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GIS MAPPING OF LAND SUITABILITY AND SOIL QUALITY FOR SOME SOILS OF EL-SHARKEYA GOVERNORATE, EGYPT

AGGAG[1], A. M. AND YEHIA[2], H. A.
[1]Nat. Res. & Agric. Eng., faculty of agriculture (Damanhour), Alexandria University.
[2]Soil salinity and alkalinity lab; soil, water and environment research institute (SWERI), Giza

ABSTRACT

Egyptian desert occupies about 95% of the total area of our country. Continuous increase of population puts pressure on the limited Egyptian natural resources particularly land and water, in the Nile Valley and Delta. Thus, an urgent demand for agricultural expansion horizontally as well as vertically is indispensable. The Egyptian strategy for land reclamation takes into account the area around El-Ismailya irrigation canal which covered about 87000 fed., (GARPAD, 1997).

The study area covers about 3600 fed. situated at El-Husyneya district. Sharkeya Governorate, Egypt. The main research goals are to 1- characterize the soil and water resources of the study area to planning for the best crop pattern using land evaluation facilities for different uses (capability and suitability), 2- determine the soil quality indicators which affect the agricultural land reclamation for the study area using mathematical methods, and 3- study how to reduce the sample numbers using geostatistical analysis (Kriging). To fulfill these goals a total number of soil profiles were 163 that dug to a depth ranged from 150 to 170 cm.

The results show that soil of the study area are characterized by sandy texture, low salinity and fertility soil with capability classes of C3t and C4t which cover about 93.50% and 6.50% of the total area respectively, and the main limitation was the texture. The land suitability results show that the area is suitable for all crops (fruit tress, field crop and vegetables).

The main soil quality indicators were divided into three main separated divisions chemical (EC, $CaCO_3$ and SAR with weights 8.22%, 5.84%, and 84.26% respectively), physical (Saturation percent, sand content, and available water with weights 5.20%, 84.46%, and 8.59% respectively), and nutritional (Available K and available Fe with weight 98.63% and 1.11% respectively). The final Relative Soil quality Indicators (RSQI) was divided into five classes. Class III covers about 83.00% of the total area followed by class IV which covers 12.00% of the total area, while classes I, V and II cover 2.00%, 2.00% and 1.00%, respectively.

The punctual kriging results show that AW, SP and $CaCO_3$ were fitted to the Spherical model. Salinity fitted to the Gaussian model while SAR was fitted to the Exponential model. The numbers of observations can be reduced from 163 to 83 with high correlation between observed and predicated data for EC, SAR, AW, SP, and $CaCO_3$, as shown by comparing the Kriging cross validation in the two cases. According to the data of infiltration rate, the area must be irrigated under sprinkler or drip irrigation system.

Keywords: GIS, land suitability, soil quality, punctual kriging.

INTRODUCTION

Soil survey (whether reconnaissance, semi-detailed, or detailed) becomes increasingly expensive and time-consuming. Therefore, there is increasing to use Geographic Information System (GIS), Remote Sensing (RS) and Global Position System (GPS) which enable to reduce costs per unit area and facilitate data storage, retrieval and analysis. Well develop analytical modules (Multivariate statistics, Soil quality indicators, Land evaluation, Sustainable development indicators…etc.) could be coupled with the GIS/RS database for modeling and supporting decision-making (FAO, 2002).

Stein *et al.* (2003) showed that geostatistics is now firmly established in soil science as a key tool for making the most of existing data. Numerous studies have demonstrated that much local and even regional soil variability can be modeled as the result of random field (the somewhat disturbing theory behind geostatistical interpolation), and its use is almost universal for field-scale studies. It also provides a sound basis for designing optimal sampling plans based on the structure of spatial dependence.

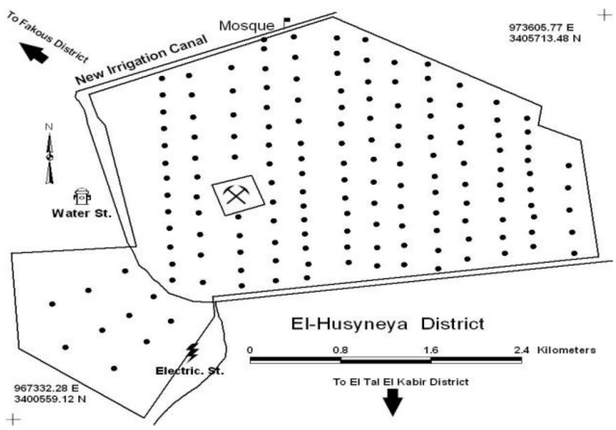
In recent years thematic mapping has undergone a revolution as the result of progress of geographic information science and remote sensing. However, mapping of soil types and characteristics has not fully shared in this revolution, because of the complexity of soil geography and the high cost of its direct observation. None the less, the demand for soil information has never been higher, since the soil resource is so important for rural and urban planning, for environmental protection, and to understand water and geochemical cycles. The advances which are leading towards multiple-use soil information systems include: (1) low-cost, wide-area data, especially elevations and spectral reflectances; (2) geostatistical interpolation and sampling design; (3) terrain modelling; (4) predictive soil mapping; (5) data integration; (6) pedotransfer functions and soil inference systems; (7) powerful desktop computing environments. The challenge is to integrate these advances into operational systems that respond to the extensive actual and latent demand for soil information. Today there is great demand for accurate soil information over large areas from environmental modellers and land use planners (both urban and rural) as well as more traditional agricultural users of soil resource inventories. All these users want interpreted information; that is, soil properties or behavior directly relevant to their application, and in the form that they can directly use in their models (Rossiter, 2005).

Soil quality cannot be measured directly, but must be inferred from soil quality indicators. Soil quality indicators are measurable soil attributes that affect on soil capacity to perform crop production or environmental functions and are sensitive to change in land use, management, or conservation practices. However, many soil attributes are highly correlated. Soil quality indicators could be physical, chemical, and biological properties, processes, or characteristics of soils. They can also be morphological or visual features of plants. Indicators can be assessed by qualitative and/or quantitative techniques. A qualitative assessment is the determination of the nature of an indicator. A quantitative assessment is the accurate measurement of an indicator (Larson and Pierce, 1991; Seybold et al., 1997).

