GIS - Comprehensive Analytical Approach for Soil Use by Linking Crop Soil Suitability to Soil Management and Reclamation

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ABSTRACT

Region of Alex-Cairo Desert Road (Egypt) has agricultural potentiality to contribute to food security; therefor the soil of the farm of Nile Company, at 63 Km Alex-Cairo Desert Road, was evaluated by applying our comprehensive analytical approach of evaluation. Soil physical and chemical characterization conducts to soil numerical classification and crops soil suitability that has the advantage to guide the practices of soil management and reclamation.

Soil physical characterization leaded to univariate numerical soil classification that pointed that the major phases were moderately soil profile depth (1996.76 Feddan), moderately permeability (3543.90 Feddan), low holding capacity (2608.11 Feddan) and sandy loam textural phases (1800.83 Feddan). Soil chemical characterization led to univariate numerical soil classification which showed that the major classes were moderately saline (3124.76 Feddan), non-sodic (3531.04 Feddan) and non-calcareous classes (3851.35 Feddan).

The study referred to selection salt tolerant crops as cultural practice for managing soil salinity. Leaching requirements (LR) of reclamation purposes, for different EC-tolerance crops, were determined to output GIS–EC edaphological map. This map that may guide the process of saline soil reclamation was composed of four mapping units having the area of 298.76, 3124.76, 845.35 and 16.11 Feddan. The map that determined the spatial distribution of (LR) application showed that: the max allover total leaching water requirements (ATLR) of 13189090.54 m³ are to cultivate all studied area by orange. (b) Wheat is more salts tolerant than orange. Accordingly, the max allover total leach requirements were 1557042.70 m³/studied soil to plant wheat, which were less greatly than the case of orange cultivation.

GIS-ESP edaphological soil classification was elaborated by assigning ESP thresholds of tolerant crop range to GIS-ESP soil map to produce the GIS-ESP edaphological map. The map divided the studied area into three categories of ESP tolerance crop soil; extremely sensitive ESP crop (1355.09 Feddan), sensitive ESP crop (2845.73 Feddan) and moderately tolerant crop (84.88 Feddan). This edaphological soil classification enabled to calculate edaphological gypsum requirement (GR) for different ESP-tolerance crops. GIS-EC and ESP overlaid maps output the soil multivariable chemical classification. The overlaid GIS-EC-map classified the studied soils into five variants; non saline-non sodic soil (298.80 Feddan) moderately saline-non sodic soil (2701.42 Feddan), highly saline-non sodic soil (535.95 Feddan), moderately saline-sodic soil (424.04 Feddan), and highly saline-sodic soil (325.47 Feddan)

Land suitability determined the main limitation factors to guide soil management and reclamation. Wheat soil suitability classified the soils into of the area was conditionally suitable (S4 =57.3%) and (S3 = 42.7%). As for faba bean, the soils had the three classes; marginally suitable (S3= 47.6%), conditionally suitable (S4 = 30.7%), and moderately suitable (S2 = 21.7%). Grape soil suitability map distributed into two main classes; 63.8% (moderately suitable = S2), 26.1 % (marginally suitable =S3). Soils majority was moderately suitable (S2 = 64.5 %) for olive tree. 61.79 % (moderately suitable = S2), 19.64 % (marginally suitable = S3), represented the majors of potato soils suitability. The largest area of the study area (88.02 %) was classified as highly (S1 = 40.5%) and moderately suitable (S2 = 47.5%) for tomato.

Keywords: GIS, Soil numerical classification, GIS-EC and ESP overlaid maps, GIS-EC edaphological map, Soil GIS-ESP edapholoical soil classification, Multivariable chemical classification, Soil suitability.

INTRODUCTION

The economic development of Egypt is highly dependent on agricultural sector that represents around 40% of the Egyptian workforce and it is the third largest economic sector after tourism and cash remittances from Egyptians working abroad (FAO, 2018a).

Due to wrong and overexploitation of land use in Egypt, the land degradation problem has become an issue of concern. (Abdelaty, 2016) studied an agricultural area (Specific area in Nile Delta) that has been declined by 11.15 % within the period of six years (2008 to 2014) .So, (Mohammed, 2006) considered that the rapidly changing in land use may result a significant resource imbalance. To face this issue, the Egyptian Government has launched the Sustainable Agricultural Development Strategy towards 2030 which aim to reclamation of 1.5 Million Feddan. Goals of this

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Strategy would be achieved when lands were categorized and utilized based upon their different characteristics (Kassim et al., 2018).

Soil numerical classification is an objective classification based on the actual differences between individual soils. The general idea is to minimize within-class variance, and maximize between-class variance, according to some objective criterion (FAO, 2018b).

Saline and sodic soils are commonly occurring in most part of the world (Prapagar et al., 2012) especially in the arid and semi-arid regions, whereas, globally there are 400 million hectares of land (over 6% of the world land area) affected by either salinity or sodicity (Gurung and Azad, 2013). Salt-affected soils (saline, sodic and saline-sodic) differ considerably in use suitability, productivity, ease of reclamation, and management (Diaz and Presley, 2017). The leaching has been identified as the most effective method for removal of soluble salts from the rhizosphere in saline soils while application of chemical amendments (such as addition of gypsum) to remove the sodium from the soil's cation exchange sites is necessary to reclaim sodic soils (Prapagar et al., 2012).

Land suitability analysis is a very important technique for agricultural activities to deciding future cropping pattern, planning and activities. It is determining appropriate crops for a specific piece of land according to its characteristics (Singha and Swain, 2016; Pan and Pan, 2012) and allows identification of the limiting factors for the crop cultivation (Joerin et al., 2001).

The coupling of soil suitability model, GIS and remote sensing has become increasingly important for getting the different soil suitability maps that will be guide for decision makers in order to achieve high agricultural productivity (Singha and Swain, 2016).

In Egypt, a number of studies were elaborated to evaluate land suitability for crops (Abdel-Hamid et al., 2010; Aldabaa et al., 2010; Abd-Elmabod et al., 2012; Wahab et al., 2013; ElGhonamey, 2015; Aldabaa and Khralifa, 2016; Afify et al., 2016; ElBaroudy, 2016; Elnaggar, 2017; Fadl and Abuzaid, 2017; Abd El-Aziz, 2018).

The main target aim of this study was to link the GIS- maps of soil numerical classification to soil management and reclamation. While, the other objectives were: (a) precise the practices of soil management and reclamation (b) determine the different soil factors limitation.

MATERIALS AND METHODS

1. **The study area:** The study area located in the north eastern part of the Western Desert, it's bounded by the Alexandria Cairo desert road in North Eastern (785263 E, 3409453 N) and El-Nasr Canal in South Western (776481 E, 3403013 N). It covers about 4285.71 Feddan (Figure 1). El-Nasr canal is the main source of irrigation in the study area.

Agroclimatic data indicated referred that the study area has an aridity index (0.02) to lay in agroclimatic region of hyper-arid, mild winter, warm summer. It has indicated mean annual temperature of 21.2 C°. The mean monthly temperature ranges from 13.7 C° (January) to 27.8 C° (August). The highest temperature recorded, as a mean value, was 34.50 C° in July and the lowest was 7.80 C° (9) January (Abdelaty, 2015).

2. Elaboration Study

The study was based on physical and chemical soil characterization that was elaboration through two phases (Figure 2).

Data collection and Georeferenced soil sampling

Data collection: The data collection including topographic maps and satellite image (ASTER images and Google Earth Pro). Topographic maps were digitized using ArcGIS 10.2 software to produce the base map of GIS soil maps. Satellite image displayed the general location of the studied area (ArcGIS 10.2 software, 2008).

Georeferenced soil sampling: Fifty-one soil samples were collected from twenty-five soil profiles that were located by the global position system (GPS). The GPS was adjusted to acquire UTM coordinates of soil samples (Figure 3). Soil samples were collected depending soil morphological characteristics to represent all soil variations. Twenty five soil profiles were dug to a depth of 120 cm, or to the hard layer, whichever is closer to the soil surface.

Soil Physical and Chemical Characterization

The collected disturbed soil samples were air-dried, ground gently, and then sieved through 2 mm sieve to elaborate soil physical and chemical analysis:

Physical analysis: Soil texture determined by hydrometer's method (FAO, 1970), hydraulic conductivity coefficient (K) (Stibinger, 2014) and water holding capacity (Viji and Rajesh, 2012).

