15 *Egypt. J. Soil. Sci.* **Vol. 59**, No. 3, pp. 209 - 221 (2019)

Egyptian Journal of Soil Science

http://ejss.journals.ekb.eg/

Soil Suitability Assessment Using MicroLEIS Model: A Case Study in Wadi El-Heriga, North Western Coast Zone, Egypt

Ibraheem Atya Hussien Yousif*

Soil Science Department, Faculty of Agriculture, Cairo University, Giza, Egypt

THE AIM of this work was to investigate land capability and soil suitability of Wadi El Heriga, north western coast zone (NWCZ) of Egypt using the Microcomputer Land Elevation Information system (MicroLEIS).To achieve this objective,a digital elevation model (DEM) and Landsat 8 image were usedto extract the landform units of the investigated area. Eighteen soil profiles were dug to represent different landforms.Soil samples were collected and prepared for laboratory analysis. The correlation between landforms and soil data was carried out and then the soil map was compiled using Arc-GIS 10.3. Results showed that the investigated area include five landforms, *i. e.,*peneplain, foot slope, back slope, tablelandand undulating. The main sub great groups of the investigated soils are TypicHaplocalcids, TypicTorripasamments and TypicTorriorthents with the TypicTorripasammentswas the most common one. The investigated soils were categorized into three capability classes; (S2) good (50%), (S3) moderate (45.5%) and (N) marginal **(**4.5%**).**Rustles of soil suitability showed that about 20% of the studied area is suitable (S2) for fruit crops (olive, peach and citrus). About 25% of the area is suitable (S2) for watermelon, alfalfa, sugar beet, sunflower, cotton and soybean. Nearly, 49, 37 and 44% of the area is moderately suitable (S3) for wheat, maize and potato, respectively. The most limiting factors for crop cultivation are texture, soil depth, drainage and excess of $CaCO_3$ content.

Keywords: Suitability, MicroLEIS, Almagra Model, Wadi Heriga, Egypt.

Introduction

The most important aim of land suitability evaluation (LSE) is sustainable land use planning (LUP) (FAO, 2007; Niekerk, 2010). Land evaluation is a process mainly focused onforeseeing land execution over time as indicated by the specific types of use like agriculture, animal production, or forest (Lee & Yeh, 2009 and Sonneveld et al., 2010). Agriculture land suitability assessment is defined as the proceduresof evaluating land performance when utilized for alternative kind of agriculture (He et al., 2011 and FAO, 2003) and predicts the potential and limitation of the land for crop production (Pan and Pan, 2012). Microcomputer Land Evaluation Information System (MicroLEIS) package is an incorporated framework for land data transfer and agro-ecological land assessment. This framework provides a computer-based series of tools for a systematic configuration and practical interpretation of land resources and agricultural administration data (Hoobler et al., 2003 and De La Rosa et al., 1992, 2004, 2009). The MicroLEISworks interactively, comparing the attributes of land unit with the generalization levels assigned for each suitability class for given types of annual, semiannual and perennial crops (wheat, maize, melon, potato, soybeans, cotton, sunflower, sugar beet, alfalfa, peach, citrus and olive). Models ofMicroLEISdecision support system (DSS) werecharacterizedin detail by De la Rosa et al. (1992, 1993, 1999), Farroni et al. (2002) and Horn et al. (2002).The MicroLEIS-Almagra model (agricultural soil suitability)

*Corresponding author: ibraheemyousif@agr.cu.edu.eg
Received 8/5/2019; Accepted 8/7/2019
DOI: 10.21608/ejss.2019.12598.1272

has been utilized to estimate the suitability of different soils (De La Rosa et.al, 1992). Bahnassy et al. 2001 used MicroLEIS models to study the impactof salinity and water table on the wheat production in West Nubaria area, Egypt. They found that mismanagement activities, including rising salinity and shallow ground water table affected the wheat production.Furthermore, MicroLEIS-Almagra modelwas utilized to perform the soil suitability of Wadi El-Rayan depression, Egypt (Aldabaa et al., 2010). Almagra model was utilized to make soil suitability evaluation of El-Nubariya area west of Nile Delta, Egypt (Darwish and Abdel Kawy, 2014), they found that garlic, maize, onion, date palm, melon, olive, potato and sunflower were the most suitable cropsin the investigated area.In addition, MicroLEIS program was used to investigate the agricultural soil suitability andland capability of El-Galaba basin in western desert ofEgypt for the horizontal expansion (Saleh et al., 2015).Darwish et al. (2006) used MicroLEIS to evaluate soils of Farafra Oasis as one of the newly reclaimed areas in Egypt. They found that TypicHaplogypsids soil unit was highly suitable for sunflower, potato and wheat while the other units had low suitability with a dominant soil texture limitation. MicroLIES-Almagra model was used to assess the land suitability for different cropsin west of Dakhla oasis, Egypt (Fadl and Abuzaid, 2017). They found that about 97% ofthe studied soils were suitable for all the selectedcrops, while the remaining area (about 3%) isunsuitable and the most common limiting factorsare salinity, lime content, sodicity and effective soil depth. Abd El-Aziz (2018) used MicroLEIS program to evaluate the soil suitability of Tushka area for crop production and identify the factors that hinder the cultivation process. He found that the coarse texture and shallow soil depth are the main limiting factors for growing crops.The main objective of this work was to perform land capability and soil suitability assessment for some crops using the MicroLEIS Land Evaluation System at Wadi El Heriga, NWCZ of Egypt.

Material and Methods

Study area

The investigated area is located east of Matrouh government, in the north western coast zone (NWCZ)of Egypt (Fig. 1) and extends between longitudes 27° 47’ 0” – 27° 54’ 0” E and latitudes 31° 3’ 0” – 31° 6’ 0” N , covering an area of 11.65 km^2. Wadi El Heriga is a basin in the coastal area of north western coast of Egypt. The area is characterized by a temperate Mediterranean climate. The agricultural system in this area is predominately cultivated with some fruit crops like fig, olive trees and cereals.

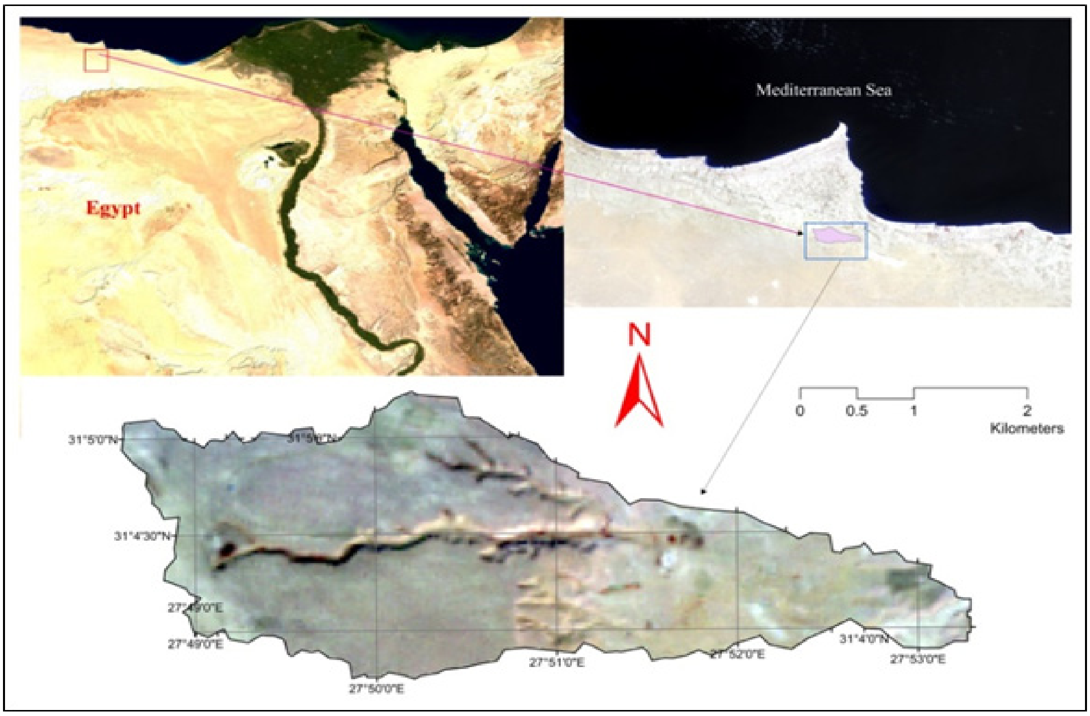

Fig.1. Location of the studied area

Geology

The north western coastal plain is underlain by limestone ridges and calcareous sand dunes, and is therefore characterized by markedly different coastal morphologies and sediment sources (El-Bastwasy, 2008 and Frihy et al., 2010).