Geostatistical analysis has been widely used in soil science for assessing spatial patterns of variation of a number of soil properties at a range of scales and with different sizes of sampling grids. Spatial interpolation is a procedure for estimating the value of a variable at unsampled locations. The interpolation techniques commonly used in earth sciences include linear regression, ordinary kriging and co-kriging (Kollias et al., 1999). The main research goals are to characterize the soil and water resources of the study area to planning for the best crop pattern using land evaluation facilities for different uses (capability and suitability), determine the soil quality indicators which affect the agricultural land reclamation for the study area using mathematical methods, and study how to reduce the sample numbers using geostatistical analysis (Kriging).

The Study Site:

The study area is situated at El-Husyneya district, El-Sharkeya Governorate, Egypt. The total acreage about 3606 fed. and is located between latitudes 30^{o} $35^{\backslash}$ and 30^{o} $45^{\backslash}$ N and longitudes 30^{o} $45^{\backslash}$ and 32^{o} $00^{\backslash}$ E, (map 1). Generally, the soils are characterized by sandy texture, deep profile, and the presence of 50 cm red calcareous loamy layer that appears at 40-60 cm depth. The main irrigation source is a new branch of El-Ismalyia Canal with good water quality. There is no drainage network due to use the new irrigation techniques (Drip and Sprinkler irrigation).



Map (1): General location of the study area.

MATERIALS AND METHODS

Soil sampling design and analysis

The fieldwork aimed at characterizing the soil properties by designing a regular 200x300 m grid system. The total number of soil profiles was 163 having a depth ranging from 150 to 170cm, with total number of 489 soil samples. The soil profiles were geo-located to UTM coordinate system by the GPS. Four sites were selected to measure infiltration rate (IR) in the filed to support irrigation and drainage network design. The soil samples were prepared and analyzed for chemical, physical and fertility characterization according to Page *et al.* (1982) and Klute, (1986).

Terrain Analysis

One topographic map sheet at scale 1:50000 named El-Tal El-Kaber was digitized using TerraSoft GIS software (Digital Resource System, 1991). Contour lines and spot height were digitized and exported to ArcView GIS software, and input to contour gridder module to generate Digital Elevation Model (DEM). Slope and aspect were derived using spatial analyst extension (ESRI, 1996).

Land Evaluation

Agricultural Land Evaluation System for arid region (ALES-Arid) is a new approach for land capability and suitability evaluation (Abdel Kawy, 2004). ALES-Arid is described as a land use decision support system, which is linked directly with integrated databases and coupled with GIS. Through ALES-Arid program, land evaluation algorithms were expressed in notation forms that can be understood by a calculating device. Optimization tools based on land evaluation models are considered very important to formulate decision alternatives. According to (Storie, 1964); six productivity classes were identified as shown in table (1).

Table(1): Productivity classes and ratings according to Storie, 1964.

Class	Description	Rating (%)
C1	Excellent	80 – 100
C2	Good	60 – 80
C3	Fair	40 – 60
C4	Poor	20 – 40
C5	Very poor	10 – 20
C6	Non-agriculture	< 10

The calculation of capability index by ALES-Arid is an indication of land capability according to multiplication method. ALES-Arid evaluates the suitability for 32 crops (field crops, vegetables, forage crops, and fruit tress) to identify the optimum land use. Land suitability classes were identified using the matching between standard crop requirements (FAO, 1977, 1985; Sys, 1975; and Sys *et al.*, 1993a, 1993b) and land characteristics.

Statistical analysis

Descriptive statistical analysis

Statistical analysis was carried out using Excel spreadsheet. The following classical statistics parameters were calculated: minimum, maximum, mean, standard deviation and coefficient of variation (Webster 1977; and Wilding and Dress, 1983).

Geostatistical analysis

The Semi-Variogram

The semi-variogram is the most important tool in geostatistical applications to soil. It represents the average rate of change of property with distance. It is the basis for modeling the data set and for drawing a contour maps or isarithms, (Burgess& Webster 1980).

The semi-variogram γ (h) is defined as:

$$\gamma(\mathrm{h}) = \frac{1}{2} Var[Z(x) - Z(x+h)] \quad (1)$$

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. Under the zero drift assumption E[z(x)-z(x+h)]=0, then the equation 1 becomes:

$$\gamma(\mathrm{h}) = \frac{1}{2} E[\left| Z(x) - Z(x+h)^2 \right|] \quad (2)$$

An estimate semi-variance function is given by:

$$\gamma^{*}(\mathrm{h}) = \frac{1}{2n(h)} \sum_{i=1}^{n(h)} [Z(xi+h) - Z(xi)]^2 \quad (3)$$

With n(h) number of pairs spirited by a distance h.

The obtained semi-variogram values for each lag were fitted to one of the semi-variogram function using the GSPLUS software Ver. 5.3.1, Gamma Design (2001).

A spherical semi-variogram model given by:

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

$$\gamma(\mathrm{h}) = C_o + C \qquad (4)$$

The Gaussian model:

$$\gamma(\mathrm{h}) = C_o + C[1 - \exp(\frac{3h^2}{A_o{}^2})] \qquad (5)$$

The exponential model:

$$\gamma(\mathrm{h}) = C_o + C[1 - \exp(\frac{-h}{A_o})] \qquad (6)$$

Where γ is the semi-variogram, C_o is the nugget variance, (C_o+C) is the sill variance, A_o is the range distance, and h is the lag distance. The nugget (C_o) is the semi-variogram values due to short scale or inherited variability, the range (A_o) is the distance at each the semi-variogram reaches its maximum, after which there is no spatial dependence among the samples occur, and within it interpolation is worth while; and the sill (C+ C_o) is the plateau (constant value) the semi-variogram reaches, Issaks & Srivastava (1989), Warrick *et al* (1986).