Chemical analysis: Electric conductivity (EC), soluble cations (Ca, Mg, Na, and K), soluble anions (CO_3, HCO_3, and Cl) of soil past extract, soil pH of (1:2.5) suspension and calcium carbonate (Page et al., 1982).
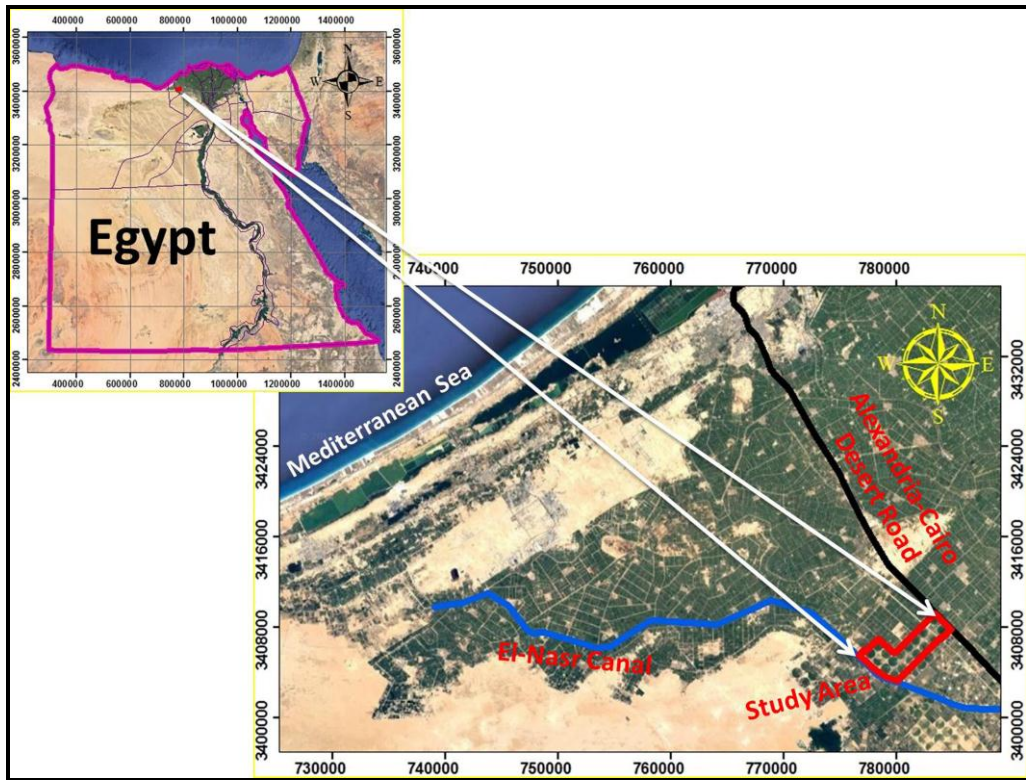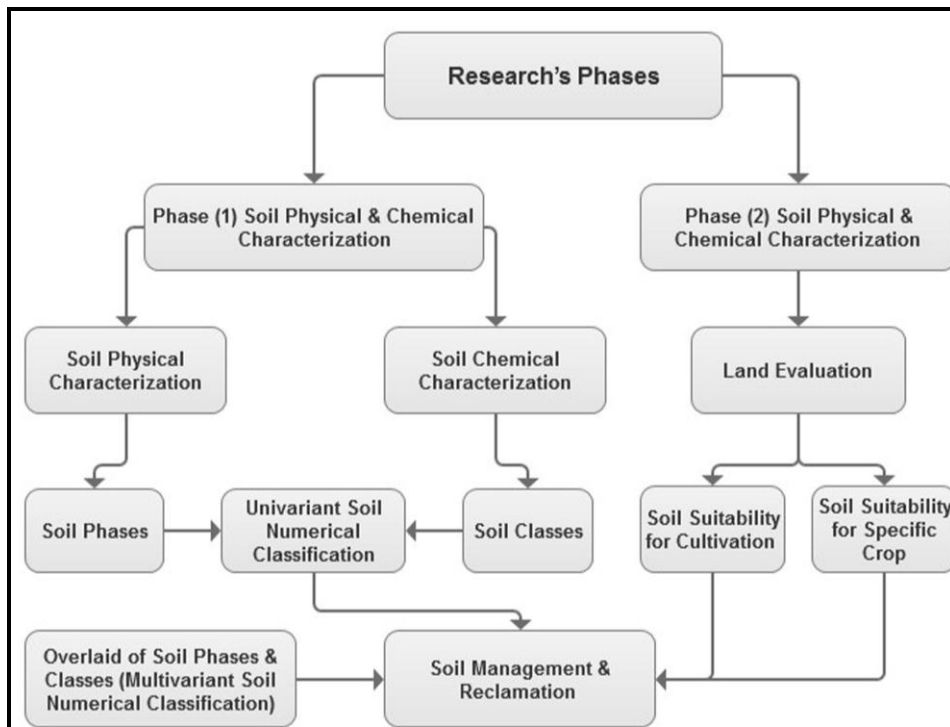
Figure 1. Location of studied area
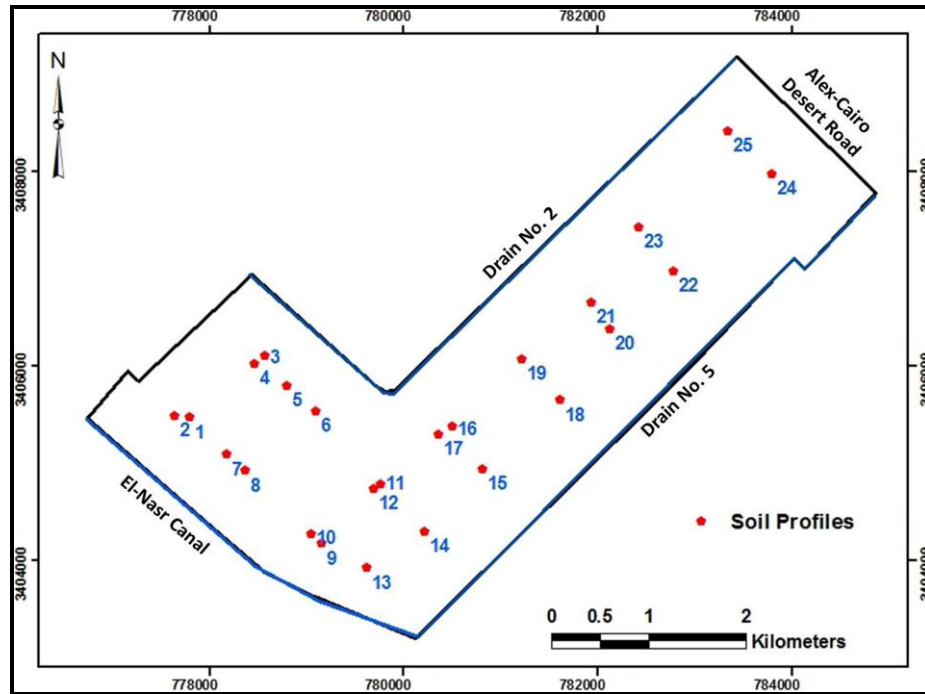

Figure 2. Research flow chart

Figure 3. Research flow chart

GIS - data processing of soil chemical and physical

The data of soil chemical and physical analysis were weighted by arithmetic mean (Mishra, 2004) to be processed to output soil maps (ArcGIS 10.2 software, 2008).

$$WM = \frac{\sum\limits_{i=1}^{n} w_i x_i}{\sum\limits_{i=1}^{n} w_i};$$

Where:

WM = Weighted Arithmetic Mean

Xi = Variable value (Soil parameter)

Wi = weighting factor (Horizon thickness)

Determination of leaching requirements (LR) for different EC-tolerance crops:

The following equation can be used to estimate how much water is required to leach salts for reclamation purposes:

DW = (K × Ds × ECei) / ECef, where :

DW = depth of water infiltrated

Ds = soil depth to be reclaimed = crop rooting depth

K = 0.30 for fine – textured soils, 0.10 for coarse – textured soils

K = 0.1 for all soils (sprinkler irrigation and pivot irrigation system)

ECei = initial soil salinity = thresholds of the mapping units or soil salinity classes

Accordingly:

Min. ECein = Min. initial soil salinity = The first (lower) threshold of the mapping unit or soil salinity class (n)

Max . ECein = Max .initial soil salinity = The second (upper) threshold of the mapping unit or soil salinity class (n)

ECef = Desired final soil salinity (target soil salinity) = EC soil paste that enables to obtain zero crop yield (Bauder et al., 2018)

Determination of gypsum requirements (GR) for different ESP-tolerance crops:

ESP values and samples coordinates were input to map GIS-ESP edapoloical soil classification. GIS-ESP map was based on the following information and considerations:

GR (ton gypsum/feddan, by rough method) =1.7 * KNa$_{ex}$ *D/30 (Abd El-Hady, 2009), Where;

D = Crop rooting depth

Naex = exchangeable sodium (meq/100 gm)

KNaex = Required Naex to be removed from the soil

Calculate the exchangeable sodium (Naex)

The studied soils characterized by had moderate cations exchange capacity (CEC) that had value of 25 meq/100 gm. The cations exchange capacity was used to calculate the exchangeable sodium (Naex): Naex (meq/100 gm) = ESP * CEC = ESP * 25

Initial Naex = Initial soil Naex (Naex before gypsum application)

RNaex = the reference ESP threshold tolerant crop ESP

KNaex = Initial Naex - RNaex

Min. RNaex and Max. RNaex thresholds, of ESP tolerant crop ESP, representing ESP

      tolerant crop range

Min KNaex = Initial Naex - Min RNaex

Max.KNaex = Initial Naex - Max.RNaex

Application efficiency of gypsum requirements gypsum requirements (EF) = 92 %

Gypsum purity (GP) = 93 %   (Abd El-Hady, 2009)

Land evaluation

Land was evaluated by applying Agricultural Land Evaluation System for arid region (ALESArid) Model (Abdel Kawy, 2004). ALES-Arid enables to evaluate the suitability for 32 crops to determine the optimum land use. FAO (1979) and Ismail et al., 1994 & 2001 rated Land suitability classes (Table 1).

Table 1. Land suitability classes

Class	Description	Rating (%)
S1	Highly suitable	100 - 80
S2	Moderately suitable	80 - 60
S3	Marginally suitable	60 – 40
S4	Conditionally suitable	40 - 20
NS1	Potentially suitable	20 - 10
NS2	Actually unsuitable	< 10

RESULTS AND DISCUSSION

Soil Physical Characterization for Univariate Soil Numerical Classification

Soil physical characterization: Table (2) summarizes some soil physical characteristics; profile depth, hydraulic conductivity (Ks), water holding capacity (WHC) and soil texture. The minimal soil profile depth was 43 cm (profile 24), and maximal was 120 cm. The min. value of soil hydraulic conductivity was 4.3 cm/hr in subsurface sample (profile 14), and max. value reached to 12 cm/hr samples; 1, 15, 17, 20, 23 and 25. Water holding capacity ranged between the minimum value 10% (surface samples of profiles, 11 and 15), and maximum value 38% (subsurface sample, profile 2). The

soil texture for the study area varied from sandy clay loam (sample 48) to sand textured sample (21).

Soil Physical-Univariate Numerical Classification for Soil Management and Reclamation: Soil profile depth, soil texture, water holding capacity, and hydraulic conductivity (Ks) were separately used to classify the studied soil into different phases. A soil phase is a unit of soil outside the system of soil taxonomy. It is a functional unit that may be designed according to the purpose of the survey (Canada Government, 1998). Meanwhile, the term of soil class was restricted to denote soil mapping units that are chemically different.