Climate

The maximum temperature (29.7 ºC) is recorded in August, while the minimum (8.4 °C) is recorded in January. The annual rate of the maximum temperature is 25 °C. The annual rainfall is low as it does not exceed 16. 6 mm. The maximum monthly rainfall is 33.2 mm in January in Matrouh. The maximum and the minimum values of relative humidity are recorded in July to August (73.0 %) and April (61.0%), respectively.Surface wind velocity varies from 7.8 to 11.9 km h^{-1}. The lowest and highest wind velocities are recorded in October and March, respectively. Evaporation dataindicate that the lowest value of evaporation (2.7 $mmday^{-1}$) is recorded in January while the highest value is monitored in June (5.9 mm day^{-1}) (EMA, 2017).

Mapping units extraction

The main landform units were extracted using the digital elevation model DEM (Fig. 2), slope map (Fig. 3), aspect map (Fig. 4), Landsat 8 image (path 179, row 38) and field work data.The ISO-DATA classification technique was used to achieve unsupervised classification (Fig. 5) for Landsat data using ENVI V. 5.2 software. This land form map of the investigated area was imported to Arc-GIS and considered as a base map (Fig. 9).

Field and Laboratory work

Eighteen soil profiles were dug to represent different land form units. Fifty soil samples were gathered for laboratory work. Physical and chemical analyses were carried out according to the soil survey laboratory methods manual (USDA, 2014).The field work and laboratory data were imported in a GIS database and then correlated with land form map to produce the soil map. The investigated soils were classified according to keys of soil taxonomy (Soil Survey Staff, 2014). The mean weighted value of soil properties were used to evaluate soil profiles as the following equation(Ismail et al., 2005):

$$V=\frac{(\sum_{i=1}^{n}(vi*di))}{Td}$$

where as:V is the mean weighted value of soil parameter, Vi is the parameter value, di is the layer thickness, Td is the total depth of soil profile

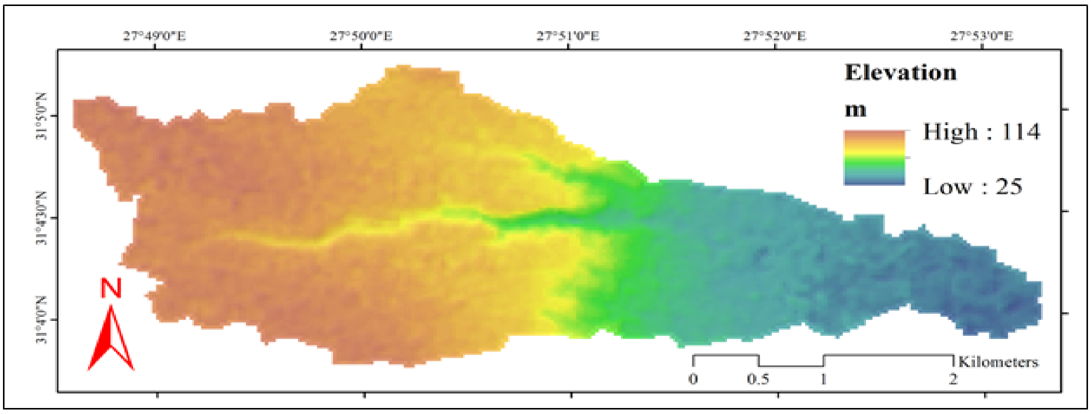

Fig. 2. DEM of the investigated area

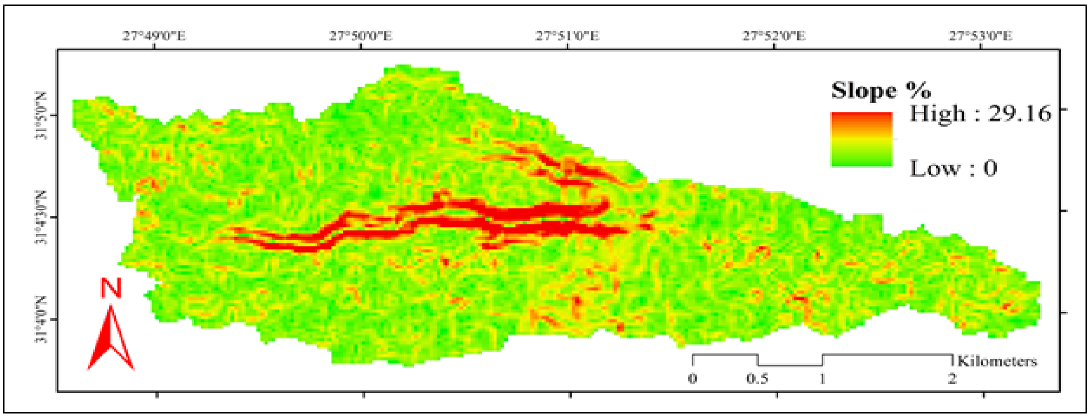

Fig. 3. Slope map

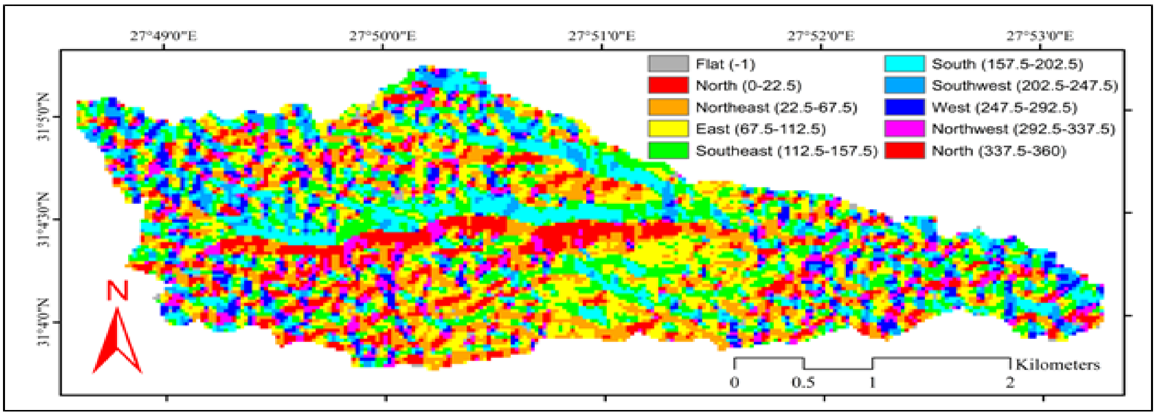

Fig. 4. Aspect map

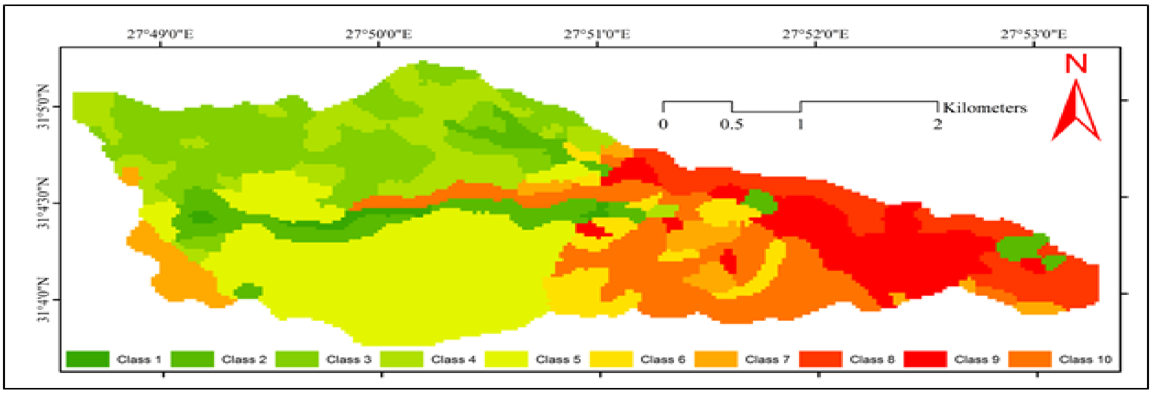

Fig. 5. Un-supervised classification

Land capability evaluation

This approach was achieved using Cervatana model of MicroLEIS (De la Rosa et al., 2004). The Cervatanamodel predicts the general landcapability for a wide series of agricultural uses following the generally accepted criteria of land evaluation (FAO, 2007). Figure 6 illustrates the methodological framework of Cervatana model designed by De la Rosa et al. (2004). General land capability is resulted from the overall qualitative assessment of some biophysical aspect: slope, soil, climate, and vegetation. Four capability classes and four subclasses are defined as shown in Fig. 6.

