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Land Suitability Evaluation for Certain Crops Using Micro LEIS DSS Program, North Western Coastal Area, Egypt

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ABSTRACT

Food security in Egypt is one of the most important issues of the interest of the Egyptian government to face population growth. The north west coast (NWC) has a large area that can be added to the national agricultural projects for achieving the sustainable development .The aimed to evaluate soil capability and suitability for crop production using MicroLEIS DSS approach. The study area located between Ras El Hekma ,Marsa Matrouh, El Negilla and Sidi Barrani , between longitudes 25° 44` and 27° 55` E, latitudes 30° 58` and 31° 22` N . The soil was evaluated based the variation of their physical, chemical properties, geomorphological characteristics in addition, the climate parameters. The results showed that, the soils were classified into two classes using CERVATANA model; Moderate capability (S3r) for most soil profiles where, the limiting factor was the soil erosion and (S3Ir) as the limiting factor was soil. on the other hand the soil suitability for crop using (ALMAGRA) model was suitability (S2) that covers an area of ranges between 41.17 % (~7880.2 hectare) for peach and citrus to 76.47% (~14936.5 hectare) for olive. moderately suitable (S3), has few limiting factors, marginally suitable (S4) and not suitable (S5) that has several limiting factors such as coarse texture and hard pan layers near the surface, this class occupies an area of about 3000 hectares. The study demonstrated that soil suitability and capability maps may support decision-makers to determine the optimal use of the area.

Keywords: land suitability for crops, soil characteristics, agricultural soil suitability model (ALMAGRA)

INTRODUCTION

Egypt has a unique geographical location and large area, it is estimated at about one million square kilometers, agricultural development faces many obstacles and limitations factors such as climatic conditions, water scarcity (Hegazi *et al.* 2005). In addition, about 92.4% of the total area of the Arab Republic of Egypt is not used in agricultural sustainable development. Statistics indicate that the population of Egypt exceeded 100 million (August 2019, https://www.capmas.gov.eg). The Egyptian population is concentrated in the Nile Valley and the Delta, in addition to the coastal areas along the Red Sea and the Mediterranean Sea, and some scattered areas in the Western Desert. The continuous population increase has led to an increase in human pressure, competition for limited natural resources, and thus the gap between food and population has increased .Recently, the Egyptian government has increased its interest in establishing agricultural development projects in many areas in the Western Desert. And given that the north coast has many advantages such as the unique location and the appropriate climate for the establishment of new communities. The soils of the North Coast, with a length of 500 km, are characterized by a sandy texture, which is suitable for most horticultural and field crops. (Belal *et al.* 2019).There are many challenges facing the Egyptian government to achieve sustainable development NWC, the most important of issues which is to optimally utilize natural resources to achieve sustainable development in the NWC region, to be more attractive for investment in the agricultural and industrial aspects.(Sayed 2013). According to Dent and Anthony (1981) the main aim of land evaluation is to predict the consequence of change. Thus, Land evaluation becomes necessary where change is contemplated. Therefore, The assessment of land helps determine alternatives to soil use according to soil characteristics, water quality, and climatic conditions, in addition to social and economic conditions, as well as the preservation of environmental resources to ensure better exploitation in the future for the following generations. (Sys *et al.* 1991).The MicroLEIS program is characterized by its ease to use in evaluating soils under various ecosystems, as well as providing alternatives to various crops that suit the conditions of the Mediterranean countries. Darwish *et al.* (2006) reported that, MicroLEIS (Mediterranean Land Evaluation Information System) has evolved towards an agro-ecological DSS. Recently, MicroLEIS DSS is a set of tools for decision-making which in a wide range of agro-ecological schemes. CERVATANA general land capability model and ALMAGRA agricultural soil suitability model are one of the MicroLEIS micro-computer DSS models. In addition, the computer based land evaluation information system (MicroLEIS) was investigated by Özcan (2006) in Turkey, where the development for optimal use of agricultural under Mediterranean conditions were identified. This system includes the assessment of the ability of the land to produce crops as well as the degree of suitability of the soil for various crops. Moreover, the outputs of the CERATANA Land Assessment Model include different degrees, as S1 indicates the highest degree of suitability, S2 indicates moderate suitability, S3 indicates low suitability, while N denotes unsuitability of the soil for crops. There are many studies that used this model on the northwest coast, where they showed that it is suitable for most crops, except for citrus, olives, and peaches because the soil texture is very heavy (Said,*et al.*,2020).According to Sayed (2013), CERVATANA and ALMAGRA models were applied based on a computer program and MicroLEIS web, the soils

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adjacent to El-Hammam canal were classified as follow: good suitable (S2), moderate suitable (S3), and Marginal suitability for crops (N). In addition (ALMAGRA) model was used to evaluate soil suitability for crops. the author indicted the soils suitability of El-Hammam were ranged between S2 to S5 .The most suitability crops were arranged from high to low as follow olive , citrus , peach , wheat, alfalfa, melon and sunflower. The objective of the current study is to evaluate the soil of NWC to make the optimum land use based on the land and water resource

MATERIALS AND METHODS

IN-SITU Study Area

Location and climate

The study area is bounded by longitudes 25° 44` and 27° 55` E, latitudes 30° 58` and 31° 22` N Figure 1. Four promising areas for agricultural development were identified for the present study; these areas from West to East are Ras El Hekma, Marsa Matrouh, El Negilla, and Sidi Barrani. The investigated regions have a special interest due to its agricultural activities, which has more soil and water resources to be sustainable. The climate of the studied area is characterized by long rainless at summer and short rainy at winter, from October to April, with limited variations in daily temperature. In general, the zone is related to the arid or hyper-arid Mediterranean climate. In the current study, the main rainfall was shown from five meteorological stations representing the area, namely; El Sallum, Sidi Barani, Mersa Matruh, El Dabaa and Alexandria (105, 144, 140, 141 and 199, respectively) Sivakumar and Ndiang (2007).