Punctual Kriging:

Kriging is a method of interpolation using the weighted local averaging. It is optimal in a sense that the weights are chosen to give unbasied estimates, while keeping the estimation variance at minimum (Webster, 1977). If a property is measured at a number of places, xi, to given z(xi), i=1,2,……..,n; then the estimate at point (β) will be the linear sum, so that,

$$Z^{-}(\beta) = \lambda_1 Z(x_1) + \lambda_2 Z(x_2) + \ldots\ldots\ldots\ldots + \lambda_n x_n \qquad (7)$$

Where the λi are the weights associated with the sampling points. The estimate is unbiased since.

$$E[Z(\beta) - Z^{-}(\beta)] = 0 \qquad (8)$$

And this is guaranteed if the weights sum to 1, ie.

$$\Sigma_{i=1}^{n} \text{ wi} = 1 \qquad (10)$$

The estimation variance (kriging variance) at (β) is the expected

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square difference between the estimate and the true value, which is

$$\underset{2}{\frac{E}{\sigma}}(\beta) = E[\left|Z(\beta - Z^{-}(\beta)^{2}\right|] \qquad (11)$$

$$= 2\sum_{i=1}^{n} \lambda i \gamma^{-}(Xi,\beta) - \sum_{i=1}^{n}\sum_{j=1}^{n} \lambda i \lambda j \gamma^{-}(\beta,\beta) \qquad (12)$$

Where $\gamma^{-}(xi,xj)$ is the average semi-variogram of the property between x_i and x_j taking into account the distance h separating them. $\gamma^{-}(xi-\beta)$ is the average semi-variance between xi and the point to be estimated (β), and $\gamma^{-}(xi,\beta)$ is the average semi-variance within the block. In punctual kriging, the last term($\sum_{i=1}^{n}\sum_{j=1}^{n} \lambda i \lambda j \gamma^{-}(\beta,\beta)$)=0.

Cross Validation

Cross validation is a technique used to compare estimated and actual values using the information available in the data set. In cross validation, the estimation method is tested at the locations of existing samples. The sample value at a particular location is temporarily discarded from the sample data set; the value at the same location is then estimated using the remaining samples. Once the estimate is calculated, it is compared to the actual sample value that was initially removed from the sample data set. This procedure is repeated for all samples. This could be expressed as (Isaaks and Srivastava, 1989):

$$Error = r = v' - v$$

Where *v'* is the estimated value and *v* is the true value. Mean square error (MSE) is calculated from the formula:

$$MSE = \frac{1}{n}\sum_{i=1}^{n} r^{2}$$

Selection of soil quality indicators

A soil quality indicator is a measurable soil property that affects the capacity of a soil to perform a specified function (Karlen *et aI.*, 1994). For evaluation of soil quality, it is desirable to select indictors that are directly related to soil quality. Because soil quality assessment is purpose and site specific, indicators used by different researchers or in different regions may not be the same. Based on the mathematical statistical analysis, eight indicators were selected for the study site, as shown in table (2).

Weights of soil quality indicators

The contribution or importance to soil quality of each indicator is usually different, and can be indicated by weighting coefficient. The calculation of weights assigned to each indicator is as follows (Kock and Link, 1971):

1- The sum squared deviation from the mean was obtained for each observation
2- This amount was summed up for all observations for a specific indictor
3- Obtaining the total sum squared deviation from the mean for all indictors.
4- The weight was obtained by dividing step 2 by step 3 and multiplying by 100
5- Soil indicators that had a value less than 1 was dropped from consideration.
6- The sum of all weights was normalized to 100%.

Subdivision of soil quality indicators and their indication

Each of the indicators was divided into four classes (I, II, III, IV). Class I is the most suitable for plant growth, class II suitable to plant growth but with slight limitations, class III with more serious limitation than class II, and class IV with severe limitations for plant growth. The range for each class, which was based on previous studies on soil quality and land evaluation as mentioned shown by FAO (1976) and Sys *et al.*, (1993a) and illustrated in Table (2). Marks of 4, 3, 2 and 1 were given to class I, II, III and IV respectively.

Table (2): Soil quality indicators, their weights and classes.

Indicator	Weight	I	II	III	IV
EC, dS/m	8.22	< 2	2 – 4	4 - 8	> 8
SAR	84.26	< 15			> 15
$CaCO_3$ %	5.84	< 5	5 – 10	10 - 20	> 20
SP*, %	5.20	> 70	70 – 50	50 - 25	<25
Sand, %	84.46	< 80	80 – 85	85 - 90	> 90
Available Water mm/m	8.59	>100	100 - 80	80 - 60	< 60
Available K, ppm	98.63	> 120	120 - 90	90 - 60	< 60
Available Fe, ppm	1.11	> 4	3 - 4	2 - 3	< 2

* Saturation Percent.

Quantitative evaluation of changes in soil quality

By introducing the concept of relative soil quality index (RSQI), and with the assistance of a geographical information system (GIS), the indicators were combined into an RSQI. The equation for calculating RSQI value is (Wang and Gong, 1998):

$$\mathbf{RSQI = (SQI / SQI_m) \times 100}$$

where SQI is soil quality index, SQI_m is the maximum value SQI is calculated from the equation:

$$\mathbf{SQI = \Sigma W_i I_i}$$

Where W_i are the weights of the indicators, I_i are the marks of the indicator classes. Therefore, summing up the indicator values can produce the SQI value for a soil. The maximum value of SQI for the soil is 400 and the minimum value 100. According to the RSQI values, soils in the study area were classified into 5 classes from best to worst, as shown in table (3).

Table (3): RSQI classes and their values.

Class	RSQI value
I	90 – 100
II	80 - 90
III	70 - 80
IV	60 - 70
V	< 60

RESULTS AND DISCUSSION

Infiltration Rate and Method of Irrigation

Four sites were chosen in the study area to cover the differentiations in IR. In general, basic IR values ranged between 11 to 42 cm hr^{-1}. So, the surface irrigation is not recommended for this area and must be irrigated through sprinkler or drip systems.

