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Classification and Mapping of Land Productivity, Capability and Suitability for Production Crops in West El-Minia Governorate, Egypt

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ABSTRACT

The aim of this work was to classify productivity, capability and suitability indices of soils in west El-Minia Governorate, Egypt. El-Minya Governorate is considered one of the important areas of horizontal expansion in the Upper Egypt. The studied area is covers around 667020 ha and it lies between latitudes of 28°00` and 28°58`N and longitudes of 29°75` and 30°64`E. Nineteen soil profiles were dug to represent the geomorphological units in the studied area. Seven geomorphological units were developed;1-Old river terraces 2- Sand sheets 3- Limestone plateau 4- Peni plains 5- Outwash plain 6-Sand dune 7-Hilly area. In the study area there are two soil orders i.e. Aridisols and Entisols were classified as Typic Torriorthents, Typic Torripsamments and Typic Haplocalcids. Land productivity index classes of the area varies from excellent (C1) to extremely poor (C5) using Riquier etal. (1970). Based on MicroLEIS-CERVATANA model, land capability is grouped into two classes, (S2: good) covers an area of 14.68 % of the total area and the limiting factors are bioclimatic factors and (S3: moderate) covers 81.49% of the total area and the limiting factors are erosion risks, bioclimatic factors, edaphic factors and slope. Twelve crops were selected to evaluate their suitability for agriculture: wheat, maize, potato, sugar beet, cotton, soybean, sunflower, alfalfa, peach, citrus, olive and watermelon. Suitability classes according to MicroLEIS-ALMAGRA model were ranged from soils with suitability (S2) to soils with no suitability (S5) classes depending on soil limitations. The main limitations are soil texture, carbonate content and sodium saturation.

Keywords: West El-Minia Governorate, Remote sensing, GIS, Land productivity, Land capability, Land suitability.

INTRODUCTION

The quantity of agricultural land in the worldwide is decreasing, and the most part of this land has become unsuitable for agricultural use (Verheye, 2008). In Egypt, the agriculture is the main economic activity in Egypt and represents approximately 3.8 Mha. (CAPMAS, 2015). Desert lands represent approximately 95% of the total area of Egypt, where the water shortage is the main problem facing any development in these lands (Shalaby and Moghanm, 2015). Due to the continuous decrease of agricultural lands, it is necessary to identify the most relevant lands for sustainable agriculture development at desert areas in which being socially equitable (Yossif etal., 2016). The agricultural expansion in new desert areas is also a priority to compensate the successive loss of agricultural land in Egypt (Aldabaa *et al*., 2010). El-Minia Governorate, one of the major provinces in Egypt (ELDeeb *et al*., 2015). The desert area of west El Minya Governorate is considered as one of the deserts which suitable for reclamation, depending mainly on the groundwater (Abdel Moneim *et al*., 2016). Growing population, agricultural expansion, and urbanization has placed a heavy pressure on water resources (Hanh *et al*., 2017), the most important problem in Egypt is the ratio between land and human resources (Abdel-Hamid *et al*., 2010). West El-Minya area is considered one of the promising areas for agricultural sustainability in Egypt (Yousif *et al*., 2018).

Assessment of land evaluation depending on estimation of land performance for the specified purposes (FAO, 1976), and is considered as the basis for sustainable management of land resources to know quality of these resources are improved or degraded (Dumanski *et al*., 2010 and Abowaly *et al*., 2018). Utilizing of land evaluation mapping to give the information for the sustainable agricultural production, managing land recourses, land capability and land suitability of various kinds of land for specific land uses (FAO, 2008; Tadesse and Negese, 2020 and Debesa etal., 2020). Land productivity capacity is a measure of capability of land to perform specific functions (Devi and Kumar, 2008). The final aim of land capability classification is to predict the agricultural capability of the land (Sys *et al*., 1991). Land suitability defined as the fitness of land for defined crop production (FAO, 2006 and He *et al*., 2011). Land suitability is a very important technique for agriculture in deciding future agricultural cropping pattern, planning and activities (Singha and Swain, 2016). MicroLEIS system has been used to determine the main limiting factors that reduce soil productivity (Yehia, 1998). Liambila and Kibret (2016), applying the MicroLEIS Almagra (agricultural soil suitability) model for agricultural land evaluation and some crops selected for evaluation were sorghum, maize, wheat, sweet potato and soybeans.

Remote sensing (RS) and Geographic Information System (GIS) techniques help for the planers and decision makers to organize the information and can effectively facilitate in vast amount of spatial information (Kushwaha *et al*., 1996 and Yossif *et al*., 2016). Geographic Information Systems (GIS) techniques have been used in several studies to identify spatially and evaluate the physical land capability

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and suitability (Abdel-Motaleb, 1997 and Saleh and Belal, 2014). Yossif etal., (2016), applying the advanced RS and GIS techniques to evaluate soils of some areas at the western desert fringes of El-Minia Governorate for producing digital land capability map.

The aim of this study is to evaluate the physical and chemical properties of soils in West El-Minia Governorate for mapping of land productivity, capability and suitability of some crops using two evaluation methods are Riquier *et al.* (1970) to assess land productivity, while MicroLEIS DSS model to assess:1- land capability using CERVATANA model and 2- land suitability of some crops using Almagra model.

