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Evaluation of Soil Fertility by Using GIS Techniques for Some Soils of Dakahlia Governorate, Egypt

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ABSTRACT

Evaluation of soil fertility of alluvial soils in the Nile-Delta of Egypt is very important, especially after long periods of intensive cropping and loss of Nile-sediments after building the High Dam in the 1960s. The main objective of this work was to evaluate soil fertility in some of Dakahlia Governorate soils by using GIS techniques. Accordingly, 17 georeferenced soil profiles were randomly distributed within the studied area. Soil samples were collected from each profile at 0-30, 30-60, and 60-90 cm soil depth interval. Collected soil samples were analyzed for their physical, chemical, and fertility properties. Water samples were also collected from both irrigation and drainage canals close to each soil profile. These water samples were analyzed for their chemical properties. Evaluation of land capability and suitability for some crops production was performed using the Agriculture Land Evaluation System for arid and semi-arid regions (ASLEarid). Soils in the studied area were classified into two classes (excellent and good) according to theirphysical index andone class (excellent) based on their chemical index. Accordingly, the soil index was ranged between excellent and good. Soils were fit into two classes according to their fertility index, which are poor and very poor. Water quality was excellent and the environmental conditions varied from good to fair. The final index indicated that soils in the studied are fit into two classes (fair and poor). Land suitability for the selected crops varied from moderately suitable to very suitable. The limitations for crop productivity in the studied area can be alleviated through using proper fertility and land management practices.

Keywords: Soil fertility, Land capability, suitability, ASLEarid, GIS.

INTRODUCTION

Soil fertility represents one of the most important factors; which play a critical role in determining the farmer's choices regarding agricultural production, fertilization and soil and water conservation regimes (Mulder, 2000). Soil fertility depends on its chemical and physical properties such as acidity, organic matter content, soil texture and ability to hold water and nutrients. The productivity of agricultural land is also affected byclimatic elements; which include precipitation, evaporation, solar radiation, temperature and wind speed. These climatic elements are beyond farmer's control. Another factor is soil fertility, which is influenced by farmer's past and present activities.

In precision agriculture, evaluation of soil fertility represents the principal for land management. It doesn't only help in assessing the level of land productivity but also guide the rational development and utilization (Liu, 2010).Land evaluation is the process used for predicting land use based on its attributes, where a variety of analytical models can be used in these predictions, ranging from qualitative to quantitative (Rossiter, 1996).

The fertility of soil can be considered in different ways, depending on the type of land use. For instance, in intensively managed agricultural and horticultural systems, soil-fertility can be defined in terms of the value of produced products relevant to the inputs used. On the other hand, the concern may be focused only on the quality or the productivity. Consequently, the concept of soil-fertility could be very useful when it is being used in a certain context. However,soil fertility in all contexts depends mainly on soil physical, chemical and biological properties. Soil physiochemical properties are very criticalin case of soil fertility is measured in terms of the highest practical-level of productivity(Ramadan and El-Fayoumy, 2005; Salem *et al.*, 2008;NajafiGhiri *et al.*, 2010). On the other hand, addition of fertilizers can affect some features of the biological component of soil fertility, which is not a simple phenomenon. The addition of fertilizer increases plant growth, which is associated with an increase in other features of the biological activity in the soil.

Soil testbased represent the conventional method infertility management practices. This is an effective tool for increasing soil agricultural productivity for soils having a high degree of spatial variability. However, there manylimitations that constraint the application of that method over a large scale,especially in most of the developing countries.In the recent decades, GIS has provided effective tools for evaluating and mapping soil fertility. Soil fertility maps can support decision makes with more accurate and valuable information needed in developing nutrient management programs. They can also help in reducing the necessity to elaborate a plot-by-plot soil testing(Iftikar *et al.*, 2010; El-Sirafy *et al.*, 2011).It also helps inreducing the amount of applied fertilizers, which is not only help in saving money but the most important, is saving human health and the surrounding environment. Accordingly,one of the most important aspects of this work is testing the efficiency and the applicability of GIS models in evaluating land capability and its suitability for certain crops.

The main objectives of thisstudy were to evaluate of soil fertility of some soils in Dakahlia Governorate and their suitability for some strategic crops by using GIS techniques.

MATERIALS AND METHODS

1. Site Description

This study was carried out at Al-Sembelawaan and Temai Elamded districts, DakahliaGovernorate, Egypt. Studied area is located between these longitudes

31◦ 19’57.52” to 31◦ 41’ 29.22” E and latitudes 30◦ 48’ 13.20” to 30◦ 59’ 46.65” N.It covers an area of about 431km^2 as represented in Figure 1.Elevation varies from 1 to 2 m above sea level and slop is changes from 0 to 1 %. Minimum temperature in the studied area varied from 6.7^{o}C in January to 21.50^{o}C in July with an average of 14.19^{o}C.On the other hand, maximum temperature varied from 19.20^{o}C in January to 34.10^{o}C in July with an average of 27.03^{o}C. The mean annual precipitation is about 57.50 mm per year according to the National Authority of Meteorology in Egypt (unpublished data). Soils in the studied area are developed on Nile silt deposits (EGSMA, 1981).

Field crops, vegetables and fruit trees in the studied area includeWheat (*Triticumaestivum*), Barley (*Hordeumvulgare*), sugar beet (*Beta vulgaris*), Tomato (*Lycopersiconesculentum*), Potato (*Solanumtuberosum*), Green Pepper (*Clethraalnifoliarosea*),Olive (*Oleaeuropaea*) and date palm (*Cocusnucifera*).