Terrain analysis

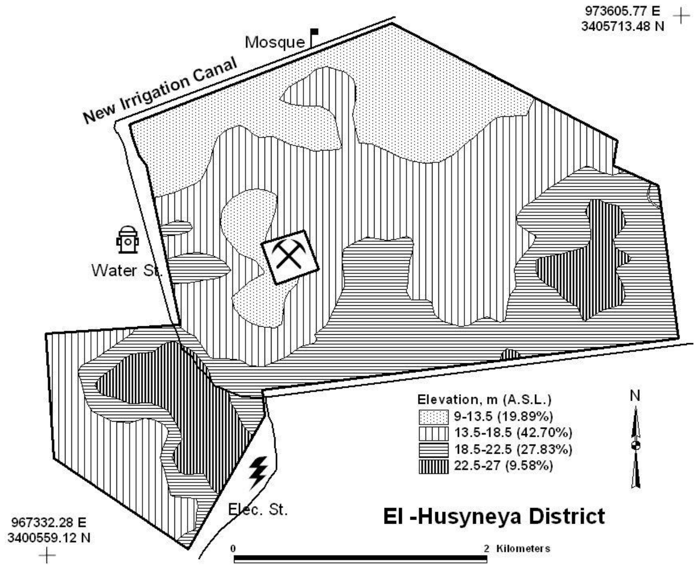
The analysis of Digital Elevation Model (DEM) indicated that the elevations varied from 9 to 27 m A.S.L. The northern part of the study area has the lowest elevation. The dominant elevation ranged from 13.5 to 18 m A.S.L. composed 42.70% of the total area as shown in map (2). Slope ranged from 0 to 6.38% and the main slope class was from 0 to 1.59% which covered about 94.47% of the total area as shown in table(4). It is noticeable that the north facing directions (N, NE, NW) are the dominant aspect classes representing 33.65% of the total area, followed by the south facing directions (S, SE, SW) with 22.34% of the total area as shown in table (5).

Table (4): DEM and slope classes and area percentage of the study area.

Digital Elevation Model (DEM)		Slope Classes	
Elevation range, m	**Area, %**	**Slope Class, %**	**Area, %**
9.00 – 13.50	19.89	0 – 1.59	94.47
13.50 – 18.00	42.70	1.59 – 3.19	5.20
18.00 – 22.50	27.83	3.19 – 4.78	0.28
22.50 – 27.00	9.58	4.78 – 6.38	0.05

Table (5): Direction and area percentage of the soil aspect.

Direction Class	Area, %
Flat	22.53
North	10.71
North East	7.20
East	5.62
South East	5.88
South	6.61
South West	9.85
West	15.86
North West	15.74



Map (2): Digital Elevation Model of study area.

Descriptive statistical parameters and soil classification

The soil is characterized as sandy deep soil with low fertility content. Table (6) shows the descriptive statistical analysis which indicated that the sand content ranged from 94.5 to 99.6%, soil salinity varied from 0.32 to 16.07 dS/m and low organic matter content (0 to 0.54%) with low calcium carbonate content (0.20 to 14%). Available K shows highest variance followed by SAR. Based on morphological characterization and laboratory analysis the soils are classified as *Typic Torripsamments*.

Semi-Variogram of the soil quality indicators

Three semi-variograms were mainly fitted to the individual soil properties. Available water, saturation percent and $CaCO_3$ were fitted to the Spherical model. Salinity fitted to the Gaussian model. Sodium Adsorption Ratio (SAR) was fitted to the Exponential model as shown in figure (1). The parameters of these models for different soil quality indicators are shown in table (7). It's clear that SAR has the highest nugget variance followed by salinity; which indicates their strong spatial dependence and high inherited variability, (Warrick et al., 1986). Maps (3, 4, 5, and 6) show the distribution and percentage of some soil quality indicators in the study area.

Table (6): Statistical characterization of soil properties

Soil Property	Statistical parameters					
	Min	Max	Mean	Variance	St. Dev.	C.V.
Ec, dS/m	0.32	16.07	1.22	1.75	1.32	108.19
SAR	1.00	43.30	5.30	17.56	4.19	79.05
pH	7.07	8.90	8.18	0.07	0.27	3.30
$CaCO_3$, %	0.20	14.00	2.55	1.31	1.14	44.70
OM, %	0.00	0.54	0.11	0.00	0.07	63.63
Av. K, ppm	0.52	200.00	53.93	194.38	13.94	25.85
Av. P, ppm	0.01	5.17	0.99	0.30	0.55	55.55
Av. Fe, ppm	0.34	13.48	1.97	2.62	1.62	82.23
Av. Zn, ppm	0.02	2.74	0.28	0.04	0.19	67.85
Av. Mn, ppm	0.04	2.98	0.43	0.08	0.29	67.44
Av. Cu, ppm	0.02	0.88	0.18	0.00	0.08	44.44
Clay, %	0.30	4.00	1.71	0.27	0.52	30.41
Silt, %	0.10	1.50	0.66	0.04	0.20	30.30
Sand, %	94.50	99.60	97.62	0.52	0.72	0.74
Sp, %θv	24.79	31.94	28.97	1.59	1.26	4.35
FC, %θv	8.16	10.59	9.42	0.16	0.40	4.25
PWP, %θv	2.62	4.14	3.39	0.06	0.25	7.37
AV. Water, mm/m	52.20	64.50	60.35	2.64	1.62	2.68
Ks*, m/d	3.44	5.53	4.51	0.15	0.39	8.65
Bulk Denisty, Mg/m^3	1.26	1.71	1.49	0.00	0.08	5.36

* Hydraulic conductivity

Table (7): Semivariogram types and parameters of soil quality indicators.