MATERIALS AND METHODS

Study area

The study area is located between latitudes 28°00` and 28°58` N and longitudes 29°75` and 30°64` E, at the western of River Nile as shown in Fig. 1. It covers around 667020 ha in El-Minya Governorate, Egypt. The area surrounded by River Nile in the East, the limestone plateau in the West, Beni-Suef Governorate in the North and Assiut Governorate in the South. El-Minya Governorate is divided administratively into 9 centers are Maghagha, Adwa, Bani mazar, Samalout, Minia, Matai, Abu Qirqas, Mallawi and Deir Mawas, 54 main villages and 340 secondary villages. The total area of El-Minya Governorate is 3227900 ha., from which 3043900 ha. are desert lands while the rest of the governorate is agricultural land. The population of El-Minya Governorate reached 5,630,468 people in 2019. According to El Deeb *et. al*. (2015), the cropping pattern for the studied area includes different crops like wheat, maize, soybean, clover, sorghum, sesame, sugar beet, sugar cane, groundnuts, potatoes, grape and vegetables. The study area contains many industrial zones, agricultural activities and urban areas (Abdalla *et al*., 2009).

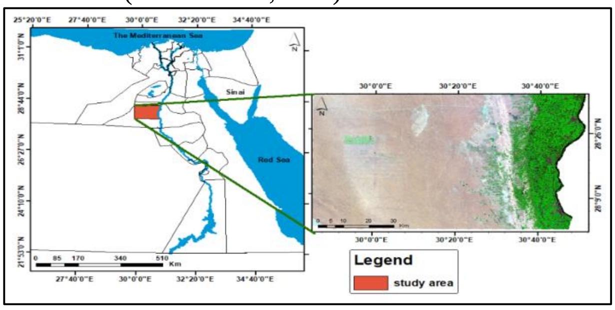


Fig. 1. Location of West El-Minia Governorate.

Climate

The climatic conditions of the study area are an important factor that affects crops consumptive use of water and the evaporation. El-Minya is generally characterized by hot dry climate in summer and cold in winter. Main monthly temperature ranges between 12.9°C in January and 30.2°C in August. The rainfall average value is 28.0 ml/ year, while evaporation values range from 4.17 ml/ day in January to 12.2 ml/ day in June. The mean relative humidity ranges from 33 % in May to 67% in December. (Azzam, 2016).

Geological aspects.

El-Minya area is represented by Tertiary and Quaternary alluvial deposits consist of sand dunes, Nile silt, proto-nil and pre-nil deposits (Klitzsch *et al*., 1987; El Sayed, 2007 and Yousif *et al*., 2018). According to Abou Heleika and Niesner (2008), West El-Minya area is predominantly composed of Quaternary sediments (Nile Silt, Prenile deposites, Protonile deposites, Sanddunes, Wadi deposites, Playa deposites, Fanglomerate and Gravel), Miocene (Moghra Fm. and Dolomitic limestone), Oligocene (Tertiary Alkali Olivine Basalt) and Eocene limestone (Hamra Fm., Rayan Fm., Samalut Fm. and Minya Fm.). The lithostratigraphic units exposed in West El-Minia area were described by Conco Coral Staff. (1987), as shown in Figure 2. According to Gedamy *et al*., (2019), four stratigraphic surface sections including as shown in Figure 3; (section no.1: the Minia Formation) which has a total thickness of 15.5 m, (section no. 2: Samalut Formation) with thickness of 42.8 m, (section no. 3: Qatrani Formation) with thickness of 5 m and (section no. 4: Prenile Deposits) which has a thickness of 19.5 m.

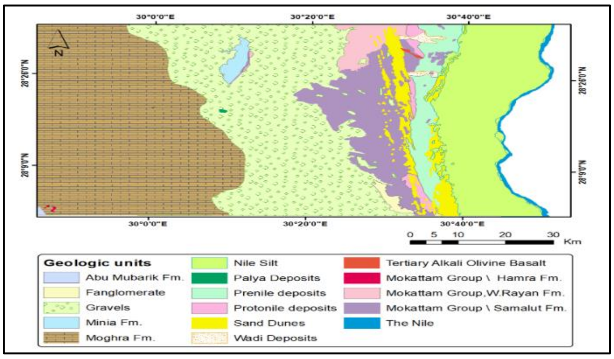
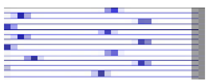


Fig. 2. Geological map of west El-Minia Governorate (After Conoco Coral Staff, 1987)

Age :Lower Eocene, Formation: Minia Formation

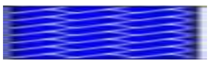
Section (a) — **Lithology**



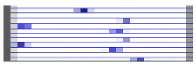
Limestone: pale brown, very hard and contian iron oxides, cacite and gypsum patches. The $CaCo_3$ (82.9%), the insoluble residue described as clay. Thickness: 15.5m.

Age:Middle Eocene, Formation: Samalut Formation

Section (b) — Lithology



Chalky limestone: white, very hard contian caves and chert. The $CaCo_3$ (93.9%). Thikness:15m.



Limestone: yellowish white, very hard and contian iron oxides, calcite and gypsum patches. The $CaCo_3$ (86.9%). Thickness:22.1m.

Marl: brown, very hard and contain iron oxides, calcite, anhydrite and gypsum. The $CaCO_3$ (47.5%). Thickness: 5.7m.

Age:Oligocene, Formation: Qatrani Formation

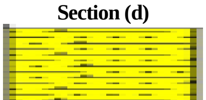
Section (c) — Lithology

Gravelly sandstone: white, pitted and moderately sorted. The $CaCo_3$ (7.45%). Thickness: 2m.