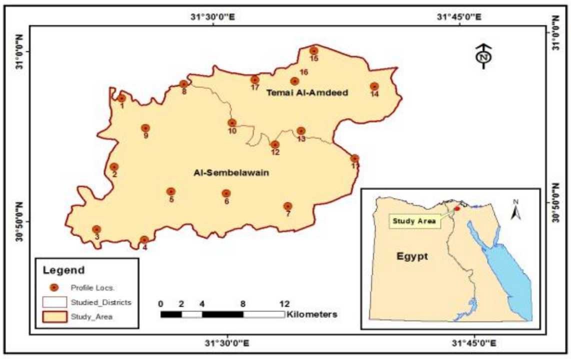

Figure 1. Location map of the study area and distribution of soil profiles.

2. Soil and water samples

Seventeen representative soil profiles were dug throughout the studied area. Coordinates of profile locations were recorded using the Global Positioning System (GPS). Soil samples were collected from each soil profile at three consequent depths (0-30, 30-60, and 60-90cm). These samples were air dried crushed, sieved to pass through a 2 mm sieve, and stored for soil physical, chemical and fertility analyses.

Water samples were also collected from irrigation, drainage and mixed water from irrigation and drainage canals. These water samples were analyzed for their chemical properties.

3. Physical analyses of soils samples

Mechanical analysis was carried out according to the international pipette method as described by Piper (1947).Bulk density was determined according to Dewis and Freitas (1970). Saturation percentage (SP) was determined using the method described by Richards, (1954).Total soil porosity was calculated based on soil real and bulk densities using the following equation:

$$\textbf{Porosity} = (1 - D_b / D_r) * 100$$

Where, D_b is soil bulk density (g cm^{-3}) and D_r is soil real density (it was estimated by 2.65 g cm^{-3}).

4. Chemical Analyses of soil and water samples

Total carbonates were determined as calcium carbonate using Collin`s calcimeterPiper, (1947). Organic matter was determined according toWalkley and Black method as described by Hesse (1971). The total nitrogen was determinedby micro-kjeldahl apparatusaccording to the method described by Jackson (1967).Available soil nitrogen was extracted in the 2.0 M KCl according to Hesse (1971) and determined by micro-kjeldahl apparatus. Available phosphorus was determined colorimetricallyusing the spectrophotometer at wavelength of 660 nm in the sodium bicarbonate extract as described by Olsen and Sommers (1982).Available potassium was extracted by ammonium acetate (1.0 N, pH=7) and measured on the flame photometer according to Knudesen *et al.* (1982).Soil reaction (pH) was directly measured in the soil paste using Beckman glass electrode pH meter Jackson, (1967).Electrical conductivity (EC) of soils was measured in the soil paste extract using the EC-meter as described by Hesse(1971). Soluble cations (Na^+, K^+, Ca^{2+}, and Mg^{2+}) and anions (CO_3^{2-}, HCO_3^-, and Cl^-) were measured in soil paste extract according to the methods described by Jackson (1967).Sulfate was calculated by subtracting the total soluble anions from the total soluble cations.Cation exchange capacity (CEC) was determined using sodium and ammonium acetate according to the method described by Hesse (1971).Exchangeable cations were determined as described by Dewis and Freitas (1970).

Water samples were analyzed for their chemical properties (soluble cations, anions, pH and EC) according to the previously mentioned methods used for soil analyses. Water quality parameter such as sodium adsorption ratio (SAR) and residual sodium carbonates (RSC) were calculated according to the following equations:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

Where; Na^+, Ca^{2+} and Mg^{2+} are the concentrations in meq L^{-1} of sodium, calcium, and magnesium ions in water samples. CO_3^{2-} andHCO_3^- are the concentrations of carbonate and bicarbonates (meq L^{-1}) in water samples.

5. Geo-statistical Analyses

Ordinary Kriging (OK) was used in this study to estimate the value of a random variable Z at one or more un-sampled points or locations, from more or less sparse sample data on a given support say: {z(x1), . . . , z(xN)} at {x1, . . . ,xN} (EPA, 2004).

Different kinds of Kriging methods exist, which pertains to the assumptions about the mean structure of the model: $E[Z(x)] = \mu(x)$

Z(x) is not intrinsically stationary. Having a deterministic model for $\mu(x)$, then $Z(x)–\mu(x)$ is intrinsically stationary (or even weakly stationary).

Ordinary Kriging is the most common type of Kriging. It was used in this work to interpolate surfaces of soil clay, available water, EC, bulk density, SOM, soluble K, exchangeable K and available K. The underlying model assumption in ordinary kriging is: E[Z(x)] = μ With μ unknown, the model for Z(x0) is:

$$\mathbf{Z(x0) - \mu} = \sum_{i=1}^{N} \lambda i\,(\mathbf{Z(x_i) - \mu}) + \mathbf{E\,(x_0)}\ \ \textbf{Or}\ \ \mathbf{Z(x0)} = \sum_{i=1}^{N} \lambda i\,(\mathbf{Z(x_i) + \mu(1-}\sum_{i=1}^{N} \lambda i\,)\mathbf{+E\,(x_0)}$$

We filter the unknown mean by requiring that the Kriging weights sum to 1, leading to the ordinary kriging estimator:

$$\mathbf{Z(x0)} = \sum_{i=1}^{N} \lambda i\,(\mathbf{Z(x_i) + E\,(x_0)}\ \textbf{subject to}\ \sum_{i=1}^{N} \lambda i = 1$$

The Geostatistical analyst in ArcGIS 10.3 (ESRI, 2008) was used to develop the semivariogram between each pairs of points versus their separation distances. This semivariogram was used in predicting the studied soil physiochemical properties.

6. Land capability and suitability evaluation

Evaluation of land capability and suitability in the studied area was carried out using the Agriculture Land Evaluation System for arid and semi-arid regions (ASLEarid) produced by Ismail *et al.* (2012).In this system soil physical, chemical and fertility properties are integrated.It also takes into account quality of irrigation water, climatic conditions and environmental conditions in the studied area.