Soil quality indicator	Model	Nugget (C_o)	Sill (C1)	Range (a)	r^2	Lag (m)
EC, dS/m	Gaussian	0.3600	1.036	5337	0.83	2500
SAR	Exponential	0.9100	4.859	276	0.93	3000
Available water, mm/m	Spherical	0.0010	2.882	822	0.75	1500
Saturation percent $\%\theta_v$	Spherical	0.0010	2.100	785	0.85	2500
$CaCO_3$, %	Spherical	0.1000	0.518	7722	0.88	2000

Geostatistical analysis and sampling strategy: To test the high density grid (163 observations) for estimating the soil characteristics through variogram analysis, the number of observations was reduced to 83 by removing every other column of samples. This was tested by comparing the kriging cross validation r^2 in the two cases (163 and 83 observations). The results showed that there are high correlations (r^2) between the actual and predict data for EC, SAR, available water, saturation percent, and total calcium carbonate (0.62, 0.98, 0.90, 0.61, and 0.62 respectively), in the case of 83 observations. This indicates that dense soil observations are not always good for interpolating soil characteristics using geostatistical analysis methods.

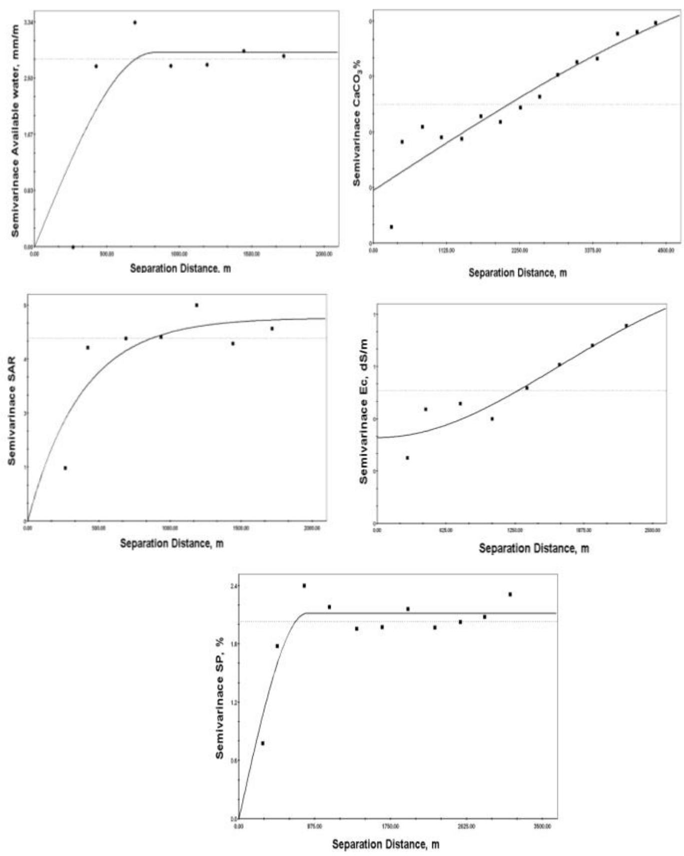
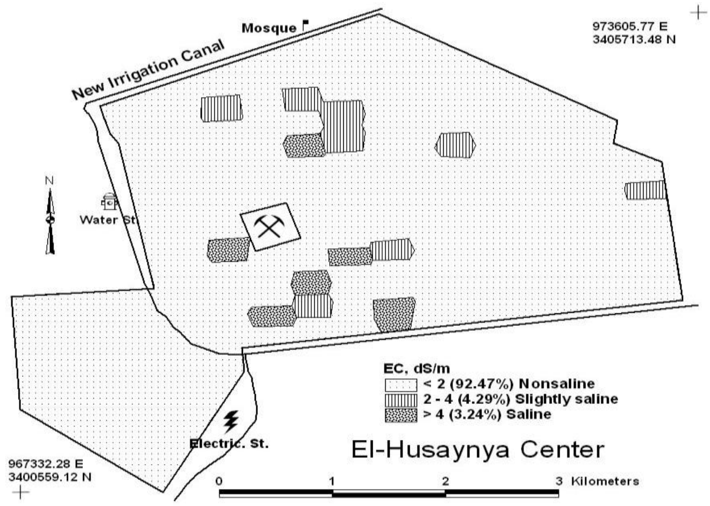


Figure (1): The semivariograms of soil quality indicators.

Land capability classes: The ALES-Arid model provides prediction for general land use capability for a broad series of possible uses. According to the model prediction, most of the study area was classified as C3t, which indicated fair capability with soil texture as limiting factors. Map (7) illustrates the distribution and percentage of each land capability class in the study area.

Land suitability classes for specific uses: The ALES-Arid Model was used to predict soil suitability for some common crops. Table (8) summarizes agriculture soil suitability class and percentage for the selected crops and trees. Maps (8, 9, 10, and 11) show the suitability class distribution for some crops which can cultivated in the study area.



Map (3): Distribution of soil salinity classes.