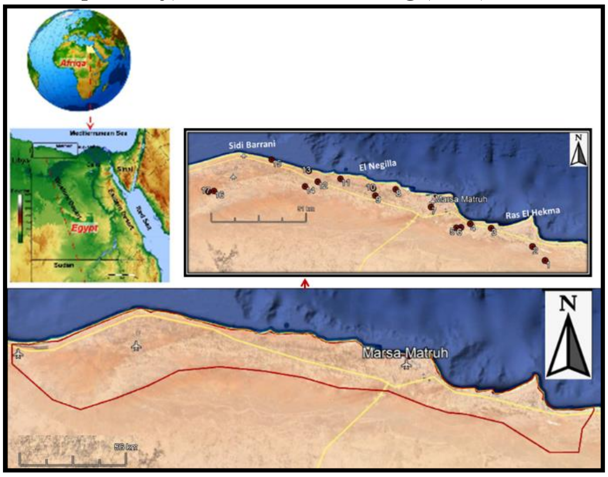

Figure 1. Location of the studied soil profiles

Geomorphological and Geological Settings

The study area reflect a portion of the Northwestern coast of Egypt, which is characterized by three main geomorphological units are identified as the tableland, piedmont plain, and the coastal plain Figure 2, Yousif and Bubenzer (2012). The coastal plain has a narrow strip of land that stretching along the Mediterranean Sea. The maximum extent inland is 4.5 km. The slopes northward and has elevations from 10 to 40 m above the sea level. It comprises shallow depressions, elongated ridges, and dunes. In addition, Hosny *et al*., (2005) showed that the piedmont plain that extends south to the coastal plain forms a transition zone between the tableland and the coastal plain. It covers an area of 145 km^2, a width of 24 km, a length of 7 km andhas ridges that separated by depressions. Moreover, (Raslan (1995) showed that salt marshes are recorded in a few spots inside the plain. The tableland reaches a maximum elevation of 170 m above sea level. The region dominated by hard limestone strata that developed into a flat to slightly undulating plain at several localities revealing closed to sub-closed hollows into which loamy deposits that accumulated. Furthermore, the geomorphologic setting of the investigated area influences the groundwater conditions and strongly controls the spreading of the surface runoffthat either accumulates in the depressions or drains into the sea.According to Selim (1969), the Northwestern Mediterranean coastal zone is occupied by sediment and sedimentary rocks are ranging in age from Tertiary to Quaternary. Quaternary deposits are exposed in the study area. It is formed of a thin cover of drift sands and loamy deposits. Hosny *et al*. (2005) reported that, the study area is a part of the Marmarica Homocline, which occupies the area north of the Qattara depression.

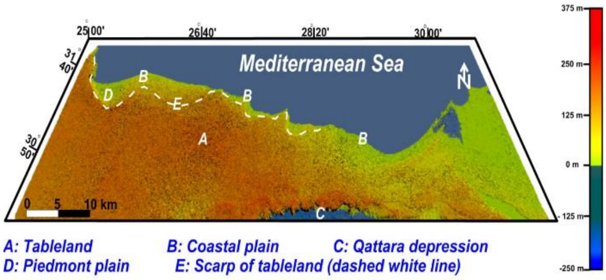

Figure 2. Geomorphology of the area under study

Field and laboratory work

Based on the topographic and geomorphological maps as well as field observations, seventeen soil profiles were selected to represent the recognized geomorphic units, four areas; Ras El Hekma, Marsa Matrouh , El Negilla and Sidi Barrani .Fifty two collected soil samples were air-dried, crushed, and passed through a 2 mm sieve. The soil paste extract were prepared to determine the soil pH, electrical conductivity, and soluble cations and anions. Sodium and potassium ions were measured using flame photometer. Calcium, magnesium, chloride, carbonates, and bicarbonates were determined titrimetrically. Sulphates were calculated according to (Black *et al*., 1982).

Cervatana model (land capability model)

A land capability model is built in Cervatana model for defining the capability of the identified map units. The program runs with sequences to match the land characteristics with the conditions required for each capability class. The land unit is assigned to a subclass that determined by the most limiting land qualities (Aldabaa *et al*., 2010). The factors that considered are; (a) site, (b) soil limitation, (c) erosion risks, and (d) bioclimatic deficiency which are inferred from the generalized values namely (a) slope, (b) useful soil depth, soil texture, stoniness, drainage and salinity, (c) slope, soil erodibility, rainfall erosivity and vegetation density, and (d) rainfall and frost risk (Mahmoud *et al*., 2019). These parameters are used to identify the capability classes: Class S1-Excellent, Class S2-Good, Class S3-Moderate, Class N-Marginal, and Not Suitable. De la Rosa *et al*. (1992) defined four subclasses are also according to the maximum limitations of site (t), soil (l), erosion risk (r), and bioclimatic deficiency (b).

Agricultural soil suitability: *Almagra model Agricultural soil suitability*

The land suitability assessment has been conducted for soil map units which has agricultural capability depending on the results of the land capability assessment. The automated land evaluation system, Almagra model - Agricultural soil suitability, used to assessment the suitability of the soil map units for selected land use types. The soil suitability model was based on the edaphic factors that influence the production of the annual traditional crops: wheat, corn, melon, potato, soybeans, cotton, sunflower, and sugarbeet. Semi-annual or perennial such as peach, alfalfa, citrus, and olive were selected and used Almagra model for assessment agricultural soil suitability (De la Rosa *et al*., 2004).