Gravelly calcareous sandstone: white. The $CaCo_3$ (40.05%). Thickness: 3m.

Age: Quaternary, Formation: Prenile deposits

Section (d) — Lithology



Calcareous sandstone: yellow, pitted and polished contain iron oxides and gypsum. Thickness: 8 m.

Gravelly sand: pale yellow, pitted. Thickness: 2.5 m.

Sand: pale yellow, pitted and polished. Thickness: 9 m.

Fig. 3. Stratigraphic section of West El Minia area.

Geomorphological aspects.

Geomorphologically, the study area is moderately elevated plateau with respect to River Nile and composed of mainly limestone covered with alluvial deposits of sands and gravels (Abou Heleika and Niesner, 2008). There are three geomorphologic units in El-Minia area, from west to east as follow: a) The limestone plateau (tableland), b) The old alluvial plain (River terraces), c) The recent alluvial plain (Abdel Moneim *et al*., 2016 and Gedamy *et al*., 2019). Four geomorphologic units in west El-Minia including the tableland, isolated hills, three flood plains (silty, sandy and gravely), sand dunes and hills (Shabana, 2010 and Salem, 2015).

Hydrological aspects.

In El-Minya Governorate, the groundwater is considered as a part of the regional Nile valley aquifer systems and there are two aquifers: Eocene and Quaternary aquifers (RIGW, 1997). The Eocene aquifer occupies the extreme eastern and western sides of the study area and composed of the Samalut Formation (El Sayed, 2007 and Shabana, 2010). Hydrogeologically, the Eocene fractured limestone aquifer is the good water bearing formation in the investigated area, while quaternary aquifer has a wide areal extension, especially on the western side of the Nile Valley. The Eocene groundwater use in both the drinking and irrigation purposes in the study area (Gedamy *et al*., 2019). The aquifer is recharged by Nile water, irrigation system, drains, agricultural and wastewater (Korany, 1984 and Tantawi, 1992).

Geomorphological units and filed work:

A Landsat-8 OLI image (path 177 / row 40) acquired in 2020 performed using ENVI 5.3© software (ITT, 2009) for classifying the geomorphologic units. Digital elevation model analysis was used to identify the geomorphological units in the studied area. by using Arc-GIS 10.2 software. 19 soil profiles were chosen to represent the geomorphological units of the investigated area, the locations of these profiles as shown in Figure 2. Soil profiles were described according to FAO (2006). 46 soil samples were air-dried, sieved through a 2 mm sieve and stored for physical and chemical analyses.

Laboratory analysis:

Particle size distribution was determined according to USDA (2004), $CaCO_3$ content using calcimeter, $CaSO_4.2H_2O$ (gypsum) content by precipitation with acetone, soil pH using pH meter, EC in the soil paste extract, soil organic matter using Walkely' s rapid titration method and cation exchange capacity (CEC) using sodium and ammonium acetate were determined according to Bandyopadhyay (2007).

Land Evaluation Methods

1- Land Productivity Classification (LPC).

The Land productivity classification (LPC) was estimated for the different mapping units in the study area using equation produced by Riquier *et al*. (1970). The output results of Riquier *et al*. (1970) classified to five capability classes: Class C1: Land productivity is excellent, Class C2: Land productivity is good, Class C3: Land productivity is average, Class C4: Land productivity is poor and Class C5: Land productivity is extremely poor to nil.

2- Land Capability Classification (LCC).

The Land capability classification (LCC) was estimated for the different mapping units in the study area using MicroLEIS-CERVATANA model (De la Rosa, 2000), and CERVATANA model is available at http://www.evenortech. com/microleis/microlei/ microlei. aspx (Microleis web-Based Program, 2013). The output results of CERVATANA model classified to four capability classes: Class S1: Land with excellent use capability, Class S2: Land with good use capability, Class S3: Land with moderate use capability and Class N: Marginal or non-productive land.

3- Land Suitability Classification (LSC).

MicroLEIS-Almagra (De la Rosa eta., 2004), and Almagra Model available at http://www.evenortech.com /microleis/microlei/microlei.aspx (Microleis web-Based Program, 2013). As for Almagra model six crops were chosen to evaluate their suitability for production in the investigated area. The selected crops are including wheat, maize, potato, sugar beet, cotton, soybean, sunflower, alfalfa, peach, citrus, olive and watermelon. The output results of Almagra model are classified to five suitability classes for crops: Class S1 (optimum suitability), Class S2 (high suitability), Class S3 (moderate suitability), Class S4 (marginal suitability) and Class S5 (no suitability).

RESULTS AND DISCUSSION

Geomorphologic features and soil taxonomy.

Seven geomorphologic units were identified in West El-Minia Governorate based on digital image process, image interpretation, digital elevation modal (DEM Fig.1) and soil survey of the study area, the main geomorphologic units as shown in Figure 4. They could be recognized as 1- Old river terraces 2- Sand sheets 3- Limestone plateau 4- Peni plains 5- Outwash plain 6-Sand dune 7-Hilly area. Landforms map was considered a Geodatabase map over which the representative soil profiles were spatially distributed. Table 1 gives the proportions of each geomorphologic units and associated soil profiles.

Table 1. Geomorphologic units and its areas in the study location.

