Integrating GIS, Geostatistical analysis and Modeling to Characterize of Soil Units and Land Evaluation in some Soils East of Idko Lake, Egypt

Fayed, R. I., Y.S. El fiky and I.M. Morsy
Soil Salinity Lab., Alex.; Soil, water and Enviro. Res. Institute; Agric. Res. Center, Egypt.

ADDITIONAL INDEX WORDS: Semivariogram, Idko Lake, Capability, Suitability, Geostatistical analysis

ABSTRACT

The aims of the present study are to characterize the main soil units and evaluate the land capability and suitability in some soils east of Idko Lake, Egypt, using coupling between Geographic Information systems (GIS) and ALES-Arid model. The results of spatial variability and dependence in the surface layer indicate that the best fitting semi-variogram models were the gaussian model for soil salinity and $CaCO_3$ and the spherical model for soluble magnesium (Mg^{++}) and soil depth. In the same time the optimum sampling distance for any further study of EC, Mg^{++}, $CaCO_3$ and soil depth were 195, 400, 308 and 484 m, respectively. Spatial interpolation maps coupling GIS and kriged maps indicate that the soils of the studied area were classified into four main soil mapping units and seven subunits. The main units are: Non saline and shallow soils (40.98%), Non saline and deep soils (52.7%), Saline and shallow soils (2.74%) and Saline and deep soils (3.58% of total area).

The Agriculture Land Evaluation System for arid region (ALES-Arid) program has been used to calculate the index values of land capability and soil suitability, as well as their classes and limitations. Resultes indicated that most of the studied soils belong to class 3 (fair or moderate), while others belong to class 4, which reflect weak or marginal degree of land capability. Also, Wheat, Barley, Rice, Onion, and Alfalfa are the most suitable crops to be grown in the studied soils. However, most of the studied soils are considered conditional suitable to actually unsuitable (S4 to NS2) for fruit trees. The main limiting factors for land capability and crops suitability in the studied soils are soil depth, saturated hydraulic conductivity (Kh) soil salinity (EC) and alkalinity (SAR). Using ARC view / GIS software, incorporate the data obtained from ALES-Arid model were mapped to show the distribution of spatial variability of capability and suitability classes for different crops.

Introduction

The soil as an open system is characterized by vertical and horizontal variations of soil properties. Different tools of analysis may be used to describe soil variability and distribution of soil properties in space. Among of them, semi-variogram is the most important one in geostatistical applications in soil studies. It can quantify the scale and intensity of spatial variability and provides the essential spatial information for local estimation and optimizing sample intensity (Oliver, 1987 and Lark and Beckett, 1998). Some studies were carried out to show the patterns of semi-variogram for different soil properties in some Egyptian soils and to find out the optimum sampling distance of the studied properties (Morsy, 1994; Abdel-Kader and Ramadan, 1995; Bahnassy and Morsy, 1996; Fayed, 1998 and El-Menshawy, 2000). Ramadan (1997) studied the spatial interpolation and simulation of soil salinity and water table in three farms namely saabahia El-Bosily and Nubaria farms. He found that semi-variogram of water table level was spherical, exponential and gaussian models in BF, SF and NF, respectively. Furthermore, semi-variogram of water table salinity was gaussian, spherical and linear models in BF, SF and NF, respectively. The level and salinity of water table had the highest nugget variance (105, 1.77m), (152, 0.51m) and (83.2, 4.2m) in BF, SF and NF, respectively, which indicate their strong spatial dependence and high inherited variability. El-Zahaby et al (1999) studied the spatial distribution of EC, $CaCO_3$% and clay% in southeast Mariut Lake soils. They found that EC, clay% and $CaCO_3$% had a gaussian model while EC transformed had spherical model. The optimum sampling distance for any further study of $CaCO_3$%, clay% and EC dS/m, were 1408, 1293 and 963m, respectively.

Geographic Information System (GIS) is a computer system designed for input, storage, retrieval, analysis, and display of interpreted geographic data (Burrough, 1986). The applications of GIS technology in soil survey indirectly impact land use and natural resource planning. Soil survey is often a layer in GIS applications, which range from land use and natural resource planning at local municipality levels to global resource inventory (Driessen and Konijn 1992). The spatial analysis in GIS using overlay of attributes on a pixel-by-pixel basis ignores interactions. We can imagine a vertical vector of attributes (such as, soil map over topographic map) containing relevant information about the point. The sets of all points or pixels containing the values of a single attribute define an overlay. The value in attribute vector could be a code or a display obtained as the result of an operation, U = f (A, B,.......) on the attributes A, B, ... at the points and U could be the result of overlaying (Burrough, 1987).

Agriculture land Evaluation System for arid region (ALES-Arid) is a new approach for land capability and suitability evaluation. It was designed using MS-VB programming language based on the minimum dataset concept, and its database was constructed using MS-access. The land evaluation parameters used in this model were soil physical, chemical and fertility characteristics; irrigation water quality; and climatic data. Ismail et al. (2004) applied this system, their results showed that soils of the East Wadi El-Natrun area could be classified into two capability classes (C3 Fair and C4 poor). Wheat followed by Olive was the most suitable crops to be grown in the studied area. The dominant limiting land capability and crop suitability factors were soil texture, available water, permeability, cation exchange capacity, and fertility parameters.