RESULTS AND DISCUSSIONS

1. Soil physical properties

Data in Table 1 show the ranges, averages and Standard deviations of some soil physical properties of the studied soil profiles. These properties include: coarse sand, fine sand, total sand, silt, clay and saturation percentage. Coarse sand in the studied soils ranged between 0.17 and 54.41%. Fine sand varied from 6.68 and 51.54%. Total sand (TS) ranged between 12.11 and 72. 26% as represented in Figure 2. Silt percentage ranged between 14.05 and 55.45%. Claypercentage varied from 10.09 to 63.12%.Accordingly, the majority of soil textures in the studied area were silt loam. Spatial distribution within clay content at the surface layer of the studied soils is represented in Figure 3. Saturation percentage (SP) ranged between 41and 138% (about 71.46% in average). SP values were associated with higher clay content in the studied soils. Spatial distribution of SP at the surface layer of the studied soils is illustrated in Figure 4. Organic matter was very low in the studied soils and ranged between 0.19 and 1.43%. Figure 5 show the spatial distribution in OM within the studied soils at 30-60 cm. These values were decreased with soil depth. Calcium carbonates varied from 0.55 to 10.40% as illustrated in Figure 6. Bulk Density ranged between 1.00 and 1.16 g cm^{-3} soil with an average of 1.08 g cm^{-3}soil, which cauterizes fine-textured soils. Porosity varied from 56and 62% with an average of 59%.

Table 1. Ranges of soil physical properties in the studied soil profiles.

Physical Property	Min.	Max.	Average	STD
Coarse Sand (%)	0.17	54.41	7.59	9.91
Fine Sand (%)	6.68	51.54	25.83	11.96
Total Sand (%)	12.11	72.26	33.42	16.14
Silt (%)	14.05	55.45	30.06	10.90
Clay (%)	10.09	63.12	36.52	13.16
Soil Texture	--	--	Clay Loam	--
Saturation Percentage (SP)	41	138	71	16.29
OM (%)	0.19	1.43	0.67	0.34
$CaCO_3$ (%)	0.55	10.4	3.07	1.95
Bulk Density (g cm^{-3})	1.00	1.16	1.08	0.05
Porosity (%)	56.12	62.26	59.40	2.03

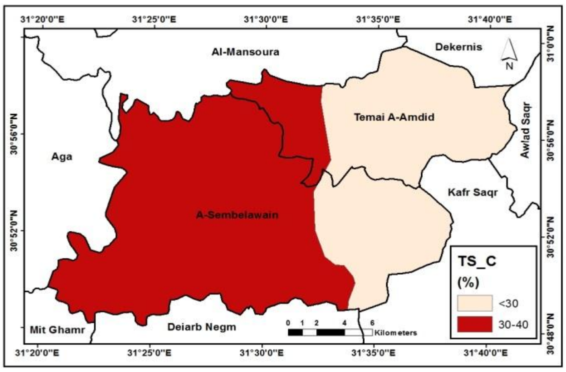

Figure 2. Spatial variability within total sand (TS) at the subsurface layer (60-90 cm) of the studied soils.

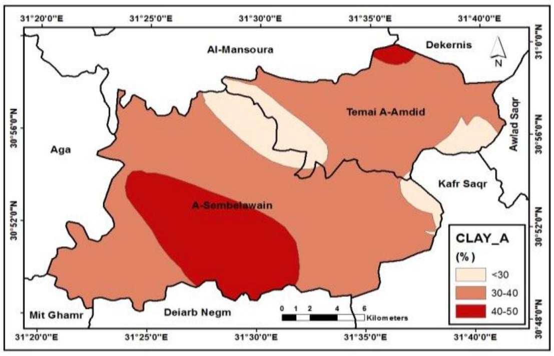

Figure 3. Spatial variability within clay content at the surface layer (0-30 cm) of the studied soils.

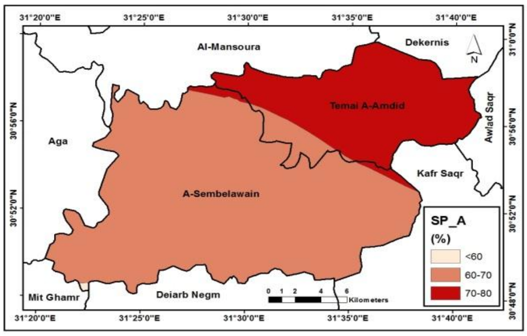

Figure 4. Spatial variability within saturation percentage (SP) at the surface layer (0-30 cm) of the studied soils.

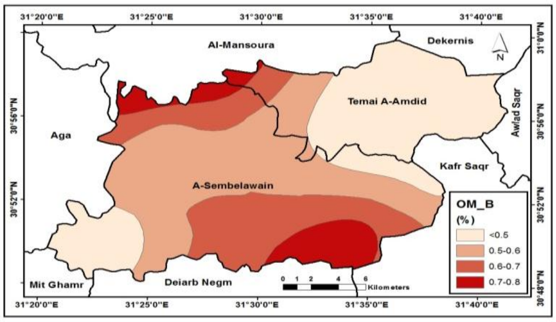

Figure 5. Spatial variability within organic matter (OM) at the subsurface layer (30-60cm) of the studied soils.

