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(Original Article)

Mapping Soil Properties and Land Evaluation for Agricultural Purposes, El Alamein Area, the North-Western Coast, Egypt

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Abstract

Land evaluation is a necessary tool in reclamation and cultivation of new lands. North-western coast represents one of the promising locations for sustainable agricultural development in Egypt. Therefore, the main objective of this work was to evaluate lands for agricultural purposes in the study area using the agriculture land evaluation system for arid and semi-arid regions (ALES-arid) model. Twenty-four locations for soil surface (0 – 30 cm) and subsurface (30 -60 cm) samples (total samples are 48), and one irrigation water sample were collected and analyzed. GIS techniques were used to produce maps of soil properties and land evaluation. The results showed that soil texture was sandy loam, soil pH ranged from 7.9 to 8.5, and $CaCO_3$ was high. Concerning land evaluation, the fair capability class (C3) occupied all the studied area. The limiting factors which affected the land evaluation were the low contents of clay and cation exchange capacity, and high soil alkalinity. Regarding soil suitability evaluation for twelve crops, the studied area was highly suitable (S1) for alfalfa (71%) and tomato (68%). Moderately suitable (S2) for barley (100%), wheat, sunflower, and onion (75%). Marginally suitable (S3) for faba bean (75%), sorghum (64%), maize, soybean, peanut, and potato (68%). The use of mapping land evaluation can help decision-makers regarding new land reclamation projects.

Keywords: *Mapping Soil Properties, Land Capability, Soil Suitability, ALES-arid, GIS.*

Introduction

Due to the rise in population and decline in agricultural land, Egypt is currently facing many difficulties, particularly in the agricultural sector. The government focuses on creating horizontal expansion initiatives for agriculture by reclaiming new lands. To solve the issue of food scarcity and achieve self-sufficiency, the reclamation and development of these lands are very important (Abd El-Kawy *et al*., 2010).

Northwestern coast is considered as one of the most promising areas for comprehensive development (agricultural, urban, and industrial) in Egypt (Karam *et al*., 2020). The land evaluation for agricultural purposes requires specified assessment of soil and water resources (Elsheikh *et al*., 2013). The Egyptian government has adopted development policies aimed at achieving two main goals:

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extending agricultural area and maximizing production of the cultivated land. Thus, there is an imperative need to investigate the rate of land cover land use changes, in addition to the land evaluation for the sustainable land use planning (Elzahaby *et al*., 2015).

Land evaluation is the process used for predicting land use according to its properties (Rossiter, 1996). Extensive information about soil characteristics as well as other vital details for agricultural yield, like water quality, meteorological conditions, and environmental factors are integrated into the land evaluation models (Dengiz and Sağlam, 2012; Elnaggar *et al*., 2016). The ALES-arid model (Ismail *et al*., 2005) has been confirmed to be exceedingly effective, user-friendly, and quick. GIS and land evaluation model integration is crucial for more effective land use (Panigrahy *et al*., 2006). Producing land evaluation maps can help decision-makers and farmers use the land to achieve high agricultural productivity (Moursy *et al*., 2020).

The integrated approach in using remote sensing (RS) data and GIS for quantitative land evaluation has been used earlier by several research on both of global and national scale. AbdelRahman *et al*. (2016) used integration RS and GIS to land evaluation for agriculture purposes in Karnataka, India. Also, Halder (2013) used RS and GIS to assess land suitability for crop cultivation in India. Al-Taani *et al*. (2021) evaluated land suitability for agricultural by using GIS and RS techniques in Maan Governorate, Jordan. In Republic of Yemen; Al-Mashreki *et al*. (2010) used the same methods for the same purpose in the Ibb governorate, Yemen. Emadi *et al*. (2010) applied the integration between geostatistics, RS, and GIS for evaluating soil suitability in arid and semiarid ecosystems. Land suitability assessment of nature conservation practices and afforestation at the southwestern corner of Crete Island, Greece, achieved using RS and GIS applications (Elhag, 2011). Kamau *et al*. (2015) used GIS and RS for crop-land suitability analysis in Kenya. Debesa *et al*. (2020) determined land suitability classes for major grain crops in Southwest Ethiopia using RS and GIS. In Indonesia; Habibie *et al*. (2021) achieved land suitability for maize production using satellite images and GIS. Land suitability was evaluated using soil and vegetation indices which derived from satellite images in Bangladesh (Mostafiz *et al*., 2021). Partoyo and Lukito (2022) used integration between GIS and RS for rice land evaluation in Indonesia.

Land suitability estimation using applications of RS and GIS has been widely applied in Egypt; For example, but not limited to: Agricultural productivity evaluation by using applications of RS and GIS in Siwa Oasis (Elnaggar *et al*., 2016). Yousif (2018) used RS and GIS for mapping land evaluation in some areas of North-Western Coast. Land evaluation in the Northwest Nile Delta using GIS techniques (El-Behairy *et al*., 2022). Abdrabelnabi and Abdelaty (2019) Linked land suitability classes and their agricultural limitations with soil reclamation in the Northeastern part of the Western desert. Said *et al*. (2020) used land evaluation and multivariate analysis for agricultural development of the Northwestern coast. land evaluation and water requirements for several crops in Dakhla Oasis (Fadl and Abuzaid, 2017). Land evaluation using different models such as ASLE model

(El-Seedy, 2019), ALES-Arid model (Mahmoud *et al*., 2020; Nada *et al*., 2022), and MicroLEIS model (Yousif, 2019) by integration with GIS techniques. Sayed and Khalafalla (2021) used GIS techniques for land evaluation of some soils in Northwest of Dashlut, Assiut, Egypt. The same techniques were used for the same purpose in Eastern Sohag (Moursy *et al*., 2020), Tushka area (Abd El-Aziz, 2018), Southwest of Aswan city (Aldabaa and Yousif, 2020), ElQusiya Area, Assiut (Fadl and Sayed, 2020), and Bahariya Oasis (Shokr *et al*., 2022).

There are no previous studies that investigated the land evaluation in this region, so this study aims to use the integration between ASLEarid model and GIS to determine the land evaluation for some cultivated crops and define the main limitations of these crops in the selected area. The development of land evaluation maps of soils in the study area will help in creating a decision-making framework for future planning of land reclamation in that area.

Materials and Methods

The study was achieved through seven stages:

1-Selection and Delineation of the Study Area

2-Data Collection.

3-Field work.

4-Laboratory Analysis.

5-RS Data Processing and GIS Analysis.

In the First Phase, the boundary of the study area was created to determine the extent of our analysis. In the Second Phase, data and information were collected (survey data, maps (https://www.google.com/maps), climatic data (https://en.tutiempo.net), …. etc.)), input, and summarized to obtain an overview of the study area. In the Third Phase and during the fieldwork, the main duties were done: (a) General data collection about soil, geology, and geomorphology. (b) Soil samples collection. In the Fourth Phase, laboratory chemical and physical soil analysis were done. In the Fifth and Final Phase, GIS techniques were used to create maps of soil properties, its capability for cultivation, and its suitability for several crops.

Study Area

Location

The study area is a portion of the northwestern coast in Egypt. It extends from 3400000 N to 3408000 N and from 682000 E to 692000 E (WGS 1984, UTM, Zone 35 N) with elevation about 15-45 m above Sea level and an area approximately 36.9 Km2 (3690 ha) (Figure 1).