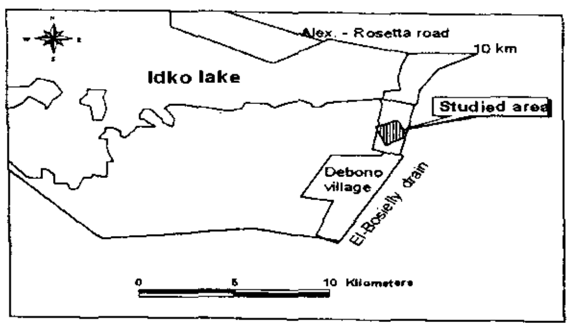
Geographic information System (GIS) and Modeling are advanced technologies and concepts that are widely available for data handling, processing and management. The integration of GIS and Modeling could provide a powerful means for analyzing and synthesizing information about land resources, and to provide land managers with information which will improve the quality of land use decisions (Olsson, 1989).

Bahnassy et al., (2001) coupled GIS with modeling tools (SALTMOD and MicroLEIS models) to support land use planning and management of Sugar Beet area, west Nubaria. They show the spatial-temporal distribution of soil salinity, water table depth and suitability of wheat plantation.

The objectives of the present study are to characterize the main soil units and evaluate the land capability and suitability in some soils east of Idko Lake, Egypt, throughout integrating Geographic Information systems (GIS) and modeling.

Materials and Methods

Study area: The studied area (Idko farm) is located at El-Bosaily in the north-western part of the Nile Delta, Idko district, Behira governorate. It is bounded to the north by Alex.-Rashid road, to the south by Debono village, to the east by El-Bosaily tard drain and to the west by Idko Lake, as shown in map (1).



Map (1): Location of the studied area.

Soil sampling: Thirty six representative soil observation (six profiles and thirty augers) were georeferenced using topographic maps (1:50000) and Geographic Position System (GPS). Soil profiles were morphologically described according to the system of FAO (1990). Samples were collected from profiles according to the morphological variations and from pits for laboratory analysis of the different physical, chemical and nutritional properties according to Page et al (1982).

Statistical analysis: It was carried out using Systat Statistical package (SY-Stat, 1990) to calculate the different classical statistical parameters (minimum, maximum, range, mean, variance, standard deviation, coefficient of variation and median) of the main chemical and physical soil properties (EC, SAR, soil depth, $CaCO_3$%, soluble Magnesium (Mg^{++}), %sand, and %clay).

Geostatistical analysis: The semi-variogram is the most important tool in geostatistical analysis in soil studies. It represents the average rate of change of a property with distance. It describes the pattern of spatial variation in terms of its magnitude, scale and general form (Burgess and Webster, 1980). It could be defined as:

$$\gamma(h) = ½ \text{ var } [Z(x) - Z(x+h)]$$

Where; Z(x) and Z(x+h) are the values of a random function representing the soil property of interest (Z), at places x and x+h separated by the vector h known as the lag or interval, and var is the variance (Warrick et al., 1986).The semi-variogram's parameters for the soil properties that have high range of variation were calculated using the GSPLUS (GS+) geostatistical analysis software, Gamma Design (1991). The model with best fitting which corresponds to the high correlation was selected to express the spatial variability of each tested soil property. The semi-variogram equations were created according to the fitted models (linear, spherical, exponential or gaussian model).

Data Handling and Pre-processing: Topographic maps (scale 1:50000) which represent the studied area were obtained and their geographic coordinates were transformed into Universal Transverse Mercator (UTM) system, then digitized using Arc view-GIS 3.2 (ESRI, 1999). The studied area had been evaluated using ALES-Arid software (Ismail et al., 2004). Spatial interpolation maps (kriged maps) of different soil characteristics were export to Arc view-GIS 3.2, then overlain to produce the soil units map. The resultant soil map units was linked with soil capability and suitability databases to visualize different land capability and crop suitability maps.

RESULTS AND DISCUSSION

Soil Characterization:

Descriptive statistical analysis are shown in Table (1). The data show that the soils of Idko Lake are characterized by a wide range of salinity and alkalinity in surface and subsurface layers. The maximum EC and SAR values are 7.67, 24.2 dS/m and 31.61, 45.16 while the minimum values dropped to an average of 0.53, 0.55 dS/m and 1.13, 1.48 with a median of 1.36, 1.62 dS/m and 4.41, 7.33 in surface and subsurface layers, respectively. Such over-spread salinity and alkalinity values are expressed relatively high coefficient of variation (C.V.) which ranged between 0.81 and 1.35. High variations are also observed in the values of soluble Mg where maximum, minimum and C.V. values are (20.0-29.0), 0.6 and (1.18-1.33) in surface and subsurface layers, respectively. Although, the values of soil depth and clay% have wide range 67 and (25-33.75), the C.V. is relatively very low (0.14-0.16). Data of $CaCO_3$% and sand% reflect intermediate variations where C.V. values are (0.50-0.47) and (0.26-0.37) respectively, as shown in table (1).

Table (1): Descriptive statistical analysis of some soil properties for surface and subsurface horizons

Prope-rties		Min	Max.	Range	Mean	V	S.D	C.V%	Median
EC dS/m	S	0.5	7.8	7.2	1.8	3.0	1.7	1.0	1.4
	Sub	0.6	24.2	23.7	3.1	17.0	4.1	1.4	1.6
SAR	S	1.1	31.6	30.5	6.9	31.6	5.6	0.8	5.4
	Sub	1.5	45.2	43.7	10.2	70.3	8.4	0.8	7.3
Soil depth, cm		63 0	130.0	67.0	93.1	225	15.0	0.2	97.0
$CaCO_3$, %	S	1.5	9.5	8.0	3..4	2.8	1.7	0.5	3.0
	Sub	1.4	9.0	7.6	3.1	2.2	1.5	0.5	3.0
Mg++, meq/l	S	0.6	20.0	19.4	3.0	12.2	3.	1.2	2.0
	Sub	0.6	29.0	28.4	3.8	25.1	5.0	1.3	2.1
Sand, %	S	12.5	35.0	22.5	20.0	27.6	5.3	0.3	18.5
	Sub	9.5	37.5	28.0	17.7	43.6	6.6	0.4	15.6
Clay, %	S	36.3	61.3	25.0	49.9	49.0	7.0	0.1	50.6
	Sub	31.3	65.0	33.8	54.0	62.0	7.9	0.2	55.0

