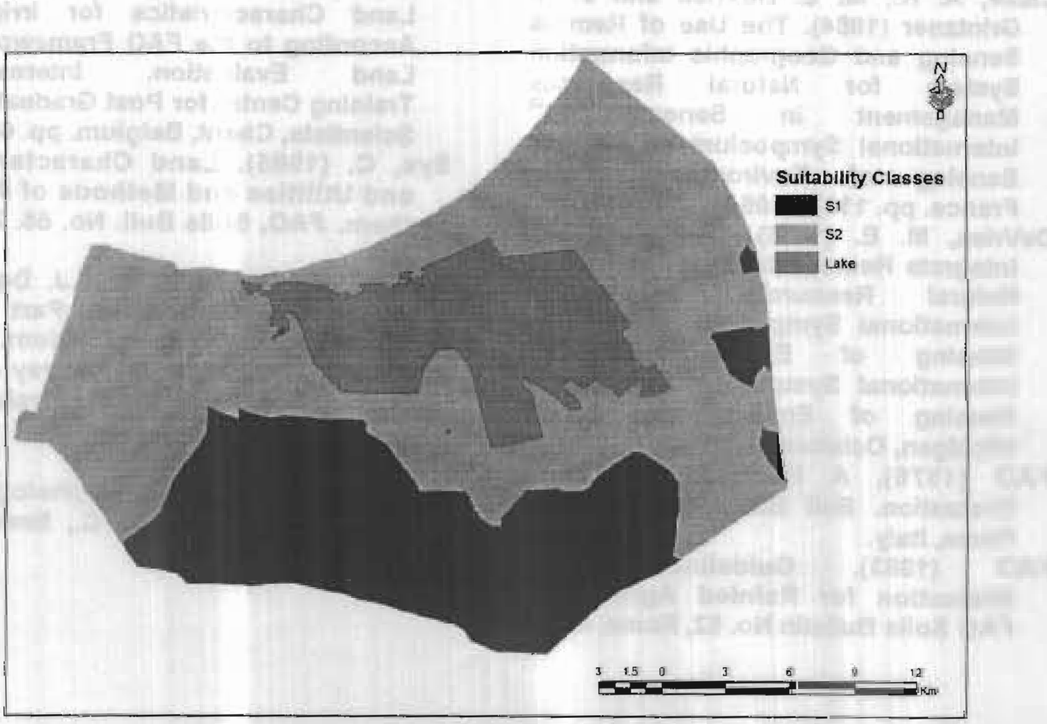

Fig. (7b) Potential land suitability map of citrus.

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استخدام الاستشعار من البعد ونظم المعلومات الجغرافية لعمل خرائط التربة وتقييم الاراضي حول بحيرة ادكو – مصر

محمد اسماعيل – يوسف قطب الغنيمى – محمد محمد حسنى شومان
معهد بحوث الاراضي والمياه والبيئة– الجيزة

الملخص العربي

تهدف هذه الدراسة الى استخدام بيانات القمر الصناعي المصري Misrsat لتحديد الوحدات الخريطية للمنطقة المحيطة ببحيرة ادكو ، والتي تغطي مساحة ١٤٧٣٠٧ ألف فدان.

ولقد تم عمل خريطة التربة لمنطقة الدراسة و تم جمع عدد ثمانية وثلاثون قطاعا أرضيا ممثلا للوحدات الخريطية بالاضافة الى اربعين حفرة صغيرة.

ولقد بينت النتائج أن التربة تختلف في ملوحتها حيث تتروواح درجة التوصيل الكهربي (EC) من ١ – ١٧,٧ديسيسمينز / م ، وتروواحت قيم كربونات الكالسيوم من ١,٢ –١٣,٩ %.

وبتقييم الصلاحية الحالية والمستقبلية للاراضي أوضحت الدراسة أن أراضي المنطقة تقع في أقسام متوسطة الصلاحية (S_2) وحدية الصلاحية (S_3). وتبين النتائج أن حوالي ٣٥،٠٦ % من اجمالي منطقة الدراسة (٥١٦٤٤ فدان) هي أراضي متوسطة الصلاحية (S_2) في ظروف التربة الحالية وأن العوامل المحددة هي قوام التربة وملوحة التربة . أما الاراضي حدية الصلاحية (S_3) فهي تغطي مساحة ٤٩،٧٤ % من اجمالي منطقة الدراسة (٧٣٢٧٩ فدان) وتشمل تحت أقسام: S_3xn حيث يعتبر القوام والملوحة العاملان المحددان ، و S_3tx حيث تشمل العوامل المحددة الميل والقوام ، S_3txn حيث يشكل الميل والقوام والملوحة العوامل المحددة ،S_3xd حيث القوام ومستوى الماء الارضي هما العاملان المحددان في زراعة هذه الاراضي.

وباتباع بعض طرق التحسين يمكن تحسين الاراضي حدية الصلاحية (S_3) لتصبح أراضي متوسطة الصلاحية (S_2).

وقد تم اختيارأربعة محاصيل لتقييم مدى ملائمتها للزراعة في منطقة الدراسة ، وتشمل محاصيل حقلية (القمح – الشعير – بنجر السكر) ومحاصيل فاكهة (الموالح).

ولقد أوضحت النتائج أن بنجر السكر هو افضل المحاصيل لمنطقة الدراسة تحت الظروف الحالية والظروف المستقبلية يليه القمح والشعير ثم الموالح.

الكلمات الداله: الاستشعار من البعد – نظم المعلومات الجغرافية – تقييم الاراضي – عمل الخرائط – بحيرة ادكو – مصر