▪ **Soil Profile Depth:** Most of the soil profiles were characterized by hard layer; therefore the classification of the profile depth was based on it (depth and hardness). Soil profiles were classified into phases; deep soil (> 95 cm), moderately deep soil (70 – 95 cm) and shallow soil (< 70 cm) that were presented by area of 1632.42, 1996.76 and 656.78 Feddan, respectively (Table 3 and Figure 4).

▪ **Soil Texture:** Mechanical analysis results showed that the studied soil were grouped four into textural phases; sand (312.00 Feddan), sandy clay Loam (583.54 Feddan), loamy sand (1589.35 Feddan) and sandy loam (1800.83 Feddan) (Table 3 and Figure 4).

▪ **Hydraulic Conductivity (Ks):** Soil hydraulic conductivity was determined due to the importance of soil permeability in the soil drainage condition and the growth of crops. The hydraulic conductivity values categorized the soil area into three categories; slow permeability (163.33 Feddan), moderately permeability (3543.90 Feddan) and rapid permeability (577.76 Feddan) with Ks values of <7.5, 7.5-10 and >10 cm/hr (Table 3 and Figure 4). The moderately permeability phase (3543.90 Feddan) dominated the area with 82.70 %.

▪ **Water Holding Capacity (WHC):** The studied soil was characterized by the dominance of the phase of low field water holding capacity (<15 %) that represented an area of 2608.11 Feddan. (60.87 **%**). The minor area (12.31%) represented the high WHC soil phase (>20**%**) (Table 3 and Figure 4).

Soil Management and Reclamation (Basing on Univariant Soil Physical Numerical Classification):

Managing hard layered-soil: The rooting depth may be affected by the soil depth, constraining soil layers (hardpan, plow pan, etc.), or even abrupt changes in soil texture, Division of Agriculture and Natural Resources, University of California (2018). Soil profile depth, plants rooting and soil penetration resistance determined the cultivated crops selection. The soil penetration resistance of 150 psi that corresponds to 50 % root penetration (Duiker, 2002) was assigned as a threshold to classify studied soils into phases of none-little and

slight-moderate penetration resistance. The research formulated the cultivation crops selection as a function of soil profile depth and plants rooting (Table 4).

• **Reclamation of hard layered-soil:** Generally, hard layered-soil can be reclaimed by deep tillage and sulfur and organic fertilizers applications. Lowering soil pH conducts to dissolve calcium carbonate that cements the soil particles forming the hard pan (Abd El-Hady, 2009).

Soil Chemical Characterization for Univariate and multivariante Soil Numerical Classification

Soil Chemical Characterization: Table (5) summarizes some soil chemical characteristics; pH, EC,

ESP and CaCO$_3$. pH values indicated that soils were alkaline (7.48) to extremely alkaline (8.70). EC had a wide range to be between the minimum value of 0.05 ds/m (subsurface horizon, profile 15) and (19.84 ds/m) as maximal (surface horizon, profile 10). Soils classes varied from nonsodic class having ESP of 2.71% (surface horizon, profile 17) to extremely sodic class that characterized by maximal ESP of 27.38 % (surface horizon, profile 13). CaCO$_3$ ranged between the minimum value (4.93%) in subsurface sample of profile number 22 and 25 to the maximum value (40.36%) in subsurface sample of profile number 19.

Table 2. Main soil physical characteristics

Profile		Sample N (Depth, cm)	Ks (cm/hr)	WHC (%)	Textural Class	Profile		Sample N (Depth, cm)	Ks (cm/hr)	WHC (%)	Textural Class
N	Depth (cm)					N	Depth (cm)				
1	120	1 (0-35)	11	15	LS			27 (0-30)	7	13	S
		2 (35-120)	12	15	LS	14	88	28 (30-52)	6.5	12	S
2	85	3 (0-41)	5	22	LS			29 (52-88)	4.3	15	SL
		4 (41-85)	6	38	SCL	15	88	30 (0-30)	12	10	S
3	120	5 (0-37)	8.5	16	SCL			31 (30-88)	11	12	S
		6 (37-120)	8	18	SCL	16	120	32 (0-58)	7	13	LS
4	95	7 (0-44)	8.5	16	LS			33 (58-120)	7	15	SL
		8 (44-95)	8	14	SCL	17	120	34 (0-55)	11	14	S
5	120	9 (0-38)	8	13	SL			35 (55-120)	12	18	SL
		10 (38-120)	9	12	SCL	18	90	36 (0-33)	6.5	18	LS
6	120	11 (0-28)	8.5	16	LS			37 (33-90)	6	17	SCL
		12 (28-120)	9	18	LS	19	120	38 (0-55)	8.5	13	LS
7	85	13 (0-33)	8	13	S			39 (55-120)	8	14	SL
		14 (33-85)	8.5	13	SCL	20	90	40 (0-45)	11	16	SCL
8	92	15 (0-28)	8	20	SL			41 (45-90)	12	13	SCL
		16 (28-92)	7.5	14	SCL	21	88	42 (0-38)	8	13	LS
9	66	17 (0-36)	7.5	16	SL			43 (38-88)	8.5	22	S
		18 (36-66)	8	13	LS	22	83	44 (0-55)	7	18	SCL
10	65	19 (0-30)	8	13	S			45 (55-83)	6.5	23	LS
		20 (30-65)	8.5	13	SL	23	83	46 (0-55)	12	20	SL
11	120	21 (0-55)	9.5	10	S			47 (55-83)	11	13	S
		22 (55-120)	9	15	SL	24	43	48 (0-25)	9	18	LS
12	120	23 (0-50)	8.5	17	S			49 (25-43)	9.5	22	SL
		24 (50-120)	9.5	11	S	25	88	50 (0-38)	11	17	LS
13	88	25 (0-28)	7.5	18	SCL			51 (38-88)	12	23	LS
		26 (28-88)	8.5	24	SCL	*: LS= Loamy Sand, SCL= Sandy Clay Loam, SL= Sandy Loam, S=Sand					
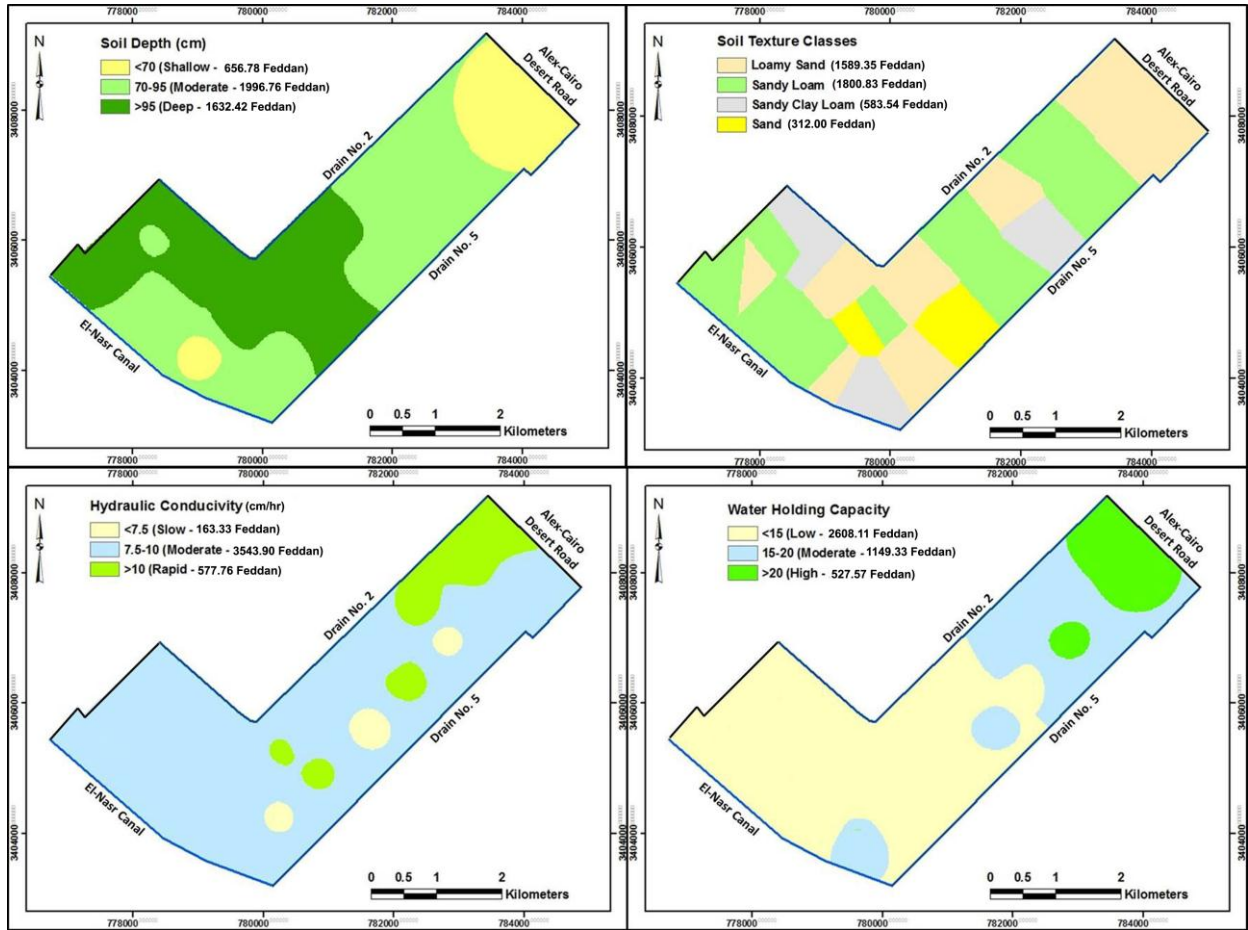
Figure 4. Soil physical phases