V=variance , S.D=Stander deviation, C.V=Coefficient of variance, S=surface, Sub= subsurface

Geostatistical analysis:

Soil properties that have relatively high coefficient of variation were selected to be analyzed geostatistically. These properties are EC, Mg^{++}, $CaCO_3$%, and soil depth, in the surface horizons, to illustrate the spatial dependence of these soil properties. Fig (1) illustrated the fitted semi-variogram models for these selected soil properties. The fitted semi-variogram models for ordinary kriging are Gaussian for soil salinity and $CaCO_3$% while spherical model for Mg^{++} and soil depth.

The general equation of the gaussian model is:

$$(h)= C_o+C [1 - exp (3h^2/A_o^2)]$$

While the equation of the spherical model is:

$$\gamma(h)= C_o+C [1.5(h/A_o)- 0.5(h/A_o)^3] \quad \text{for } h \leq A_o$$

$$\gamma(h)= C_o+C \quad \text{for } h > A_o$$

Where (h): is the semi-variogram

C_o: is the nugget variance (inherited variability)

C_o+C: is the sill variance (structural variability)

A_o: is the rang (spatial dependence)

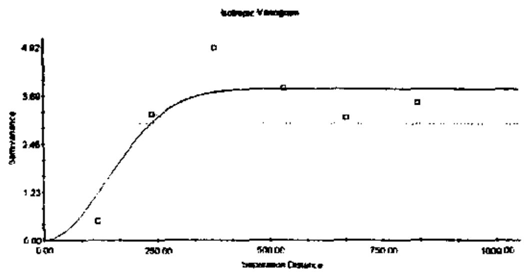
The parameters of these two models for different soil properties are shown in table (2). The highest correlation coefficient (r^2) value of fitted curves was 0.99 for soil depth, while the lowest value was 0.73 for soluble magnesium. The range (A_o) which reflect the spatial dependence over specific lag distance show that the maximum interpolation distance for EC, Mg^{++}, $CaCO_3$ and soil depth were 195, 400, 308 and 484 m, respectively. These distances are the ideal for showing the variability and should be considered in any further study for these properties in the area under consideration. Magnesium has the highest nugget variance (3.87) which reflect strong spatial dependence and high inherited variability, Xu and Webster (1984) and Warrick et al (1986). On the other hand, EC has the lowest one which reflects weak spatial dependence and low inherited variability.

Table (2): Semi-variogram parameters of some soil properties

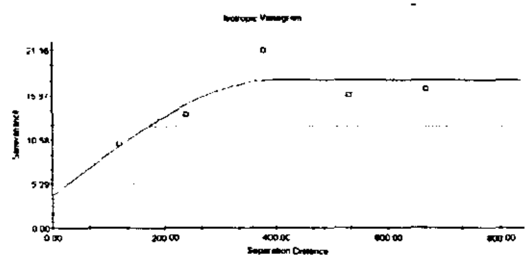
property	Model	C_o	$C_o + C$	A_o, m	r^2
EC	Gaussian	0.01	3.89	195	0.80
Mg^{++}	Spherical	3.87	17.70	400	0.73
$CaCO_3$	Gaussian	1.74	3.47	308	0.93
Depth	Spherical	0.10	27.90	484	0.99

C_o: Nugget variance, C_o+C: Sill variance and A_o: Range distance.

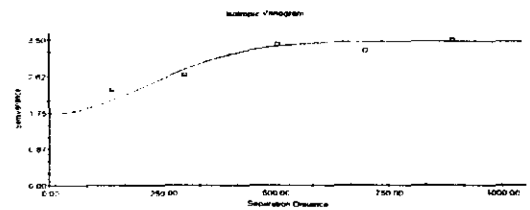
Soil Salinity



Mg^{++}



$CaCO_3$



Soil depth

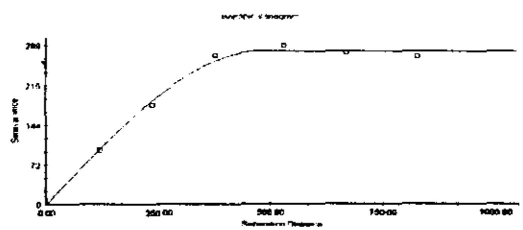
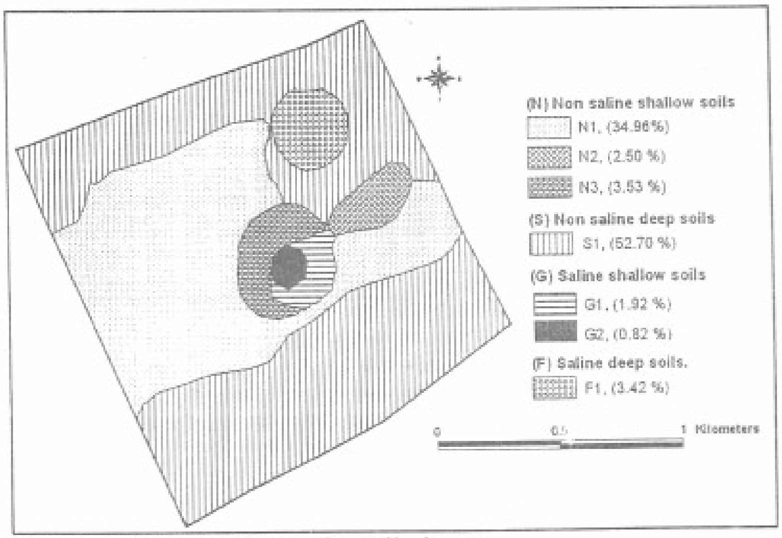


Fig. (1). Fitted semi-variogram models for some soil properties.