Land suitability evaluation

This procedure was achieved following the methodological framework of Almagra model (Fig. 7) for some selected crops (De la Rosa et al., 1992, 2004). Five suitability classes are defined by Almagra model: highly suitable (S1), suitable (S2), moderately suitable (S3), marginal suitable (S4), and not suitable (S5). The main limiting factors are depth (p), texture (t), drainage (d), carbonates content (c), salinity (s), sodium saturation (a) and development of soil profile (g). In Almagra model, the maximum limitation method was used to assesse the overall soil suitability where suitability depends on the highest limiting factor of soil characteristics. Soil suitability was examined for twelve crops in the investigated area, namely, wheat, maize, melon, potato, soybean, cotton, sunflower, sugar beet, alfalfa, peach, citrus, olive.

Results and Disscution

As shown in Fig. 8, the normalized differences vegetation index (NDVI) analysis illustrated that the vegetation densitywas very low in the investigated area.Field work confirmed that there were some scattered desert grasses, some barley cultivations and scattered olive and fig trees in the studied area. The DEM analysis (Fig. 2) indicated that the elevation in the investigated area varied between 25 and 114 m asl.Slope map (Fig. 3) which extracted from the DEM showed that the dominant slope gradient classes were verygently sloping (34.76% of studied area) and gently sloping (38.90%). As illustrated in the aspect map (Figure 4), the common slope directions in the studied area were east (17.5%), northeast (16.7%), southeast (16.5%) and north (14%). Table 1 shows some chemical and physical analyses of studied soils.

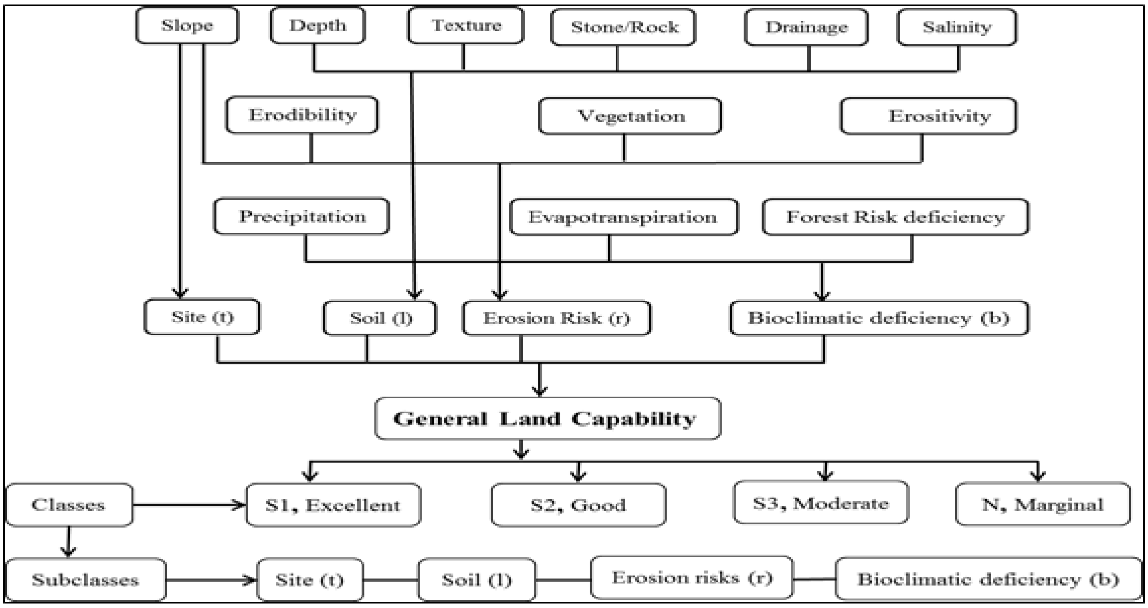

Fig. 6. Flowchart of Cervatana for predicting land capability

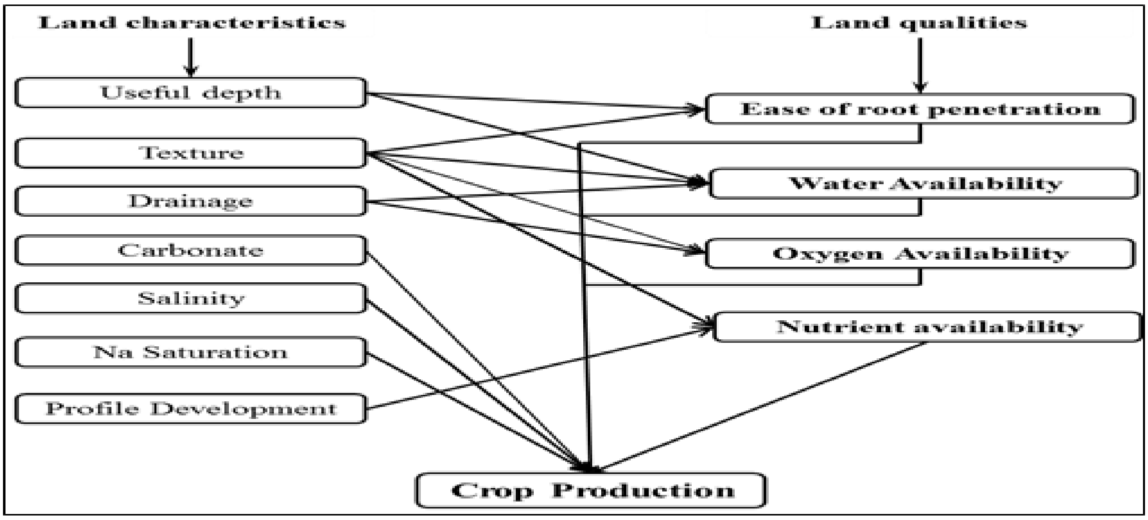

Fig. 7. General scheme of the Almagra model

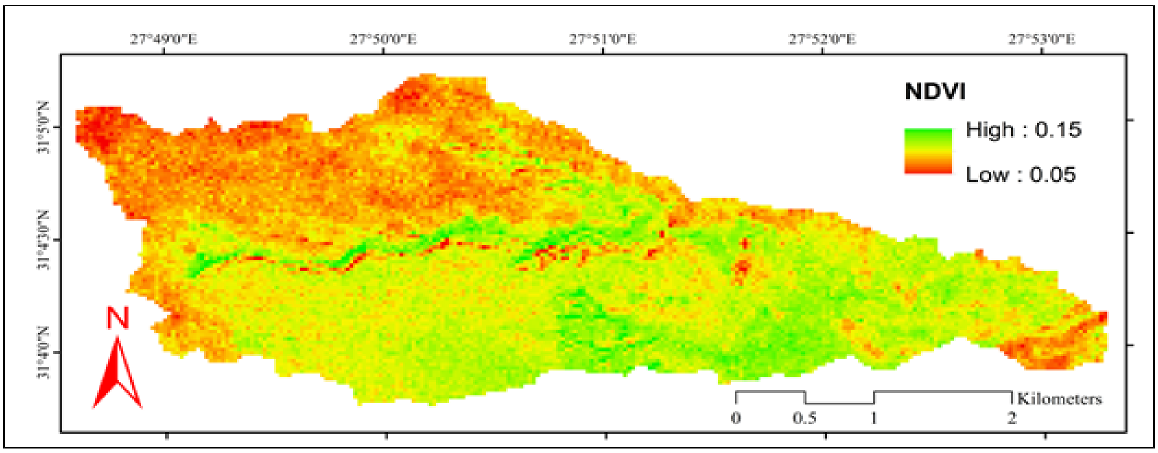

Fig. 8. Normalized differences vegetation index (NDVI)

The soil investigated area is covered by five mapping units (Fig. 9). These units can be summarized as follows:

Peneplain

It occupies an area of 2.35 km^2 (20.14%).Soil depth of this mapping unit was shallow to very deepwith soil texture ranging from sand to sandy loam.The slope gradient varied between flat and gently sloping (0 - 5 %) with elevation between 25 and 44 m asl. Gravel content ranged between nil and 54.76 %. Values of electrical conductivity (EC) ranged between 0.7 and 8.4 dSm^{-1}. The $CaCO_3$ content extended between 2.18 and 33.59 g kg^{-1} in the different representative soil profiles. The soil organic matter (OM) content was very low and ranged between 2.2 and 8.4 g g kg^{-1}.The soil reaction (pH) values extended between 7.00 and 7.88 in the successive layers of the studied soils. The exchangeable sodium percent (ESP) ranged between 5.5 and 14.81 % in the different layers of the studied soil profiles.