Geomorphologic unit	Representative soil profile	Maximum Elevation	Area ha.	Area %
Old river terraces	1, 2, 3 and 4	70	97907	14.68
Sand sheets	5, 6 and 7	100	29579	4.43
Limestone plateau	8, 9,10 and 11	142	80104	12.01
Peni plain	12, 13, and 14	146	207004	31.03
Outwash plain	15, 16, 17, 18 and 19	75	226888	34.02
Sand dunes	______	114	19751	2.96
Hills	______	202	5787	0.87
Total area			667020	100

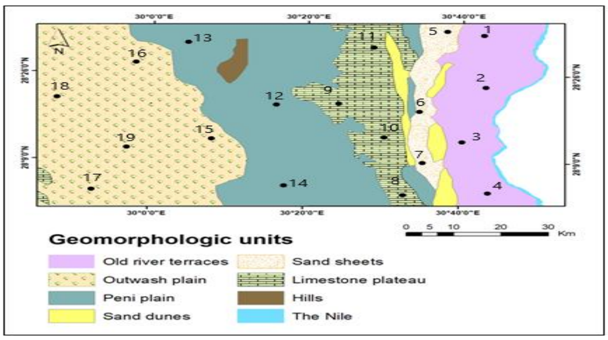


Fig. 4. Geomorphologic map and location of soil profiles in West El-Minia area.

The Outwash plain soils dominate the area of West El-Minia Governorate. Elevation of the studied area varies from 70 to 202 m above sea level (a.s.l.). The old river terraces are in the western part of the study area and represented by 4 profiles. The area of this unit is about 97907 ha. (14.68%). Sand sheets unit represents an area of about 29579 ha. (4.43%) and was represented by 3 soil profiles. Limestone plateau is in the western middle part of the studied area and it represents an area of about 80104 ha. (12.01%). The unit was represented by 4 soil profiles. Peni plain is in the middle part of the studied area and it represents an area of about 207004 ha. (31.03%). The unit was represented by 3 soil profiles. Outwash plain is in the eastern part of the studied area and it represents an area of about 226888ha. (34.02%). The unit was represented by 5 soil profiles. The sand dunes and hills are out of soil profiles and represent a small area about 25538 ha. (3.83 %). According to USDA (2014), the soil temperature regime of the study area is hyper thermic, and the soil moisture regime is torric. In the study area there are two soil orders i.e. Aridisols and Entisols, which Entisols are dominated in the study area. These orders are differentiated into suborders, great groups, subgroups and families. The investigated soils are classified as Typic Torriorthents, Typic Torripsamments and Typic Haplocalcids.

Land Evaluation

1- Land Evaluation of Land Productivity Classification (LPC).

The Land productivity classification (LPC) was estimated for the different mapping units in the study area using equation produced by Riquier *et al*. (1970) as follows:

LPC = (H/100) x (D/100) x (P/100) x (E/100) x (T/100) x (N/100) x (S/100) x (O/100) x (A/100) x (M/100) x 100

Where,

LPC is the Land Productivity classification, H is the moisture availability, D is the drainage, P is effective depth (cm), E is the slope (%), T is the texture/structure, N is the soil pH, S is the soluble salt concentration (dS/m), O is the organic matter (g/kg), A is the mineral exchange capacity/nature of clay cmol$_c$/kg), and M is the mineral reserves.

The parametric evaluation system of Riquier *et al.* (1970) based on soil properties, were given in Tables 2 to 4. Each factor is rated on a scale from 0 to 100 and the resultant is the index of productivity classification (between 0 and 100). The rating of the productivity of the soils was done according to the grading system in Table 5. Most of the study area 77.06% (513996 ha.) consists of extremely poor class (C5) in terms of no agricultural use: this class found in limestone plateau, peni plain and outwash plain mapping units, these soils are affected by very high limitations of texture, moisture availability, slope, CEC and organic matter content. A portion of 4.43% (29579 ha.) of study area has poor class (C4): This class found in sand sheets mapping unit, and these soils are affected by high limitations such as texture, effective depth, CEC, organic matter content and mineral reserve. Excellent class (C1) occupies an area about 97907 ha. (14.68% of the total area: this class found in old river terraces mapping unit, the soils in this class are affected by low limitation such as texture, CEC and organic matter content. Table 5 shows values of the classes land productivity index. Land productivity index classes of the area varies from “excellent” to “extremely poor” due to different limiting factors. Some of these limiting factors are not correctable such as soil texture, soil depth and soil slope, while CEC and organic matter content that can be corrected. Improving the soil properties and applying modern irrigation systems, the soil could be improved to be highly suitable for agricultural use. One of the best ways to improve such light soils (sandy soils) is through additions of organic manures, such as animal manure, green manure, and compost. Continuous agriculture use of these soils will upgrade their productivity in the future. Land productivity index map is shown in Figure 5.

Table 2. Values of the factors of land productivity index of the studied soils of the investigated area.