Table 3. Univariant soil physical classification

Soil Physical Criteria	Thresholds	Soil Phases	Area		Soil Physical Criteria	Thresholds	Soil Phases	Area	
			Feddan	%				Feddan	%
Depth cm	<70	Shallow	656.78	15.32	Hydraulic Conductivity (Ks) cm/hr	<7.5	Slow	163.33	3.81
	70-95	Moderate	1996.76	46.59		7.5-10	Moderate	3543.90	82.70
	>95	Deep	1632.42	38.09		>10	Rapid	577.76	13.48
Texture	Textural Classes	LS	1589.35	37.08	Water Holding Capacity (WHC) (%)	<15	Low	2608.11	60.87
		SCL	583.54	13.62		15-20	Moderate	1149.33	26.82
		SL	1800.83	42.02		>20	High	527.57	12.31
		S	312.00	7.28					

Table 4. Crop selection as function of soil profile depth, plants rooting and soil penetration resistance

Soil profile depth		Soil Penetration Resistance		Recommended Sub soiling Tillage	Recommended Crops	Area	
Thresholds (cm)	Soil Phases	Thresholds (psi)	Soil Phases			Feddan	%
< 70	Shallow soil profile	< 150	None - Little penetration resistance	No	garlic ,cucumber , spinach ,onion , lettuce	656.78	15.32
70-95	Moderate depth-soil profile	> 150	Slight - Moderate penetration resistance	Yes	carrot , beets , Potatoes , beans	1996.76	46.59
> 95	Deep soil profile				All crops	1632.42	38.09

150 psi = 10 bar according to the manual

Table 5. Main soil chemical characteristics

Profile N.	Sample N.	pH	EC ds/m	ESP	CaCO₃ (%)	Profile N.	Sample N.	pH	EC ds/m	ESP	CaCO₃ (%)
1	1	7.6	10.85	8.09	10.76	14	27	8.16	4.49	16.65	13
	2	7.98	4.02	4.11	8.97		28	8.38	2.27	8.54	8.52
2	3	7.6	10.85	8.09	10.76	15	29	8.06	3.79	4.42	16.59
	4	8.21	5.78	11.98	9.87		30	7.73	6.22	6.26	14.35
3	5	8.07	4.42	7.92	21.52	16	31	8.26	0.05	6.75	14.35
	6	8.23	1.06	6.14	21.52		32	7.75	6.96	10.3	8.52
4	7	8.17	1.17	6.49	7.17	17	33	7.87	3.28	9.52	12.11
	8	8.26	1.06	12.74	21.52		34	8.03	0.57	2.71	9.42
5	9	7.69	8.23	6.15	12.11	18	35	7.87	11.53	10.41	23.32
	10	7.86	2.35	10.8	23.77		36	7.61	4.93	15.71	13.45
6	11	7.48	7.51	16.24	7.62	19	37	8.04	3.39	12.51	11.66
	12	7.65	13.41	21	12.56		38	7.48	7.51	16.24	7.62
7	13	8.15	4.96	12.76	7.17	20	39	8.7	1.64	13.48	40.36
	14	8.04	7.04	22.68	20.18		40	7.79	4.99	11.01	17.49
8	15	8.33	1.35	6.01	23.32	21	41	8.1	3.45	9.25	26.46
	16	8.35	0.78	12	17.04		42	7.74	9.83	5.76	14.35
9	17	8.1	13.12	12.76	14.35	22	43	7.62	11.53	8.13	12.11
	18	7.85	5.9	18.28	8.52		44	7.88	2.03	6.41	8.52
10	19	7.7	19.84	15.52	22.87	23	45	8.68	0.09	3.66	4.93
	20	7.76	14.55	12.74	26.01		46	8.08	4.9	24	16.59
11	21	8.04	9.52	9.21	10.31	24	47	7.98	3.71	12.91	13.9
	22	8.26	1.06	9.92	19.73		48	7.65	13.41	21	12.56
12	23	7.82	4.25	6.39	7.17	25	49	8.6	4.75	26.23	21.52
	24	7.82	8.74	8.65	17.94		50	8.19	0.33	5.01	6.73
13	25	8.08	6.47	27.38	13.9		51	8.68	0.09	3.66	4.93
	26	8.22	3.11	22.67	7.17						

Soil Univariant Chemical Classification for Management and Reclamation:

The studied soils were chemically classified basing separately on the thresholds of pH, EC, ESP and CaCO₃ that are the most effective factors on soil production:

▪ **Soil Salinity:** The results of electrical conductivity indicated that the studied soils were generally positioned into the moderately saline class that had an area of (3124.76 Feddan) representing (72.92 %). The soils assembled into four classes; low saline (298.76 Feddan) and it is suitable for most crops, moderately saline (3124.76 Feddan), high saline (845.35 Feddan) where

crops salt tolerant crops give yield with marginal reduction. Finally, very high saline class (16.11 Feddan) that it is suitable just for high salt tolerant crops but also with yield reduction (Table 6 and Figure 5).

▪ **Soil Sodicity:** Results showed that the non-sodic soil class occupied the majority of the studied area with 82.40 % (3531.04 Feddan). The sodic soil had only 753.95 Feddan (17.60 %) (Table 6 and Figure 5).

▪ **Calcium Carbonate Content:** Calcium carbonate of the study area had different forms such as powder, nodules, concretions and hard layer. Calcium carbonate in calcareous soil gives it one of the important morphological phenomena, which is the surface crust. The study area was classified into three classes according to percentage of calcium carbonate to: non calcareous soil (3851.35 Feddan), moderately calcareous soil (411.85 Feddan) and calcareous soil (21.78 Feddan) (Table 6 and Figure 5).

Soil Management and Reclamation (Basing on soil chemical univariate classification):

Soil Salinity Problem

• **Managing Soil Salinity**: Suitable crops were selected to reduce the problem of soil salinity (Table 7).

• **Reclamation of saline soil by determination of leaching requirements (LR) for different EC-tolerance crops:** The equation of Bauder et al., 2018 was applied to estimate how much water is required to leach salts for reclamation purposes. Crops tolerance and EC soil parameters that are EC tolerant crop range and soil initial EC (EC_{ei}) were calculated and showed in table 7.These parameters were assigned to the equation, Bauder et al. (2018), to calculate the depth of water infiltrated (DW) (Table 8). DW was used to determine the min and max allover net LR (ANLR), and min and max allover total LR (ATLR), tables (9,10).The tables pointed to the following outputs:

- To cultivate orange in the mapping units (1, 2, 3, 4) the total leaching water requirements (TLR), of 98414.5 (min), 393661.1 (max), 4117308.8 (min), 8234648.8 (max), 2227742.4 (min), 4455493.3 (max), and 84909.2 (min), 105287.4 (max), m³ water/mapping unit, are needed to be applied respectively. This briefly means that max allover total leaching water requirements (ATLR) of 13189090.54 m³ are to cultivate all studied by orange (Table 9).

- Wheat is more salts tolerant that orange, whereas ECef has the values of 6.0 and 1.7 (dS/m), for wheat and orange, respectively. In addition the rooting depth of wheat and orange are 50 and 120 cm. Accordingly, the max allover total leach requirements were 1557042.70 m3/studied soil (Table 10), to plant wheat, which are less than the case of orange cultivation.

- 296.47 m³ water were needed as minimum net leaching requirements to reclaim soil feddan (NLRF), of mapping unit (1), to be cultivated by orange. This value certainly is not logically acceptable. Min ECei representing the first threshold mapping unit (1) is less than ECef for the case of orange cultivation. Min ECei equals 1 (ds/m), while ECef for the case of orange cultivation has the value of 1.7 (ds/m). Thus, there no need to min NLRF application. This same false value was found in the case of wheat cultivation, where min NLRF equaled to 35 m³ water. This conclude that The leaching requirements (LR) equation of Bauder et al., 2018, is not applicable when min ECei (initial EC soil) is lower than ECef (EC reference crop) because it outputs false values indicating the LR needs.