Foot slope

It occupies an area about 1.11 km^2 (9.53%). Soil depth of this unit varied between shallow to deep with sandy to loamy sand soils. The slope gradient varied from level and gently sloping (0.2 - 5%) with elevation between 44 and 63 m asl. Gravel content ranged between nil and 50%. The EC values ranged between 0.65 and 2.90 dSm^{-1}. The calcium carbonate content extended between 43.6 and 327.1 g kg^{-1} in the different soil profiles. The soil OM content was very low and ranged between 3.2 and 6.7 g kg^{-1}. Soil pH values extend between 7.18 and 7.51 in the successive layers of the studied soils. The ESP ranged between 5.8 and 11.88 % in the different layers of the studied soil profiles.

Back slope

It occupies an area of 2.43 km^2 (20.85%). Soil depth of this mapping unit varied between shallow to deep with sandy to loamy sand soils. The slope gradient varied from level and sloping (0.2 - 10%) with elevation between 63 and 98 m asl. Gravel content ranged between nil and 36.36%. The EC values ranged between 0.68 and 8.72dSm^{-1}. The calcium carbonate content extended between 28.2 and 261.7 g kg^{-1}in the representative soil profiles. The soil OM content was very low and ranged between 2.2 and 7.0 g kg^{-1}. Soil pH values extended between 7.00 and 7.90 in the successive layers of the studied soils. The ESP ranged between 5.90 and 12.22 % in the different layers of soil profiles.