Mapping unit	H	D	P (cm)	E (%)	T	N	S (dS/m)	O (g/kg)	A (cmol$_c$/kg)	M
Old river terraces	Rooting zone above wilting point and below field capacity for most of the year	Well drained	Deep soil	Flat	Sandy loam	8.04	1.93	14.9	10.30	Minerals derived from basic or calcareous rocks
Sand sheets	Rooting zone above wilting point and below field capacity for most of the year	Good drained	Shallow soil	Slightly	Sand	8.25	1.43	15.2	5.10	Minerals derived from sands, sandy material
Limestone plateau	Rooting zone below wilting point for 9 to 11 months of the year	Moderate drained	Shallow soil	Moderately	Sand	8.17	1.23	19.3	6.83	Minerals derived from sands, sandy material
Peniplain	Rooting zone below wilting point for 9 to 11 months of the year	Good drained	Fairly deep soil	Moderately	Sand	8.14	1.81	15.0	4.90	Reserves very low to nil
Outwash plain	Rooting zone below wilting point for 9 to 11 months of the year	Good drained	Fairly deep soil	Slightly	Sand	8.10	1.47	16.0	5.73	Minerals derived from sands, sandy material

Note: H (the moisture availability), D (the drainage), P (the effective depth), E (the slope), T (the texture/structure), N (the soil pH), S (the soluble salt concentration), O (the organic matter), A (the mineral exchange capacity/nature of clay), and M (the mineral reserves).

Table 3. Soil characteristics of the investigated area.

Mapping unit	H	D	P	E	T	N	S	O	A	M
Old river terraces	H5	D4	P5	E1	T6b	N5	S1	O2	A1	M3c
Sand sheets	H5	D3a	P4	E2	T2b	N5	S1	O2	A1	M2a
Limestone plateau	H2c	D2a	P3	E3	T2b	N5	S1	O2	A1	M2a
Peniplain	H2c	D3a	P4	E3	T2b	N5	S1	O2	A0	M1
Outwash plain	H2c	D3a	P4	E2	T2b	N5	S1	O2	A1	M2a

Table 4. Assessment of land productivity index of the investigated area.

Mapping unit	H	D	P	E	T	N	S	O	A	M	Land Productivity Index (LPI)
Old river terraces	100	100	100	100	90	100	100	90	90	100	72.90
Sand sheets	100	90	80	80	30	100	100	90	90	85	11.90
Limestone plateau	40	80	50	80	10	100	100	90	90	85	0.88
Peniplain	40	90	80	80	10	100	100	90	85	85	1.50
Outwash plain	40	90	80	90	10	100	100	90	90	85	1.78

Table 5. Distribution of land productivity index of the study area

Land Productivity Index class	Rate	Grade	Mapping unit	Area (ha)	Area %
Excellent	65-100	C1	Old river terraces	97907	14.68
Good	35-64	C2	______	_____	_____
Average	20-34	C3	______	_____	_____
Poor	8-19	C4	Sand sheets	29579	4.43
Extremely poor or nil	0-7	C5	Limestone plateau, Peniplain and Outwash plain	513996	77.06

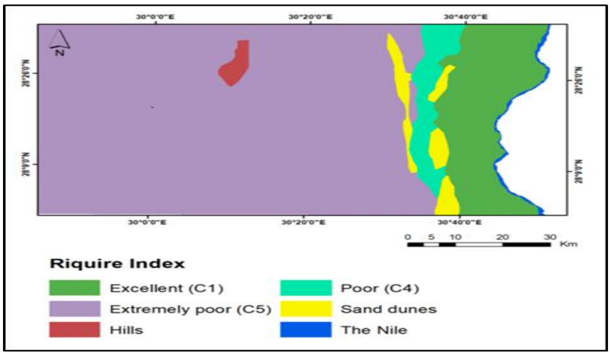


Fig. 5. Land Productivity Index map.

2- Land Evaluation of Land capability classification (LCC).

Land capability refers to the present use of land with improved management practices. A land capability classification of the soils of West El-Minia Governorate was applied using MicroLEIS-CERVATANA model. This model was designed by De la Rosa *et al.* (1992) and modified for computing purpose by De la Rosa (2000). The MicroLEIS-CERVATANA model forecasts the general land use capability for multiple purposes mainly used for agriculture uses depending on the nature and properties of soils. Based on the capability or limitations, the classification helps in estimating soil resources available for different purposes. Classes range from S1 to N. The rating of each class and kinds of subclasses are shown in Table 6.

Table 6. Land capability classes, grades, rating and subclasses according to MicroLEIS-CERVATANA model.

Land capability class			Land capability subclass	
Class	Grade	Rate %	Symbol	
S1	Excellent	>80	r	Erosion risk factors
S2	Good	60-80	b	Biolimatic factors
S3	Moderate	20-60	l	Soil factors
N	Marginal or non-productive land	<20	t	Topographic factor

The rating of capability classes and kinds of limitation condition types of the studied soils are present in Table 7 and illustrated in Figure 6. According to MicroLEIS-CERVATANA model, there are two capability classes in the investigated area as follows:

1- **Good capability (S2):** This class is represented by only one soil mapping unit (old river terraces) and represent about 14.68 % of the studied area. Soils in this class have one subclasses “S2b” and minor limitations, which require good management practices. Soils in this class, mostly affected by the bioclimatic factors. These soils need good management practices to improve its current capability.

2- **Moderate capability (S3):** most of soil mapping units found in this class. Soils in this class represent about 81.49% of the studied area and have limitations that require moderately intensive management practices. These soils have some limitations such as erosion risks factors, bioclimatic factors, soil factors (soil depth, soil texture, soil stoniness/rockiness %, soil drainage and soil salinity dS/m) and topographic factor (slope %). However, these mapping units with very good management practices could be improved to be “good” class. Lands of moderate capability have four subclasses abbreviated as:

- S3b subclass: include soils of sand sheets mapping unit and referring to moderate capability affected by climatic factors.
- S3rb subclass: including soils of moderate capability and there are in limestone plateau mapping unit, which affected by erosion risk and climatic factors.
- S3tlr subclass: include soils of peniplains mapping unit, which have moderate limitation regarding slope, soil factors and erosion risks.
- S3trb subclass: include soils of outwash plains mapping unit, which have moderate limitation regarding soil factors. This class has considerable limitations linked to slope, erosion risk and climatic factors.