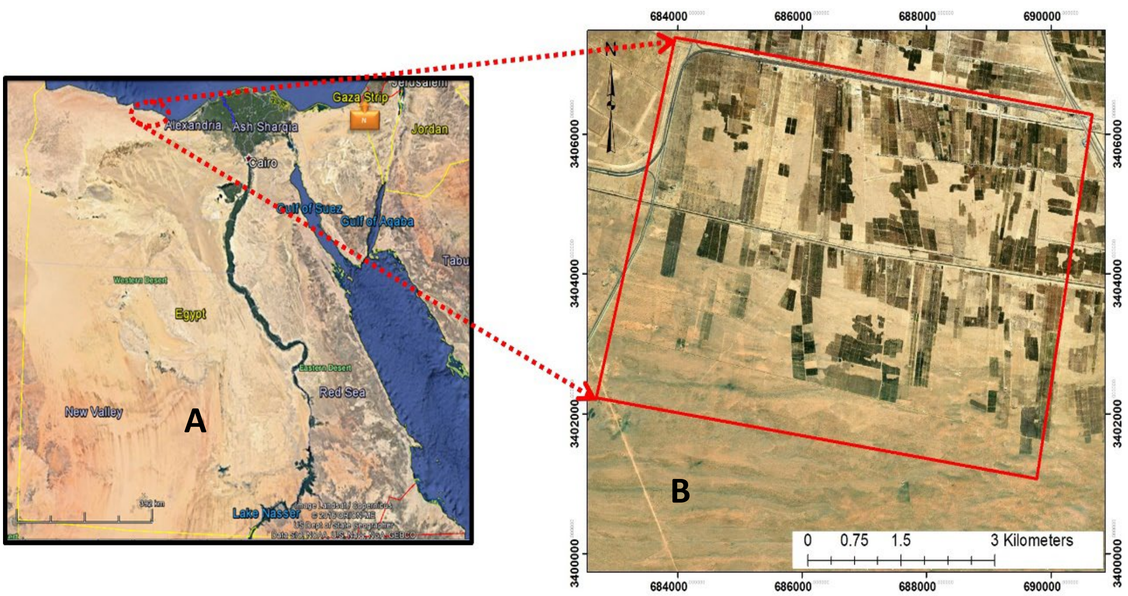

Figure 1. A- Egypt map; B- The study area.

Climate

The study area is in the arid and semi-arid region. It has a hot dry summer and mild winter, and the maximum values of temperature are recorded in August (30 °C), the minimum values are recorded in January (16.5 °C) with an annual rainfall of about 150 mm, and high evaporation with moderately to high relative humidity. The maximum values of relative humidity are recorded in July (72.0%) and the minimum values are recorded in March (65.0%) (Sayed, 2013).

The Sources of irrigation water

The irrigation water comes from the Nile River to the study area through the El-Hammam canal which receives its water from El-Nasser canal which is connected El-Nubaria canal. Surface water has moderate salinity and slight alkalinity with sodium bicarbonate dominated (Sayed, 2013).

Field work

Soil and Water Sampling

The Geographical distribution of twenty-four locations for soil surface (0-30 cm) and subsurface (30-60 cm) samples (total samples are 48) were chosen based on systematic grid method. The Global Position System (GPS) guided the field trip to locate soil samples. The soil samples geo-coordinates were expressed by the Universal Transverse Mercator (UTM) system, zone 35 N (Figure 2), locational accuracy varied from 5 m to 6 m according to GPS accuracy. One irrigation water sample was collected from an irrigation water source (Alhamam canal) with elevation about 15-30 m above Sea level.

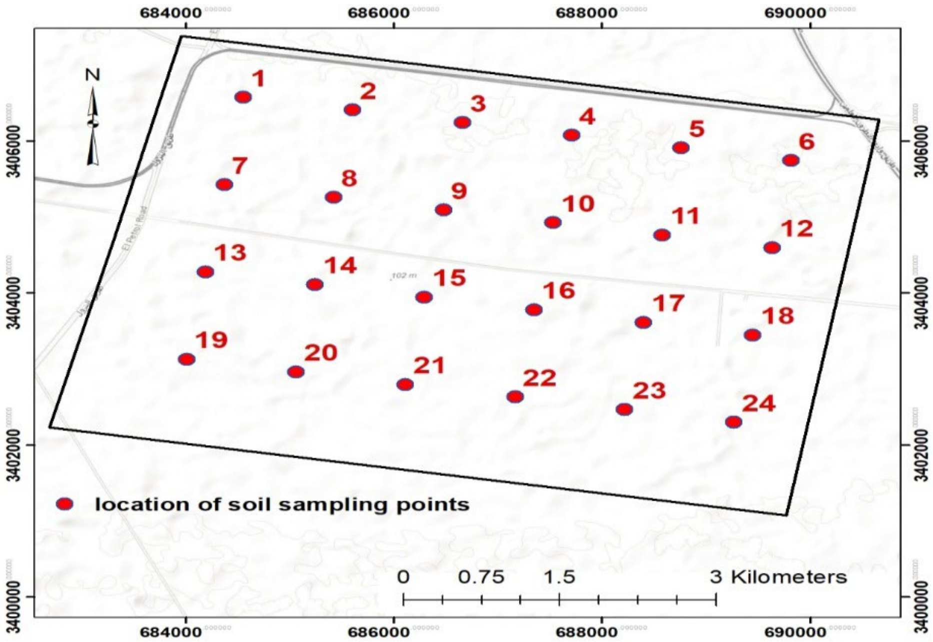

Fig. 2. Soil sample locations.

Soil and water analysis

The main following soil physical and chemical properties were carried out: Soil texture was determined by hydrometer's method (FAO, 1970). Soil reaction (pH) of soil water (1:2.5) suspension and Electric Conductivity (EC) of soil past extract were determined according to Page *et al*. (1982). Soluble Cations (Ca, Mg) were determined by versenate titration, while sodium (Na) and potassium (K) were photometrically determined by the flame photometer (Jackson, 1967). Available N and P were determined according to Page *et al*. (1982). Soluble (CO3 and HCO) anions were titrated by using phenolphthalein and methyl orange indicators for CO3 and methyl orange respectively. Mohr's method was applied to determine (Cl) (Jackson, 1967). Total carbonates and organic matter were determined by Collin's calcimeter and Walkely Black methods, respectively (Wright, 1939).

GIS - processing of soil analysis data

Data analysis of soil properties was interpolated to produce soil surface maps by using ArcMap software (ArcMap_10.8, 2011). The spatial distribution of the soil properties was produced using the inverse distance weighted (IDW) method.

Land Evaluation

Land capability and agriculture suitability were determined by applying ALES-arid model (Abd El-Kawy *et al*., 2010). The classes of land capability and suitability according to this software and limitation factors of soil and irrigation water are shown in table 1. The outputs of the land evaluation software were linked to the ArcMap software (ArcMap_10.8, 2011) across a database file and different queries were carried out to get the final maps of land evaluation.

Table 1. Land evaluation classes, and limitation factors of soil and irrigation water (Abd El-Kawy *et al*., 2010)

Classes of land evaluation			
Land Capability		**Land Suitability**	
Symbol	**Class**	**Symbol**	**Class**
C1	Excellent	S1	Highly Suitable
C2	Good	S2	Moderately Suitable
C3	Fair	S3	Marginally Suitable
C4	Poor	S4	Conditionally Suitable
C5	Very Poor	NS1	Potentially Suitable
C6	Non-Agriculture	NS2	Actually Unsuitable
Limitation factors of soil and irrigation water			
Soil limitation factors		**Water limitation factors**	
Symbol	**Factor**	**Symbol**	**Factor**
t	Clay	ecw	Water salinity
aw	Available water	ac	Water acidity
kh	Soil hydraulic conductivity	sar	Water sodicity
sd	Soil depth	na	Na
ac	Acidity	cl	Cl
ca	$CaCO_3$	bo	B
gy	Gypsum	temp	Temperature
al	Alkalinity	tw	Mean temperature winter
cec	CEC	ts	Mean temperature summer
ece	Soil salinity		
esp	Exchangeable Sodium Percentage		
om	Organic mater		
n	Nitrogen		
p	Phosphorus		
k	Potassium		

Results and Discussion

Descriptive statistics for some chemical soil characteristics of the study area

Some soil physical and chemical characteristics were determined and the descriptive statistics of these properties such as minimum, maximum, mean, standard deviation (StdDev), and coefficient of variation (CV) were calculated (Table 2). The data showed that the soil has high calcium carbonate (23.35% average) and low organic matter contents (0.04% average). These have pH values ranging from 7.9 to 8.5, with a mean value of 8.19. This low soil organic matter content clearly reflected the aridity conditions of the studied region that is characterized by sandy loam of textural class. The low values of the coefficient of variation (CV) indicate that the samples did not have extreme values except in exchangeable sodium percentage (ESP).