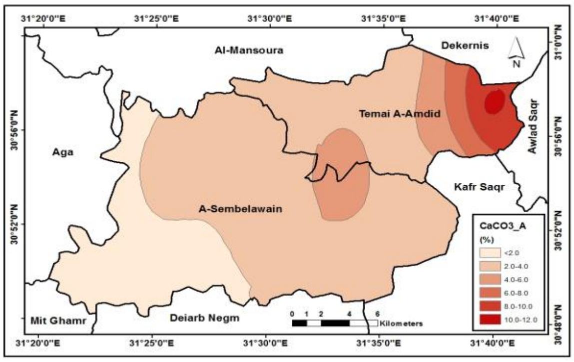

Figure 6. Spatial variability within total carbonates as $CaCO_3$ at the surface layer (0-30 cm) of the studied soils.

2. Soil chemical properties

Data in Table (2) show the ranges, averages and Standard deviations for some soil chemical properties of the studied soil profiles. These properties include soluble cations(Na^+, K^+, Ca^{2+} and Mg^{2+}) and anions (CO_3^{2-}, HCO_3^-, Cl^- and SO_4^{2-}), pH,electrical conductivity (EC),exchangeable cations, cationexchange capacity (CEC), and exchangeable sodium percentage (ESP).Sodium ions (Na^+)varied from 0.04 and 2.17 cmol/kg soil. Potassium ions (K^+) ranged between 0.003 and 0.044 cmol/kgsoil.Calcium ions (Ca^{2+}) varied from 0.05 and 0.60 cmol/kgsoil. Magnesium ions (Mg^{2+}) ranged between 0.05 and 0.53 cmol/kgsoil.

Carbonates ions (CO_3^{2-}) were null in soil paste extracts of the studied soil samples. Bicarbonate ions (HCO_3^-) varied from 0.10 and 0.45 cmol/kgsoil. Chloride ions (Cl^-) ranged between 0.05 and 1.77 cmol/kg soil. Sulfate ions (SO_4^{2-}) varied from 0.03 and 1.cmol/kgsoil. Soil pH ranged between 7.64 and 8.24 (about 7.95 in average) as illustrated in Figure 7. Electrical conductivity (EC) varied from 0.41 and 4.65 dS m^{-1} (about 1.88 dS m^{-1} in average). This indicates that most of the studied soils are non-saline, which could be contributed to the good management practices in the studied area.These results agree with those reported by Kaoud (1979).Figure 8 illustrates the spatial variability within EC values in the surface layer (0-30 cm) of the studied soils.

Exchangeable Na^+ varied from 1.03 and 5.13 cmol/kgsoil. Exchangeable K^+ ranged between 0.39 and 2.28 cmol/kgsoil. Exchangeable Ca^{2+}varied from 15.1 and 38.19 cmol/kgsoil. Exchangeable Mg^{2+} ranged between 11.1 and 29.14 cmol/kgsoil. The CEC values varied from 40.61 and 58.87 cmol/kgsoil (about 50.80cmol/kg soil in average). On the other hand, the ESP valuesranged between 1.90 and 11.10 % soil (about 4.17%), which indicates that the studied soils were non-sodic soils.

Table 2.Ranges of soil chemical properties in the studied soil profiles.

Chemical Properties		Min.	Max.	Average	STD
Soluble Cations (cmol/kgsoil)	Na^+	0.04	2.17	0.93	0.55
	K^+	0.003	0.044	0.011	0.01
	Ca^{2+}	0.05	0.6	0.22	0.10
	Mg^{2+}	0.05	0.53	0.19	0.11
Soluble Anions (cmol/kgsoil)	CO_3^{2-}	0.00	0.00	0.00	0.00
	HCO_3^-	0.10	0.45	0.20	0.07
	Cl^-	0.05	1.77	0.81	0.46
	SO_4^{2-}	0.03	1.41	0.34	0.29
pH		7.64	8.24	7.95	0.12
EC (dS m^{-1})		0.41	4.65	1.88	0.95
Exchangeable Cations (cmol/kgsoil)	Na^+	1.03	5.13	2.1	0.92
	K^+	0.39	2.28	1.05	0.41
	Ca^{2+}	15.1	38.19	26.36	4.33
	Mg^{2+}	11.1	29.14	21.28	3.85
CEC (cmol/kgsoil)		40.61	58.87	50.8	4.53
ESP (%)		1.9	11.1	4.17	1.86

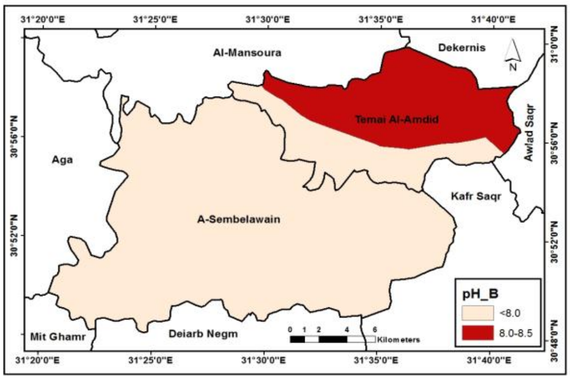

Figure 7. Spatial variability within pH values in subsurface layer (30-60 cm) of the studied soils.

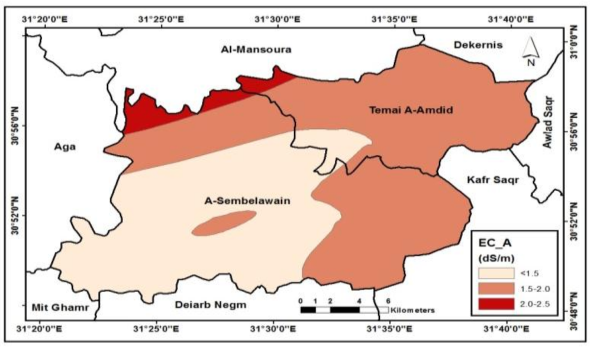

Figure 8. Spatial variability within EC values in surface layer (0-30 cm) of the studied soils.