Soil Mapping Units:

This study used GIS overly technique to map differentiated soil characteristics. Map (2) illustrates the soil mapping units of the studied area. This map was classified based on EC, Mg^{++}, $CaCO_3$, water table depth (soil depth) and texture to explain soil complexity and variability and to evaluate the land for specific uses. Table (3) showed the properties of the soil mapping units in the studied area. Table (4) showed the water table analysis of each sub mapping units and irrigation water analysis for the studied area. Generally, studied area could be divided into four soil units and seven sub units as flows:-



Map(2). Soil units and sub units of studied area.

1- N, Non salin <4 dS/m and shallow soil depth < 90 cm (40.98% of total area)

1.a- N1, Mg^{++} < 5 meq/l, $CaCO_3$ < 5 % and clay texture.

1.b- N2, Mg^{++} < 5 meq/l, $CaCO_3$ > 5 % and silty clay loam texture.

1.c- N3, Mg^{++} 5-10 meq/l, $CaCO_3$ < 5 % and silty clay texture

2- S, Non saline < 4 and deep soil 90 -120 cm (52.7% of total area).

2.a- S1 , Mg^{++} < 5 meq/l, $CaCO_3$ < 5 % and Clay texture.

3- G, Saline 4-8 dS/m and shallow soil depth <90 cm (2.74%. of total area)

3.a- G1, Mg^{++} 5-10 meq/, $CaCO_3$ > 5 % and clay texture.

3.b- G2, Mg^{+} >10 meq/, $CaCO_3$ > 5 % and clay texture.

4- F, Saline 4-8 and deep soil 90-120 cm occupied about (3.58% of total area).

4.a- F1, Mg^{++} 5 3- 10 meq/, $CaCO_3$ < 5 % and clay texture.

Table (3): Soil unit properties of the studied area

properties	unit / sub unit	N / N1	N2	N3	S / S1	G / G1	G2	F / F1
EC dS/m	Surface	1.19	2.28	3.45	1.21	5.38	7.65	7.76
	Sub s.	1.72	3.95	5.17	1.41	7.98	24.20	7.05
SAR	Surface	6.58	13.28	8.96	5.98	31.61	12.08	12.97
	Sub s.	11.40	9.19	10.70	11.00	12.33	45.17	12.06
Mg^{++} meq/l	Surface	0.80	4.20	6.00	1.20	5.40	20.00	11.60
	Sub s.	1.30	5.00	6.00	1.00	7.40	29.00	11.00
$CaCO_3$, %	Surface	2.00	9.50	4.00	2.50	6.50	6.50	3.00
	Sub s.	2.00	9.00	3.50	2.00	3.20	2.50	2.00
Sand, %	Surface	25.00	17.50	20.00	13.75	20.00	21.25	17.50
	Sub s.	27.50	32.50	30.00	22.50	11.25	20.00	15.00
Clay, %	Surface	42.50	38.75	40.00	58.75	53.75	48.75	47.50
	Sub s.	52.50	47.50	50.00	60.00	61.25	55.00	57.50
Depth, cm		85	85.00	70	106.00	68.00	63.00	105.0
Kh cm/day	Surface	26	31.60	36	24.00	28.11	0.8	13.00
	Sub s.	5	12.11	13.5	2.00	5.70	0.7	9.00
Available N, ppm	Surface	69.50	18.75	15.00	45.00	8.75	52.50	22.50
	Sub s.	62.50	12.50	10.00	25.00	7.50	52.50	15.00
Available P, ppm	Surface	1.17	1.22	2.39	0.98	2.42	1.25	2.65
	Sub s.	1.58			1.10		0.79	
Available K, ppm	Surface	1287	858	1287	975	1482	1287	1287
	Sub s.	1638			1716		1365	
Available water	Surface	22.30	15.79	24.40	25.57	25.98	22.45	21.29
	Sub s.	26.77	21.91	26.07	28.50	26.42	23.95	28.69
Soil texture	Surface	Clay	sil cl l.	Sil.Cl	clay	Clay	Clay	Clay
	Sub s.	Clay	Clay	Clay	clay	Clay	Clay	Clay

Table (4): Water table and irrigation water analysis.