RESULTS AND DISCUSSION

Soil Characteristics

Among the recognized geomorphic units and subunits already mentioned before, and four areas were selected to study their soils from the East to West are: Marsa Matrouh, Ras El Hekma, El Negilla and Sidi Barrani. Based on the specific soil parameters, soil depth and texture of the studied soil profiles, the morphological, physical and chemical properties of each soil mapping unit are given in the following:

Ras El Hekma region

Deep coarse-textured soils

The soils in this mapping unit represented by soil profile No. (1 and 2), the main features of th soil mapping unit are; depth (>100 cm), coarse texture (sand to loamy sand), with a strongly to extremely calcium carbonate contents (23.16 to 40.98 %), and a moderately well drained soils. Soil structure and the dry consistence are varied from massive and soft to friable on the surface and deeper layers, respectively. Nevertheless, the soil reaction is varied from slightly alkaline to moderately alkaline, as the pH values ranged from7.6 to 7.9. Electrical conductivity values ranged between 0.21 and 0.36 dSm^{-1} indicating non saline soils, while the highest values are detected in the deepest soils and increased throughout the soil depth. The cationic composition of the investigated soil saturation extract of the soil layers is dominated by Na^+ followed by Ca^2 and Mg^2 while K^+ is the least abundant cation. Cation exchange capacity values are considerably low (3.79 and 5.48 cmol kg^{-1} soil) and coincide well with soil texture, Table 1.

Table 1. Analytical data of the profiles representing studied area (Particle size distribution and physical properties)

Location	Profile No.	Depth cm.	Gravel %	$CaCO_3$ %	Particle size distributions (%) Sand	Silt	Clay	Soil texture	FC %	WP %	AW %
Ras El Hekma	1	0-50	0.37	40.98	90.90	2.50	6.60	Sand	8.04	5.52	2.52
		50-100	0.20	40.56	90.90	2.50	6.60	Sand	8.04	5.52	2.52
		100-150	0.00	35.07	90.90	2.50	6.60	Sand	8.04	5.52	2.52
	2	0-50	0.00	26.33	90.56	2.50	6.94	Sand	8.24	5.57	2.67
		50-100	0.00	29.34	90.56	2.50	6.94	Sand	8.24	5.57	2.67
		100-150	0.32	23.16	83.06	7.50	9.44	Loamy sand	12.55	6.84	5.71
	3	0-50	32.21	27.51	76.00	10.00	14.00	Sandy loam	16.35	8.09	8.27
		50-90	15.26	36.80	76.00	7.50	16.50	Sandy loam	16.29	8.03	8.26
		90-150	3.18	36.09	81.00	5.00	14.00	Sandy loam	13.61	7.13	6.47
Marsa Matrouh	4	0-30	1.32	22.51	79.95	5.00	15.05	Sandy loam	14.16	7.30	6.86
		30-90	1.82	25.01	79.95	7.50	12.55	Sandy loam	14.23	7.36	6.87
		90-150	14.52	26.80	82.45	2.50	15.05	Sandy loam	12.74	6.82	5.92
	5	0-40	1.99	19.06	90.90	2.50	6.60	Sand	8.04	5.52	2.52
		40-70	1.30	24.17	90.90	2.50	6.60	Sand	8.04	5.52	2.52
		70-120	0.55	14.69	83.40	5.00	11.60	Loamy sand	12.32	6.75	5.57
	6	0-50	2.41	16.91	89.39	2.50	8.11	Sand	8.91	5.75	3.16
		50-90	25.79	18.15	76.89	7.50	15.61	Sandy loam	15.84	7.88	7.95
		90-130	8.64	10.23	74.39	10.00	15.61	Sandy loam	17.18	8.37	8.81
	7	0-40	3.03	25.16	71.00	12.50	16.50	Sandy loam	18.92	9.02	9.90
		40-100	9.61	28.63	66.00	15.00	19.00	Sandy loam	21.38	10.00	11.38
		100-150	5.38	22.15	73.50	10.00	16.50	Sandy loam	17.63	8.53	9.10
	8	0-50	3.57	23.22	78.40	10.00	11.60	Sandy loam	15.09	7.66	7.43
		50-90	11.19	21.79	71.89	10.00	18.11	Sandy loam	18.43	8.81	9.61
		90-150	17.69	14.79	74.39	7.50	18.11	Sandy loam	17.10	8.31	8.79
	9	0-30	12.87	21.97	84.95	5.00	10.05	Loamy sand	11.47	6.50	4.97
		30-65	67.65	23.24	69.95	10.00	20.05	Sandy clay loam	19.37	9.16	10.21
		65-120	23.31	20.36	69.95	7.50	22.55	Sandy clay loam	19.25	9.06	10.19

FC is Field Capacity; WP is witting point and AW is available water.

Table 1. cont.