Table 7. Land capability classification for of west El-Minia Governorate according to MicroLEIS-CERVATANA model.

Land Capability Class	Land Capability Subclass	Landform	Degree	Occupied Area (ha.)	(%)
S1		--	Excellent	0.00	0.00
S2	S2b	Old river terraces	Good	97907	14.68
S3	S3b	Sand sheets	Moderate	29579	4.43
	S3rb	Limestone plateau		80104	12.01
	S3tlr	Peniplain		207004	31.03
	S3trb	Outwash plain		226888	34.02
N	N	--	Marginal or non-productive land	-	-
Sand dunes and Hills				25538	3.83
Total area				667020	100

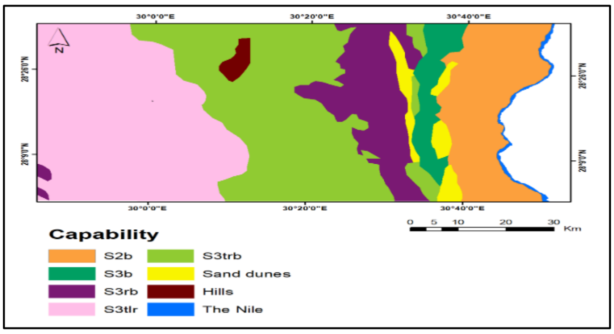


Fig. 6. Land capability classification for of west El-Minia Governorate.

3- Land Evaluation of Land Suitability Classification (LCC).

Land suitability classification analysis is a prerequisite for sustainable agricultural production (Debesa *et al*., 2020), and is one of the most beneficial applications in planning and managing land recourses (Tadesse and Negese, 2020). The evaluation of land suitability needs a specification of the respective crop requirements and calibrating them with the nature of the land and soil parameters. A land suitability classification of the soils of West El-Minia Governorate was evaluated by using MicroLEIS-ALMAGRA model, which was designed by De la Rosa *et. al.* (2004) and was used in the quantitative parameters of the agro-ecological evaluation in the investigated area for the land use types of different crops. The soil parameters used for estimating the suitability index for different crops were, climate, slope, drainage, texture, soil profile depth, $CaCO_3$, gypsum, pH, EC, ESP and profile development. The results indicate that the area under consideration has a good potential to produce field crops under irrigation, provided that the water requirements are met. Twelve crops were selected to assess their suitability for agriculture, namely, wheat, maize, potato, sugar beet, cotton, soybean, sunflower, alfalfa, peach, citrus, olive and watermelon. These crops are most suitable for arid and semi-arid soils. Based on the MicroLIES-ALMAGARA model as shown in Figures 7 to 18 and Table 8, the studied area is classified into three suitability classes and six sub classes. Suitability classes are ranged from S2 (soils with suitability) to S5 (soils with no suitability). The main limitations are soil texture, carbonate content and sodium saturation.

Table 8. Land suitability classes of the study area for different crops using MicroLEIS-Almagra model.

Landform	Wheat	Maize	Potato	Sugar beet	Cotton	Soybean	Sunflower	Alfalfa	Peach	Citrus	Olive	Watermelon
Old river terraces	S2tca	S3c	S3c	S2tc	S3c	S2tca	S2tca	S2ca	S3c	S3c	S2tca	S3c
Sand sheets	S3t	S3tc	S3tc	S3t	S3tc	S3t	S3t	S3t	S3c	S3c	S2tca	S3tc
Limestone plateau	S3t	S3tc	S3tc	S3t	S3tc	S3t	S3t	S3t	S3c	S3c	S2tdc	S3tc
Peniplain	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S4t	S3t	S3t	S3t	S4t
Outwash plain	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S5t	S4ptd	S4ptd	S4ptd	S5t

Note: S1 = highly suitable, S2 = suitable, S3 = moderately suitable, S4 = marginally suitable, S1 = not suitable, p: useful depth, t = texture, d = drainage, c = carbonate, s = salinity and a = sodium saturation.

The current land suitability for different crops produced by MicroLEIS-ALMAGRA model as shown in Table 9, about 20 % of the studied area are suitable (S2), 40% are moderately suitable (S3), 20% are marginally suitable (S4) and 20% are not suitable (S5) for wheat, sugar beet, soybean, sunflower and alfalfa. Crops such as: maize, potato, cotton and watermelon are moderately suitable (60%), marginally suitable (20%) and not suitable (20%) to be grown in this area. For growing peach and citrus, about 80% of area are moderately suitable (S3), while 20% are marginally suitable (S4). About 60 % of the studied area are suitable (S2), 20% are moderately suitable (S3) and 20% are not suitable for olive. The crops which are considered not suitable (S5) due to the moderate to severe fertility limitations of the study area. The coarse texture and shallow depth of the soils in some soil profiles are the main limiting factors for growing crops especially fruit trees. Proper fertilization and management associated can improve the soil suitability for growing crops. Many options to improve the soil suitability for growing different crops such as:

1- Choose the crops which are suitable to this area can be increased the sustainable land use for crop production.
2- Application of the organic fertilizers and crop residue which can reduce the alkalinity of the soil and increase the fertility of these soils for producing different crops.
3- Intensive water management and conservation of soil are necessary to maintain a continued crop production.
4- Using advanced management techniques can be increased the crop production in the studied area but are difficult to be applied because the higher costs.