Table 6. Univariant soil chemical classification

| Soil chemical Criteria	Thresholds	Soil Chemical Classes	Area		Soil chemical Criteria	Thresholds	Soil Chemical Classes	Area	
			Feddan	%				Feddan	%
Exchangeable Sodium Percentage (ESP) %	<15	Non-Sodic	3531.04	82.40		<4	Low	298.76	6.97
	>15	Sodic	753.97	17.60	Electrical Conductivity (EC) ds/m	4-8	Moderate	3124.76	72.92
CaCO3 %	<15	Non Calcareous	3851.35	89.88		8-16	High	845.35	19.73
	15-20	Moderately Calcareous	411.85	9.61		>16	Very High	16.11	0.38
	>20	Calcareous	21.80	0.51					
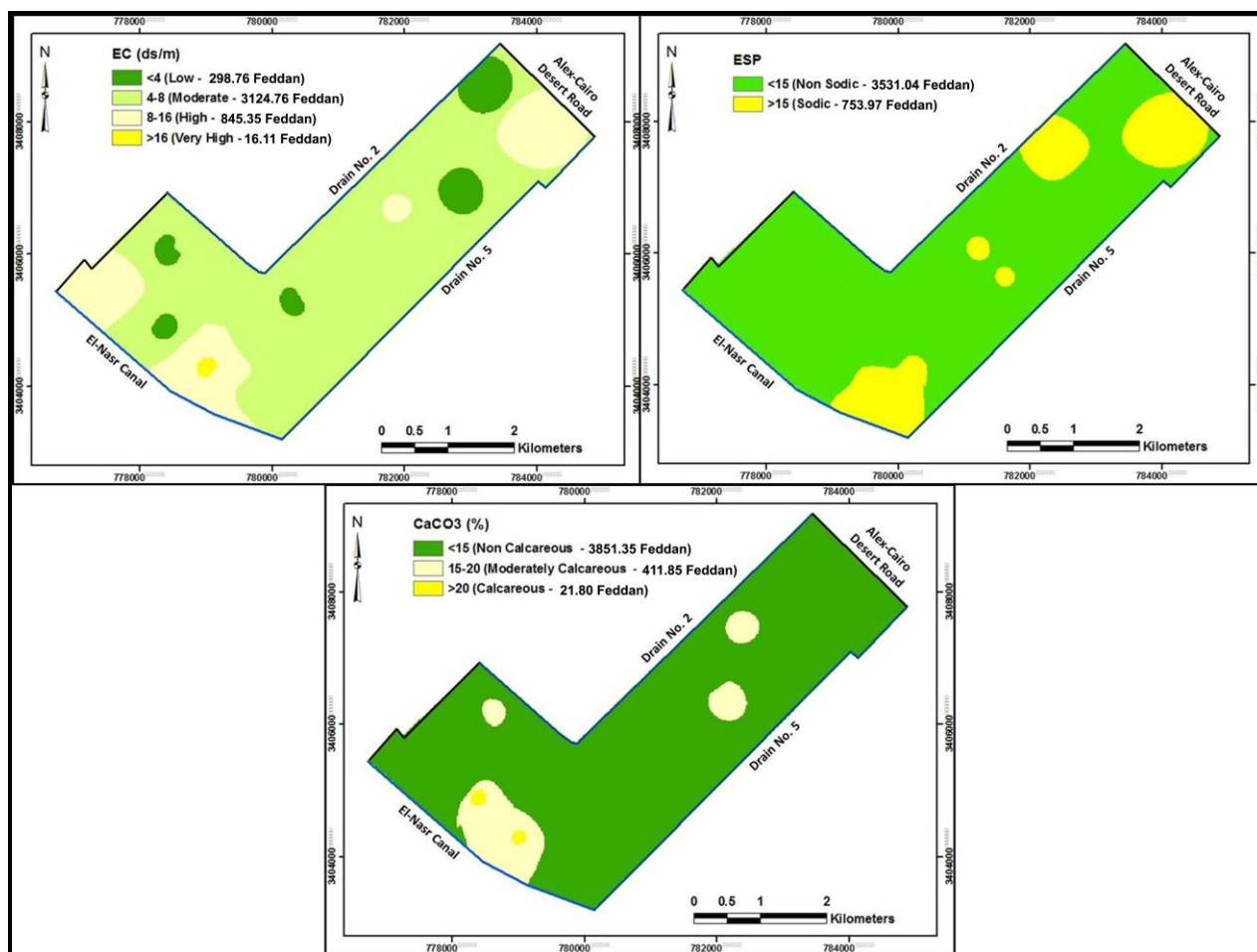
Figure 5. Soil chemical classes

Table 7. Crops tolerance and EC soil parameters

Mapping Unit	EC Crop Tolerance	EC (dS/m) tolerant crop range	Initial EC$_{ei}$ (dS/m) Min.	Initial EC$_{ei}$ (dS/m) Max.
1	Sensitive EC crops: (Field crops) Sunflower, Soybean, Faba bean, Lins, (Vegetable crops) Sweet corn, Lettuce, Onion, Eggplant, Carrot, (Fruit crops) Date, Olive, Peach , Orange, Grapes	1 - 4	1	4
2	Moderately EC tolerant crops: only field crops Barley, Cotton, Sugar beet, Grain sorghum, Wheat	4-8	4	8
3	EC tolerant crops: No crops have 0 % yield reduction	8-16	8	16
4	Highly EC tolerant crops: No crops have 0 % yield reduction	16-32	16	32

Table 8. Depth of water infiltrated (DW)

ECei(dS/m)		Crops			
		Orange		Wheat	
		DW (cm)		DW (cm)	
Min	Max	Min	Max	Min	Max
1	4	7.06	28.24	0.83	3.33
4	8	28.24	56.47	3.33	6.66
8	16	56.47	112.94	6.66	13.33
16	19.84	112.94	140.05	13.33	16.53

K (constant) =0.10, Ds (rooting depth) = 120 and 50 cm for orange and wheat ECef (EC soil paste that enables to obtain zero orange yield) = 1. 7 and 6 (dS/m) for orange and wheat (Max EC_{ei} = max. initial EC of the studied soils 19.84 (dS/m)

Table 9. Leaching requirements (LR) to reclaim soil to cultivate orange

Mapping Unit	NLR & TLR (m³ water/feddan)				Area (feddan)	NLRU & TLRU (m³ water / mapping unit)			
	N LRF		TLRF			NLRU		TLRU	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
1	296.47	1185.88	329.41	1317.65	298.76	88573.38	354293.5	98414.5	393661.1
2	1185.88	2371.76	1317.64	2635.29	3124.76	3705590.39	7411180.8	4117308.8	8234648.8
3	2371.76	4743.53	2635.29	5270.59	845.35	2004967.32	4009943.1	2227742.4	4455493.3
4	4743.53	5881.98	5270.59	6535.53	16.11	76418.27	94758.7	84909.2	105287.4

All studied Soils

Min. allover net LR (AN LR)   = 5875549.35 (m³/ studied soil)
Max. allover net LR (ANLR)   = 11870176.07 (m³/ studied soil)
Min. allover total LR GR (ATLR) = 6528374.90 (m³/ studied soil)
Max. allover total LR (ATLR)   = 13189090.54 (m³/ studied soil)

The leaching requirements (LR) equation of Bauder et al., 2018, is not applicable when min ECei is lower than ECef because it outputs false values indicating the LR needs. That is not true
NLRF and TLRF = Net and total water leaching requirements, for reclamation purposes, for feddan (m³ water/feddan)
NLRU and TLRU = Net and total water leaching requirements, for reclamation purposes, for mapping unit (m³ water / mapping unit)
ANLR and ATLR = Net and total water leaching requirements, for reclamation purposes, for all mapping units, (m³ water / all studied soils)
Application efficiency of leaching (LF) = 90 %

Table 10. Leaching requirements (LR) to reclaim soil to cultivate wheat

Mapping Unit	NLR & TLR (m3/feddan)				Area (feddan)	NLRU & TLRU (m3/ mapping unit)			
	N LRF		TLRF			NLRU		TLRU	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
1	35	140	38.89	155.56	298.76	10456.6	41826.4	11618.8	46475.1
2	140	280	155.56	311.11	3124.76	437466.4	874932.8	486087.7	972144.1
3	280	560	311.11	622.22	845.35	236698.0	473396.0	262996.8	525993.7
4	560	694.4	622.22	771.56	16.11	9021.6	11186.8	10023.9	12429.8

All studied Soils

Min. allover net LR (AN LR)   = 693642.60 (m3/ studied soil)
Max. allover net LR (AN LR)   = 1401341.98 (m3/ studied soil)
Min. allover total LR GR (ATLR) = 770727.24 (m3/ studied soil)
Max. allover total LR (ATLR)   = 1557042.70 (m3/ studied soil)

The leaching requirements (LR) equation of Bauder et al., 2018, is not applicable when min ECei is lower than ECef because it outputs false values indicating the LR needs. That is not true
Wheat reference EC =   ECef = 6.0 (dS/m) = EC soil paste that enables to obtain zero wheat yield
Application efficiency of leaching (LF) = 90 %

Soil Sodicity Problem

- **Managing Sodic Soil by application of Cultural methods:** Applying friendly ESP irrigation and optimal selection of ESP crops tolerant and friendly ESP irrigation water conduct to reliable soil sodicity management.

- For the studied soils they are irrigated by Nile water that has values of EC (0.51 ds/m) and SAR (1.76)

(Abdelaty, 2018). These low values classified Nile water as suitable irrigation water, even for sensitive crops (Lenntech, 2018). While, Kupper, (1996) considered that there values may cause a moderate risk for sensitive crops. Irrigation water can be practiced in the light of EC-SAR standard tables of Kupper, 1996 and Lenntech, 2018.

- The standard tables of ESP tolerance crops (Ggeorge, 1960; Qadir, et al., 2008) enabled to determine the more

suitable crops to be cultivated in the studied soils (Table 11). The table indicated that extremely sensitive ESP crops, Nuts, Citrus and Avocado, can only be cultivated in the class of non sodic soil (ESP = 2-10%). The sensitive ESP crops, such as beans, may be planted with some yield reduction in the soil having ESP range of 10-20. Meanwhile, non sodic soils can be cultivated different crops having, ESP wide range, from sensitive ESP crops to friendly ESP.

• **Reclamation of Sodic Soil by determination of edaphological soil gypsum requirements for different ESP-tolerance crops:** The determination of edaphological soil gypsum requirements (GR) was based on classification ESP-tolerance crops (Qadir et al., 2008) and Na_{ex} soil parameters. GIS-ESP edapholoical soil classification was elaborated by assignment ESP thresholds of tolerant crop range (Table 12) to GIS-ESP soil map (Figure 6). The GIS-ESP edapholoical soil map divided the studied area into three categories of ESP tolerance crops soil; extremely sensitive ESP crop (1355.09 Feddan), sensitive ESP crop (2845.73 Feddan) and moderately tolerant crop (84.88 Feddan). The calculation of edaphological gypsum requirement (GR) for different ESP-tolerance crops (Tables 13, 14 and 15) indicated that:

- Mapping unit (1) can be used to cultivate all the crops, even sensitive ones (such as citrus), without any gypsum application. The case of cultivation mapping unit (2 and 3) by such crops, required gypsum applications of 417115.1 and 53221.73 tons as min and max allover net GR (ANGR), respectively. Consequently amounts of 463461.2 and 59135.26 tons gypsum must be applied such as min and max allover actual GR (ATGR), respectively (Table 13-b).

- Sensitive ESP crops such as beans can be cultivated in the mapping units (1) and (2) without any gypsum application. Nevertheless, is preferable to notify that the second mapping unit may needs to GR in the future because RNaex = Soil initial Naex. This application is necessary to avoid any probable Na effect on the crop. As for mapping unit (3), it may be suitable soils for planting by cultivate sensitive ESP crops by applying GR of 360.78 and 721.57 tons as min and max NGRU, and 400.87 and 801.74 tons as min and max TGRU. Contrary, gypsum application will not be need in the case of planting tolerant and most crops (Table 14-b).