Location	Profile No.	Depth cm.	Gravel %	$CaCO_3$ %	Particle size distributions (%) Sand	Silt	Clay	Soil texture	FC %	WP %	AW %
El Negilla	10	0-35	2.73	20.72	75.40	10.00	14.60	Sandy loam	16.66	8.19	8.47
		35-85	0.66	21.08	67.90	10.00	22.10	Sandy clay loam	20.34	9.52	10.81
		85-115	1.71	18.14	70.40	5.00	24.60	Sandy clay loam	18.87	8.85	10.02
	11	0-20	30.11	18.06	71.82	10.00	18.18	Sandy loam	18.46	8.83	9.63
		20-50	44.39	18.14	71.82	7.50	20.68	Sandy clay loam	18.36	8.74	9.61
		50-90	33.00	31.77	69.32	10.00	20.68	Sandy clay loam	19.67	9.27	10.4
Sidi Barrani	12	0-25	3.65	13.38	82.45	5.00	12.55	Sandy loam	12.83	6.90	5.93
		25-75	0.93	20.01	82.45	7.50	10.05	Loamy sand	12.88	6.94	5.94
		75-115	4.49	23.94	67.45	7.50	25.05	Sandy clay loam	20.4	9.48	10.92
	13	0-20	3.54	22.15	82.90	7.50	9.60	Loamy sand	12.64	6.86	5.77
		20-57	1.51	11.70	85.40	2.50	12.10	Loamy sand	11.15	6.37	4.78
		57-90	0.27	10.20	82.90	2.50	14.60	Sandy loam	12.5	6.75	5.75
		90-130	1.10	11.29	75.40	10.00	14.60	Sandy loam	16.66	8.19	8.47
	14	0-40	0.00	13.21	84.32	7.50	8.18	Loamy sand	11.85	6.62	5.22
		40-85	1.36	18.06	81.82	7.50	10.68	Loamy sand	13.23	7.05	6.18
	15	0-35	2.50	16.80	83.06	5.00	11.94	Loamy sand	12.50	6.80	5.70
		35-80	5.64	18.81	78.06	7.50	14.44	Sandy loam	15.23	7.68	7.55
		80-115	2.54	19.90	80.56	5.00	14.44	Sandy loam	13.84	7.21	6.64
	16	0-40	0.63	16.72	89.95	2.50	7.55	Sand	8.59	5.67	2.93
		40-110	64.77	21.79	82.45	5.00	12.55	Sandy loam	12.83	6.90	5.93
	17	0-30	1.66	22.87	92.45	2.50	5.05	Sand	7.13	5.28	1.85
		30-85	1.47	26.21	89.95	2.50	7.55	Sand	8.59	5.67	2.93
		85-120	11.84	26.56	90.40	2.50	7.10	Sand	8.33	5.60	2.73

Deep, moderately coarse textured soils

The soils in this mapping unit represented by soil profile No. (3). The landscape has an almost flat to nearly level sloping plain surface, while the mainfeatures of this soil mapping unit with a depth of (150 cm), and thesoil texture throughout the entire depth is sandy loam. Calcium carbonate contents are strongly to extremely calcareous (27.51 to 36.8 %). Soil reaction mostly is slightly alkaline. Electrical conductivity values of the soils vary from 2.6 to 14.8 dSm^{-1}, indicating a variation from free to slightly saline to strongly saline soils. The lowest ECe values are detected in the surface layer and increased with the soil depth. As to the characteristics of soils in this mapping unit, the CEC values varied from 9.39 to 11.89 cmol kg^{-1} soil and coincide well with soil texture, Table 2.

Table 2. Analytical data of the profiles representing studied area (Some chemical and physico-chemical properties .)

Profile	Depth	pH	EC	Soluble Cations (mmole L^{-1})				Soluble Anions (mmole L^{-1})				CEC	ESP	OM
No.	cm.		dSm^{-1}	Na^+	K^+	Ca^{+2}	Mg^{+2}	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}	cmol kg^{-1} soil	%	%
							Ras El Hekma							
1	0-50	7.58	0.21	1.02	0.08	0.50	0.50	n.d.	0.98	1.01	0.11	3.79	3.43	0.13
	50-100	7.58	0.24	1.13	0.27	0.50	0.50	n.d.	1.22	1.12	0.06	3.79	3.60	
	100-150	7.69	0.36	1.57	0.53	1.00	0.50	n.d.	1.44	1.41	0.75	3.79	3.81	
2	0-50	7.79	0.21	1.02	0.08	0.50	0.50	n.d.	1.04	1.01	0.05	4.23	3.43	0.22
	50-100	7.69	0.25	1.07	0.43	0.50	0.50	n.d.	1.02	1.01	0.47	4.23	3.51	
	100-150	7.77	0.23	1.07	0.23	0.50	0.50	n.d.	1.00	1.01	0.29	5.48	3.51	
3	0-50	7.82	2.66	17.68	0.42	5.00	3.50	n.d.	1.50	15.09	10.01	9.39	10.79	0.33
	50-90	7.63	12.63	97.62	0.68	16.50	11.50	n.d.	1.68	95.81	28.81	10.64	28.82	
	90-150	7.69	14.81	125.42	0.68	13.50	8.50	n.d.	1.56	123.56	22.98	11.89	40.90	
							Marsa Matrouh							
4	0-30	7.86	0.32	1.41	0.29	1.00	0.50	n.d.	0.90	1.31	0.99	9.16	3.63	0.43
	30-90	7.95	0.21	1.01	0.09	0.50	0.50	n.d.	0.88	1.00	0.22	7.61	3.42	0.35
	90-150	7.91	0.22	1.02	0.18	0.50	0.50	n.d.	1.04	1.00	0.16	8.86	3.43	
5	0-40	7.80	0.24	1.11	0.29	0.50	0.50	n.d.	1.12	1.01	0.27	3.79	3.57	0.13
	40-70	7.85	0.22	1.06	0.14	0.50	0.50	n.d.	0.98	1.01	0.21	3.57	3.50	0.07
	70-120	7.65	0.27	1.46	0.24	0.50	0.50	n.d.	1.2	1.41	0.09	6.07	4.07	
6	0-50	7.76	0.27	1.44	0.26	0.50	0.50	n.d.	1.14	1.41	0.15	4.47	4.05	0.11
	50-90	8.72	0.49	3.24	0.16	1.00	0.50	n.d.	1.56	3.23	0.11	8.22	5.80	
	90-130	8.66	0.55	3.71	0.29	1.00	0.50	n.d.	1.88	3.64	0.18	8.22	6.36	
7	0-40	7.88	7.85	59.26	1.24	10.50	7.50	n.d.	2.65	55.52	20.33	10.19	22.29	0.51
	40-100	7.65	12.03	98.62	0.68	13.00	8.00	n.d.	3.6	96.65	20.05	11.06	33.29	0.41
	100-150	7.74	9.02	74.82	0.38	9.00	6.00	n.d.	2.8	72.84	14.56	9.81	30.09	
8	0-50	7.52	0.25	1.28	0.22	0.50	0.50	n.d.	0.88	1.25	0.37	8.23	3.81	0.64
	50-90	7.53	0.22	1.07	0.13	0.50	0.50	n.d.	0.90	1.01	0.29	11.49	3.51	
	90-150	7.49	0.21	1.02	0.08	0.50	0.50	n.d.	0.88	1.01	0.21	11.49	3.43	
9	0-30	7.51	0.34	1.57	0.33	1.00	0.50	n.d.	1.04	1.45	0.91	7.19	3.81	0.57
	30-65	7.19	0.43	2.08	0.22	1.50	0.50	n.d.	1.50	1.75	1.05	14.24	4.09	1.11
	65-120	7.45	0.32	1.52	0.18	1.00	0.50	n.d.	1.26	1.51	0.43	15.49	3.76	