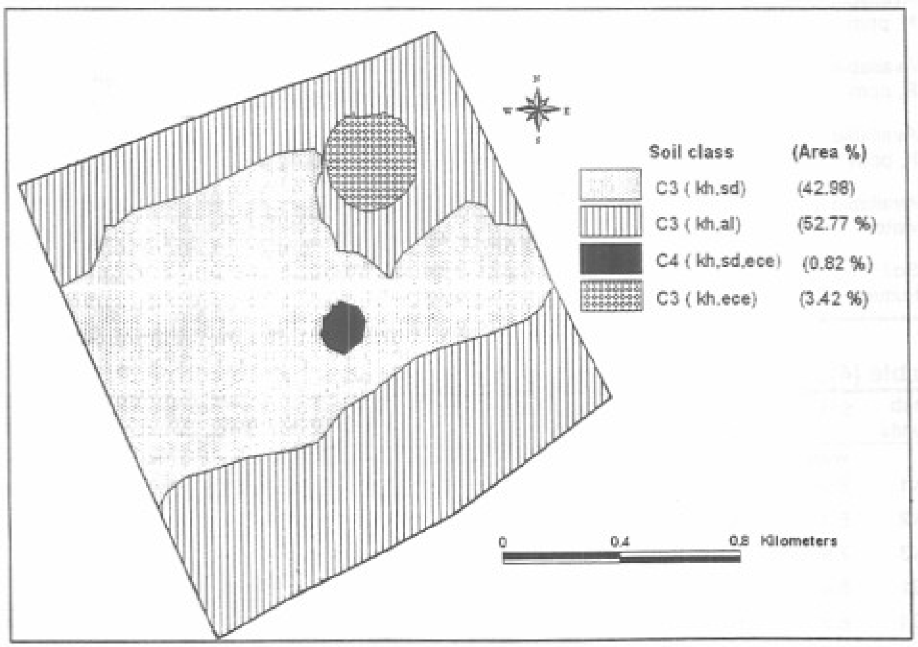
sub units	pH	EC dS/m	SAR	Cations, meq/L Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Anions, meq/l $HCO3^{-}$	Cl^{-}	ESP
	water table									
N1	8.2	14.9	28.5	1.8	26.2	106.5	2.4	26.0	50.0	41.1
N2	8.4	13.6	15.9	8.7	42.6	80.5	4.5	22.5	82.5	22.4
N3	7.9	28.2	32.5	5.0	70.7	200.0	5.8	15.0	220	47.2
S1	8.4	17.3	38.7	5.0	22.0	142.0	2.2	16.0	102.5	56.3
G1	8.5	16.9	18.1	4.5	50.9	95.3	7.8	19.5	105	25.7
G2	7.4	95.5	115.2	40.0	370.0	1649.0	16.5	12.0	2400.0	170.3
F1	7.9	22.5	22.4	9.8	69.6	140.8	4.8	28.0	155.5	32.0
	Irrigation water (all units)									
	8.0	0.56	1.0	2.86	1.3	2.05	0.14	1.15	3.12	0.22

Land evaluation using ALES-Arid software

Land Evaluation System for arid region (ALES-Arid) is used to define the land capability and suitability. The data obtained from ALES-Arid model were input to the Arc View/ GIS software to map the spatial variability and distributions of capability classes and suitability classes for different crops.

A) Land capability classification:

The spatial distribution of the capability classes in the studied area are shown in map (3). Table (5) show land capability classes, values of soil index (S.I), area percent for each class and limitation parameters in the studied area. These data show that 99.18% from the total area belong to land capability class 3 (fair or moderate) while 0.82% belongs to class 4 which reflect weak or marginal degree of land capability. Soil index values of the studied soils are low and ranged between 26.54 and 50.89%. The dominate limitation parameters in the studied soils were saturated hydraulic conductivity (h), soil depth (d), salinity (s) and alkalinity (a).



Map (3): Land capability classes and limitation factors of studied area

Table (5): Land capability classes and limitation of the studied area

Sub units	Soil class*	Limitations	Soil Index	Area, %
N1	C3	kh, d	50.89	34.96
N2	C3	kh, d	48.99	2.50
N3	C3	kh, d	50.28	3.53
S1	C3	kh,	50.59	52.70
G1	C3	kh, d, a	45.07	1.92
G2	C4	kh, d, s,a	26.54	0.82
F1	C3	kh, s	46.87	3.42

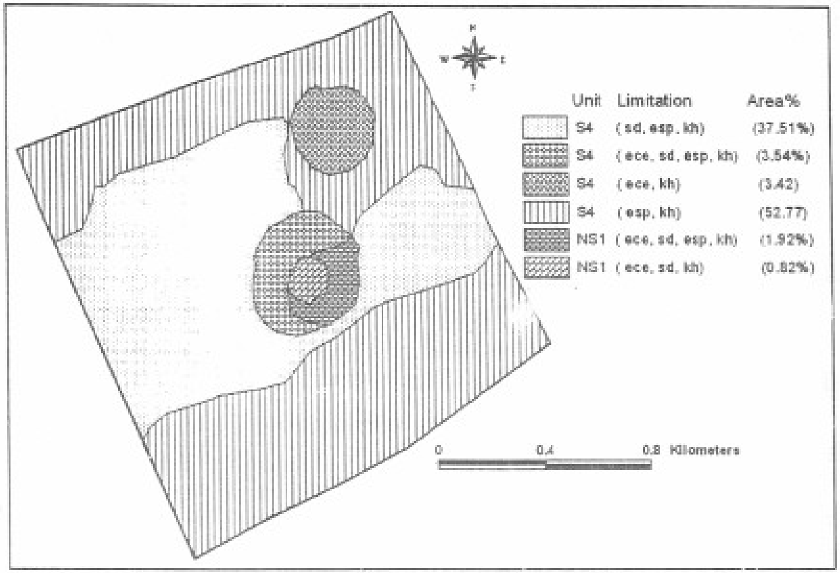
*C1: Excellent, C2: good, C3: fair, C4: poor, C5: very poor, C6: non-agriculture