- There is no need for GR to cultivate moderately tolerant ESP crops in all studied soils because RNaex ≥ Soil initial Naex.

- GIS-ESP map enabled to assess not only the gypsum requirements (GR) but also their optimum spatial distribution.

Managing CaCO₃ % problem: Alkalinity that was due calcium carbonate represented a minor problem, where alkaline soils occupied only 10.11 % of the studied area. Chicken manure application of 400 kg/fed (950 kg/ha) reduced greatly the alkalinity problem to increase plant micronutrients uptake (Wafaa, 2013).

This information and GIS area of moderately calcareous and calcareous soil phases (433.66 Feddan) enabled to not only calculate chicken manure application (173.03 ton) but also determined the application locations by map of figure 5.

Soil Chemical Multivariate Classification:

The overlay process output the soil multivariable chemical classification maps, as resulted from overlay two characteristics by EC and ESP as shown in figure 7. This map involved five classes. The largest class was of moderately saline-non sodic soil class which represents about 63 % total study area. Non saline-non sodic soil was the smallest one to represent about 7 % total study area.

Land evaluation:

Soil Suitability for Cultivation: The Agricultural Land Evaluation System for Arid Region program (ALES-Arid) was used to predict soil suitability for some common crops cultivated in the study area including: wheat, faba_bean, grape, olive, potato and tomato. Table (16) summarizes agriculture soil suitability for each profile for the selected crops. This table represents a guide of soil reclamation that can be carried out by removal of restricted factors.

The six suitability classes for each crop are the following: Class S1: Highly suitable, Class S2: Moderately suitable, Class S3: Marginally suitable, Class S4: Conditionally suitable, NS1: Potentially suitable and NS2: Actually unsuitable.

Crops Soil suitability:

• **Cereals crops (Exa. Wheat):** The data indicated that the studied soil is marginally suitable and conditionally suitable for wheat crop. The class of conditionally suitable (S4) and marginally suitable soils (S3) represent about 57.28 % and 42.72 % of the studied area, respectively (Table 17 and Figure 8). This low degree of soil suitability may due to the coarse texture and high soil permeability.

• **Leguminous crops (Exa. Feba-bean):** The data indicated that the studied soil is moderately suitable, marginally suitable and conditionally suitable for Faba bean crop.

The class of marginally suitable soils (S3) represents about 47.65 %, conditionally suitable class (S4) represents about 30.65 % and moderately suitable soils

(S2) represents about 21.70 % of the studied area (Table 17 and Figure 8).

- **Perennial crops (Exa. Grape and Olive):** Mostly, the grapes can grow in wide range of soil types. According to Bucelli, and Costantini, 2009, the ideal soil for grapes is a well-drained sandy loam soil. Soil pH of 5.5 to 8 is an ideal to grow grapes, because at this level, nutrients are available for the root (Lanyon et al., 2004). The results showed that all studied area was suitable for grape plantation. The largest portion of the study area (63.81 %) was classified as moderately suitable (S2). The remaining portions (26.08 %, 6.89 % and 3.22 %) were classified as marginally suitable (S3), highly suitable (S1) and conditionally suitable (S4), respectively (Table 17 and Figure 8).

In order to define soil suitability for the growth of olive trees a number of criteria concerning to the soil properties were delineated. These properties were all evaluated with respect to the fact that the major portion of olive tree roots is concentrated in upper layer of 40-50cm thickness and that olives trees don't tolerate waterlogged soils or soils with a low degree of percolation. Open, perfectly aerated, well drained loamy soils without slow permeability horizons within their upper 80-100cm are ideal (Franchini, 2009).

The results of this study showed that the region is meanly suitable for olive plantation (Table 17 and Figure 8). More than half part of the study area (64.5 %) was classified as moderately suitable (S2) and 5.5 % of it classified as highly suitable for olive tree as due to physical and chemical soil parameters such as pH, CaCO3 and EC. Marginally suitable class (S3) represents about 16.3 % and actually unsuitable class (NS2) is about (13.8 %), these soils have low soil suitability because of soil shallow depth limitation.

Table 11. Selection ESP crops tolerant

| Soil Chemical Classes | ESP Thresholds | Area | | ESP Crops Tolerant |
		Feddan	%	
Non-Sodic	<15	3531.04	82.40	Extremely sensitive ESP Crops(ESP = 2-10) ; Nuts , Citrus, Avocado
Sodic	>15	753.97	17.60	Sensitive ESP crops (ESP = 10-20); Beans
				Moderately tolerant (ESP = 20-40) ; Clover
				Tolerant crops (ESP = (40-60) ; Wheat, Cotton , Alfalfa , Barely , Tomato, Beets
				Most tolerant crops (ESP > 60) ;Tall wheat grass , Rhodes grass

Table 12. ESP crops tolerance and Na$_{ex}$ soil parameters

| Mapping Unit | Crop Tolerance | ESP Tolerant Crop Range | ESP Thresholds | | Initial Na$_{ex}$ | |
			Min.	Max.	Min.	Max.
1	Extremely sensitive ESP crops: citrus	2- 10	2	10	0.5	2.5
2	Sensitive ESP crops : beans	10 -20	10	20	2.5	5
3	Moderately tolerant crops : clover	20 - 40	20	40	5	10

Table 13- a. Thresholds of extremely sensitive ESP crops and Naex parameters

| Mapping Unit | Thresholds of ESP crops Tolerance | | Initial Naex | | RNaex | | KNaex | |
	Min	Max	Min	Max	Min	Max	Min	Max
1	2	10	0.5	2.5	0.5	2.5	0	0
2	10	20	2.5	5	0.5	2.5	2	2.5
3	20	40	5	10	0.5	2.5	4.5	7.5

Table 13-b. Gypsum requirement (GR) to reclaim soil to cultivate extremely sensitive ESP crops Citrus = rooting depth (D) 120 cm

Mapping Unit	Area		NGRU		TGRU	
	feddan	%	Min	Max	Min	Max
1	1355.66	31.40	No Need for Gypsum Application*			
2	2876.02	66.63	391138.7	48892.34	43459.86	54324.82
3	84.89	1.97	2597.63	4329.39	2886.26	4810.43
All studied Soils	Min allover net GR (ANGR) , (ton/ studied soil)					417115.1
	Max allover net GR (ANGR) , (ton/ studied soil)					53221.73
	Min allover total GR (ATGR) , (ton/ studied soil)					463461.2
	Max allover total GR (ATGR) , (ton/ studied soil)					59135.26

EF = efficiency of gypsum application = 95 %, GP = gypsum purity = 95 %
Allover total gypsum requirements (ATGR) = (ANGR) ×100 /90   (ton/ studied soil)
*No need for Gypsum Application when RNaex ≥ Soil initial Naex

Table 14- a. Thresholds of sensitive ESP crops and Naex parameters

Mapping Unit	Thresholds of ESP crops Tolerance		Initial Naex		RNaex		KNaex	
	Min	Max	Min	Max	Min	Max	Min	Max
1	2	10	0.5	2.5	0.5	2.5	-2	-2.5
2	10	20	2.5	5	0.5	2.5	0	0
3	20	40	5	10	0.5	2.5	2.5	5

Table 14-b. Gypsum requirement (GR) to reclaim soil to cultivate sensitive ESP crops Beans = rooting depth (D) = 30 cm

Mapping Unit	Area		NGRU		TGRU	
	feddan	%	Min	Max	Min	Max
1	1355.66	31.40	No Need for Gypsum Application*			
2	2876.02	66.63	No Need for Gypsum Application*			
3	84.89	1.97	360.78	721.57	400.87	801.74
All studied Soils	Min allover net GR (ANGR) , (ton/ studied soil)					360.78
	Max allover net GR (ANGR) , (ton/ studied soil)					721.57
	Min allover total GR (ATGR) , (ton/ studied soil)					400.87
	Max allover total GR (ATGR) , (ton/ studied soil)					801.74

EF = efficiency of gypsum application = 95 %, GP = gypsum purity = 95 %
Allover total gypsum requirements (ATGR) = (ANGR) ×100 /90   (ton/ studied soil)
*No need for Gypsum Application when RNaex ≥ Soil initial Naex

Table 15. Thresholds of to cultivate moderately tolerant ESP crops and Naex parameters

Mapping Unit	Thresholds of ESP crops Tolerance		Initial Naex		RNaex		KNaex	
	Min	Max	Min	Max	Min	Max	Min	Max
1	2	10	0.5	2.5	5	10	-4.5	-7.5
2	10	20	2.5	5	5	10	-2.5	-5
3	20	40	5	10	5	10	0	0