Table 2. cont.,

Profile	Depth	pH	EC	Soluble Cations (mmole L^{-1})				Soluble Anions (mmole L^{-1})				CEC	ESP	OM
No.	cm.		dSm^{-1}	Na^+	K^+	Ca^{+2}	Mg^{+2}	CO_3^{-2}	HCO_3^-	Cl^-	SO_4^{-2}	cmol kg^{-1} soil	%	%
							El Negilla							
10	0-35	7.52	0.27	1.28	0.42	0.50	0.50	n.d.	0.88	1.21	0.61	10.26	3.81	0.78
	35-85	7.27	0.29	1.59	0.31	0.50	0.50	n.d.	0.98	1.45	0.47	13.52	4.27	0.65
	85-110	7.27	0.27	1.26	0.44	0.50	0.50	n.d.	0.88	1.22	0.60	14.77	3.78	
11	0-20	7.36	0.26	1.29	0.31	0.50	0.50	n.d.	0.86	1.17	0.57	12.32	3.82	0.85
	20-50	7.37	0.21	1.00	0.10	0.50	0.50	n.d.	0.84	1.00	0.26	13.27	3.40	0.77
	50-90	7.22	0.25	1.28	0.22	0.50	0.50	n.d.	1.04	1.17	0.29	13.27	3.81	
							Sidi Barrani							
12	0-25	8.02	0.46	2.13	0.47	1.50	0.50	n.d.	1.54	2.01	1.05	9.62	4.14	0.88
	25-75	7.93	0.22	1.02	0.18	0.50	0.50	n.d.	1.04	1.02	0.14	6.96	3.43	0.51
	75-115	7.92	0.22	1.03	0.17	0.50	0.50	n.d.	0.98	1.01	0.21	14.46	3.45	
13	0-20	7.46	0.33	1.39	0.41	1.00	0.50	n.d.	1.06	1.33	0.91	8.14	3.61	0.88
	20-57	7.30	0.28	1.56	0.24	0.50	0.50	n.d.	1.02	1.51	0.27	8.25	4.23	0.58
	57-90	7.24	0.26	1.42	0.18	0.50	0.50	n.d.	1.20	1.40	0.10	9.50	4.02	
	90-130	7.18	0.26	1.42	0.18	0.50	0.50	n.d.	1.04	1.38	0.18	9.50	4.02	
14	0-40	7.38	0.27	1.32	0.38	0.50	0.50	n.d.	1.40	1.23	0.07	6.18	3.88	0.55
	40-85	7.45	0.36	1.72	0.38	1.00	0.50	n.d.	1.50	1.63	0.47	8.00	4.00	0.70
15	0-35	7.71	0.26	1.09	0.51	0.50	0.50	n.d.	1.04	1.07	0.49	7.34	3.54	0.36
	35-80	7.91	0.31	1.53	0.57	0.50	0.50	n.d.	1.22	1.41	0.47	8.25	4.17	0.27
	80-115	7.82	0.48	2.67	0.63	1.00	0.50	n.d.	1.42	2.52	0.86	8.25	5.12	
16	0-40	8.62	0.27	1.26	0.44	0.50	0.50	n.d.	1.06	1.21	0.43	4.92	3.78	0.30
	40-110	8.50	0.22	1.05	0.15	0.50	0.50	n.d.	1.02	1.03	0.15	7.61	3.47	0.35
17	0-30	8.26	0.36	1.87	0.23	1.00	0.50	n.d.	1.42	1.82	0.36	3.17	4.17	0.17
	30-85	8.29	0.32	1.51	0.19	1.00	0.50	n.d.	1.36	1.44	0.40	4.42	3.74	0.17
	85-120	8.38	0.32	1.50	0.20	1.00	0.50	n.d.	1.28	1.47	0.45	4.20	3.73	

Marsa Matrouh region

Deep, moderately coarse textured soils

These soils cover a great portion of the study area of about 4650.0 hectare. The surface is almost flat, sometimes gently undulating. The natural vegetation cover is common scattered desert shrubs. The main features of the soil mapping unit are varied from 120 to 150 cm, while the soil texture throughout the entire depth is sandy loam to loamy sand in the deeper layers. Calcium carbonate contents are moderate to extremely calcareous (10.2 to 28.6 %), while the soil reaction is varied from slightly alkaline to strongly alkalineand indicated by pH values with a range from 7.5 to 8.7. Soil salinity is very low as indicated by the EC, which exceeds 1.2 dSm^{-1}, except for the surface and subsurface layers of profile No (8) whose soil salinity is strongly saline (9.0 to 12.02 dSm^{-1}). In addition, the results reveals that he cationic composition is dominated by Na^+ followed by Ca^{2+}, Mg^{2+} and K^+. The anionic composition is characterized by the dominance of Cl^- followed by SO_4^{2-} and HCO_3^- while the CO_3^{2-} is entirely absent. The soil organic matter content is varied from0.07 to 0.6 %.