3. Soil fertility properties

Data in Table(3) show the ranges of available NPK, total nitrogen (TN), organic carbon (OC) and C/N ratio in the studied soil profiles.Ammonia (NH_4^+) ranged between 32.96 and 120.16 mg/kg. Nitrates(NO_3^-) varied from 21.55 and 97.37 mg/kg. Available (N) ranged between 54.93 and 216.38 mg/kg (about 124 mg/kg in average). Available (P) varied from 0.17 and 8.68 mg/kg(about 5.4 mg/kgin average); which indicates a lower phosphorous content. This also indicates that soils in the studied area are in need to fertilization with phosphorus fertilizers. Available (K) ranged between 101 and 701mg/kg(about 310 mg/kg in average), which reveals a higher content. This could be attributed to the annuals additions of silt deposits before building the High Dam (El-Agrodi *et al*., 1998). Total (N) varied from 0.11 and 0.39%, which indicates a very low content. Organic carbon (OC)ranged between 0.20 and 0.83% (about 0.47% in average). The C/N ratiovaried from 0.99 and 5.03, which indicates that nitrogen mineralization is the dominant process in the studied soils

Table 3.Available NPK, total nitrogen (TN) and C/N ratio in the studied soil profiles.

Property		Min.	Max.	Average	STD
NH_4^+	(mg/kg)	32.96	120.16	77.74	21.80
NO_3^-	(mg/kg)	21.55	97.37	45.95	16.65
Available (NPK) (mg/kg)	N	54.93	216.38	123.69	34.17
	P	0.17	8.68	5.4	2.02
	K	100.78	700.61	310.39	122.50
Total Nitrogen (TN)	(%)	0.11	0.39	0.26	0.07
Organic Carbon (OC)	(%)	0.2	0.83	0.47	0.19
C/N Ratio	(%)	0.99	5.03	1.83	0.69

4. Irrigation Water Properties

Data in Table (4) show the ranges, averages and Standard deviations ofchemical parameters in the collected water samples (irrigation, drainage, and mixed (irrigation&drainage) water). Sodium was the dominant cation in the collected water samples. This was followed by calcium, magnisum and potassium ions, respectively. The average value of $Na^+$was 3.2, 5.23, and 6.09meq l^{-1} in irrigation, drainage, and mixed water samples; respectively. The average value of $Ca^{2+}$was 0.94, 1.53, and 1.87meq l^{-1} in the same sequence of water samples.The average value of $Mg^{2+}$was 0.83, 1.43, and 2.33meq l^{-1} in the same sequence of water samples. The average value of $K^+$was 0.12, 0.18, and 0.17meq l^{-1} in the same sequence of water samples.

Chloride was the dominant anion in the collected water samples. This was followed by bicarbonates and sulfates; respectively.Carbonates ions (CO_3^{2-}) were not detected in the collected water samples.The average value of Cl^- was 2.92, 4.58, and 5.61 meq l^{-1} in irrigation, drainage, and mixed water samples; respectively. The average value of bicarbonate ions (HCO_3^-) was 1.13, 2.26, and 2.63 meq l^{-1} in the same sequence of water samples. The average value of sulfate ions (SO_4^{2-}) was 1.04, 1.52, and 2.22meq l^{-1} in the same sequence of water samples.

There weren't significant variations in the pH values of the collected water samples. The average pH value was 8.77, 8.65, and 8.78 in irrigation, drainage, and mixed water samples; respectively. On the other hand, there were significant variations among the EC values of water sample. They were increased from 0.51 dSm^{-1} in irrigation water to 0.83 dSm^{-1}in drainage water, and 1.05 dSm^{-1} in mixed water. The calculated SAR values were 3.14, 4.24, and 4.07% in average within irrigation, drainage and mixed water samples; respectively. These values indicate no significant risk of soil alkalinity when these waters are used in irrigating field crops. The calculated RSC values were -0.65, -0.70, and -1.57 meq l^{-1} in average within the same sequence of water samples.These negative values also indicate no significant risk when used in crop irrigation.

Table 4. Chemical properties of the collected water samples from irrigation and drainage canals in the studied area.

Type of Water		Irrigation				Drainage				Mixed water			
Chemical Parameter		Min.	Max.	Aver.	STD	Min.	Max.	Aver.	STD	Min.	Max.	Aver.	STD
Soluble cations (meq/l)	Ca^{2+}	0.48	2.13	0.94	0.60	0.90	2.30	1.53	0.59	1.50	2.10	1.87	0.32
	Mg^{2+}	0.30	2.70	0.83	0.84	1.20	1.94	1.43	0.35	1.08	3.49	2.33	1.21
	Na^+	1.25	10.58	3.20	3.30	2.87	7.47	5.23	1.90	2.20	9.05	6.09	3.52
	K^+	0.08	0.21	0.12	0.05	0.11	0.24	0.18	0.06	0.14	0.19	0.17	0.03
Soluble anions (meq/l)	CO_3^{2-}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	HCO_3^-	0.60	2.52	1.13	0.66	1.92	2.72	2.26	0.40	1.60	3.48	2.63	0.95
	Cl^-	1.35	10.06	2.92	3.17	2.45	7.26	4.58	1.99	2.30	7.67	5.61	2.90
	SO_4^{2-}	0.53	3.04	1.04	0.89	0.74	1.95	1.52	0.56	1.02	3.11	2.22	1.08
pH	pH	8.41	9.15	8.77	0.25	8.27	9.10	8.65	0.37	8.70	8.83	8.78	0.07
EC	dS/m	0.25	1.55	0.51	0.47	0.51	1.19	0.83	0.28	0.50	1.36	1.05	0.48
SAR		1.68	6.81	3.14	1.75	2.80	5.13	4.24	1.02	1.94	6.09	4.07	2.08
RSC	(meq/l)	-2.31	-0.05	-0.65	0.77	-1.52	-0.18	-0.70	0.60	-2.79	-0.95	-1.57	1.05