B) Soil suitability classification

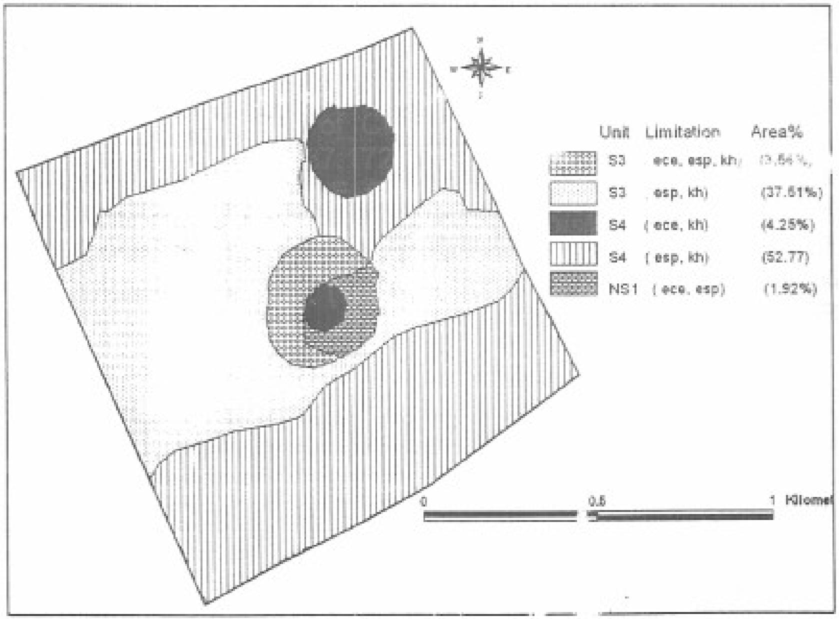
Different soil suitability classes and indices for several crops were predicted based on the matching between land qualities and characteristics and crop standard requirements using ALES-Arid program. The soil suitability for twenty four crops (field crops, vegetables and forage crops, and fruit trees) were investigated.

Generally, data of soil suitability class, subclasses and limitations resulted from the application of ALES-Arid program on the study soils are presented in table (6).These data indicate that most of the studied soils are suitable (class 1 and class 2) for wheat, Barley, Rice, onion, and alfalfa, while these soils are moderately (class 3) to low (class 4) suitable for Soya bean, Faba bean, Maize, cotton, Cabbage, tomato and Pepper. However, most of the studied soils are conditionally suitable to actually unsuitable (S4 to NS2) for fruit trees. Regarding the sub classes, data show that the main limiting soil properties in most of the studied soils are saturated hydraulic conductivity (kh), soil depth (water table depth), soil salinity (EC) and alkalinity (SAR). The geo-spatial distribution of suitability for soya bean, Pepper, faba bean and cotton are represented in maps (4 and 5).

Soya bean

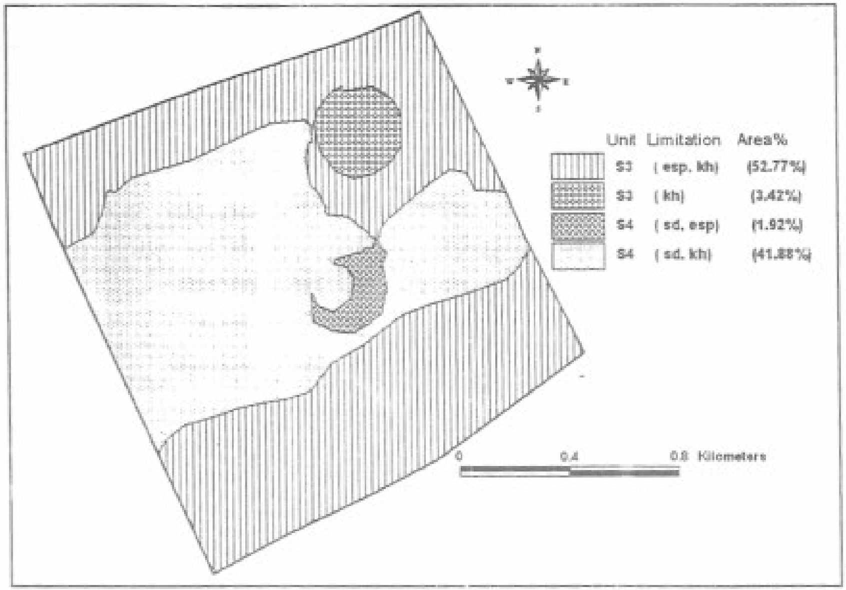


Faba bean

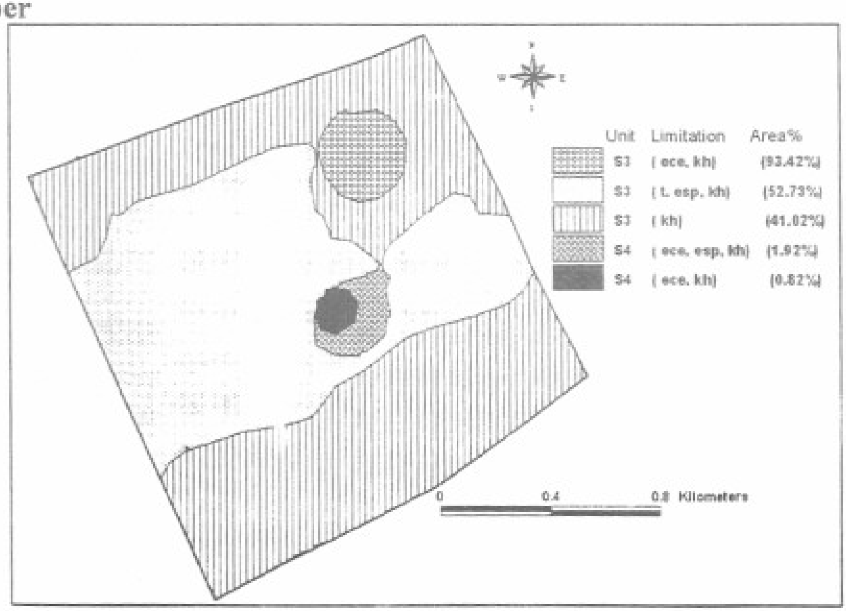


Map (4): Geo-spatial distribution of suitability classes and limitations for soya bean and faba bean