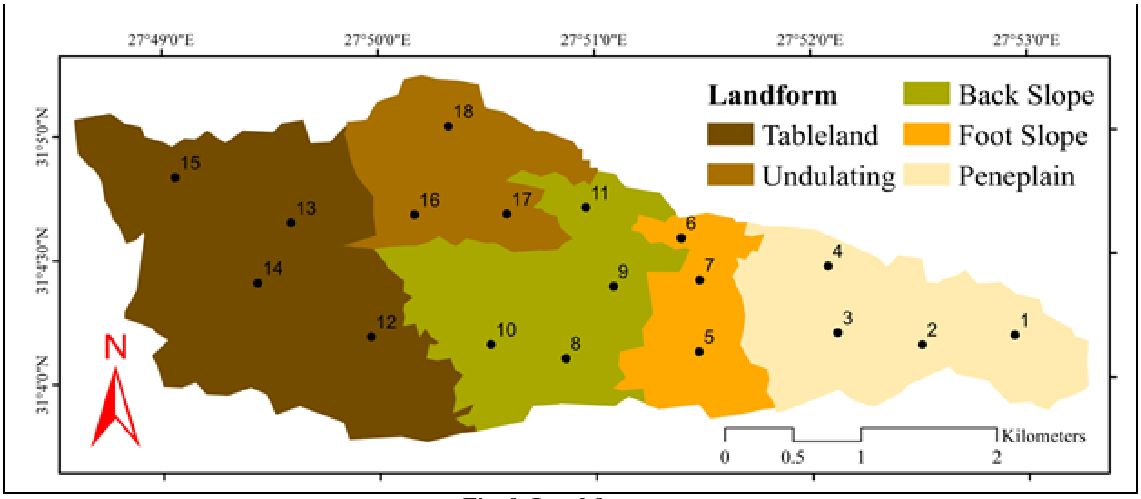

Fig. 9. Land form map

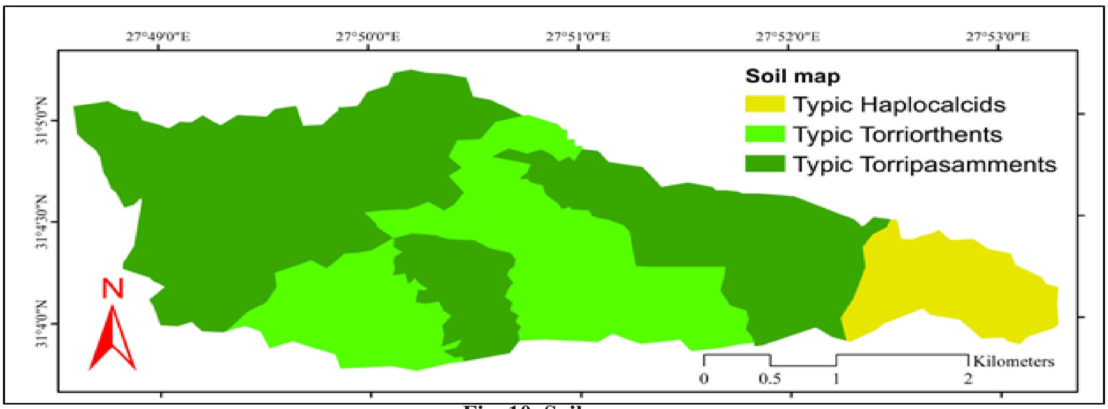

Fig. 10. Soil map

TABLE 1. Some properties of the investigated soils

Unit	P. No.	Depth (cm)	pH	EC dSm^{-1}	Soluble cations and anions mmolc L^{-1}: Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO^{3-}	Cl^-	$SO4^{2-}$	$CaCO_3$ g kg^{-1}	Gravel %	SP %	ESP %	Particle size distribution (%): Sand	Silt	Clay	Class	OM g kg^{-1}	Available macro and micronutrients mg kg^{-1}: N	P	K	Fe	Mn	Zn	Cu
Peneplain	1	0-7	7.56	1.60	8.3	0.5	4.7	2.5	1.7	9	5.2	109	5.08	18.5	6.46	93.19	3.4	3.41	S	8.4	66	5	103	3.7	2.6	0.7	1.24
		7-30	7.62	8.40	49.7	2.6	22.2	9.5	4	45.8	34.1	239.9	4.61	21.5	14.81	82.78	7.12	10.1	LS	0.9	36	3.1	100	2.2	1.6	0.1	0.85
		30-80	7.70	1.42	6.7	0.6	4.7	2.1	1.5	8.6	4	109	2.60	20.7	5.68	78.06	13.82	8.12	LS								
		80-130	7.58	4.60	26.9	1.2	11.4	6.4	2.9	26.4	16.6	21.8	9.58	25.3	11.22	80.93	6.93	12.14	SL								
		130-180	7.44	0.70	4	0.3	1.7	1	1.5	3	2.5	174.5	8.82	21.8	5.50	83.5	10.5	6	LS								
	2	0-25	7.88	1.34	6.8	0.3	4.2	2	1.7	6.1	5.5	54.5	3.12	19.2	5.96	91.51	4.24	4.25	S	4.3	88	5.1	110	3.2	1.8	0.09	0.88
		25-50	7.50	0.95	5	0.5	2.7	1.2	1.7	4.8	3	327.1	0.00	21.7	5.59	82.57	8.52	8.91	LS	4.0	30	4.5	76	6.8	2.4	0.2	0.81
		50-130	7.18	3.30	18.2	0.7	9.3	4.7	2	21.4	9.6	130.8	5.10	22.0	9.05	85.68	8.31	6.01	LS								
	3	0-15	7.00	4.91	27.7	1.1	12	8.2	2.5	29.3	17.2	305.3	6.89	20.0	10.93	92.03	3.98	3.99	S	8.3	81	3.2	122	0.84	1.1	0.23	0.23
		15-50	7.01	5.83	30	1.5	17.7	9.1	3	35.8	19.5	305.3	13.58	26.1	10.39	81.46	6.53	12.01	LS	7.7	62	1.1	113	1.7	1.3	0.14	0.6
		50-85	7.03	5.85	3	1.3	14.1	8	3.	36.7	18.8	305.3	25.71	24.3	12.78	88.6	3.23	8.17	LS								
		85-140	7.05	7.78	4	2.0	21.5	10.2	3.5	47.1	27.1	283.5	54.76	21.5	13.33	86.13	10.31	3.56	LS								
		+140	Limestone bedrock																								
	4	0-15	7.02	2.80	19.6	0.7	5.1	2.5	2.1	18.8	7	335.9	40.44	28.8	12.30	65.94	16.26	17.8	SL	4.3	113	4.4	82	1.4	136	0.13	0.47
		15-45	7.09	4.70	30	1.2	11	4.8	3	28.5	15	414.4	53.84	23.6	12.94	81.16	10.23	8.61	LS	2.2	56	2.3	61	3.3	2.7	0.18	0.59
		+45	Limestone bedrock																								
Foot slope	5	0-15	7.45	0.88	5.2	0.3	2.2	1	1	4.8	3	305.3	19.48	29.0	6.23	80.89	5.6	13.51	SL	3.7	78	2.6	88	1.7	1.8	0.59	0.59
		15-40	7.18	0.65	4	0.3	1.4	0.8	0.8	3.1	2.5	43.6	50.00	23.7	5.88	81.87	8.01	10.12	LS	3.2	66	2	76	1.2	1.8	0.26	0.54
		+40	Limestone bedrock																								
	6	0-20	7.32	0.73	4.5	0.2	1.7	0.8	1	3.4	2.9	261.7	30.76	28.1	6.14	75.6	10.24	14.16	SL	3.7	113	3.8	118	1.9	1.2	0.2	0.49
		20-40	7.28	6.63	36.6	0.9	20	8.8	3	36.3	27	305.3	46.42	17.4	11.88	89.87	5.06	5.07	S	3.2	67	2.6	75	3.2	0.53	0.18	24
		+40	Limestone bedrock																								
	7	0-15	7.51	2.90	16.2	0.8	8.3	3.6	2.2	18	8.7	314.1	5.17	27.0	8.80	74.47	16.91	8.62	SL	6.7	78	2.6	79	1.4	0.48	0.09	0.18
		15-25	7.38	1.30	7.4	0.3	3.7	1.5	1.7	7	4.2	327.1	35.61	19.5	6.65	93.81	3.09	3.1	S	6.0	33	1.5	67	4.9	1.8	0.2	0.83
		25-55	7.50	1.40	7.4	0.3	4	2.1	1.7	7.7	4.5	52.3	0.00	20.1	6.31	90.49	4.75	4.76	S								
		55-80	7.30	1.40	7.4	0.3	4	2.1	1.7	8.2	4	122.1	4.22	21.1	6.30	88.87	5.56	5.57	S								
		80-140	7.29	1.50	8.1	0.4	4.2	2.3	2	7.9	5	152.6	6.66	18.8	6.58	94.29	2.85	2.86	S								
		140-170	7.31	2.50	15.5	0.5	5.9	3	2	16.3	6.7	47.9	3.61	26.6	9.50	74.56	15.83	9.61	SL								
Back slope	8	0-15	7.09	0.89	5.4	0.5	2	1	1	5.1	2.7	93.7	30.76	22.5	6.49	68.47	21.33	10.2	LS	3.4	68	2.4	69	4.7	1.3	0.33	0.5
		15-40	7.08	1.84	12.2	0.7	4.2	1.2	2	11.3	5	272.6	36.36	29.0	9.56	83.66	7.71	8.63	LS	2.9	55	1.4	61	1.9	0.8	0.15	0.4
		+40	Limestone bedrock																								
	9	0-25	7.94	0.68	4	0.2	1.6	1	1	3.3	2.5	196.3	6.62	24.5	5.56	81.55	6.35	12.1	SL	5.9	49	5.4	156	6.6	3	0.19	0.53
		25-75	7.095	0.74	4.2	0.2	1.8	1	1	3.6	2.7	218.1	4.16	22.1	5.59	87.04	8.1	4.86	LS	4.9	42	3.5	118	2	1.3	0.12	0.52
		75-150	7.058	0.82	4.8	0.3	2	1	1	4.1	3	261.7	13.80	18.8	6.00	94.52	2.74	2.74	S								
	10	0-25	7.05	6.16	34.5	1.2	17.7	8.1	2	36.9	22.6	196.3	16.25	27.5	11.84	71.57	16.13	12.3	SL	7.0	70	4.3	125	3.2	3.6	0.24	0.52
		25-40	7.00	8.72	45	1.4	27.2	13.5	2.2	54.9	30	28.3	28.94	24.0	12.22	77.19	18.2	4.61	LS	6.1	61	3.1	114	1.3	0.9	0.18	0.21
		+40	Limestone bedrock																								
	11	0-20	7.81	0.81	4.8	0.3	2	1	1	4	3	130.8	8.00	23.5	5.99	91.87	3.12	4.01	S	2.5	70	4.3	78	2.5	1.8	0.1	0.48
		20-80	7.77	0.82	5.2	0.3	1.8	0.8	1	4	3.1	152.6	-	26.0	6.56	93.51	3.29	3.2	S	2.2	40	3.6	61	1.7	0.4	0.09	0.25
		80-120	7.75	0.83	5	0.3	2	1	1	4.3	3	174.5	-	25.5	6.15	84.06	10.2	5.41	LS								
		+120	Limestone bedrock																								
Tableland	12	0-20	7.74	0.92	5.7	0.3	2.1	1	1	4.3	3.8	109.0	4.61	25.0	6.63	76.3	15.56	8.14	SL	4.0	100	4.7	110	3.4	1.7	0.58	0.73
		20-70	7.71	0.81	4.9	0.3	1.9	1	1	3.9	3.1	109.0	3.33	24.5	6.14	80.41	15.36	4.23	LS	3.9	63	2.3	69	2.6	2.2	0.12	0.4
		70-150	7.58	0.70	4.1	0.2	1.8	0.8	0.8	3.6	3.5	239.9	27.84	23.5	5.62	93.13	1.86	5.01	S								
	13	0-15	7.00	10.66	71.3	2	22.5	10.7	4	57.5	45	349.0	27.20	24.0	19.96	76.61	11.26	12.13	SL	5.2	67	3.1	96	1.2	0.43	0.17	0.21
		15-50	7.05	15.67	110	2.4	29.7	14.5	4.2	86.4	66	392.6	36.84	29.0	26.05	85.01	6.61	8.38	LS	5.0	33	2.7	79	0.98	1.4	0.12	0.42
		+50	Limestone bedrock																								
	14	0-10	7.85	0.62	3	0.2	2	1	1	2.9	2.3	239.9	0.00	20.1	4.47	93.74	3.13	3.13	S	7.8	66	3.7	131	1.5	1.4	0.09	0.32
		10-50	7.67	0.80	4.7	0.2	2.1	0.8	1	3.9	3	174.5	0.00	23.0	5.94	81.42	14.3	4.28	LS	6.6	38	2.7	118	2.1	1.1	0.08	0.61
		50-100	7.84	2.60	17	0.5	6.1	2.2	2.1	13.6	10.2	196.3	0.00	22.7	10.52	83.88	10.11	6.01	LS								
		100-150	7.82	0.81	5.1	0.2	2	0.7	1	4.6	2.4	109.0	0.00	27.6	6.43	76.46	11.21	12.33	LS								
	15	0-20	7.19	3.50	24.3	0.5	7.1	3	2.2	18.3	14.4	196.3	16.12	27.0	13.03	78.76	11.01	10.23	LS	6.5	73	5	135	7.8	0.9	0.47	0.29
		20-50	7.14	7.30	55	1	12.1	4.8	3	37.9	32	392.6	30.00	22.3	21.40	79.75	14.2	6.05	LS	5.9	45	3.6	69	3.6	2.8	0.41	0.65
		+50	Limestone bedrock																								
[illegible]	16	0-15	7.26	4.39	29.2	1	10.1	3.5	2.4	21.4	20	152.6	17.80	30.1	13.46	73.77	20.1	6.13	SL	5.9	88	5.4	96	1.3	2.5	0.22	0.86
		15-40	7.18	7.84	56	1.7	14.5	6.1	3	40.3	35	207.2	25.60	24.6	19.91	80.59	12	7.41	LS	5.6	58	4.2	83	2.9	0.25	0.16	0.17
		+40	Limestone bedrock																								
	17	0-20	7.81	0.74	4	0.4	2	1	1	4	2.4	196.3	8.47	30.3	5.31	73.43	10.34	16.23	SL	6.8	56	3.9	138	3.8	2.4	0.85	0.37
		20-40	7.45	2.40	14.8	0.4	6.6	2.1	2	13.5	8.5	283.5	37.50	21.6	9.24	85.86	4.12	10.02	LS	6.4	33	3.4	88	0.97	1.8	0.81	0.21
		+40	Limestone bedrock																								
	18	0-25	7.70	5.51	29.7	0.8	1.7	7.5	2.7	33.7	18.6	196.3	33.33	25.0	16.24	78.1	10.15	12.6	SL	4.1	63	4.1	60	1.3	1.6	0.17	0.48
		+25	Limestone bedrock																								

EC, Electrical Conductivity; SP, Saturation Percent; ESP, Exchangeable Sodium Percent; OM, Organic Matter.