5. Land capability indices

Data in Table 5 show soil physical, chemical, and fertility indices, water index, environmental index and final land capability index of the studied soils.According to the physical index the studied soilswere fit into two classes, which are excellent and good.Soils in the studied area were fitone class (excellent) according to the chemical index. Accordingly, the soil class of the studied soilswas fit into two classes, which are excellent and good. The fertility index was fit into two classes,which are poor and very poor. This could be attributed to the intensive cropping systems in the area, the lower addition of organic fertilizers and loss of Nile-sediments after building the High Dam(Lawrence *et al*., 2010)(Ali *et al*.,2008). The water class in the studied area wasexcellent and the environmental index was fit into two classes (good and fair). Accordingly, the final land capability index for the studied soilswas fit into two classes,which are fair and poor as illustrated in Figure 9. These limitations for crop productivity in the studied area are not permanent and they can be improved through applying proper fertility and land management practices.

Table 5 .Soil physical, chemical, and fertility indices, water, environmental and final land capability indices of the studied soils.

	Physical Index	Chemical Index	Soil Index	Soil Class	Fertility Index	Fertility Class	Water Index	Water Class	Environ. Index	Environ. Class	Final Index	Final Class
1	92.48	96.15	88.92	C1	16.57	C5	96.92	C1	75.77	C2	42.05	C3
2	81.6	96.36	78.63	C2	12.47	C5	98.4	C1	59.91	C3	33.4	C4
3	71.12	95.41	67.86	C2	11.47	C5	100	C1	59.91	C3	31.09	C4
4	83.77	98.42	82.45	C1	13.6	C5	99.85	C1	59.91	C3	35.6	C4
5	86.78	95.92	83.24	C1	20.25	C4	98.81	C1	64.86	C2	46.01	C3
6	82.64	98.06	81.04	C1	18.91	C5	98.06	C1	64.86	C2	44.04	C3
7	76.08	97.66	74.3	C2	19.07	C5	98.71	C1	64.86	C2	43.74	C3
8	76.93	97.03	74.65	C2	17.79	C5	98.71	C1	64.86	C2	42.04	C3
9	86.11	96.94	83.48	C1	20.15	C4	97.83	C1	64.86	C2	45.85	C3
10	67.5	96.39	65.07	C2	16.89	C5	100	C1	64.86	C2	40	C3
11	70.42	95.31	67.12	C2	18.27	C5	100	C1	64.86	C2	42.08	C3
12	86.31	97.12	83.82	C1	18.31	C5	99.07	C1	64.86	C2	43.46	C3
13	84.48	95.2	80.43	C1	19.09	C5	89.66	C1	64.86	C2	43.76	C3
14	85.89	96.34	82.75	C1	15.79	C5	88.4	C1	64.86	C2	39.17	C4
15	78.5	96.94	76.1	C2	18.26	C5	89.36	C1	64.86	C2	42.32	C3
16	91.23	96.68	88.2	C1	20.49	C4	93.66	C1	64.86	C2	46.38	C3
17	85.26	96.98	82.69	C1	19.21	C5	91.28	C1	64.86	C2	44.19	C3
Min.	67.50	95.20	65.07	---	11.47	---	88.40	---	59.91	---	31.09	---
Max.	92.48	98.42	88.92	---	20.49	---	100.00	---	75.77	---	46.38	---
Average	81.59	96.64	78.87	---	17.45	---	96.40	---	64.63	---	41.48	---

C1= Excellent, C2= Good, C3= Fair, C4= Poor, and C5= Very poor

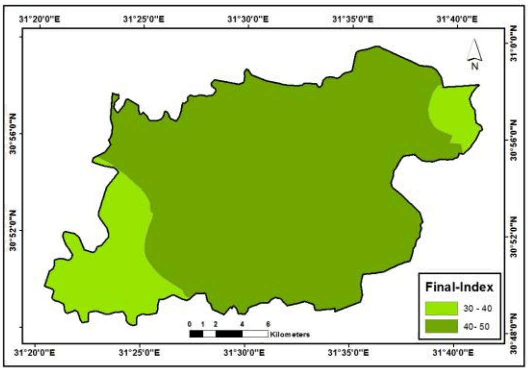

Figure 9. Final land capability index for the studied soils.

6. Land Suitability:

Data in Table 6 represent land suitability results for the selected field crops, vegetables, and fruit trees in the studied area. These data indicate that soils in the studied area are highly suitable for wheat, barley, maize, peanut, faba bean, alfalfa, sugar beet, potato, pea, date palm, fig, grape, and citrus. However, they were moderately suitable for tomato, pepper, watermelon, onion and olive. This may be due to the sensitivity of these crops for soil salinity, alkalinity and heavy soil texture.Figures 10 to 12 show the spatial distribution of land suitability for some of the studied crops.

Table 6. Land suitability results for the selected field crops, vegetables, and fruit trees in the studied area.