Table 9. Soil suitability rating and percentage for growing some crops according to MicroLEIS-Almagra model.

	MicroLEIS-Almagra model											
Rating suitability	Wheat	Maize	Potato	Sugar beet	Cotton	Soybean	Sunflower	Alfalfa	Peach	Citrus	Olive	Watermelon
S1	--	--	--	--	--	--	--	--	--	--	--	--
S2	20	--	--	20	--	20	20	20	--	--	60	--
S3	40	60	60	40	60	40	40	40	80	80	20	60
S4	20	20	20	20	20	20	20	20	20	20	20	20
S5	20	20	20	20	20	20	20	20	--	--	--	20

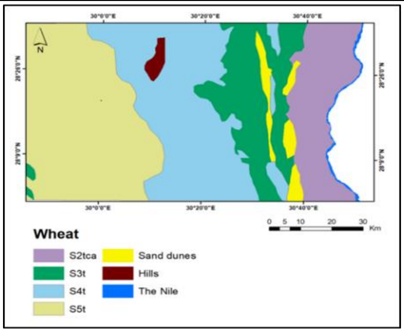


Fig. 7. Suitability map for Wheat of west El-Minia.

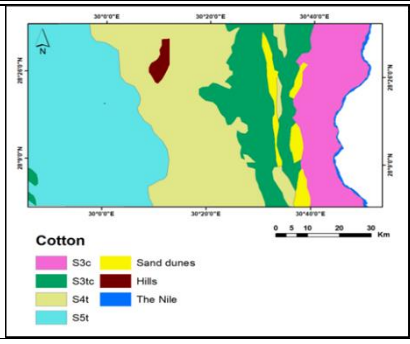


Fig. 8. Suitability map for Cotton of west El-Minia.

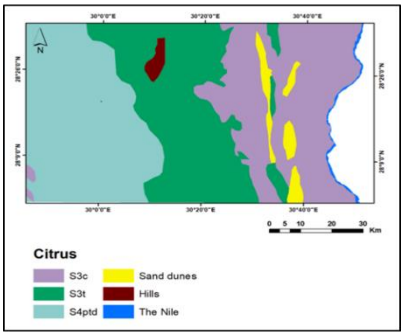


Fig. 9. Suitability map for Citrus of west El-Minia.

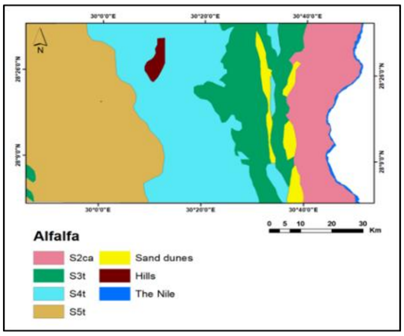


Fig. 10. Suitability map for Alfalfa of west El-Minia.

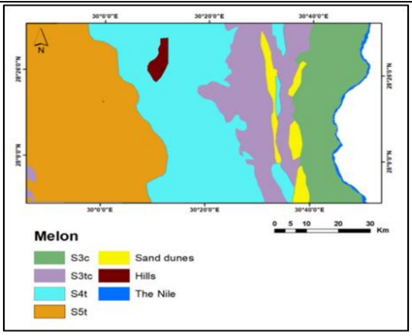


Fig. 11. Suitability map for Watermelon of west El-Minia

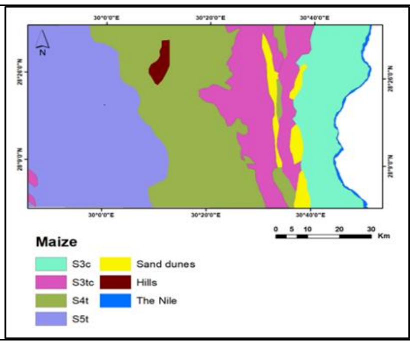


Fig. 12. Suitability map for Maize of west El-Minia.

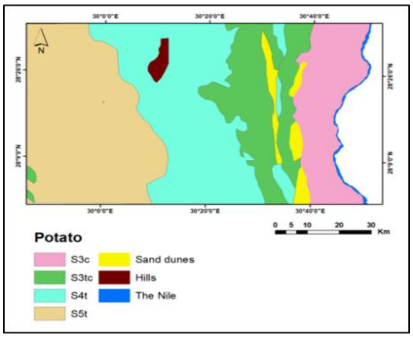


Fig. 13. Suitability map for Potato of west El-Minia

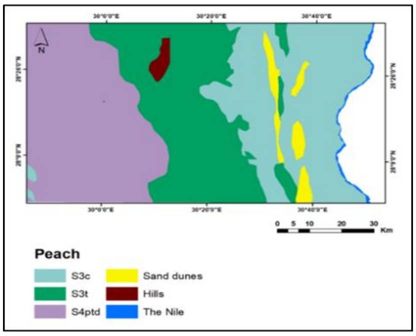


Fig. 14. Suitability map for Peach of west El-Minia.