Table 2. Some statistical parameters of some chemical soil characteristics

Property	Descriptive Statistics				
	Min.	**Max.**	**Mean**	**StdDev**	**C.V**
E.C (dsm^{-1})	0.1	2.4	0.5	0.5	1
pH	7.9	8.5	8.19	0.17	2.07
ESP (%)	16	45	29.39	9.37	31.88
CaCO3 (%)	22.3	24.5	23.35	0.6	2.56
O.M (%)	0.3	0.5	0.4	0.05	11.24

Water properties

The data of water analysis in Table 3 indicated that this water is suitable for irrigating most crops, except for those crops that are highly sensitive to salts. Also, it can be used on most lands without fear of sodium accumulation, unless the soil is poorly permeable and drained, in which case the soil profile should be washed occasionally.

Table 3. Main characteristics of water sample

pH	EC (dSm^{-1})	Cations (ppm)				Anions (ppm)		
		Ca	Mg	Na	K	Cl	SO4	HCO3
7.8	0.96	66.4	22.8	95	8	73.5	134.4	144

GIS-Mapping Soil Properties

Inverse distance weighted (IDW) interpolation method is employed to estimate the values of soil properties at the unsampled locations. The value of the soil pH is a very important factor in plant nutrition as it controls the availability of the nutrients in the soil for uptake by the plant. It also specifies the soil suitability for cultivating a specific crop (Mustafa *et al*., 2011). The findings of this investigation demonstrated that 93 % of the study area has pH value more than 8, so, these high values of pH indicated that the soils are in the classes of alkaline soils (7.8) or highly alkaline soils (8.5) (FAO, 2006) (Figure 3). The results of EC showed that the studied soils were classified as non-saline soils with ECe less than 4 dSm-1 (FAO, 1988) and it is suitable for most crops as shown in map (Figure 3). The study area has a percentage of CaCO3 ranging between 20% and 25% as shown in (Figure 3), and this indicates that the soil in the study area is strongly calcareous (FAO, 2006). High values of CaCO3 in the study area can lead to hard surface crust formation, in addition to the fixation of chemical fertilizers, especially phosphorus (Shokr *et al*., 2021). Figure 3 showed that all the studied area was sodic soil.

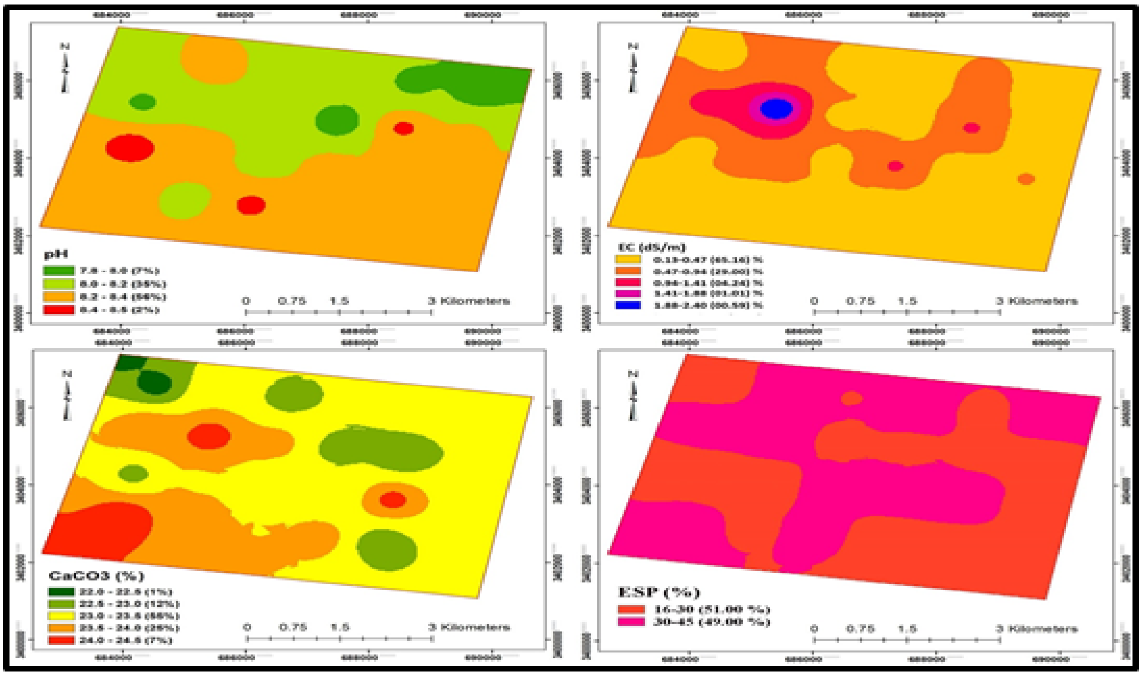

Fig. 3. GIS-maps of soil chemical properties.

The exchangeable sodium percentage (ESP) varied from 16 to 45% with an average of 29.39%. This indicates that all the studied soils were sodic soils, which are characterized by low permeability and poor structure, which negatively affects the growth and productivity of crops (Shokr *et al.*, 2021).

Soil available macronutrients and organic matter

The concentration of available NPK in addition to organic matter (OM) is an important indicator of soil fertility. The obtained results showed that 54.39 % of the study area has low available nitrogen level (less than 108 ppm), 40.49 % medium (108-217 ppm), and 5.21 % high (more than 217 ppm) (Figure 4). The study area has an available phosphorus value less than 5 ppm and it falls under the low phosphorus level in the soil. The results showed that 37.52 % of the study area has a marginal potassium (45-112 ppm), and 62.37 % has an adequate potassium (more than 112 ppm) (Figure 4). Organic matter improves the soil's chemical, physical and biological properties in addition to providing the plant with nutrients (FAO, 2000). The study area was poor in organic matter where it contains organic matter less than 0.68% due to the dominance of the climate of arid and semi-arid regions. The levels of soil available macronutrients and organic matter classified according to Verma *et al.*, 2005.

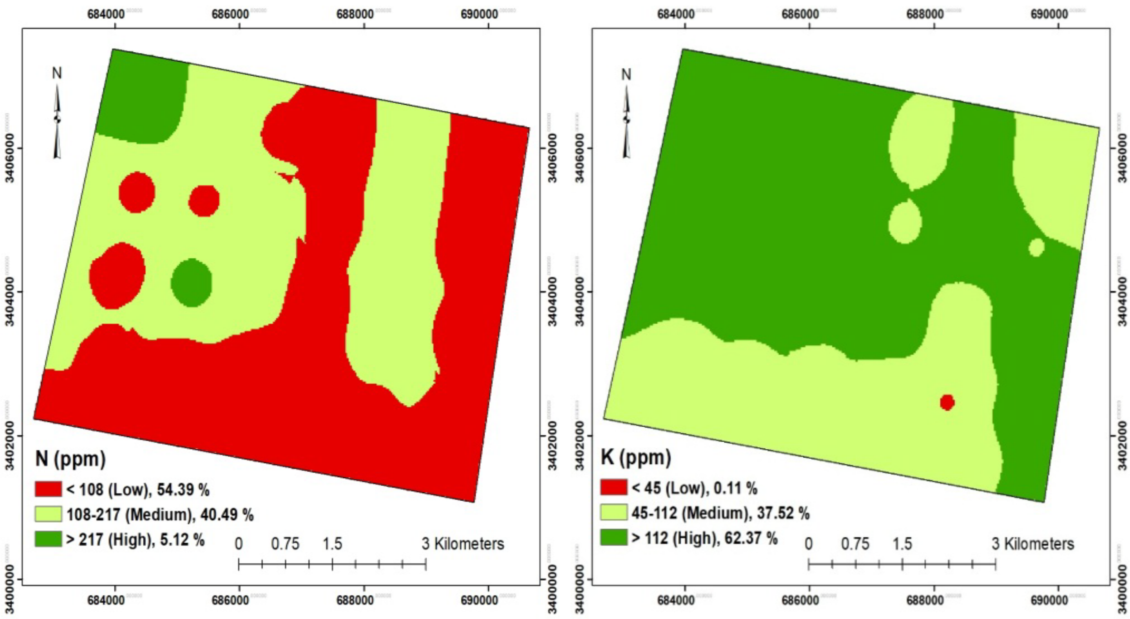

Fig. 4. GIS-maps of soil content of available macronutrients and organic matter.