Profile No	Wheat	Barley	Maize	Sugar Beet	Peanut	Faba Bean	Alfalfa	Potato	Tomato	Pepper	Water-melon	Onion	Pea	Date Palm	Olive	Fig	Grape	Citrus
1	93.16	93.16	92.21	93.45	93.00	92.21	88.57	88.72	49.45	42.01	42.01	43.14	92.21	90.07	42.01	90.07	90.07	91.12
2	92.29	92.29	92.88	94.13	90.73	92.88	90.59	89.36	49.81	43.69	42.31	44.86	95.90	90.73	40.98	87.87	90.73	94.76
3	88.75	88.75	87.10	91.14	92.66	87.10	84.38	88.39	50.87	43.22	41.86	42.07	89.92	92.66	41.86	89.75	89.75	88.85
4	90.62	90.62	94.80	93.05	94.74	94.80	88.95	93.31	50.37	44.18	44.18	44.35	94.80	91.76	42.79	91.76	94.74	93.67
5	91.99	91.99	93.09	94.34	93.88	88.99	87.45	89.56	48.35	42.41	42.41	41.63	88.99	90.93	42.41	90.93	90.93	91.98
6	92.84	92.84	95.47	93.71	90.32	92.47	91.13	88.96	49.59	43.49	43.49	44.66	92.47	90.32	42.13	90.32	93.26	91.37
7	87.57	87.57	88.73	89.92	96.16	86.63	85.96	91.73	51.13	43.44	43.44	41.51	86.63	93.13	43.44	93.13	93.13	87.67
8	86.74	86.74	87.89	89.07	96.46	82.02	82.46	92.02	51.29	43.57	43.57	41.11	82.02	93.43	43.57	93.43	93.43	86.84
9	89.87	89.87	91.06	92.29	92.15	88.90	88.22	87.90	50.59	42.98	42.98	42.60	88.90	92.15	42.98	92.15	92.15	87.14
10	84.67	84.67	85.79	86.94	91.08	85.79	83.11	89.71	51.63	45.29	43.86	41.43	88.57	94.04	42.48	91.08	94.04	84.76
11	84.38	84.38	85.50	86.65	97.17	81.73	80.22	92.70	50.04	43.89	43.89	40.00	81.73	94.12	43.89	94.12	94.12	84.48
12	91.21	91.42	92.41	93.66	91.42	92.41	86.72	87.21	50.19	42.64	42.64	43.23	92.41	91.42	42.64	91.42	91.42	88.44
13	91.14	91.14	90.15	93.58	91.46	83.32	84.59	85.18	50.21	41.85	41.85	42.38	83.32	91.46	42.66	91.46	89.39	86.69
14	92.26	92.26	93.65	94.15	90.75	90.70	88.41	87.26	49.82	41.52	42.87	42.63	90.70	90.75	42.32	90.75	88.60	90.06
15	95.88	95.88	87.29	91.61	87.33	87.29	91.16	81.34	47.95	39.96	39.96	41.03	87.29	87.33	40.73	87.33	85.26	83.93
16	91.58	91.58	90.59	94.03	91.19	90.59	87.06	84.93	50.07	41.72	41.72	42.58	90.59	91.19	42.53	91.19	89.03	87.11
17	94.24	94.24	89.09	92.48	92.03	89.09	92.51	85.71	48.94	40.78	40.78	41.88	89.09	89.14	41.57	89.14	87.02	88.45
Min.	84.38	84.38	85.50	86.65	87.33	81.73	80.22	81.34	47.95	39.96	39.96	40.00	81.73	87.33	40.73	87.33	85.26	83.93
Max.	95.88	95.88	95.47	94.34	97.17	94.80	92.51	93.31	51.63	45.29	44.18	44.86	95.90	94.12	43.89	94.12	94.74	94.76
Average	90.54	90.55	90.45	92.01	92.50	88.64	87.15	88.47	50.02	42.74	42.58	42.42	89.15	91.45	42.41	90.94	91.00	88.67

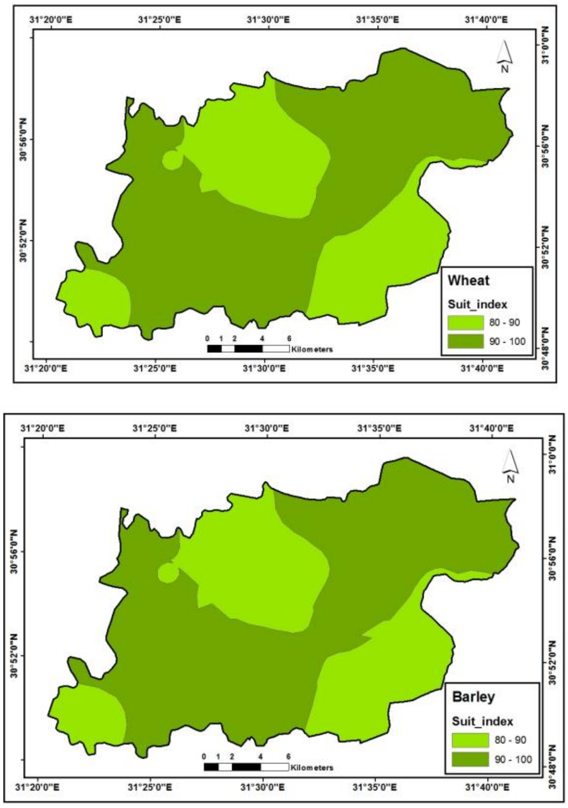

Figure 10. Land suitability for wheat and barley in the studied area.

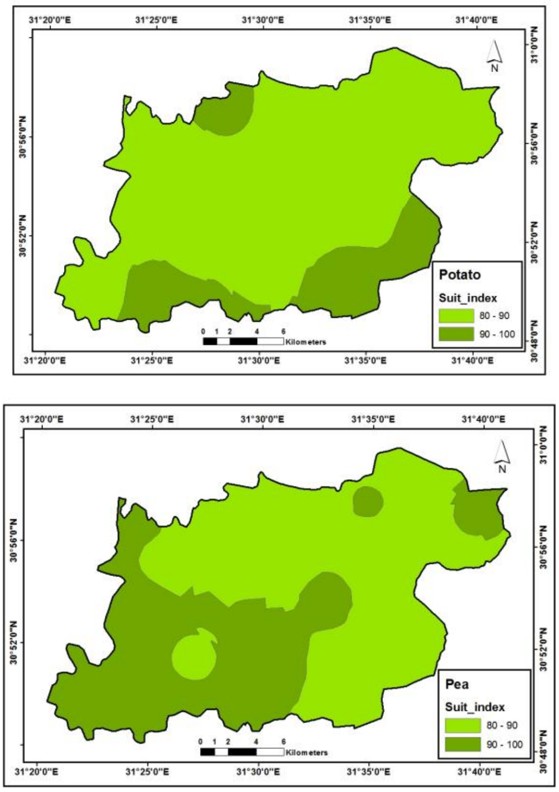

Figure 11. Land suitability for tomato and pea in the studied area.