Tableland

It occupies an area of 4.18 km^2 (35.85%). Soil depth of this mapping unit varied between moderately and deep with sandy to loamy sand soils. The slope gradient varied from level and sloping (0.2 - 10%) with elevation between 98 and 114 m asl. Gravel content ranged between nil and 37.5%. The EC values ranged between 0.7 and 7.3dSm^{-1}. The calcium carbonate content extended between 109.0 and 392.6 g kg^{-1}in the different soil profiles. The soil OM content was very low and ranged between 3.9 and 7.8 g kg^{-1}. Soil pH values extended between 7.14 and 7.85 in the successive layers of the studied soils. The ESP ranged between 5.31 and 21.40 % in the different layers of the studied soil profiles.

Undulating

It occupies an area of 1.58 km^2 (13.63%).Soil depth varied between shallow and moderately deep with sandy loam to loamy sand soils. The slope gradient varied from level and sloping (0.2 - 10%) with elevation between 83 and 114 m asl. Gravel content ranged between 16.12 and 36.84 %. The EC values ranged between 4.3 and 15.67dSm^{-1}. The calcium carbonate content extended between 152.6 and 283.5 g kg^{-1} in the different soil profiles. The soil OM content was very low and ranged between 4.1 and 6.8 g kg^{-1}. Soil pH values extended between 7.00 and 7.70 in the successive layers of the studied soils. The ESP ranged between 13.03 and 26.05 % in the different layers of the studied soil profiles.

Soil map

The studied soils could be classified as TypicHaplocalcids,TypicTorripasammentsand TypicTorriorthents as illustrated in Fig. 10 and Table 2. The TypicTorripasamments is the most common sub great group in the studied area.

Land capability assessment

Interpolation technique in ArcGIS 10.3 was used to generate land capability and land suitability maps and then these interpolated maps were overplayed with the physiographic map to calculate the represented area by each soil profile. As illustrated in Table 3 and Fig. 11, the investigated soils could be classified into three capability classes; good (S2), moderate (S3) and marginal (N). Good class (S2) covers an area of 5.81 km^2 representing 49.87 %, moderate class (S3) covers an area of 5.30 km^2 representing 45.49 % andmarginal class (N) covers an area of 0.54 km^2 representing 4.64% of the investigated area. Table 4 displays the distribution of land capability classes with various soil mapping units.The acquired data indicated that the most common limiting factors in the studied area are texture, soil depth and excess of $CaCO_3$ content. Sandy texture (sand and loamy sand) is the predominant soil texture.The importance effect of coarse soil texture is related to its role on soil erosion sensitivity, low level of organic matter, weakness of water holding capacity, lack of nutrient content and retention and weakness of microorganism's activity (Villas-Boas *et al.*, 2016).Results indicated that the soil depthwas a significant limiting factor in the investigated area and it can be considered the main limiting factor in undulating soil mapping unit. Shallow Soil depth adversely impact plant growth and development especially in case of fruit crops through the limitation of root growth, available nutrients and water movement. The excess of $CaCO_3$ directly and indirectly affects the nutrients availability due to the effect on soil pH and also affects soil water relationships.

TABLE 2. Legend of the physiographic soil map of the studied area

Landform	Area km^2	%	Main Soils	% of Mapping unit	Soil profiles	Kind of Mapping Unit
Peneplain	2.35	20.14	TypicHaplocalcids	50	1, 2	Association
			TypicTorripasamments	25	3	
			TypicTorriorthents	25	4	
Foot Slope	1.11	9.53	TypicTorriorthents	33.3	5, 6	Association
			TypicTorripasamments	66.7	7	
Back Slope	2.43	20.85	TypicTorriorthents	25	8	Consociation
			TypicTorripasamments	75	9, 10, 11	
Tableland	4.18	35.85	TypicTorripasamments	75	12, 14, 15	Consociation
			TypicTorriorthents	25	13	
Undulating	1.58	13.63	TypicTorripasamments	100	16, 17, 18	Consociation
Total	11.65	100 %				

TABLE 3. Soil suitability and land capability classification by MicroLEIS Models

Unit	Profile	Crops												Capability class
		Wh.	Ma	Me	Po	So	Co	Sf	Su	Al	Pe	Ci	Ol	
Peneplain	1	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tds	S2lr
	2	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S3t	S2lr
	3	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3ts	S3ts	S3ts	S2lr
Foot slope	4	S4t	S4t	S4pt	S4t	S4pt	S4pt	S4pt	S4pt	S4pt	S5p	S5p	S5p	S3l
	5	S4t	S4t	S4pt	S4t	S4pt	S4pt	S4pt	S4pt	S4pt	S5p	S5p	S5p	S3l
	6	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tda	S2lr
	7	S3ptd	S3pts	S4p	S3pts	S4p	S4p	S4p	S4p	S4p	S5p	S5p	S5p	S3l
Back slope	8	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tda	S2lr
	9	S3ptd	S3pt	S4p	S3pt	S4p	S4p	S4p	S4p	S4p	S5p	S5p	S5p	S3l
	10	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tda	S2lr
	11	S4t	S4ta	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4pd	S4pd	S4pd	S3l
Tableland	12	S3ptd	S4a	S4p	S3pta	S4p	S4p	S4p	S4p	S4p	S5p	S5p	S5p	S3l
	13	S3tc	S3tc	S3tc	S4c	S3tc	S3tc	S3tc	S3tc	S3tc	S4c	S4c	S3c	S2lr
	14	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5p	S5p	S5p	S3l
	15	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S3t	S2tdc	S2tdc	S2tda	S2lr
Undulating	16	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5p	S5p	S5p	S3l
	17	S5ts	S5tsa	S5ts	S5ts	S5ts	S5t	S5ts	S5t	S5t	S5pds	S5pds	S5pds	Nl
	18	S5p	S5p	S5p	S5p	S5p	S5p	S5p	S5p	S5p	S5p	S5p	S5p	S3l

Crops: Wheat, Wh. ; Maize, Ma. ; Melon, Me. ; Potato, Po. ; Soybean, So. ; Cotton, Co. ; Sunflower, Sf. ; Sugar beet, Su. ; Alfalfa. Al. ; Peach, Pe. ; Citrus, Ci. ; Olive, Ol.
Suitability class: Highly suitable, S1; Suitable, S2 ; Moderately suitable, S3 ; Marginally suitable, S4; Not suitable, S5 ;
Useful depth, p ; Texture, t ; Drainage, d ; Carbonate, c ; Salinity, s ; Sodium saturation, a.
Capability class: Excellent, S1; Good . S2 ; Moderate , S3; Marginal , N ; Soil, l ; Slope, t ; Drainage, d ; Erosion risks, r

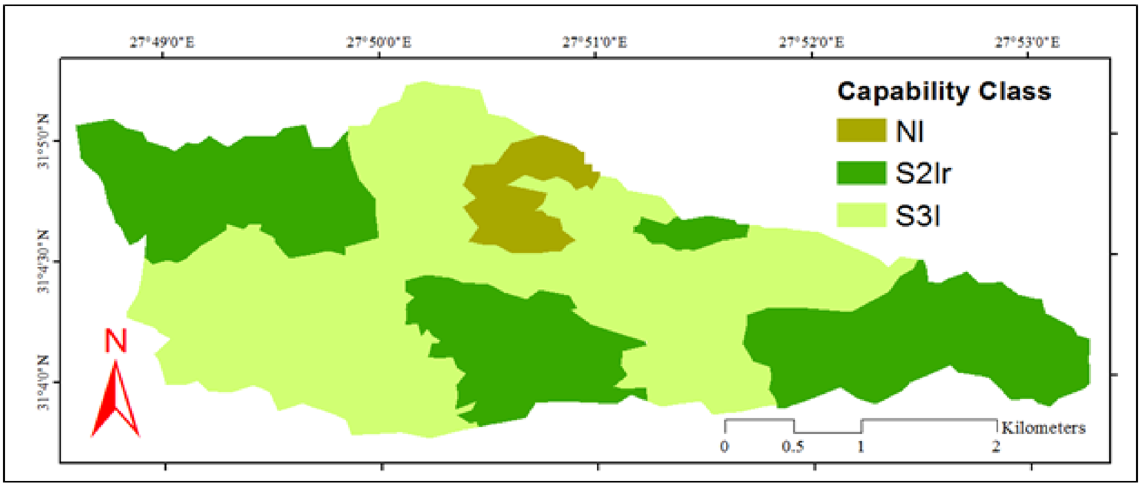

Fig. 11. Land capability evaluation map

TABLE 4. Area in km² of general land capability classes of investigated area

Unit / Class	Peneplain	Foot slope	Back slope	Tableland	Undulating	Total	% of studied area
N	--	--	--	--	0.54	0.54	4.60
S2	1.76	0.15	1.23	1.63	0.00	4.78	40.99
S3	0.59	0.96	1.19	2.54	1.06	6.34	54.44
Total	2.35	1.11	2.42	4.18	1.60	11.65	100 %

Capability class: Good .S2 ; Moderate , S3; Marginal , N .