Land Evaluation

To achieve land evaluation an integrated assessment was conducted considering each of; climate (mean temperature in summer and winter), soil physical properties (clay content (%), soil depth (cm)), soil chemical properties (pH, CaCO3 (%), ESP (%), EC (dS/m)), soil fertility properties (organic matter (%), N (ppm), P (ppm), K (ppm)), and water parameters (EC (dS/m), pH, SAR (%), Na (meq/l), Cl (meq/l). These parameters were used in ALES-arid software.

Land Capability

Table (4) shows the relative distribution of capability classes in the study area. The result of the land evaluation assessment shows that in the study area all land units have been categorized as class 3 (fair class), which has some limitations for agricultural use (Clay content, CEC, and alkalinity). For this reason, there is no need to map the capability classes in the study area. These limiting factors will decrease the possible kinds of crops for cultivation, and when cultivating these soils, it will need careful management and maintenance practices to improve and maintain their properties (Ghabour *et al*., 2008). However, some of these limitations such as CEC and alkalinity can be easily addressed by some good practices such as adding organic matter to improve the soil's ability to hold water and nutrients and reduce the value of soil pH.

Table 4. Land capability classes of the study area

Sample No.	Capability Classes	Sample No.	Capability Classes	Sample No.	Capability Classes
1	C3 (t,cec)	**9**	C3 (t, cec)	**17**	C3 (t, al, cec)
2	C3 (t, al, cec)	**10**	C3 (t, cec)	**18**	C3 (t, cec)
3	C3 (t, cec)	**11**	C3 (t, cec)	**19**	C3 (t, al, cec)
4	C3 (t, al, cec)	**12**	C3 (t, cec)	**20**	C3 (t, cec)
5	C3 (t, cec)	**13**	C3 (t, cec)	**21**	C3 (t, al, cec)
6	C3 (t, al, cec)	**14**	C3 (t, cec)	**22**	C3 (t, cec)
7	C3 (t, al, cec)	**15**	C3 (t, al, cec)	**23**	C3 (t, cec)
8	C3 (t, al, cec)	**16**	C3 (t, al, cec)	**24**	C3 (t, cec)

Fertility Classes

Table (5) shows the relative distribution of fertility classes in the study area. The result of the land evaluation assessment shows that in the study area all land units have been categorized as class 4 and class 5 (poor and very poor classes), which have some limitations (OM, P, and K).

Table 5. Land fertility classes of the study area

Sample No.	Fertility Classes	Sample No.	Fertility Classes	Sample No.	Fertility Classes
1	C4 (om, p)	**9**	C5 (om, p, k)	**17**	C5 (om, p, k)
2	C4 (om, p)	**10**	C5 (om, p, k)	**18**	C4 (om, p)
3	C4 (om, p)	**11**	C4 (om, p)	**19**	C5 (om, p, k)
4	C5 (om, p, k)	**12**	C5 (om, p, k)	**20**	C5 (om, p, k)
5	C4 (om, p, k)	**13**	C5 (om, p, k)	**21**	C5 (om, p, k)
6	C5 (om, p, k)	**14**	C4 (om, p)	**22**	C5 (om, p, k)
7	C4 (om, p)	**15**	C5 (om, p, k)	**23**	C5 (om, p, k)
8	C4 (om, p)	**16**	C5 (om, p)	**24**	C5 (om, p, k)

Land Suitability for Cultivation

Finding the right crop for the suitable soil is very important to increase production, conserve the soil and reduce costs (Ostovari *et al*., 2019). ALES-arid software was employed to predict land suitability for common crops in the studied area. The land suitability for a specific crop was determined by investigating the properties of soil, water, and climate. The software outputs are one class of the six classes for each crop in specified location (Table 1). The low soil content of clay (t) and the increase in ESP were the main limiting factors to producing most crops in the study area.

Land suitability for perennial crops (Exa. Alfalfa)

The land suitability was evaluated for alfalfa as a perennial crop. Table (6) shows the agricultural soil suitability for each soil sample for the alfalfa crop and restricted factors for cultivating it, so this table can be used as a guide for soil reclamation in the studied area.

Table 6. Agriculture soil suitability classes and their limitations for Alfalfa planting.

Sample No.	Suitable classes	Sample No.	Suitable classes	Sample No.	Suitable classes
1	S1	**9**	S1	**17**	S2 (esp)
2	S1	**10**	S3 (t)	**18**	S1
3	S1	**11**	S1	**19**	S1
4	S2 (esp)	**12**	S1	**20**	S1
5	S1	**13**	S1	**21**	S1
6	S2 (esp)	**14**	S1	**22**	S1
7	S2 (esp)	**15**	S1	**23**	S1
8	S3 (t, esp)	**16**	S2 (esp)	**24**	S1

The results showed that all the soil of the studied area are generally suitable for alfalfa plantation, where they occupied the category of suitable soils (S). The soils had the interior distribution to have 72 %, 21 % and 7 % as S1, S2, and S3, respectively (Figure 5). Alfalfa high soil suitability may be because this perennial legume grows well on rich, friable, well-drained loamy soil with loose topsoil characterized by pH of 7.5 (Duke and James, 1981).

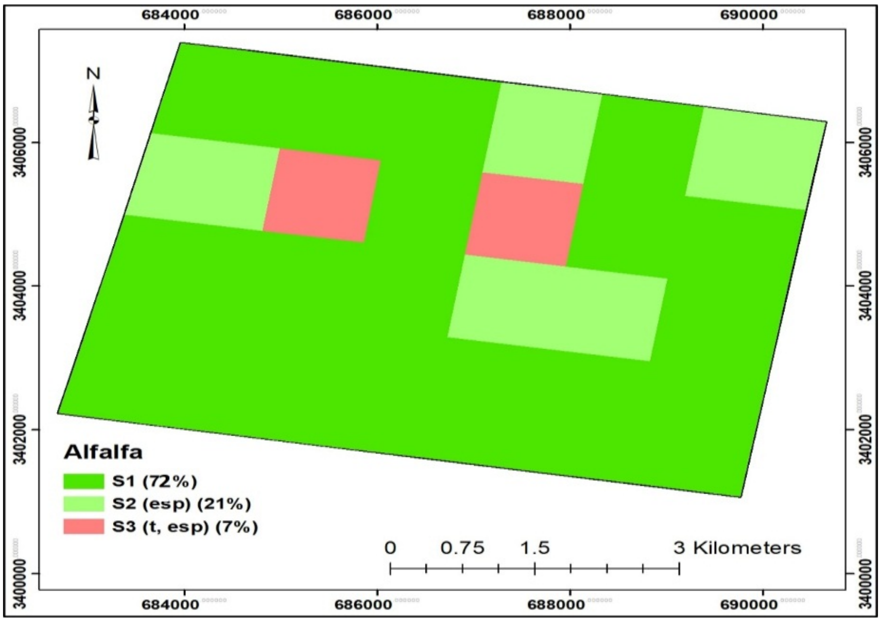

Fig. 5. GIS – maps of soil suitability classes and their limitations for Alfalfa crop.