Cotton



Pepper



Map (5): Geo-spatial distribution of suitability classes and limitations for cotton and Pepper

Table (6): Agricultural soil suitability subclasses of the studied area

Crops	Soil subunits N1	N2	N3	S1	G1	G2	F1
Field Crops							
Wheat	S1	S1	S1	S1	S1	S2 sal	S1
Soya bean	S4dak	S4 dakh	S4 sadh	S3 ah	NS sdah	NS1sadh	S4 sah
Barley	S1	S1	S1	S1	S1	S2 a	S1
Faba bean	S3 ah	S3 ah	S3 sah	S3 h	NS1 sah	NS1sah	S4 sah
Rice	S1	S1	S1	S1	S1	S3 sa	S2 s
Maize	S3 ah	S3 ah	S3 ah	S3 h	S4 sah	NS1sah	S3 sah
Cotton	S4 dh	S4 d h	S4 dh	S3 h	S4 dah	S4 adh	S3 h
Sugerbeat	S1	S1a	S1	S1	S3 a	S3 sa	S1 a
Sunflower	S4 dh	S4 d h	S4 dh	S3 h	S4 dh	S4 sdh	S3 h
vegetables and forage							
Onion	S1	S1	S1	S1	S2 s	S3 sa	S3 s
Cabbage	S3 h	S3 h	S3 h		S3 h	S4 sah	S3 sh
Tomato	S3 h	S3 h	S3 h	S3 th	S3 h	S4 sah	S3 h
Pepper	S3 h	S3 h	S3 h	S3 th	S4 sah	S4 sah	S3 sh
Watermelon	S3 h	S3 a h	S3 h	S3 th	S4 sah	NS1sah	S3 sah
Pea	S3 h	S3 h	S3 Sh	S3 h	S4 sh	S4 sah	S4 sah
Afafa	S1	S1	S1	S1t	S2 s	S2 sa	S2 s
Sorghum	S3 h	S3 s h	S3 h	S3 h	S4 ah	NS1sah	S3 ah
Fruit trees							
Banana	NS2 d	NS2 d	NS2 d	S3 dh	NS2 d	NS2 d	S3 sah
Grape	NS2 d	NS2 d	NS2 d	S4 th	NS2 d	NS2 d	S4 sah
Citrus	NS2 d	NS2 d	NS2 d	NS1dh	NS2 d	NS2 d	NS1sdh
Fig	NS2 d	NS2 d	NS2 d	S3 th	NS2 d	NS2 d	S3 ah
apple	NS2 d	NS2 d	NS2 d	NS1dh	NS2 d	NS2 d	S4adh
Date pam	NS2 d	NS2 d	NS2 d	S4 th	NS2 d	NS2 d	S3 ah
Olive	NS2 d	NS2 d	NS2 d	S4 th	NS2 d	NS2 d	S3 ah

S1: Highly suitable, S2: Moderately, S3: Marginally, S4: Conditionally, NS1: Potentially suitable and NS2: Actually unsuitable
h: saturated hydraulic conductivity, d: soil depth, s= soil salinity, a= soil alkalinity t: soil texture

REFERENCES

Abdel-Kader, F. H., and H.M.Ramadan (1995). Land evaluation of Dabaa-Fuka area, north western coast, Egypt, using geographical information system (GIS). Egypt. J. Soil Sci. 35 (2): 203-214.

Bahnassy, M., H.M. Ramadan, F. Abdel-Kader and H.Y. Yehia (2001). Coupling GIS with modeling tools to support land use planning and management of sugar Beet area, west Nubaria, Egypt. Alex. Jour. Agric. Res. 46 (1): 169-180.

Bahnassy, M. and I. Morsy (1996). Geostatistical study of surface and subsurface variables of Bangar El-Sokkar soils. J. Agric. Sci. Mansoura Univ. 21(7): 2745 - 2758.

Burgess, E. and R. Webester (1980). Optimal interpolation and isarithmic mapping of soil properties: 1-The Semi-Variogram and punctual kriging. J. Soil Sci. 31: 315-331.

Burrough, P.A. (1987). Mapping and map analysis: New tools for land evaluation. Soil Use and Management. 3 (1) : 20-25.

Burrough, P.A., (1986). Priniciples of Geographical Information systems for Land Resources Assessment. Clarendon Press. Oxford.

Driessen P.M. and N.T. Konijn (1992). Land-use system analysis. Indonesia.

El-menshawy , A. B. (2000). Geostatistical analysis of some topsoils in El-Nahda area, Egypt. Alex. J. Agric. Res. 45 (1): 23-34.

El-Zahaby, E.M., M.H. Bahnassy, A.M. El-Saadani and R.I. fayed (1999). Chemical and mineralogical properties and spatial variability of soils under different environments of deposition, southeast Mariut Lake. Alex. J, Agric. Res.44 (3): 71-85.

ESRI. (1999). Arc View user manual. Version 3.2a Redlands. California.

Fayed, R.I. (1998). Pedological studies on some soils under different environments of deposition, southeast Mariut Lake, Egypt. M.Sc. Thesis, Fac. of Agric., Univ. of Alex.

FAO (1990). Guidelines for soil profile description. 3rd ed., FAO, Rome.

Gamma Design. 1991. GS^{+}, Geostatistics for the biological environmental assessment software (1.1). User's Manual, Plaivwell, MI, USA.

Ismail H.A., M.H. Bahnassy and O.R. Abd El-kawy (2004). Integrating GIS and Modeling for Agricultural Land Suitability Evaluation at East Wadi El-Natrun, Egypt Egyptian Soil Science Society, Cairo, 27-28 Dec. 2004.