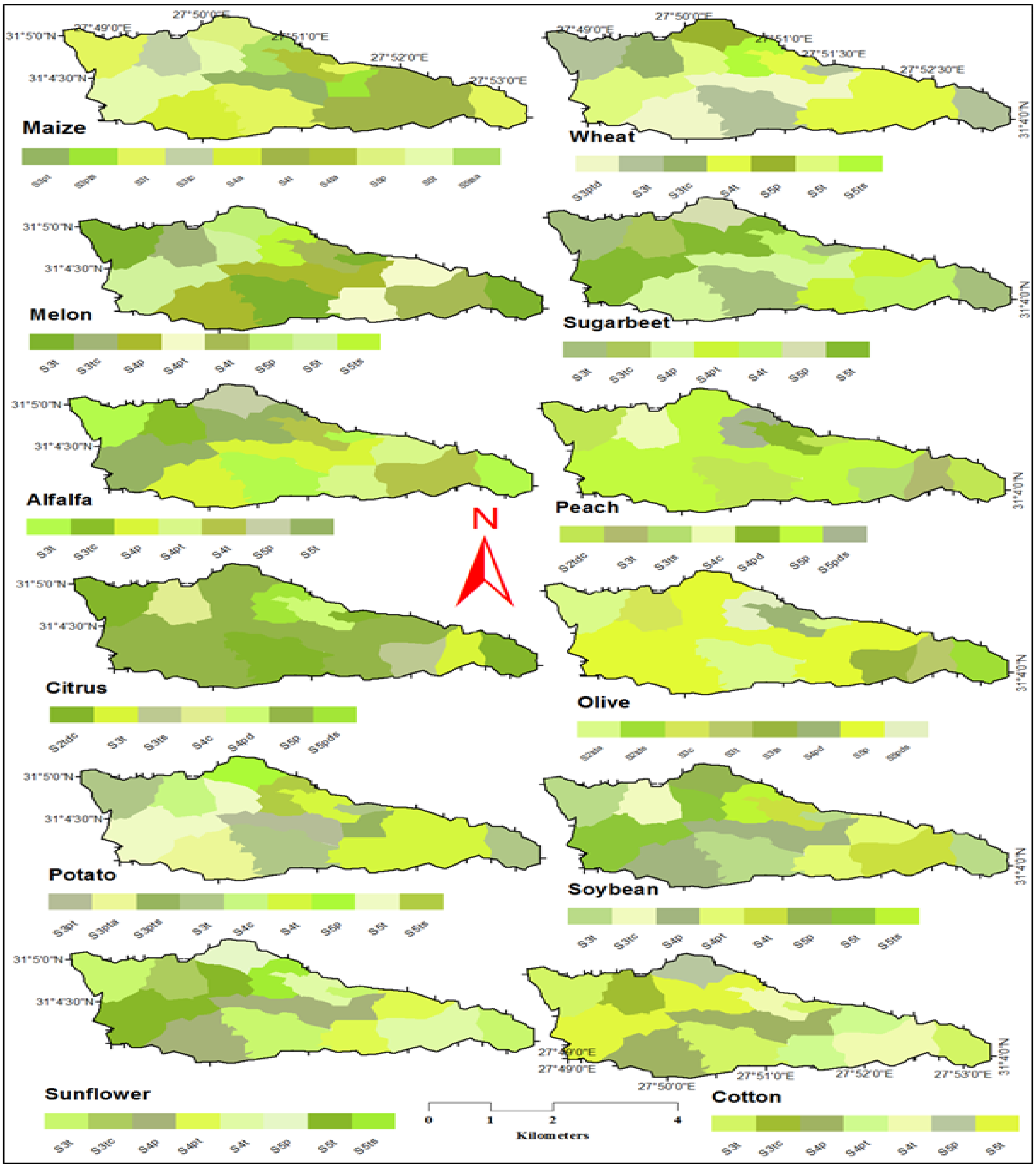

Fig. 12. Suitability maps of examined crops using MicroLEIS, Almagra model

Soil suitability classification

MicroLEIS Model, the overall soil suitability of a soil component was assessed through the maximum limitation method; this means that, the suitability is taken from the most limiting factor of soil characteristics. Soil suitability was examined for twelve crops in the investigated area as shown in Table 3 and Table 5.

Soil suitability rustles showed that, most of examined crops were classified as S3 (moderately suitable) and S4 (marginally suitable) as illustrated in Tables 3, 5 and Figure 12. The marginally suitable (S4) class was dominating the study area followed by moderately suitable class (S3) and not suitable class (S5),while the suitable class (S2) was the least abundant in the investigated area. About 20 % of the studied area were suitable (S2), 15 % were moderately suitable (S3) for fruit crops (olive, peach and citrus). About 25 and 60% of the studied soils were moderately and marginally suitable, respectively for watermelon, alfalfa, sugar beet, sunflower, cotton and soybean (Tables 3, 5 and Figure 12). For growing wheat, about 49 % of the area was moderately suitable (S3), while 35 % were marginally suitable. For growing maize, about 37 % of area was moderately suitable, while 47 % were marginally suitable. For growing potato, about 44 % of areas were moderately suitable, while 40 % were marginally suitable. About 50 % of the studied area was not suitable (S5) for fruit crops (olive, peach and citrus) while 15 % of the area was not suitable for the other examined crops (Table 5 and Figure 12). The most common limiting factors for crop cultivation in the studied area are soil texture (t), effective depth (p) and drainage (d). Furthermore, limitations related to excessive CaCO3 as well as sodium saturation occurred in few localities.

TABLE 5. Soil suitability percentage (%) for growing examined crops

Crop	Wheat	Maize	Water melon	Potato	Soya	Cotton	Sun flower	Sugar beet	Alfalfa	Peach	Citrus	Olives
S2	--	--	--	--	--	--	--	--	--	24.95	24.95	24.92
S3	50.12	40.13	31.13	43.93	31.13	31.13	31.13	31.13	31.13	9.86	9.86	16.04
S4	24.35	34.33	43.33	30.53	43.33	43.33	43.33	43.33	43.33	10.15	10.15	4
S5	25.54	25.54	25.54	25.54	25.54	25.54	25.54	25.54	25.54	55.04	55.04	55.04

Suitability class: S2, Suitable ; S3, Moderately suitable ; S4, Marginally suitable ; S5, Not suitable.

Conclusion

Agricultural classification of land according to its own ecological potentialities and limitations is the first main target of land use planning. At the same time , the second main target is to foreseethe inherent suitability of each soil for supporting a particularcrop over a long period of time. In a particular area, both complex objectives can be achieved through agro-ecological land evaluation and analysis through computerized systems such as MicroLEIS DSS (Almagra&Cervatana). The obtaind results of land capability revealed that about 45.5% and 50 % of the studied area is good(S2) and moderately suitable (S3) respectively. The most suitable crops to be grown in the studied area are wheat, potato, maize, peach, citrus and olives in the order indicated. The most effective soil parameter that influences the suitability classification in the studied area was soil texture. Also, soil depth has been distinguished as a limitation factor in some areas. Furthermore, the soil maps for agricultural suitability designed in this research can be beneficial in performing the management processes.

References

Abd El-Aziz, S.H. (2018) Soil capability and suitability assessment of Tushka area, Egypt by using different programs (ASLE, MicroLEIS and Modified Storie Index). *MJSA.,* **2** (2), 09-15.

Aldabaa, A., Zhang, H., Shata, A., El-Sawey, S., Abdel-Hameed, A., Schroder, J. (2010) Land suitability classification of a desert area in Egypt for some crops using microleis program. *American-Eurasian J. Agric. Environ Sci*., **8** (1), 80–94.

Ali A.O., Rashid M., El Naggar S. and Abdul Al A. (2007) Water harvesting options in the drylands at different spatial scales. *Land Use Water Resour Res.,* **7**, 1–13.

Bahnassy, M., H. Ramadan, F. Abdel-Kader and H.M. Yehia, (2001) Utilizing GIS/RS/GPS for land resources assessment of Wadi El-Natroun, West Delta Fringe, Egypt. *Alex. J. Agric. Res.* **46**,155.

Darwish, K.M., Wahba, M.M. and Awad, F. (2006) Agricultural soil suitability of Haplo-soils for some crops in Newly Reclaimed Areas of Egypt. *J. Appl. Sci. Res.,* **2**, 1235-1243.