Land suitability for Annual crops

The land suitability was evaluated for annual crops (wheat, barley, maize, sorghum, and sunflower) (Table 7).

Table 7. Suitable classes and their limitation factors for some annual crops

Sample No.	Suitable classes				
	Wheat	**Barley**	**Maize**	**Sorghum**	**Sunflower**
1	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
2	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
3	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
4	S2 (t, esp)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S3 (t, esp)
5	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
6	S2 (t, esp)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S3 (t, esp)
7	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S3 (t, esp)
8	S2 (t)	S2 (t)	S4 (t, esp)	S4 (t, esp)	S4 (t, esp)
9	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
10	S2 (t)	S2 (t)	S4 (t, esp)	S4 (t, esp)	S2 (t)
11	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
12	S1 (t)	S2 (t)	S2 (t, esp)	S2 (t, esp)	S2 (t)
13	S1 (t)	S2 (t)	S2 (t, esp)	S2 (t, esp)	S2 (t)
14	S1 (t)	S2 (t)	S2 (t, esp)	S2 (t, esp)	S2 (t)
15	S2 (t)	S2 (t)	S3 (t, esp)	S2 (t, esp)	S2 (t)
16	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S3 (t, esp)
17	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S3 (t, esp)
18	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
19	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
20	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
21	S2 (t)	S2 (t)	S3 (t, esp)	S3 (t, esp)	S2 (t)
22	S1 (t)	S2 (t)	S2 (t, esp)	S2 (t, esp)	S2 (t)
23	S1 (t)	S2 (t)	S2 (t, esp)	S2 (t, esp)	S2 (t)
24	S1 (t)	S2 (t)	S2 (t, esp)	S2 (t, esp)	S2 (t)

Land suitability was evaluated for the annual crops (wheat, barley, maize, sorghum, and sunflower). The data showed that most of the studied area is moderately suitable for wheat, barley, and sunflower crops (75%, 100%, and 75%, respectively), and marginally suitable for maize and sorghum (68%, and 64%, respectively) (Figure 6). This moderate soil suitability may be because wheat, barley and sorghum do not require much for its growth (IAO, 2007). These results make the study area suitable for achieving the goals of the Egyptian government policy in achieving the highest possible self-sufficiency in major crops such as wheat (Elasraag, 2015).

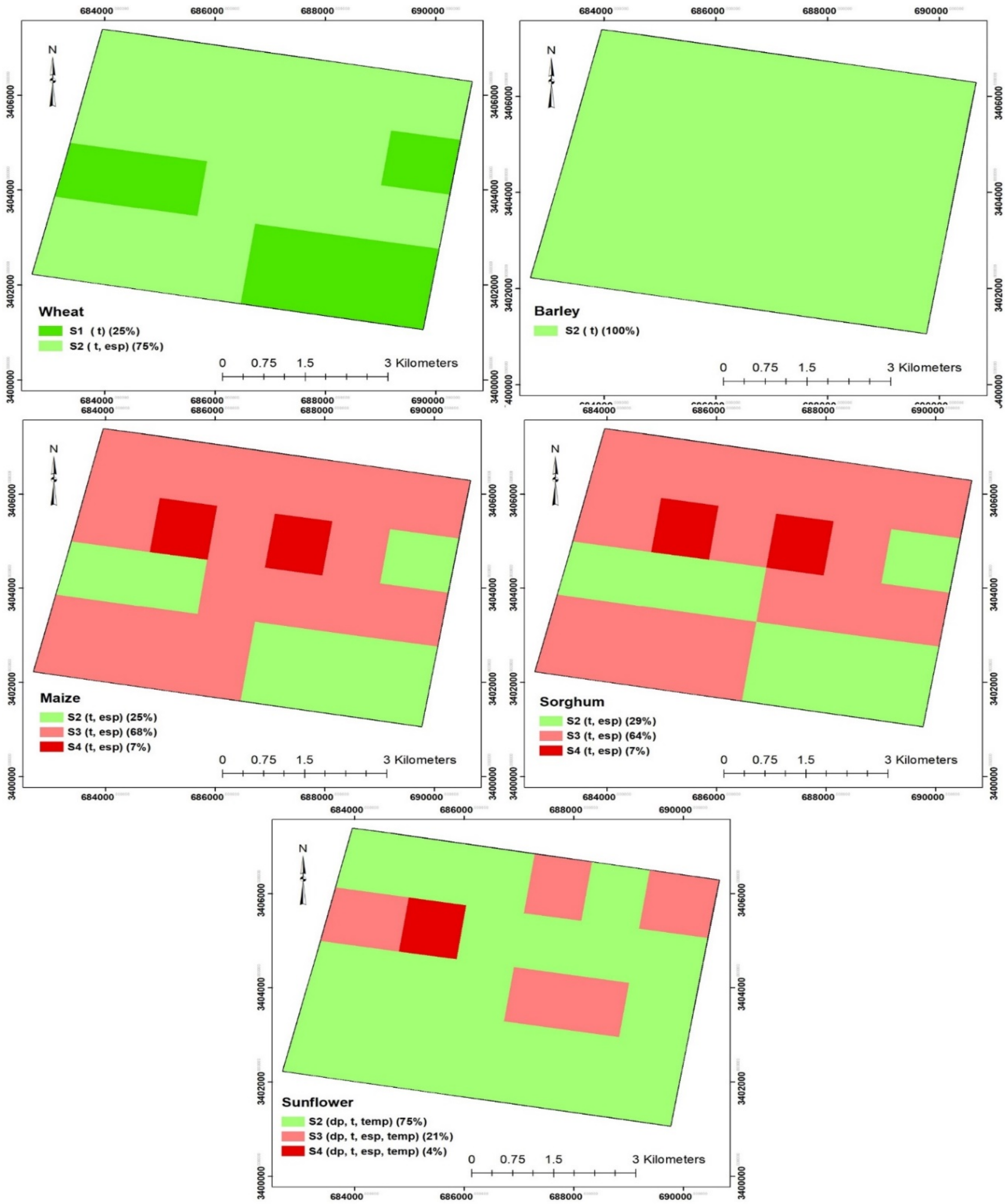

Figure 6. GIS-map soil suitability classes and their limitations of Annual Crops: (Wheat, Barley, Maize, Sorghum, and Sunflower).

Land suitability for Leguminous crops

The land suitability was evaluated for faba-bean, soybean, and peanut as a leguminous crop. Leguminous crops have an important function in fixing nitrogen in the soil. The result of the land evaluation assessment shows that in the study area all land units have been categorized as class 2 (good class), and class 3 (fair class) which has some limitations (Clay, and ESP) (Table 8).

Table 8. Suitable classes and their limitation factors for leguminous crops

Sample No.	Faba_bean	Soybean	Peanut	Sample No.	Faba_bean	Soybean	Peanut
1	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**13**	S2 (t, esp)	S3 (t, esp)	S2 (esp)
2	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**14**	S2 (t, esp)	S2 (t, esp)	S2 (esp)
3	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**15**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
4	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**16**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
5	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**17**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
6	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**18**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
7	S3 (t, esp)	S4 (t, esp)	S3 (esp)	**19**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
8	S3 (t, esp)	S4 (t, esp)	S4 (t, esp)	**20**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
9	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**21**	S3 (t, esp)	S3 (t, esp)	S3 (esp)
10	S3 (t, esp)	S4 (t, esp)	S4 (t, esp)	**22**	S2 (t, esp)	S2 (t, esp)	S2 (esp)
11	S3 (t, esp)	S3 (t, esp)	S3 (esp)	**23**	S2 (t, esp)	S2 (t, esp)	S2 (esp)
12	S2 (t, esp)	S2 (t, esp)	S2 (esp)	**24**	S2 (t, esp)	S2 (t, esp)	S2 (esp)

The results indicated that the land of the studied area is S2, and S3 for Faba bean crop (25%, and 75%, respectively). Soybean is an important crop especially for Egypt, providing oil and protein. The studied soil is S2, S3, and S4 for soybean (21%, 68, and 11%, respectively), and peanut crops (25%, 658%, and 7%, respectively) (Figure 7).