*No need for Gypsum Application when RNaex ≥ Soil initial Naex
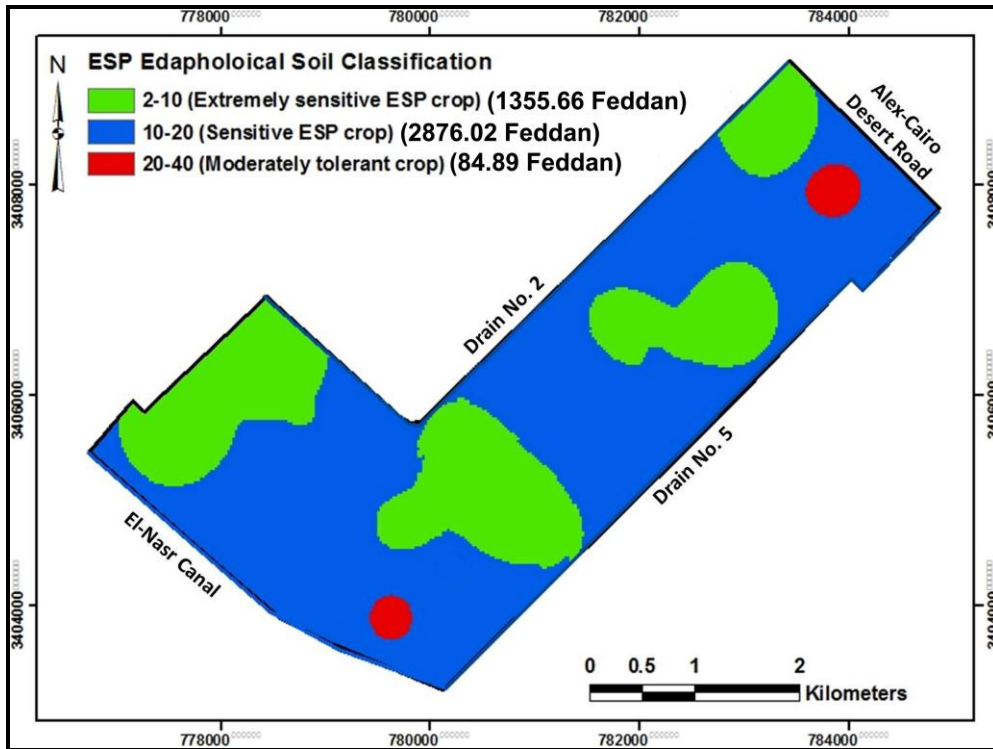 Clover = rooting depth (D) = 30 cm
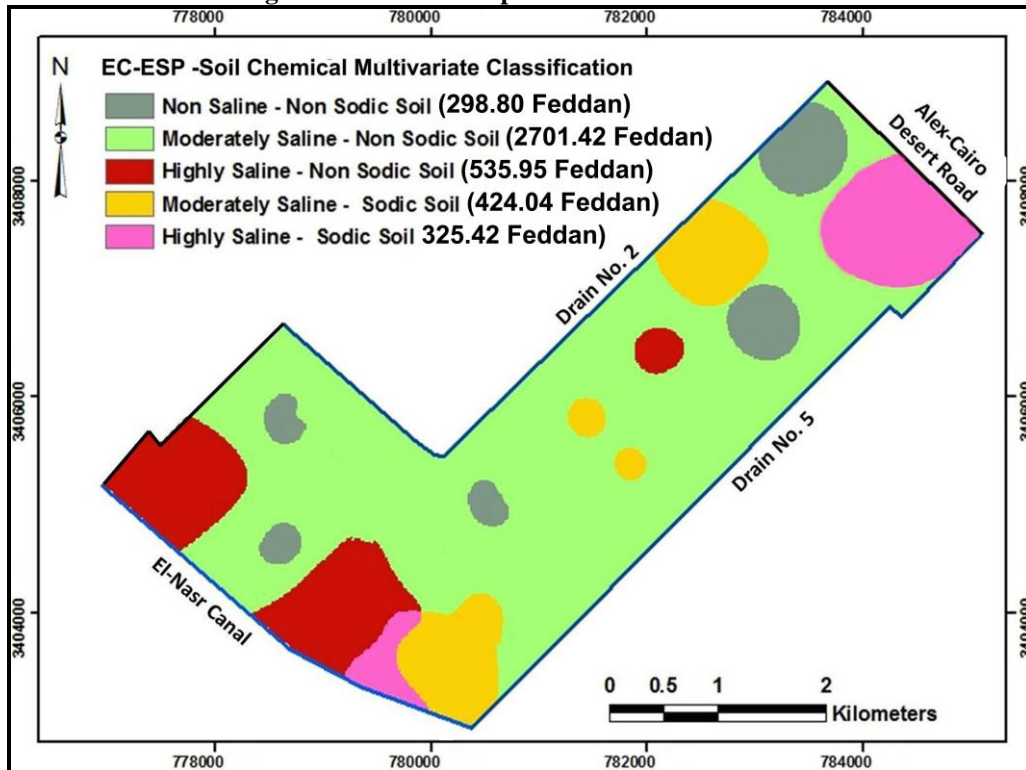
Figure 6. GIS-ESP edapholoical soil classification

Figure 7. EC–ESP soil variants soil chemical classification overlaid map

Table 16. Agriculture soil suitability for each profile for the selected crops in the study area

Profile No.	Wheat	Faba_bean	Grape	Olive	Potato	Tomato
1	S4 (t, hr)	S4 (ece, t, hr)	S2 (ece)	S2	S2 (ece)	S1
2	S4 (t, hr)	S4 (ece, t)	S3 (ece, hr)	S3 (dp, hr)	S3 (ece, hr)	S2 (ece, hr)
3	S3 (t, hr)	S2 (t)	S2	S1	S2	S1
4	S3 (t, hr)	S2	S2	S2 (dp)	S2	S1
5	S3 (t, hr)	S3 (ece, hr)	S2	S2	S2	S2
6	S4 (t, hr)	S4 (ece, t, esp, hr)	S3 (ece, esp)	S2 (esp)	S4 (ece, esp)	S2 (ece)
7	S4 (t, hr)	S3 (ece, t, esp)	S3 (esp)	S3 (dp, esp)	S3 (ece, esp)	S2
8	S3 (t, hr)	S2 (t)	S2	S2 (dp)	S2	S1
9	S4 (t, hr)	S4 (ece, t, esp)	S3 (ece, dp, esp)	NS2	S3 (ece, esp)	S2 (ece)
10	S4 (ece, t, hr)	S4 (ece, t)	S4 (ece, dp)	NS2	S4 (ece)	S3 (ece)
11	S3 (t, hr)	S3 (ece, t, hr)	S2	S2	S2	S2
12	S4 (t, hr)	S4 (ece, t, hr)	S2 (ece, t)	S2 (t)	S3 (ece, t)	S2 (ece, t)
13	S3 (t, hr)	S3 (ece, esp)	S2 (esp)	S2 (dp, esp)	S2 (esp)	S1
14	S4 (t, hr)	S3 (t)	S2 (t)	S3 (dp, t)	S2 (t)	S2 (t)
15	S4 (t, hr)	S3 (t, hr)	S2 (t)	S2 (t)	S2 (t)	S2 (t)
16	S3 (t, hr)	S3 (ece, t)	S2	S2	S2	S1
17	S4 (t, hr)	S3 (ece, t, hr)	S2	S1	S2 (ece)	S2
18	S3 (t, hr)	S2 (ece, t)	S2 (hr)	S2 (dp, hr)	S2 (hr)	S2 (hr)
19	S3 (t, hr)	S3 (ece, t)	S2	S2	S2	S1
20	S3 (t, hr)	S3 (ece, hr)	S2	S2 (dp)	S2	S1
21	S4 (t, hr)	S4 (ece, t)	S3 (ece, t)	S3 (dp, t)	S4 (ece, t)	S2 (ece, t)
22	S3 (t, hr)	S2 (t)	S1	S2 (dp)	S1	S1
23	S4 (t, hr)	S3 (ece, t, esp, hr)	S2 (esp)	S2 (dp, esp)	S2 (esp)	S1
24	S4 (t, hr)	S4 (ece, t, esp, hr)	S3 (ece, dp, t, esp)	NS2	S3 (ece, t, esp)	S3 (ece, t)
25	S4 (t, hr)	S3 (t, hr)	S2 (t)	S2 (dp, t)	S2 (t)	S2 (t)

The limitation factors: Soil Electrical Conductivity (ece), Exchangeable Sodium Percentage (esp), Texture (t), Hydraulic Conductivity (hr), Soil Depth (dp).

Table 17. Soil suitability classes for different crops

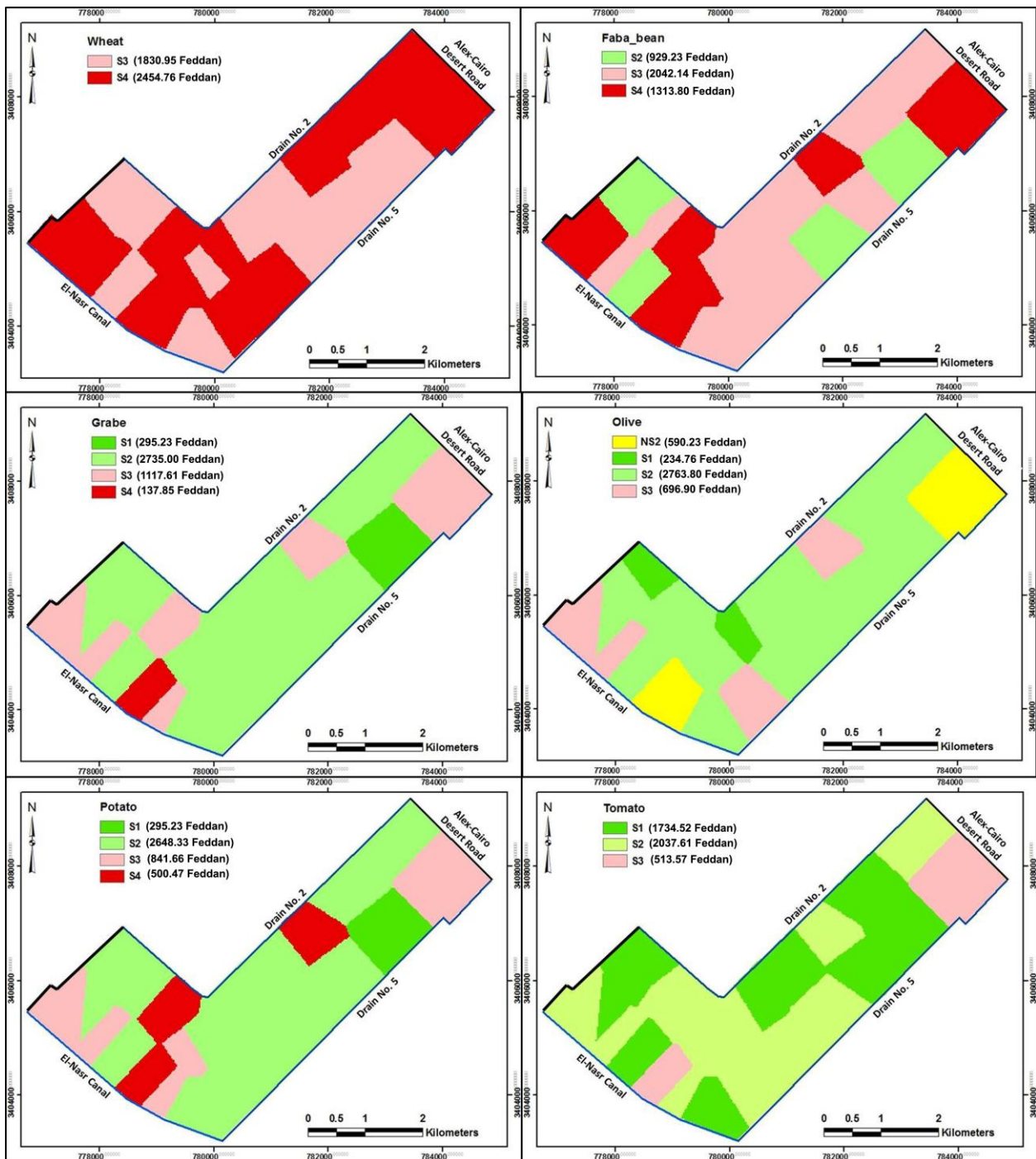| Suitability Classes	Wheat		Feba bean		Grape		Olive		Potato		Tomato	
	Feddan	%	Feddan	%	Feddan	%	Feddan	%	Feddan	%	Feddan	%
S1	…..	…..	…..	…..	295.2	6.9	234.8	5.5	295.2	6.9	1734.5	40.5
S2	…..	…..	929.8	21.7	2735.0	63.8	2763.8	64.5	2648.3	61.8	2037.6	47.5
S3	1830.9	42.7	2042.1	47.6	1117.6	26.1	696.9	16.3	841.7	19.6	513.6	12.0
S4	2454.8	57.3	1313.8	30.7	137.8	3.2	…..	…..	500.5	11.7	…..	…..
NS1	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..	…..
NS2	…..	…..	…..	…..	…..	…..	590.2	13.8	…..	…..	…..	…..