Lark, R. M. and P. H. Beckett (1998). Geostatistical description of the spatial distribution of soil classes, and it's use in predicting the purity of possible soil map units. Geoderma 83: 243-267

Morsy, I.M. (1994). A model relating soil properties and variability to land capability and suitability for crops in arid irrigated region. Ph. D. Thesis Fac. of Agric., Univ. of Alex.

Oliver, M.A. (1987). Geostatistics and its application to soil sciences. Soil Use and Management, 3 (1): 8-20.

Olsson, L. (1989). Integrated resource monitoring by means of remote sensing, GIS and spatial modeling in arid environments. Soil Use and Management. 5 (1).

Page, A.L., R.H. Miller and R. Keeny (1982). Methods of Soil Analysis. Part 2 Chemical and microbiological properties. Agron. Monograph No. 9, ASA Madison, Wisc., USA.

Ramadan, H.M. (1997): Spatial interpolation and simulation of soil salinity and water table in some irrigated soils in Egypt. Alex. Sci. Exch. 18 (2): 191 211.

SY-Stat Inc. (1990). User's Manual, Copywright, Version (5.1), SYSTAT Inc.

Warrick, A.W., D.E. Myers and D.R. Nielsen (1986). Geostatistical method applied to soil science. Soil Sci. Soc. Am. J. Agron. Mon. 9: 53-81.

Xu, J. and R. Webster (1984). A geostatistical study of topsoil properties in Zhangwu County, China. Catena. 11: 13-26.

الملخص العربى

تكامل نظم المعلومات الجغرافية, التحليل الجيواحصائى والنماذج الرياضية لتحديد وحدات التربة وتقييمها لبعض أراضى منطقة شرق بحيرة ادكو – مصر

رجب إسماعيل فايد, يسرى سعد الفقي, ايهاب محرم مرسى

معمل بحوث الأراضى الملحية والقلوية بالإسكندرية – معهد بحوث الأراضي و المياه والبيئة– مركز البحوث الزراعية– مصر

تهدف هذه الدراسة الى تحديد الوحدات الأرضية و تقييم قــدرة الأراضـــي الانتاجيـــة ومـــدى ملائمتها للزراعة بالمحاصيل المختلفة لبعض الأراضى الواقعة شرق بحيرة ادكو وذلك من خلال الدمج

بين نظم المعلومات الجغرافية (GIS) والتحليل الاحصائى الطبيعى ونظـام تحديـد المواقـع(GPS) وبرنامج تقيم الأراضى الزراعية بالمناطق الجافة (ALES-Arid).

وقد أظهرت دراسة الاختلافات المكانيـة باسـتخدام التحليـل الجيواحـصائى أن ال Semi-variogram في حالة التوصيل الكهربائى (EC) وكربونات الكالسيوم يتبع نموذج Gaussian أمـا فى حالة الماغنسيوم الذائب(Mg^{++}) وعمق القطاع الأرضى فانه يتبع نموذج Spherical. أوضـحت تلك النماذج أن مسافة اخذ العينات للدراسات المستقبلية فى هذه المنطقة لكل من الأملاح الكليـة الذائبـة والماغنسيوم الذائب والكربونات الكلية وعمق القطاع الأرضى كانت 195، 400، 308، 484م علـى التوالى.

تمت عملية الربط والتطابق Overlaying process لخرائط التوزيع الفراغـى لخـواص التربة المختلفة مثل الملوحة، عمق قطاع الأرض، الكربونات الكلية، الماغنسيوم الذائب والقوام باستخدام نظم المعلومات الجغرافية (GIS) لانتاج خريطة الوحدات الأرضية والتى أظهرت أن منطقة الدراسـة تشمل أربع وحدات أرضيه رئيسيه (تم تقسيمها الى سبعة تحت وحدات) وهى 1- أراضى غير ملحيـه وماء أرضى مرتفع تمثل 40.98% 2- أراضى غير ملحيه وماء أرضى منخفض وتمثل 52.70% 3- أراضى ملحيه وماء أرضى مرتفع وتمثل 2.74% 4- أراضى ملحيه وماء أرضـى مـنخفض وتمثل 3.58% من المساحة الكلية.

أظهرت نتائج تطبيق برنامج التقييم ALES-Arid أن معظم الأراضى المدروسة تقع فى قسم 3 (C3) من أقسام القدرة الانتاجية أى ذات قدرة إنتاجية متوسطة بينما مساحة محدودة تقع فى قسم 4 (C4) وهو ذات قدره إنتاجيه ضعيفة أو حديه. كما أوضحت الدراسـة أن الأراضـي المدروسـة ذات ملائمة عاليه (S1, S2) لمحاصيل القمح, الشعير, الأرز, البصل و البرسيم وذات ملائمة متوسطة الـى ضعيفة (S3, S4) لباقى المحاصيل الحقلية والخضر. كما تشير النتائج ان معظم الأراضى المدروسة ذات ملائمة مشروطة الى عديمة الملائمة (S4 to NS2) لأشجار الفاكهـة. وأوضـحت الدراسـة أن العوامل الرئيسية المحددة للقدرة الانتاجيه للأراضى والتى تؤثر على مدى ملاءمتها للمحاصيل المختلفـة فى هذه المنطقة هى التوصيل الهيدروليكى للتربة المشبعة, عمق القطـاع الأرضـى (مـستوى المـاء الأراضى), وملوحة التربة و القلوية.

وقد تم ربط النتائج المتحصل عليهـا مـن برنـامج التقيـيم ALES-Arid وبرنـامج ArcView-GIS مع الخرائط الأرضية وذلك للحصول على الخـرائط الخاصـة بالقـدرة الانتاجيـة للارراضى ومدى ملائمتها للمحاصيل المختلفة.