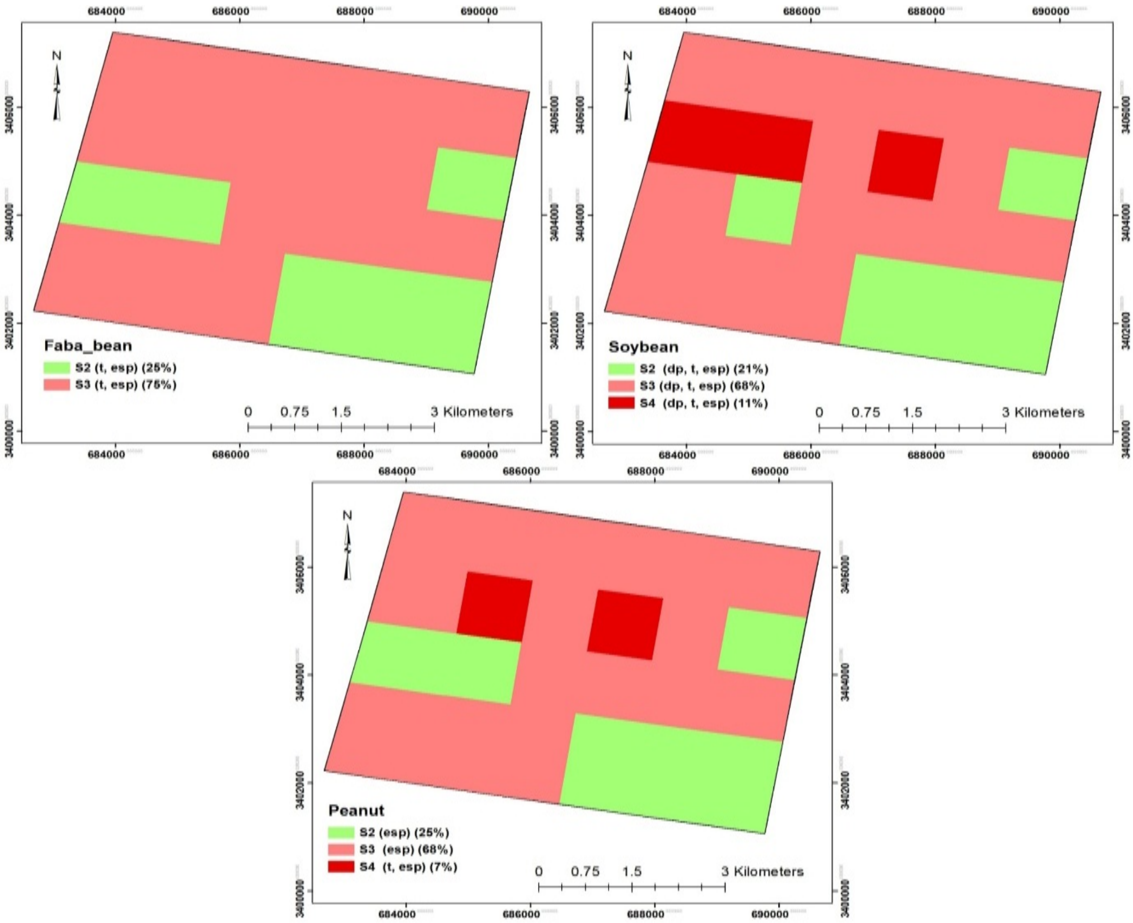

Fig. 7. GIS-map soil suitability classes and their limitations of legume crops (Faba bean, Soybean, and Peanut).

Land suitability for Vegetables

The land suitability was evaluated for potato, tomato, and onion as vegetables. Table (9) shows the agricultural soil suitability for each soil sample for these crops, and it can be used as a guide for soil reclamation in the studied area by removing restricted factors.

Table 9. Suitable classes and their limitation factors for vegetable crops.

Sample No.	Potato	Tomato	Onion	Sample No.	Potato	Tomato	Onion
1	S3 (esp)	S1	S2 (t)	**13**	S2 (esp)	S1	S2 (t)
2	S3 (esp)	S1	S2 (t)	**14**	S2 (esp)	S1	S1 (t)
3	S3 (esp)	S1	S2 (t)	**15**	S3 (esp)	S1	S2 (t)
4	S3 (esp)	S2 (esp)	S2 (t, esp)	**16**	S3 (esp)	S2 (esp)	S2 (t, esp)
5	S3 (esp)	S1	S2 (t)	**17**	S3 (esp)	S2 (esp)	S2 (t, esp)
6	S3 (esp)	S2 (esp)	S2 (t, esp)	**18**	S3 (esp)	S2	S2 (t)
7	S3 (esp)	S2 (esp)	S2 (t, esp)	**19**	S3 (esp)	S1	S2 (t)
8	S4 (t, esp)	S3 (t, esp)	S3 (t, esp)	**20**	S3 (esp)	S1	S2 (t)
9	S3 (esp)	S1	S2 (t)	**21**	S3 (esp)	S1	S2 (t)
10	S4 (t, esp)	S3 (t)	S3 (t)	**22**	S2 (esp)	S1	S1 (t)
11	S3 (esp)	S1	S2 (t)	**23**	S2 (esp)	S1	S2 (t)
12	S2 (esp)	S1	S1 (t)	**24**	S2 (esp)	S1	S1 (t)

The results of this study showed that 25% of the studied soil is S2, 68% is S3, and 7% is S4 for potato plantation (Figure 8). The results showed that 93% of the studied area is suitable (S1, and S2) for tomato (Figure 8). The data indicated that most of the studied area is suitable for onion plantation; 18% of the studied soil is highly suitable and 75% is moderately suitable, and the rest portion (7%) is marginally suitable (Figure 8).

Conclusion

Land evaluation is an essential tool for sustainable agricultural development. ASLE-arid software was used for land evaluation in the study area, and ArcMap 10.8 was used for interpolation and mapping of results. The soil characteristics are as follows: texture was sandy loam, soil pH ranged from 7.9 to 8.5, and calcium carbonate from 22.0% to 24.5%. The low contents of clay and cation exchange capacity, and high soil alkalinity are the major limiting factors for the land suitability, and which can be improved by applying agricultural proper management practices such as adding organic matter to the soil. According to land capability, the fair capability class (C3) occupied all the studied area. The major classes of land suitability of the studied area are highly suitable (S1) for alfalfa and tomato, moderately suitable (S2) for barley, wheat, sunflower, and onion, and marginally suitable (S3) for faba bean, sorghum, maize, soybean, peanut, and potato. The land reclamation is only possible after conducting a land evaluation. Therefore, this study and similar ones can contribute significantly to any decision regarding land reclamation and development in the study area for optimum crop production.