Deep, moderately fine textured soils

The soil mapping unit results covers an area of 2530.0 hectare, and represented by soil profile 9, the common characteristics of these soils are deep. Gravel content ranges from 9.97 to 10.21 %, table (1). The soil texture throughout the entire depth is varied from sandy loam to sandy clay loam. In addition, the calcium carbonate content ranges from 20.3 to 23.2 %and the soil reaction is slightly alkaline as indicated by pH values that ranged from 7.49 to 7.53. For the soil salinity, The EC values varied from 0.21 to 0.34 dSm^{-1}. The soil cationic composition is dominated by Na^+ followed by Ca^{2+} and Mg^{2+}, while the K^+ is the least abundant cation. Moreover, the anionic composition is characterized by Cl^- followed by HCO_3^-, while CO_3^{2-} in entirely absent. The organic matter content is very low (0.57%).

El Negilla region

Deep, moderately fine -textured soils

The obtained topography result of the landscape is almost flat with nearly level to gently sloping surface. Whilethe main features of this soil mapping unit are deep with115 cm and a texture of sandy clay loam and/or sandy loam. Calcium carbonate content varies from 18.06 to 21.08 %, whereas the calcium carbonate content decreases with soil depth. The soil reaction is generally slightly alkaline (pH 7.2 - 7.65). While the EC ranges from 0.27 to 0.43 dSm^{-1}, with the highest EC values being measured in the surface layer. In addition, the cationic composition is dominated by Na^+, while the soil anionic composition is dominated by Cl^-. Organic matter content is low (0.8 to 1.1 %).

Moderately deep, moderately fine -textured soils

The obtained topography results of the landscape are generally flat with the nearly level sloping surface. The main features of the soil mapping unit are moderately depth of 90 cm and a texture of sandy clay loam or sandy loam. Gravel contents range widely from 12.8 to 67.6 %, the highest content is detected in the subsurface layer. Moreover the calcium carbonate content varies from 18.1 to 35.4 %, soil and coincides well with soil texture. The investigated soil reaction is slightly alkaline that indicated by pH value (7.3 to 7.4). EC ranges from 0.21 to 0.27 dSm^{-1} with the lowest value being obsrved in the deepest layer. Regarding the levels of organic matter, the obtained data show that soil organic matter content is 0.77 and 0.85 % in the subsurface and the surface layer, respectively.

Sidi Barrani region

Deep coarse -textured soils

The soil map unit covers an area of 2120.0 hectare. The main soil features of the unit depth are (110 and 120cm)doinated with coarse texture, high calcium carbonate contents, and moderate drainage. Texture of the entire soil depth of this mapping unit is sand. The gravel content is widely ranges from 0.63 to 64.77%. That the soils are strongly calcareous, where the obtained calcium carbonate content varies from 16.7 to 26.7 % in which the highest calcium carbonate contents are detected in the deeper horizons. In addition, the soil reaction is varied from moderate to strongly alkaline, as indicated by pH values that ranging from 7.8 to 8.6. Furthermore, the soil salinity varies from 0.22 to 0.48 dSm^{-1} indicating non-saline soils. The cationic composition is dominated by Na^+ followed by Ca^{2+}, Mg^{2+} and K^+, while the anionic compositions are characterized by the dominance of Cl^-. While the soil organic matter content is very low (0.17 to 0.35 %).

Deep, moderately coarse- textured soils

The main features of this soil mapping unit are varied from a depth of115 to 130 cm, while the soil topography of the landscape is almost flat with a nearly level sloping surface. Soil texture throughout the entire depth is sandy clay loam to sandy loam at the soil surface. Calcium carbonate contents are moderate to strongly calcareous (10.2 to 23.9 %), the highest aclcium carbonate contents are mostly identfied in the deeper layers. While the soil reaction is varied from slightly alkaline to moderately alkaline as indicated by pH values that range from 7.2 to 8.0. In addition, the EC values showed a non-saline soil (0.22 to 0.46 dSm^{-1}). The obtained results show that the soil organic matter content is 0.27 and 0.88 % in the subsurface and the surface layer, respectively.

Moderately deep, coarse -textured soils

The obtained soil mapping unit covers an area of about 1800.0 hectare and represented by soil profile No.14. Topography results of the landscape are generally undulating, the soil surface is covered with common scattered desert shrubs. The common characteristics of these soils are moderately deep (85 cm.), gravel content ranges from 0.5 to 1.36 %. Soil texture throughout the entire depth is loamy sand. The obtained soil reaction is slightly alkaline, as indicated by pH values ranging from 7.2 to 7.4. In addition, the soil salinity varies from 0.26 to 0.4827 dSm^{-1} indicating non-saline soils. Moreover, the cationic composition of most soil layers is dominated by Na^+, while the anionic compositions are dominated by Cl^-. The soil organic matter content is very low (0.5 %).

Land capability model and suitability for crops (Micro LEIS)

Cervatana model: General land capability

The main target of this study is to assessthe soil characteristics (physical, and chemical), and their applicability for land evaluation by using MicroLEIS DSS program, North western coastal area, Egypt. Applying CERVATANA model, the weighted mean of soil profile properties, Tables 3 and 4 show that, these soils could be followed the following classes: Moderately suitable S3. That represented soil profiles for Ras El Hekma, Marsa Matrouh, El Negilla and Sidi Barrani. These soils have very few of extermely gravels content, and characterized by deep and moderately deep soils, coarse to moderate fine textured soils throughout the effective root zone depth,. The soils of this class distinguished into (S3r and S3lr). These soils are characterized by moderate severe to severe limitations in their soil factors (l) or/and erosion risk factors (r).