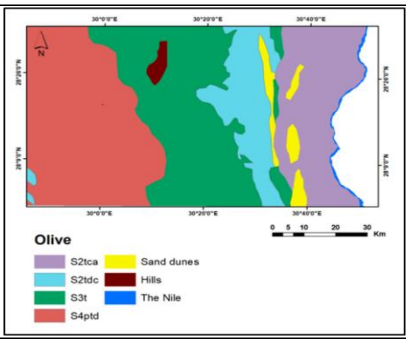


Fig. 15. Suitability map for Olive of west El-Minia

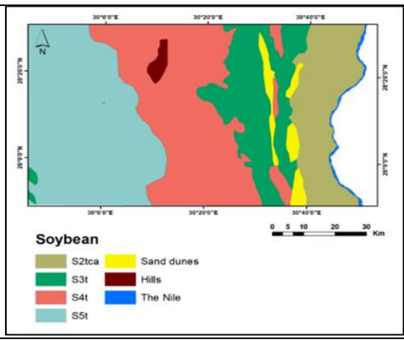


Fig. 16.Suitability map for Soybean of west El-Minia.

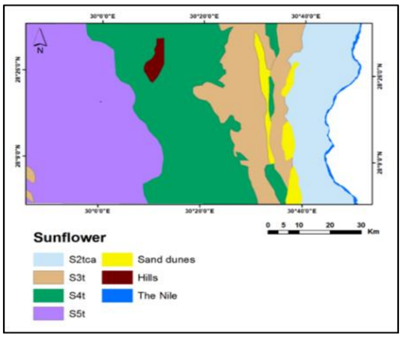


Fig. 17. Suitability map for Sunflower of west El-Minia

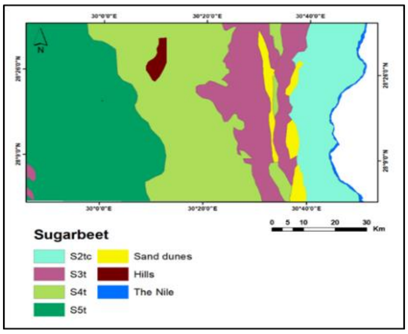


Fig. 18. Suitability map for Sugarbeet of west El-Minia.

CONCLUSION

The purpose of this study was to classify productivity, capability and suitability of the soils in west El-Minia Governorate for crop production and identify the limiting factors that hinder the cultivation process. The results of the limiting factors of the crop production in the studied area are slope, surface stoniness, erosion, light texture and low soil fertilities. The investigated area is considered one of the importance areas for the management of natural resources and decision makers in the western desert of Egypt. GIS and Remote sensing techniques are helpful tools to quantitative evaluate of land productivity, capability and suitability classifications. The integrating of Ruqire *et al*. (1970) with a GIS framework for mapping of land productivity, and of MicroLEIS (CERVATANA and ALMAGRA) model with a GIS framework for analysis and mapping of land capability and land suitability for some crops.

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تصنيف وعمل خرائط إنتاجية ومقدرة وملائمة التربة لإنتاج المحاصيل في غرب محافظة المنيا-مصر.

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تهدف الدراسة الحالية الى تصنيف إنتاجية ومقدرة ومدى ملائمة الأراضي لنمو المحاصيل المختلفة في غرب محافظة المنيا-مصر. غرب محافظة المنيا يعتبر من المناطق الواعدة في التوسع الرأسي في مصر العليا. منطقة الدراسة تغطى مساحة مقدارها ٦٦٧٠٢٠ هكتار وتقع ما بين دائرتي عرض ٢٨°٠٠'و٢٨° ٥٨' شمالا وخطى طول ٢٩° ٧٥'و٣٠° ٦٤' شرقا. تم حفر تسعة عشر قطاع أرضي لتمثيل جميع الوحدات الجيومرفولوجية بمنطقة الدراسة وهي: ١- الشرفات النهرية القديمة ٢- الفرشات الرملية ٣- هضبة الحجر الجيري ٤- السهل الحصوي ٥- السهل الرملي ٦- الكثبان الرملية ٧- المناطق الجبلية. وتنقسم أراضي منطقة الدراسة الى تحت رتبتين هما: رتبة الأراضي الجافة ورتبة الأراضي الحديثة وتصنف كالتالي: Typic Torriorthents, Typic Torripsamments, Typic Haplocalcids. اقسام دليل إنتاجية التربة يتنوع ما بين ممتاز الى فقير للغاية باستخدام Riquier etal. (1970). ودليل مقدرة التربة على الإنتاج طبقا للنموذج MicroLEIS-CERVATANA تنقسم منطقة الدراسة الى قسمين: جيدة وتشغل مساحة قدرها ١٤,٦٨% من المساحة الكلية مع محددات للعوامل المناخية، ومتوسطة وتغطى مساحة قدرها ٨١,٤٩% من مساحة منطقة الدراسة الكلية مع وجود محددات لعوامل التعرية والمناخ والتربة و الميل. ١٢ محصول اختيرت لتقييم مدى ملائمة التربة لزراعة المحاصيل وهي: القمح، الذرة، البطاطس، قصب السكر، القطن، فول الصويا، عباد الشمس، البرسيم الحجازي، الخوخ، الموالح، الزيتون والبطيخ. أقسام الملائمة طبقا للنموذج MicroLEIS-ALMAGRA تنقسم التربة من ملائمة الى غير ملائمة اعتمادا على محددات التربة وهي: قوام التربة ومحتوى التربة من الكربونات والتشبع بالصوديوم.