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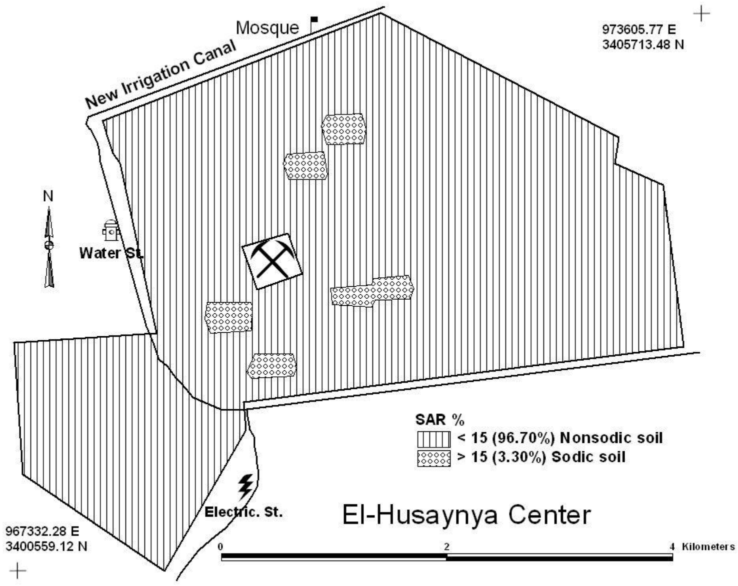
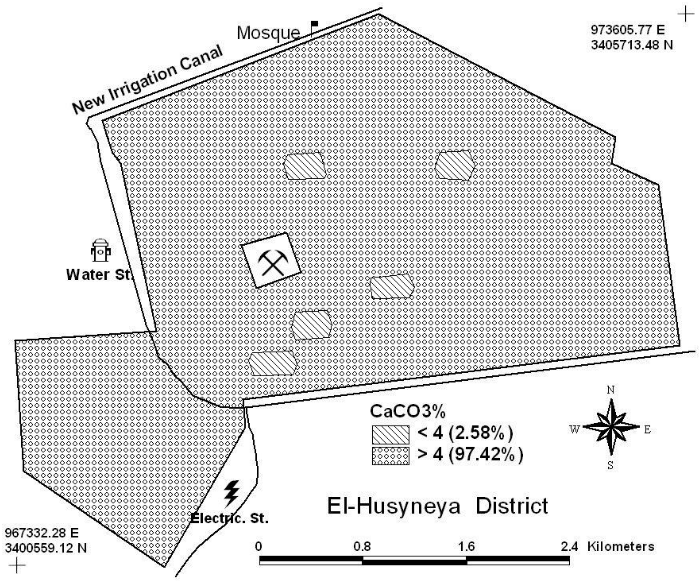
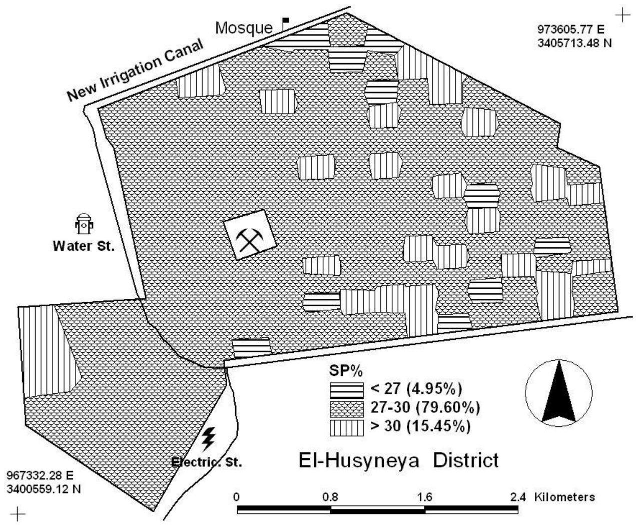


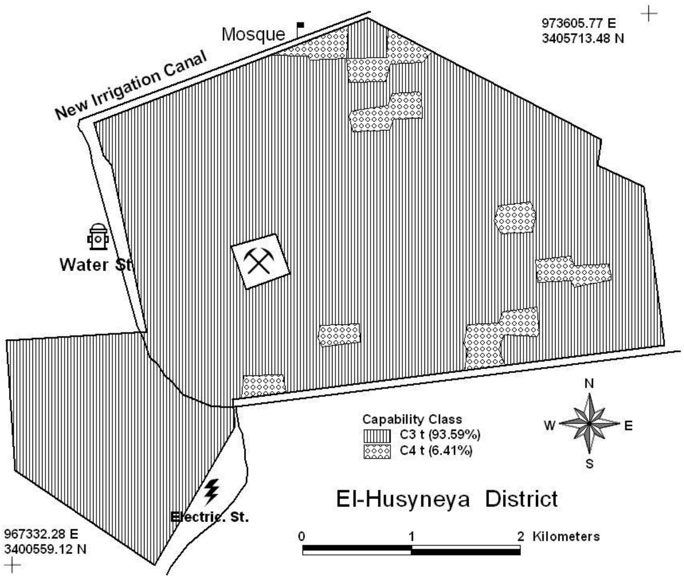
Map (4): Distribution of sodic and nonsodic soils.



Map (5): Distribution of chemically calcareous soils.



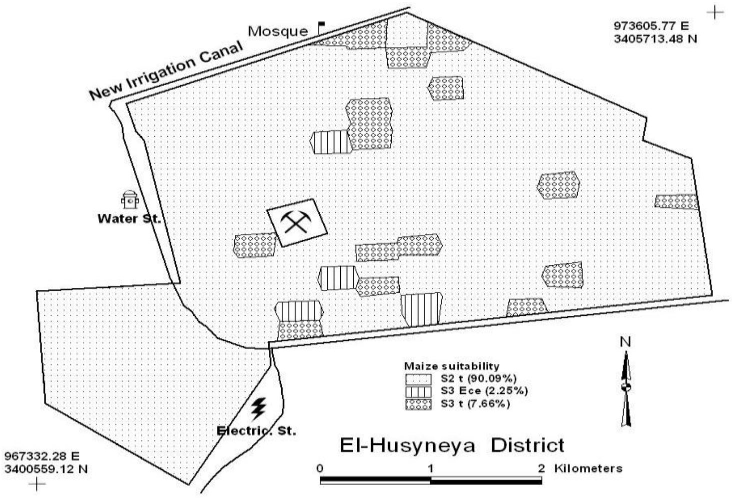
Map (6): Saturation percent distribution.



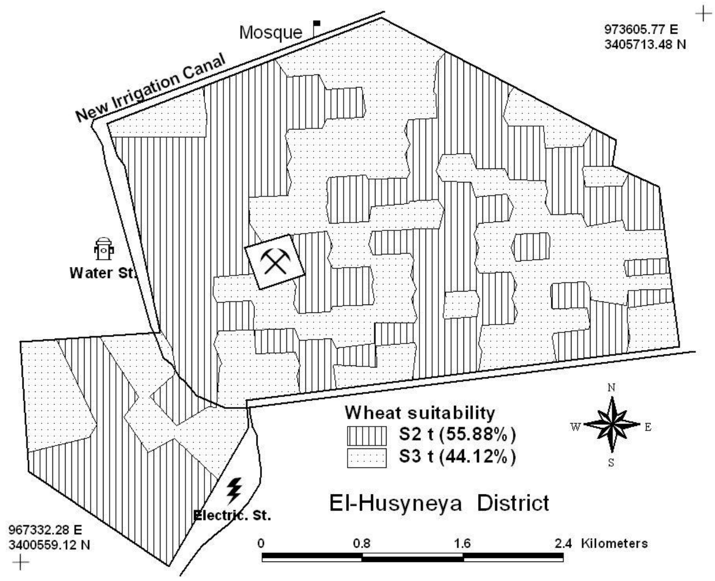
Map (7): Land capability classes.