Darwish, Kh. M. and Abdel Kawy, W. A. (2014) Land suitability decision support for assessing land use changes in areas west of Nile Delta, *Egypt. Arab J Geosci,* **7**, 865–875.

De la Rosa, D., Anaya-Romero, M., Diaz-Pereira, E., Heredia, N., Shahbazi, F. (2009) Soilspecific agro-ecological strategies for sustainable land use—a case study by using MicroLEIS DSS in Sevilla Province (Spain). *Land Use Policy*, **26** (4), 1055–1065.

De La Rosa, D., J.A. Moreno, L.V. Garcia and J. Almorza. (1992) MicroLEIS: a microcomputer-based Mediterranean land evaluation information system. *Soil Use and Management,* **8**, 89-96.

De la Rosa, D., Mayol, F., Fernandez, M. and Diaz-Pereira, E. (2004) A land evaluation decision support system (MicroLEIS DSS) for agricultural soil protection with special reference to the Mediterranean region. *Environmental Modeling & Software*, **19**, 929–942.

De la Rosa, D., Mayol, F., Moreno, J.A., Bonson, T. and Lozano, S. (1999) An expert system/neural network model (ImpelERO) for evaluating agricultural soil erosion in Andalucia region. *AgricEcosys Environ,* **73**, 211–226.

De la Rosa, D., Moreno, J.A. and Garcia, L.V. (1993) Expert evaluation system for assessing field vulnerability to agrochemical compounds in Mediterranean region. *J. Agric. Eng. Res.*, **56**, 153–164.

El-Bastwasy, M.A. (2008) The Use of Remote Sensing and GIS for Catchments Delination in Northwestern Coast of Egypt: An Assessment of water Resources and Soil Potential., *Egypt J. Remote Sensing Space Sci.,* **11**, 3-16.

Egyptian Metrological Authority "EMA", (2017) Climatic Atlas of Egypt.Public Arab Republic of Egypt, Ministry of Civil Aviation, Cairo, Egypt.

Fadl, M. E. andAbuzaid, A. S. (2017) Assessment of Land Suitability and Water Requirements for Different Crops in Dakhla Oasis, *Western Desert, Egypt. IJPSS*, **16**(6), 1-16.

FAO (2003) Theoretical framework for land Evaluation. *Geoderma,* **72**, pp. 165-190.

FAO (2007) Land Evaluation, towards a revised framework. FAO, Rome, 107 pp.

Farroni, A., Magaldi D., Tallini M. (2002**)** Total sediment transport by the rivers of Abruzzi(Central Italy): prediction with the Raizal model. *Bull Eng. Geol. Environ.* **61**, 121–127.

Frihy, O.E., Deabes, E.A. and El Gindy, A.A. (2010) Wave Climate and Nearshore Processes on the Mediterranean Coast of Egypt. *JCR,* **261**, 103-112.

He, Y., Yao, Y., Chen, Y., Ongaro, L., (2011) Regional Land Suitability Assessment for Tree Crops Using Remote Sensing and GIS. CDCIEM (IEEE), Changsha, pp. 354-363.

Hoobler, B.M., Vance, G.F., Hamerlinck, J.D., Munn, L.C., Hayward, J.A., (2003) Applications of land evaluation and site assessment (LESA) and a geographical information system in East Part Couny, Wyoming. *Journal of Soil and Water Conservation,* **58**, 105–112.

Horn, R., Simota, C., Fleige, H., Dexter, A.R., Rajkay, K., De la Rosa, D. (2002) Prognose der mechanischenBelastbarkeit und der auflastabhangigenAnderung des Lufthaushaltes in Ackerbodenanhand von Bodenkarten. *J. Plant Nutr. Soil Sci.,* **165**, 235–239.

Ismail, H.A., M.H. Bahnassy and O.R. Abd El-Kawy. (2005). Integrating GIS and modeling for agricultural land suitability evaluation at East Wadi El-Natroun, Egypt. *Egypt.J. Soil Sci.* **45** (3), 297-322.

Lee, T.M., Yeh, H.C., (2009) Applying remote sensing techniques to monitor shifting wetland vegetation: a case study of Danshui River estuary mangrove communities, Taiwan. *Ecological Engineering,* **35**, 487-496.

Niekerk, A. V. (2010) A comparison of land unit delineation techniques for land evaluation in the Western Cape, South Africa. *Land Use Policy,* **27**, 937-945.

Pan, G., Pan, J., (2012) Research in crop land suitability analysis based on GIS. *CCTA,* **369**, 314–325.

Saleh, A.M., Belal, A.B. and Mohamed, E.S. (2015) Land resources assessment of El-Galaba basin, South Egypt for the potentiality of agriculture expansion using remote sensing and GIS techniques.*The Egyptian J. of Remote Sensing and Space Sciences,* **18**, 19-30.

Soil Survey Staff. (2014) *Key to Soil Taxonomy.* Twelfth edition, U.S.D.A., Washington, D.C., **372** p.

Sonneveld, M.P.W., Hack-ten Broeke, M.J.D., van Diepen, C.A., Boogaard, H.L., 2010. Thirty years of systematic land evaluation in the Netherlands. *Geoderma,* **156**, 84–92.

USDA. (2014) Kellogg Soil Survey Laboratory Methods Manual. United States Department of Agriculture. Soil Survey Investigation Report No. **42,** Version 5.0, 1031p.

Villas-Boas, P.R., Romano, R.A., Franco, M.A.D., Ferreira, E.C., Ferreira, E.J.,Crestana, S. and Milori, D. (2016) Laser-induced breakdown spectroscopy to determine soil texture: A fast analytical technique. *Geoderma ,* **263**, 195-202.

تقييم صلاحية استخدام الأراضي باستخدام برنامج الـ MicroLEIS : دراسة حالة في وادى حريجة بمنطقة الساحل الشمالي الغربي، مصر

ابراهيم عطيه حسين يوسف
قسم علوم الاراضى – كلية الزراعة – جامعة القاهرة – جيزة –مصر

يهدف هذا العمل الى دراسة قدرة الارض الانتاجية وصلاحية الارض للاستخدام الزراعي بمنطقة وادى حريجة بالساحل الشمالي الغربي لمصر وذلك باستخدامبرنامج الـ MicroLEIS . ولتحقيق هذا الهدف تم استخدام نموذج الارتفاعات الرقمية DEM مع مرئية القمر الصناعي Landsat ٨ لتحديد ورسم الوحدات الفيزيوجغرافية المختلفة لمنطقة الدراسة. تم حفر ١٨ قطاع ارضى ممثلة لمنطقة الدراسةوتم جمع عينات التربة من الطبقات المختلفة واعدادها للتحليل المعملي. باستخدام برنامج نظم المعلومات الجغرافية تم عمل ارتباط بين بيانات التربة والوحدات الارضية المختلفة لإعداد خريطة التربة. اوضحت نتائج الدراسة ان المنطقة بها خمس وحدات ارضية وهى peneplain ، foot slope ، back slope ، tableland و undulating. تم تصنيف التربة بمنطقة الدراسة الى ثلاث تحت مجموعات كبرى وهىTypicHaplocalcids ،TypicTorripasamments و TypicTorriorthents. وكانت تحت المجموعة الكبرى TypicTorripasamments هي الاكثر انتشاراً بمنطقة الدراسة. اشارت نتائج الدراسة الى تصنيف الارض الى ثلاث درجات قدرة انتاجية مختلفة وهى جيدة القدرة الانتاجية S2 (٥٠٪) ومتوسطة القدرة الانتاجية S3 (٤٥,٥٪) وحدية القدرة الانتاجية N (٤,٥٪). اظهرت نتائج صلاحية استخدام الارض للزراعة الى ان ٢٠ ٪ من مساحة منطقة الدراسة ملائمة (S2) لزراعة محاصيل الفاكهة (الموالح ، الخوخ و الزيتون) ، كما ان ٢٥ ٪ من المساحة ملائمة لزراعة محاصيل البطيخ ، البرسيم الحجازي ، بنجر السكر ، دوار الشمس ، القطن و فول الصويا. كما اظهرت نتائج الدراسة ايضاً ان ٤٩ ٪ ، ٣٧ ٪ و ٤٤٪ من مساحة منطقة الدراسة متوسطة الملائمة (S3) لمحاصيل القمح ، الذرة والبطاطس على التوالي. أوضحت النتائج اناهم محددات التربة بالمنطقة المدروسة هي قوام التربة ، عمق القطاع الأرضي ، حالة الصرف و زيادة محتوى التربة من كربونات الكالسيوم.