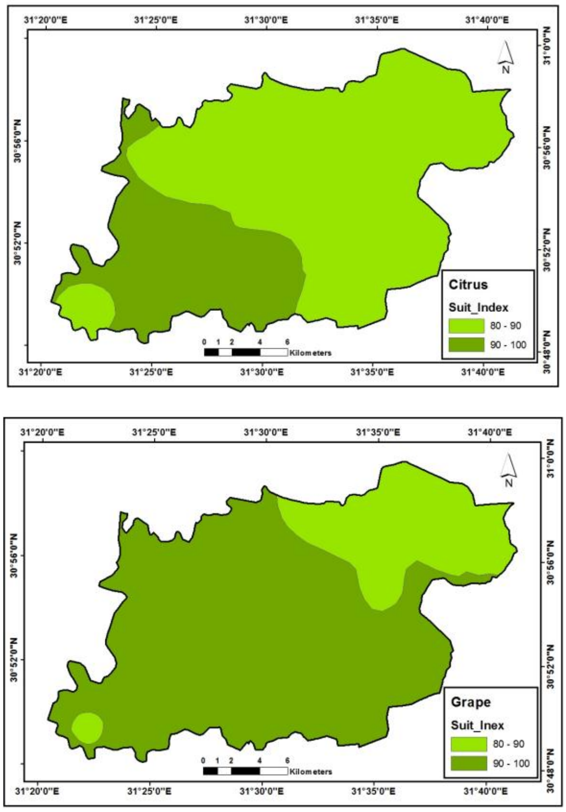

Figure 12. Land suitability for citrus and grape in the studied area.

CONCLUSIONS

It could be concluded that soil fertility evaluation using GIS models and techniques could be very helpful in providing more accurate and time-wise information about the status of soil fertility within certain area. Soils in the studied area varied from excellent to good according to their physical index and they were excellent depending on their chemical index. The soil index was ranged between excellent and good. However, these soils varied from poor to very poor according to their fertility index. This could be attributed to the use of intensive cropping system, lower addition of organic fertilizers and loss of Nile-sediments after building the high dam. Water quality of irrigation water was excellent and the environmental conditions ranged between good and fair. The overall index of land capability within the studied area ranged between fair and poor. Land suitability for the studied crops varied from moderately suitable to very suitable.

In conclusion, the limitations for crop productivity in the studied area were not permanent and they can be improved through proper fertility and land management practices.

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تقييم خصوبة التربة باستخدام تقنيات نظم المعلومات الجغرافية لبعض أراضى محافظة الدقهلية، مصر

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يعتبر تقييم خصوبة التربة الرسوبية في دلتا النيل بمصر على درجة كبيرة من الأهمية وخصوصا بعد فترات طويلة من الزراعة الكثيفة للمحاصيل وفقدان الرواسب النيلية بعد بناء السد العالي في ستينات القرن الماضى. وكان الهدف الرئيسي من هذه العمل هو تقييم خصوبة التربة لبعض الأراضى بمحافظة الدقهلية باستخدام تقنيات نظم المعلومات الجغرافية. وبناءعلى ذلك،تم توزيع ١٧ قطاعا أراضيا معلومة الأحداثيات بطريقة عشوائية داخل منطقة الدراسة. وتم جمع عينات تربة من كل قطاع على أعماق ٠ـ٣٠ ، ٣٠ـ٦٠ ، ٦٠ـ٩٠ سم. وقد تم تحليل عينات التربة بالنسبة لخصائصها الفيزيائية والكيميائية وخصوبتها. كما تم أيضا جمع عينات مياه من كل من قنوات الري والصرف القريبة من كل قطاع أرضى. وقد تم تحليل عينات المياة بالنسبة لخصائصها الكيميائية. وتم إجراء تقييم القدرة الإنتاجية للأراضى ومدى ملائمتها لبعض المحاصيل باستخدام نظام تقييم الأراضى الزراعية فى المناطق الجافة وشبه الجافة (ASLEarid). وتم تصنيف التربة في منطقة الدراسة فى فئتين (ممتازة وجيدة) تبعا للمؤشر الفيزيائى للتربة وفئة واحدة (ممتازة) على أساس المؤشر الكيميائي. وتبعا لذلك، تراوح مؤشرالتربة بين ممتاز وجيد. ووقعت الأراضى فى فئتين تبعا لمؤشر الخصوبة وهما فقيرة وفقيرة جدا. وكانت جودة مياة الرى ممتازة وتراوحت الظروف البيئية بين جيدة ومعتدلة. وأشارالمؤشرالنهائي للقدرة الإنتاجية للتربة أن التربة فى منطقة الدراسة تقع فى فيفئتين (معتدلة و فقيرة). واختلفت ملائمة التربة للمحاصيل المختارة بين ملائمة جدا ومتوسطة الملائمة. ويمكن الحد من معوقات إنتاجية التربة للمحاصيل في منطقة الدراسة عن طريق استخدام الممارسات المناسبة لخصوبة وإدارة التربة.