Table (8): Soil suitability class and percentage for each crop in the study area.

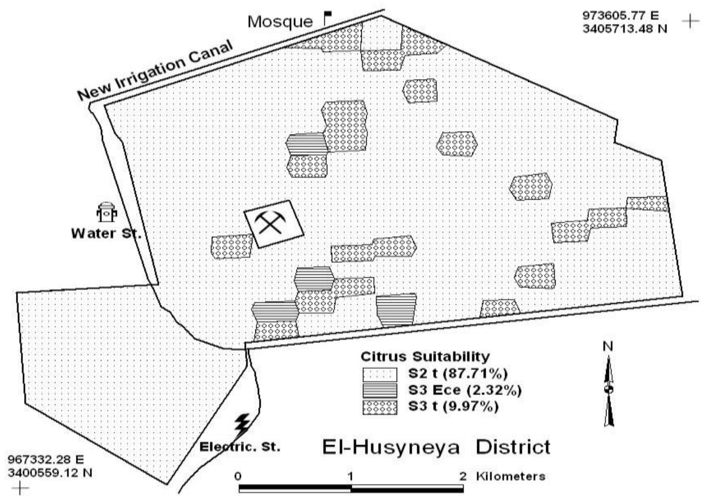
Crops	Suitability Class	Area, %	Crops	Suitability Class	Area, %
Wheat	S2t S3t	55.88 44.12	Sugarcane	S2t S3t	53.43 46.57
Maize	S2t S3 ECe S3t	90.09 2.25 7.66	Apple	S2t S3 Ece S3t	90.09 2.25 7.66
Faba Bean	S2t S3ECe,t S3t S4ECe,t	87.19 0.99 9.58 2.24	Banana	S2t S3ECe S3t	42.73 2.25 55.02
Onion	S2t S3ECe S3t	88.64 2.84 8.52	Sorgum	S2t S3t	96.04 3.96
Pea	S2t S3ECe S3t S4Ec	87.19 0.99 9.58 2.24	Peanut	S2ECe,t S2t S3ECe S4ECe	0.73 97.69 0.53 1.05
Potato	S2ECe S2t S3Ece	0.73 97.69 1.58	Pear	S2t S3ECe S3t	53.43 2.24 44.33
Soyabean	S2t S3ECe,t S3t S4ECe,t	87.19 0.99 9.58 2.24	Citrus	S2t S3ECe S3t	87.71 2.32 9.97



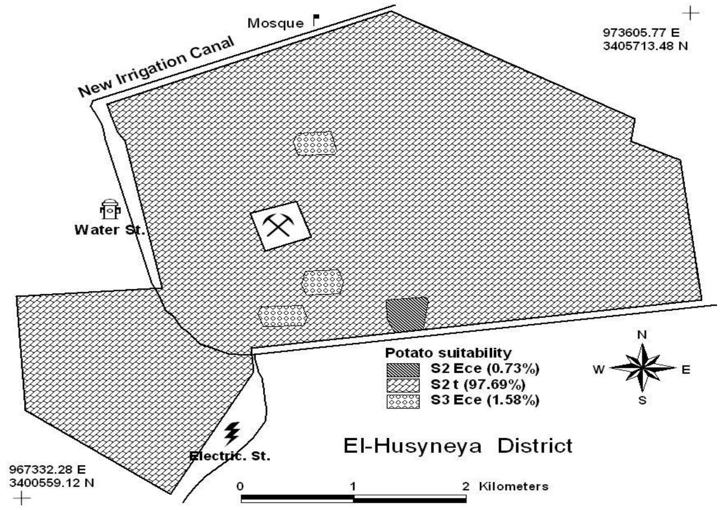
Map (8): Maize soil suitability classes.



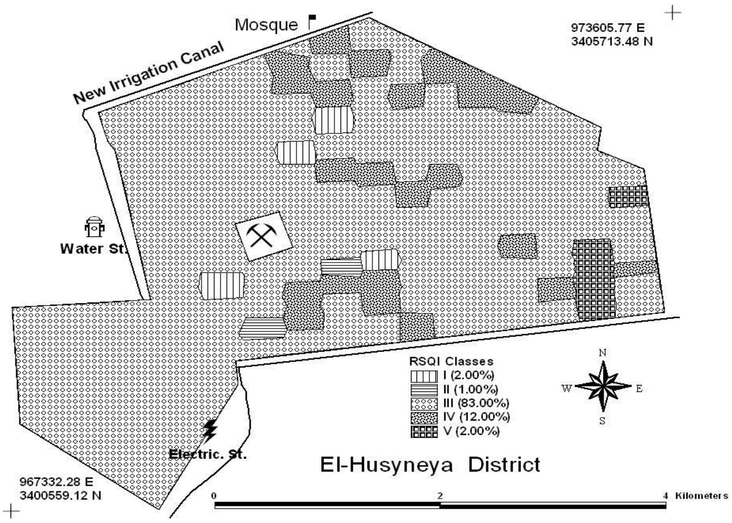
Map (9): Wheat soil suitability classes.



Map (10): Citrus soil suitability classes.



Map (11): Potato soil suitability classes.



Map (12): Relative soil quality index (RSQI) for the study area.

Map (12) shows that the relative soil quality index (RSQI) for the study area divided into five classes. Class III is the largest one cover about 83.00% of the total area followed by class IV, I, V, and II which cover about 12.00%, 2.00%, 2.00% and 1.00% respectively.