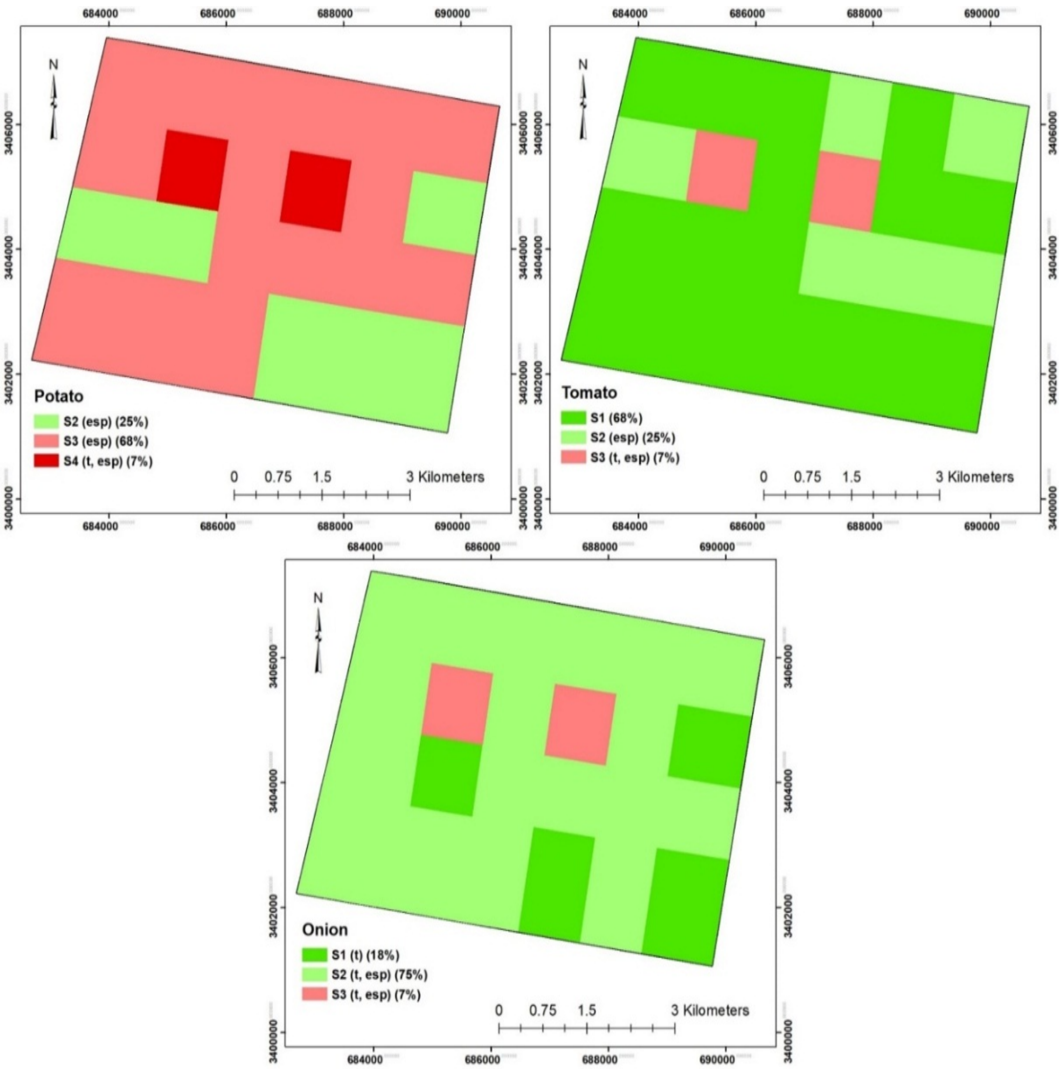

Fig. 8. GIS-map soil suitability classes and their limitations of vegetable crops (Potato, Tomato, and Onion).

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). Malaysian Journal of Sustainable Agriculture (MJSA), 2 (2): 09-15. DOI: http://doi.org/10.26480/mjsa.02.2018.09.15

Abd El-Kawy, O.R., Ismail, H.A., Rod, J.K., and Suliman, A.S. (2010). A Developed GIS-based Land Evaluation Model for Agricultural Land Suitability Assessments in Arid and Semi-Arid Regions. Research Journal of Agriculture and Biological Sciences, 6 (5): 589-599.

AbdelRahman, M.A.E., Natarajan, A., and Hegde, R. (2016). Assessment of land sutability and capability by integrating remote sensing and GIS for agriculture in Chamarajanagar district, Karanataka, India. The Egyptian journal of remote sensing and space sciences, 19: 125-141. http://dx.doi.org/10.1016/j.ejrs.2016.02.001

Abdrabelnabi, M.A., and Abdelaty, E.F. (2019). GIS - Comprehensive Analytical Approach for Soil Use by Linking Crop Soil Suitability to Soil Management and

Reclamation. Alexandria Science Exchange Journal, 40(1): January-March. DOI: 10.21608/ASEJAIQJSAE.2019.27532.

Aldabaa, A.A.A., and Yousif, I.A.H. (2020). Geostatistical Approach for Land Suitability Assessment of Some Desert Soils. Egyptian Journal of Soil Science, 60(3):195-209. DOI: 10.21608/ejss.2020.26767.1350

Al-Mashreki, M.H., Akhir, J.B.M., and Abd-Rahim, S. (2010). Remote sensing and GIS applications for assessment of land suitability potential for agriculture in the Ibb governorate, the Republic of Yemen. Pakistan journal of biological sciences, 13 (23): 1116-1128.

Al-Taani, A., Al-Husban, Y., and Farhan, I. (2021). Land suitability evaluation for agricultural use using GIS and remote sensing techniques: The case study of Maan Governorate, Jordan. The Egyptian journal of remote sensing and space sciences, 24: 109-117. https://doi.org/10.1016/j.ejrs.2020.01.001

ArcMap, 10.8. (2011). ESRI, Environmental Systems Research Institute. U.S. copyright 2008 ESRI Inc.

Debesa, G., Gebre, S.L., Melese, A., Regassa, A., and Teka, S. (2020). GIS and remote sensing-based physical land suitability analysis for major cereal crops in Dabo Hana district, South-West Ethiopia. Cogent Food & Agriculture, 6: 1780100. https://doi.org/10.1080/23311932.2020.1780100

Dengiz, O., and Sağlam, M. (2012). Determination of land productivity index based on parametric approach using GIS technique. Eurasian Journal of Soil Science, 1: 51-57.

Duke., and James. (1981). Handbook of Legumes of World Economic Importance.

Elasraag, Y.H.A. (2015). Economics of Wheat in Egypt, PhD, Superior Technical School of Agricultural, Technical University, of Madrid (Spain).

El-Behairy, R.A., El Baroudy, A.A., Ibrahim, M.M., Mohamed, E.S., Kucher, D.E., and Shokr, M.S. (2022). Assessment of soil capability and crop suitability in the Northwest Nile Delta using integrated multivariate and GIS approaches toward agricultural sustainability. Land, 11: 1027. https://doi.org/10.3390/land11071027

Elhag, M. (2011). Land suitability for afforestation and nature conservation practices using remote sensing and GIS techniques. CATRINA, 6 (1): 11-17.

Elnaggar, A.A., Mosa, A., El-Seedy, M.E., and Biki, F.G. (2016). Evaluation of Soil Agricultural Productive Capability by Using Remote Sensing and GIS Techniques in Siwa Oasis, Egypt. J.Soil Sci. and Agric. Eng., Mansoura University, 7(8): 547 – 555.

El-Seedy, M.E. (2019). Evaluation of Land Capability and Suitability Using Asle Program and GIS Techniques: A Case Study on Some Soils of East Nile Delta, Dakahlia Governorate, Egypt. J. Soil Sci. and Agric. Eng., Mansoura University, 10 (8): 491 – 498.

Elsheikh, R., Shariff, A.R., Amiri, F., Ahmed, N.B., Balasundarm, S.K., and Soom, M.A. (2013). Agriculture Land Suitability Evaluator (ALSE): A decision and planning support tool for tropical and subtropical crops. Comput. Electron. Agric, 93: 98–110.

Elzahaby, E.M., Suliman, A.S., Bakr, N., and Al- janabi, A.A. (2015). Land Cover Change Detection and Land Evaluation of Burg El Arab Region, North West Coast, Egypt. Alex. J. Agric. Res, 60(3):193-204.

Emadi, M., Baghernejad, M., Pakparvar, M., and Kowsar, S.A. (2010). An approach for land suitability evaluation using geostatistics, remote sensing, and geographic information system in arid and semiarid ecosystems. Environ Monit Assess, 164:501–511. DOI: 10.1007/s10661-009-0909-6

Fadl, M.E., and Abuzaid, A.S. (2017). Assessment of Land Suitability and Water Requirements for Different Crops in Dakhla Oasis, Western Desert. International Journal of Plant and Soil Science, 16(6): 1-16.