Almagra model: Agricultural soil suitability

ALMAGRA model for the soil suitability is depend on the analysis of edaphic factors that affect the productivity of annual, semiannual, and perennial crops. Land suitability evaluation of the studied area was performed using useful depth, texture, drainage, carbonate, salinity, sodium saturation and profile development as limitation factors for crop's development. Twelve crops (annual and semi-annual / perennial crops, Table 4) were selected and evaluated according to their requirements with the land characteristics of the mapping units. For semi-annual / perennial crops, the main limitation factor for suitability classes are, calcium carbonate, drainage, soil texture, and soil depth. The soils have very severe limitation in salinity. However, the main limitation factors for annual crops suitability classes are soil texture (t), calcium carbonate (c), soil salinity (s) and alkalinity (a).

Accordingly, the soils of the studied area associated with the type of the mapping units are classified into four classes of land suitability as follows:-

Table 3. Weighted mean of soil properties for the profiles representing studied area.

Location	Mapping unit	Profile	Depth	Gravel	$CaCO_3$	Particle size distributions (%)			pH	EC	CEC	ESP
		No.	cm.	%	%	Sand	Silt	Clay		dSm^{-1}	$Cmol\ kg^{-1}$	%
Ras El Hekma	Deep coarse-textured soils	1	150	0.19	38.87	90.90	2.50	6.60	7.62	0.27	3.79	3.61
		2	150	0.11	26.28	88.06	4.17	7.77	7.75	0.23	4.65	3.48
	Deep moderately coarse-textured soils	3	150	16.32	33.78	77.67	7.42	14.92	7.71	10.37	10.68	27.44
Marsa Matrouh	Deep moderately coarse textured soils	4	120	6.80	25.23	80.95	5.00	14.05	7.92	0.24	8.42	3.47
		5	130	0.97	18.52	70.22	3.54	8.68	7.95	0.58	6.42	5.30
		6	150	9.98	15.24	70.14	6.35	12.73	7.76	0.25	4.62	3.84
		7	150	6.45	25.54	69.83	12.67	17.50	8.42	2.97	8.88	11.52
		8	150	11.25	19.47	75.06	9.00	15.94	7.62	6.52	9.59	20.64
	Deep moderately fine-textured soils	9	120	26.91	21.60	58.96	7.60	18.70	7.51	0.27	9.52	3.62
El Negilla	Deep moderately fine -textured soils	10	115	1.14	19.41	51.96	8.48	19.40	7.06	0.33	13.30	3.71
	Moderately deep moderately fine -textured soils	11	90	21.69	30.34	42.43	9.17	20.12	7.34	0.24	13.29	3.62
Sidi Barrani	Deep moderately coarse-textured soils	12	115	2.12	19.94	59.21	6.96	15.81	7.81	0.33	9.49	3.82
		13	130	0.90	12.80	50.36	5.58	13.12	7.42	0.28	9.56	3.87
		15	115	2.87	18.53	61.60	5.98	13.68	7.69	0.31	7.82	3.87
	Deep coarse -textured soils	16	110	30.73	19.95	80.95	4.09	10.73	8.33	0.35	6.13	4.27
		17	120	3.63	25.48	72.57	2.50	6.79	8.33	0.31	4.64	3.87
	Moderately deep coarse -textured soils	14	85	0.99	15.78	66.41	7.50	9.50	7.29	0.27	7.74	3.95

Table 4. Land capability and suitability for crops using MicroLEIS DSS system.

Location/ area	Profile	Land capability	Annual crops								Semi annual / perennial crops			
	No	Model	Wheat	Maize	Melon	Potatoe	Soybean	Cotton	Sunflower	Sugarbeet	Alfalfa	Peach	Citrus	Olive
Ras El Hekma	1	S3r	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3tc	S3tc	S2tca
	2	S3r	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S2ta
	3	S3Ir	S5t	S5ta	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5s	S5s	S4a
Marsa Matrouh	4	S3r	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2ptd	S2ptd	S2ptd
	5	S3r	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S2ptd
	6	S3r	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S2ta
	7	S3r	S3t	S3ta	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tds
	8	S3r	S3ts	S3tsa	S3ts	S3ts	S3ts	S3t	S3ts	S3t	S3ts	S4s	S4s	S3s
	9	S3Ir	S3t	S3t	S2tca	S2tca	S3t	S2tc	S3t	S3t	S3t	S2tca	S2tca	S2ta
El Negilla	10	S3Ir	S2ta	S2tca	S2ca	S2ca	S2ta	S2c	S2ta	S2t	S2ta	S2dca	S2dca	S2da
	11	S3Ir	S3t	S3t	S2tca	S2tca	S3t	S2tc	S3t	S3t	S3t	S2tdc	S2tdc	S2tda
Sidi Barrani	12	S3r	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tda
	13	S3r	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tda
	14	S3Ir	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4d	S4d	S4d
	15	S3r	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S2tda
	16	S3Ir	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S4td
	17	S3r	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S2tda

- **Suitable (S2):** In the study area, soils of this class cover a small area for annual crops, Table (4), these soils were represented by deep moderately fine textured soils and moderately deep, moderately fine textured soil units. On the other hand, slightly suitable (S2) are covering large an area for semi-annual / perennial (peach, citrus and olive), covers an area of ranges between 41.17 % for peach and citrus to 76.47% for olive, Figure 3.
- **Moderately suitable (S3):** These are good soils with few limitations such as; coarse texture and high salinity. This soils covers an area of about 4531.0 hectare, and represented by soil profiles located in El Negilla, Marsa Matrouh and a small portion of Sidi Barrani and Ras El Hekma areas.
- **Marginally suitable (S4):** Soils belonging to this class are those of moderately deep coarse textured soils, deep moderately coarse textured soils and deep coarse textured soils , they are occupied an area of about 40.0 % (about 7530 hectare). The soils are marginally suitable for annual crops and alfalfa, Table 4.
- **Not suitable (S5):** The land belonging to this class is devoid of any current potentialities that allow agriculture use. These soils were represented by deep coarse textured soils, It is extremely saline and highly alkaline. The land corresponding to this class is that coarse texture which occupies an area of about 3000 hectare, Figure 4.