Figure 8. Soil suitability classes for selected crops

- **Vegetables (Exa. Potato and Tomato):** The results of this study showed that all area is suitable for potato plantation; 61.8 % of the study area is moderately suitable (S2), 19.6 % is marginally suitable (S3), 11.7 % is conditionally suitable (S4) and 6.9 % is highly suitable (S1) (Table 17 and Figure 8). This high potato soil suitability may explained as potatoes ability to be

adapted to a wide range of soil types, though a deep, well-drained sandy loam is ideal (Nunn and Qian, 2010).

Generally, Tomato grows best under temperature of 20-27 ºC. fruit setting is poor when average temperature exceed 30ºC or fall below 10ºC. it prefer a well-drained soil because they are sensitive to water logging, and grows on all types of soil, but is best adapted in light,

well drained and fertile soils with a neutral to slightly acid pH of 5.5 to 7.0. (Bagli et al., 2003). The results of this study showed that all soil is suitable for tomato plantation (Table 17 and Figure 8). The largest portion of the study area (88.0 %) was classified as highly suitable (S1) and moderately suitable (S2). The remaining portion (12.0 %) was classified as marginally suitable (S3).

CONCLUSIONS

Physical and chemical soil characterization led to soil numerical classification that guide accurately and quantitatively the practices of soil management and reclamation. Comprehensive analytical approach of soil evaluation may be based on the processes of soil numerical classification, land suitability and crop soil suitability. GIS–EC edapholical maps are trustworthy tools to quantify the spatial distribution of leaching requirements for saline soils and gypsum requirements for reclaiming sodic soils. GIS-EC and ESP overlaid maps conduct to output the soil multivariable chemical classification. The leaching requirements (LR) equation of Bauder et al., 2018, is not applicable when min ECei (initial EC soil) is lower than ECef (EC reference crop) because it outputs false values indicating the LR needs. As well as, no need for gypsum application when RNaex ≥ Soil initial Naex .

Hence land suitability analysis outputs reliable information related cropping and limitation opportunity and limitation, it provides great contribution for reliable and economic land use. Soil suitability information could be used by farmers to select suitable crops for their soil, as well as an accurate database and guide maps for decision makers. Crops soil suitability is mainly determined by soil properties, crop rooting depth, and EC and ESP crops tolerance. After reducing or elimination of soil limiting factors the studied area may be cultivated wheat, faba bean, fruits (grape and olive) and vegetables (potato and tomato). Some selected crops such as grape, olive, potato and tomato are recommended to be grown in the study area .Most of marginally suitable land with severe limiting factors such as soil depth, texture, EC, Ks and ESP hazards located in the northern east higher part of the study area.

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الملخص العربي

النهج التحليلي الشامل لنظم المعلومات الجغرافية لاستخدامات الأراضي عن طريق ربط صلاحية التربة للمحاصيل بإدارة واستصلاح الأراضي

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تمتلك منطقة طريق القاهرة– الأسكندرية الصحراوي (مصر) مقدرات زراعية للمساهمة في الأمن الغذائي القومي ؛ لذا تم تقييم أراضي مزرعة شركة النيل(الكيلو ٦٣ بالصحراوي) ، بتطبيق المنهج التحليلي الشامل، حيث أجرى تقسيم رقمى للأراضى بناء على خصائصها الفيزيائية والكيميائية، الأمر الذى ساعد على تحديد مدى ملائمة الأراضى للمحاصيل وتوجيه ممارسات إدارة وأستصلاح الأراضى.

أشار التقسيم الرقمى (أحادي المتغير) الفيزيائي univariate numerical soil classification إلى الأنماط الرئيسية soil phases لأراضي منطقة الدراسة والتى رسمت خرائطها بأستخدام نظم المعلومات الجغرافية GIS، حيث أوضحت الخرائط مساحات الأنماط الرئيسية : تربة متوسطة العمق (١٩٩٦,٧٦ فدان) – تربة ذات نفاذية متوسطة (٣٥٤٣,٩٠ فدان) – تربة ذات قدرة منخفضة على الاحتفاظ بالماء (٢٦٠٨,١١ فدان) – وتربة ذات قوام لومي رملي (١٨٠٠,٨٣ فدان)، بينما أدى التقسيم الرقمى (أحادي المتغير) الكيميائي إلى بيان مساحة الصفوف soil classes المختلفة للأراضى: تربة متوسطة الملوحة (٣١٢٤,٧٦ فدان) – تربة غير صودية (٣٥٣١,٠٤ فدان) – وتربة غير كلسية (٣٨٥١,٣٥ فدان).

كنوع من الممارسة الجيدة cultural practice لإدارة ملوحة التربة، فقد أشارت الدراسة إلى توليفة المحاصيل combination of EC- tolerance crops التي تتحمل درجات مختلفة من ملوحة التربة، وحسبت الاحتياجات الغسيلية لأغراض أستصلاح الأراضى الملحية لزراعة محاصيل مختلفة في

مقاومتها للملوحة ، ووزعت الاحتياجات الغسيلية على خريطة ملوحة التربة والتى تكونت من أربعة وحدات خرائطية مساحتها ٢٩٨,٧٦، ٣١٢٤,٧٦ ، ٨٤٥,٣٥ و ١٦,١١ فدان ، وتميزت الخريطة كذلك بتحديد التوزيع المكاني للاحتياجات الغسيلية ، وذلك على النحو التالى (أ) الاحتياجات الغسيلية الكلية كحد أقصى لزراعة البرتقال هو ١٣١٨٩٠٩٠,٥٤ متر مكعب لكل منطقة الدراسة. (ب) القمح أكثر تحملا للملوحة من البرتقال لذا أنخفضت الاحتياجات الغسيلية الاجمالية فى حالة زراعة القمح الى ١٥٥٧٠٤٢,٧٠ متر مكعب ، وهى أقل بكثير منها في حالة زراعة البرتقال.

رسمت الخريطة الايدافولوجية لملوحة وصودية التربة (ارتباطا بمقاومة المحاصيل لملوحة التربة GIS-ESP edapholoical soil classification) ، والتى قسمت منطقة الدراسة إلى ثلاث مراتب من الأراضي three categories of ESP tolerance crop soil: وحدة خرائطية للمحاصيل شديد الحساسية للصوديوم (١٣٥٥,٠٩ فدان) – وحدة خرائطية للمحاصيل الحساسة للصوديوم (٢٨٤٥,٧٣ فدان) – وحدة خرائطية للمحاصيل المتحملة للصوديوم (٨٤,٨٨ فدان). وأستخدمت هذه الخريطه في حساب وتحديد التوزيع المكانى للاحتياجات الجبسية وفقا للمحاصيل المختلفة.

رسمت خريطة متعددة المتغيرات تجمع خريطة الملوحه مع خريطة الصوديوم المتبادل GIS-EC and ESP overlaid maps ، وتكونت هذه الخريطة من خمس مراتب : تربة غير ملحية وغير صودية (٢٩٨,٨٠ فدان)، تربة متوسطة الملوحة وغير صودية (٢٧٠١,٤٢ فدان) ، تربة عالية الملوحة وغير صودية (٥٣٥,٩٥ فدان)، تربة متوسطة الملوحة وصودية

(٤٢٤,٠٤ فدان) ، تربة عالية الملوحة وصودية (٣٢٥,٤٧ فدان).

حددت المعوقات الرئيسية main limiting factors للتربة بخريطة ملائمة الاراضي لزراعة المحاصيل والتى أوضحت أن صلاحية التربة لزراعة محصول القمح (57.3% = S4) و (42.7% = S3). بالنسبة لزراعة الفول ، كانت الصلاحية كالتالي: (47.6% = S3) ، (30.7% = S4) ، (21.7% = S2).

، أما صلاحيتها للعنب فبلغت   (63.8% = S2) ، (S3 = 26.1%). يعتبر معظم المنطقة صالحة لزراعة الزيتون (64.5% = S2) ، كما أشارت الدراسة الى ان معظم منطقة الدراسة كانت صالحة لزراعة محصول البطاطس (S2 = 61.79%) ، (19.64% = S3) وكذلك لمحصول الطماطم (S1 = 40.5%) ، (47.5% = S2).