CONCLUSION

The results show that the study area is suitable for all crops and the only limitation was the sandy texture, which could be eliminated by optimum agricultural management practices. Geostatistical analysis (Kriging) played a key role in sampling strategy by reducing the number of samples needed for mapping, and consequently decreased the time, efforts, and costs required to carry out the soil survey. Relative Soil Quality Index (RSQI) showed that class III was the dominant class for the virgin soil, which might be improved after land reclamation practices. Topographic attributes (DEM, slope and aspect) were very important, and should be taken into consideration when designing the irrigation and drainage networks. Environmental Impact Assessment (EIA) and sustainability indictors should be considered for reclamation practices.

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الملخص العربى

استخدام نظم المعلومات الجغرافية لرسم خرائط صلاحية وجودة التربة لبعض أراضى محافظة الشرقية – مصر

أحمد محمد عجاج[1] وهيثم عبد اللطيف محمد يحيى[2]

1 -قسم الموارد الطبيعية والهندسة الزراعية – كلية الزراعة (دمنهور) – جامعة الاسكندرية.
2 معمل بحوث الاراضى الملحية والقلوية – معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية.

تحتل مساحة الصحراء المصرية حوالى 95% من المساحة الكلية لأراضى جمهورية مصر العربية ونظرا لزيادة التعداد السكانى المتواصل وندرة الموارد الطبيعية خاصة الأرض والمياه وخاصة فى أراضى الدلتا والوادى مما يؤكد أنه لاغنى عن التوسع الزراعى الأفقى فى الأراضى الصحراوية. لقد اهتمت استراتيجية أستصلاح الأراضى المصرية حتى عام 2017 بالمنطقة حول ترعة الاسماعيلية والتى تقدر بحوالى 87000 فدان بمحافظة الشرقية لإضافتها إلى مساحة الرقعة الزراعية المصرية. تقع منطقة الدراسة فى مركز الحسينية بمحافظة الشرقية وتقدر بحوالى 3600 فدان. لدراسة خواص التربة والمياه بمنطقة الدراسة تم حفر 163 قطاع أرضى تتراواح اعماقها من 150 الى 170 سم وتم جمع عينات مياه من الترعة الرئيسية المستخدمة فى الرى. وتهدف الدراسة إلى تقويم صلاحية التربة والمياه لزراعة المحاصيل المختلفة سواء حقلية أو أشجار فاكهة أو محاصيل خضر وكذلك تحديد دلائل جودة التربة والتى تؤثر مباشرة على عمليات استصلاح الأراضى بأستخدام الطرق الحسابية وليست الوصفية وأيضا دراسة كيفية أستخدام تقنيات التحليلات الجيوإحصائية (الإحصاء الفراغية) فى وضع استراتيجية جمع العينات وتقليلها إلى أقل حد ممكن وكل ذلك تم فى بيئة نظم المعلومات الجغرافية.

ومن خلال ما سبق أوضحت النتائج ان أراضى منطقة الدراسة تتميز بأنها أراضى رملية عميقة ذات ملوحة وخصوبة منخفضة وذات قدرة إنتاجية تتراوح بين C3 & C4 وتغطى مساحات 93.50 % و 6.50% من اجمالى المساحة على التوالى وكان المعوق الأساسى هو قوام التربة الرملى وأوضحت النتائج أيضا أن هذه الأراضى ملائمة لزراعة معظم أنواع المحاصيل وأن دلائل جودة التربة الكيميائية السائدة بمنطقة الدراسة هى ملوحة التربة وكربونات الكالسيوم ونسبة الصوديوم المدمص (أوزان هذه الخواص هى 8.22% و5.84% و84.26% على التوالى) أما الدلائل الفيزيائية فكانت نسبة التشبع ومحتوى التربة من الرمل والماء المتاح (أوزان هذه الخواص 5.20% و84.46%و 8.59% على التوالى) ودلائل الخصوبة كانت البوتاسيوم المتاح وأيضا الحديد المتاح (أوزان هذه الخواص كانت 98.63% و1.11% على التوالى) وقد قدر دليل جودة التربة النهائى وكان القسم الثالث يحتل أكبر مساحة وتقدر بحوالى 83.00% من اجمالى المساحة المدروسة يليه القسم الرابع ثم الأول ثم الخامس وأخيرا القسم الثانى بمساحات 12.00% و2.00% و2.00% و 1.00% على التوالى.

وقد أوضحت نتائج التحليل الاحصائى أن الماء المتاح ونسبة التشبع وكربونات الكالسيوم تتبع فى توزيعها Spherical model وبالنسبة لملوحة التربة فتتبع فى توزيعها Gaussian model أما بالنسبة لنسبة الصوديوم المتبادل فتتبع Exponential model. وفى النهاية تم زيادة مسافات شبكة أخذ العينات المستخدمة لتكون 200م × 600م بدلا من 200م × 300م وبالتالى ليقل عدد

القطاعات من 163 الى 83 قطاع وتم عمل التحليل الجيواحصائى لها وتم دراسة معامل الإرتباط بين التحليل الجيواحصائى فى الحالتين بإستخدام Cross Validation وجد أن معامل الأرتباط له قيم مرتفعة بين العينات فى الحالتين مما يدل على أنه يمكن أختزال عدد العينات من 163 قطاع الى 83 قطاع وتكون النتائج بنفس وضوحها وقوتها ويوضح دور التحليل الجيواحصائى وأهميته فى وضع استراتيجيات جمع العينات. كذلك ظهر ببعض القطاعات طبقة بها تجمعات من أكاسيد الحديد وأحيانا تكون متصلبة بعض الشئ مما يؤكد الى أهمية الأخذ فى الأعتبار دراسات تقويم الأثر البيئ عند البدء فى استصلاح هذه الأراضى وتصميم شبكات الرى والصرف المناسبة لمنطقة الدراسة مع الأخذ فى الأعتبار وجود هذه الطبقة وعلاقتها بنموذج الأرتفاعات الرقمية والميول واتجاهاتها. وبالتالى لابد من الأهتمام بدراسة دلائل التنمية المستدامة حتى يكون هناك مجتمع مستدام.