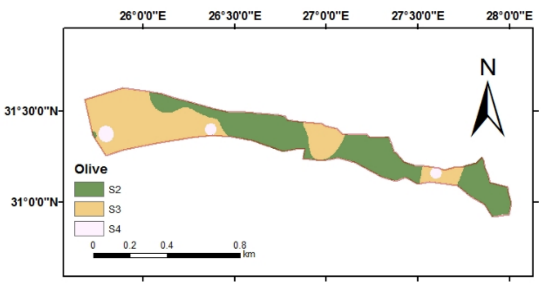

Figure 3. Land suitability for Olive crop

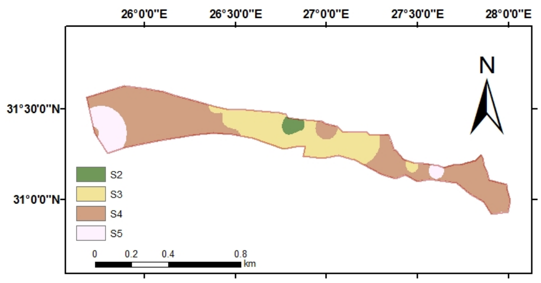

Figure 4. Land suitability for Wheat crop

CONCLUSION

In Egypt, the arid to semi-arid regions were characterized by a scarcity of land and water resources, the coastal zone of Egypt has become the major site for extensive and diverse economic activities. The study area was carried out to investigate the land suitability for some crops using MicroLEIS DSS system under Mediterranean area conditions, and demonstrate the applicability of quantitative systems for assessing land capability and suitability for crops on basis of most soil properties relevant to pedogenetic classification. Based on specific soil attributes, soil depth and texture of the studied soil profiles, the studied area could be classified to five soil mapping units. A Web-based program, MicroLEIS, was used to compare the soil characteristics and quality needed for 12 different types of crops. The Web-based soil evaluation system indicated that the soils of the study area are suitable (S2) to not suitable (S5) for the selected crops due to one or more limiting factors. The results showed that methods integrating properties to one index have a higher precision than methods that qualify soils on limitations for single parameters. Modern software controlled methods such as MicroLEIS are more suitable and easier to apply than parametric methods. The classifications of land suitable for crops generated by the ALMAGRA system have a good result for the North Western coastal zone (Mediterranmnean area). The study proved that the analysis of soil properties and the application of tools to assess the land capability and suitability are powerful tools that can be used to support decision-making.

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تقييم ملائمة التربة لزراعة بعض المحاصيل باستخدام برنامج ميكروليز – الساحل الشمالى الغربى، مصر

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يعتبر الساحل الشمالي الغربي للبحر الأبيض المتوسط في مصر من أهم المناطق الواعدة لإستصلاح الأراضي ومشروعات التوسع الزراعي والتنمية السياحية. تهدف هذه الدراسة إلى تقييم ملائمة الأرض للزراعة على طول الساحل الشمالى الغربى من رأس الحكمة حتى سيدى براني وكذلك مدى ملائمتها للمحاصيل باستخدام MicroLEIS DSS - نموذج (CERVATANA) و (ALMAGRA). تقع منطقة الدراسة بين خطي الطول `55 °27 and `44 °25 شرقا، ودائرتى العرض `22 °31 and `58 °30 شمالا. تم إختيار أربعة مناطق واعدة للتنمية الزراعية ؛ هذه المناطق من الغرب إلى الشرق هي رأس الحكمة ومرسى مطروح والنجيلة وسيدي براني. بناءً على خصائص التربة المختلفة مثل عمق التربة والقوام ، يمكن تصنيف منطقة الدراسة إلى خمس وحدات أرضية . لدراسة ملائمة التربة للزراعة إستخدم نموذج قدرة الأرض (CERVATANA) على أساس خصائص التربة ، والنتيجة التي تم الحصول عليها أن الأراضي تحت الدراسة متوسطة الصلاحية (S3) لمعظم قطاعات التربة. في حين أن ملائمة الأراضي للمحاصيل السنوية ونصف السنوية / المعمرة وفقًا لنموذج (ALMAGRA) تعتبر ملائمة للمحاصيل (S2) ، وملائمة إلى حد ما (S3) ، وهامشية الصلاحية (S4) وغير ملائمة لزراعة المحاصيل (S5) تعتبر الأراضي الممثلة للتربة الملائمة للمحاصيل (S2) هى أراضي جيدة وتحتوى على قليل جدا من المحددات التى تعيق أو تقلل من إنتاجية التربة ، وتغطي مساحة تتراوح بين 41.17 ٪ (7880.0 هكتار تقريبا) للخوخ والحمضيات إلى 76.47٪ للزيتون. فى حين الأراضي الممثلة للأراضي الغير ملائمة فى الوقت الحالي لزراعة المحاصيل (S5) تمثل معظم الأراضي خشنة القوام وتشغل مساحة 2980.0 هكتار تقريبا. أثبت الدراسة أن خصائص التربة وتطبيق نظم تقييم التربة ومدى ملائمتها للمحاصيل المختلفة تعتبر أدوات قوية لإتخاذ القرارات ويمكن إستخدامها كنظام لدعم إتخاذ القرار.