Fadl, M.E., and Sayed, Y.A. (2020). Land Resources Evaluation for Sustainable Agriculture in ElQusiya Area, Assiut, Egypt. Egyptian Journal of Soil Science, Vol. 60(3): 289-302. DOI: 10.21608/ejss.2020.33931.1365

FAO. (2000). Fertilizers and Their Use: A Pocket Guide for Extension Officers, 4th Edition, Food and Agriculture Organization of the United Nations and International Fertilizer Industry Association, Rome, Retrieved from ftp://ftp.fao.org/agl/agll/docs/fertuse.pdf

FAO. (2006). Guideline for soil description, fourth edition. Food and Agriculture Organization of the United Nations, Rome, Italy, 97p. Available at [access date: 13.01.2023], http://www.fao.org/docrep/019/a0541e/a0541e.pdf

FAO. (1970). Physical and Chemical Methods of Soil and Water Analysis. Soils bulletin 10. FAO, Rome.

FAO. (1988). Salt-Affected Soils and Their Management. Soils Bulletin No. 39. Food and Agriculture Organization of the United Nations, Rome, Italy, 131p. Available at [access date: 13-01.2023], http://www.fao.org/docrep/x5871e/x5871e00.htm

Ghabour, T.K., Meshref, H.A., Wahba, M.M., Ghali, F.A., and Selim, S.A. (2008). Parametric assessment of land capability and suitability for some crops using advanced techniques. J. Agric. Sci. Mansoura University, 33 (11): 8305-8315.

Habibie, M.I., Noguchi, R., Shusuke, M., and Ahamed, T. (2021). Land suitability analysis for maize production in Indonesia using satellite remote sensing and GIS-based multicriteria decision support system. Geo Journal, 86:777–807. https://doi.org/10.1007/s10708-019-10091-5

Halder, J.C. (2013). Land Suitability Assessment for Crop Cultivation by Using Remote Sensing and GIS. Journal of Geography and Geology, 5(3). doi:10.5539/jgg.v5n3p65.

https://en.tutiempo.net, [accessed Nov 17, 2023].

https://www.google.com/maps, [accessed Nov 17, 2023].

IAO. (2007). Geographic Information Systems Knowledge base and applications. 27th Course on Geomatics and Natural Resources Evaluation. Land evaluation in Essaouira province (Morocco), IAO, Florence, Italy, http: //www.iao.florence.it.

Ismail, H.A., Bahnassy, M.H., and Abd El-Kawy, O.R. (2005). Integrating GIS and modelling foragricultural land suitability evaluation at East WadiEl-Natrun, Egypt. Egyptian Journal of Soil Science, 45: 297-322.

Jackson, M.L. (1967). Soil Chemical Analysis Prentice, Hall of India Private Limited, New Delhi.

Kamau, S., Kuria, D., and Gachari, M.K. (2015). Crop-land Suitability Analysis Using GIS and Remote Sensing in Nyandarua County, Kenya. Journal of Environment and Earth Science, 5(6).

Karam, M.A., Hegazi, A.M., and Seleem, T.A. (2020). Geotechnical Evaluation of Soil at El-Alamein New City, Northern Coast, Egypt. Journal of Petroleum and Mining Engineering, 22(1). DOI: 10.21608/jpme.2020.23635.1026.

Mahmoud, H.A., Binmiskeen, A.M.A., and Moghanm, F.S. (2020). Land Evaluation for Crop Production in the Banger El-Sokkar Region of Egypt Using A Geographic Information System and ALES-arid Model. Egyptian Journal of Soil Science, Vol. 60(2):129-143. DOI: 10.21608/ejss.2020.19523.1325

Mostafiz, R.B., Noguchi, R., and Ahamed, T. (2021). Agricultural land suitability Assessment using satellite remote sensing-derived soil-vegetation indices. Land, 10, 223. https://doi.org/10.3390/land10020223

Moursy, A.R.A., Abdelgalil, A.A., Ibrahim, M.S., and Mustafa, A.A. (2020). Land Suitability Evaluation for Different Crops in Soils of Eastern Sohag, Egypt. International Journal of Academic and Applied Research (IJAAR), 4 (7): 126-138.

Mustafa, A.A., Singh, M., Sahoo, R.N., Ahmed, N., Khanna, M., Sarangi, A., and Mishra, A.K. (2011). Land Suitability Analysis for Different Crops: A Multi Criteria Decision Approach using Remote Sensing and GIS. Researcher, 3(12): 61-84.

Nada, W.M., Bahnassy, M.H., and Ahmed, D.M. (2022). Soil Maps based on GIS and ALES-Arid Model as Tools for Assessing Land Capability and Suitability in El-Sadat Region of Egypt. Egyptian Journal of Soil Science, 62(4) 311 – 324. DOI: 10.21608/EJSS.2022.164837.1542

Ostovari, Y., Honarbakhsh, A., Sangoony, H., Zolfaghari, F., Maleki, K., and Ingram, B. (2019). GIS and multi-criteria decision-making analysis assessment of land suitability for rapeseed farming in calcareous soils of semi-arid regions. Ecological Indicators, 103: 479-487. https://doi.org/10.1016/j.ecolind.2019.04.051

Page, A.L., Miller, R.H., and Keeny, R. (1982). Methods of Soil Analysis. Part2. Chemical and Microbiological Properties. Agron. Monograph, No. 9, ASA, Madison, WI, USA.

Panigrahy, S., Manjunath, K.R., and Ray, S.S. (2006). Deriving cropping system performance indices using remote sensing data and GIS. Int. J. Remote Sensing, 26: 2595–2606.

Partoyo, L.H. (2022). Integrating between GIS and Remote Sensing for Land Suitability Evaluation for Rice in Sleman Regency, Yogyakarta, Indonesia. Earth and Environmental Science, 1018, 012037. doi:10.1088/1755-1315/1018/1/012037

Rossiter, D.G. (1996). A theoretical framework for land evaluation. Geoderma, 72: 165-202.

Said, M.E., Ali, A.M., Borin, M., Abd-Elmabod, S.K., Aldosari, A.A., Khalil, M.M.N., and Abdel-Fattah. M.K. (2020). On the Use of Multivariate Analysis and Land

Evaluation for Potential Agricultural Development of the Northwestern Coast of Egypt. Agronomy, 10, 1318. doi:10.3390/agronomy10091318.

Sayed, A.S. (2013). Evaluation of the land resources for agricultural development-case study: El-Hammam Canal and its extension, NW Coast of Egypt (p. 229). Germany: Ph.D, Thesis, Hamburg University.

Sayed, Y.A., and Khalafalla, M.Y. (2021). Land capability and suitability of some soils at North-West of Dashlut, Assiut, Egypt. Archives of agriculture sciences journal, 4 (1): 205-220.

Shokr, M.S., Abdellatif, M.A., El Baroudy, A.A., Elnashar, A., Ali, E.F., Belal, A.A., Attia, W., Ahmed, M., Aldosari, A.A., Szantoi, Z., Jalhoum, M.E., and Kheir, A.M.S. (2021). Development of a Spatial Model for Soil Quality Assessment under Arid and Semi-Arid Conditions. Sustainability, 13: 2893. https://doi.org/10.3390/su13052893

Shokr, M.S., Jalhoum, M.E.M., Abdellatif, M.A., Belal, A.A., and Abdelhameed, H.H. (2022). Assessment of Agricultural Sustainability of Bahariya Oasis using Geo-Informatic techniques. Egyptian Journal of Soil Science, 62(2):85 – 99. DOI: 10.21608/EJSS.2022.143674.1507

Verma, V.K., Patel, L.B., Toor, G.S., and Sharma, P.K. (2005). Spatial distribution of macronutrients in soilsof arid tract of Punjab, India. International Journal ofAgricultural and Biology, 7:295 -29 (11) (PDF) Tracking Changes in Soil Fertility at North Nile Delta, Egypt Using GIS Techniques. Available from:

https://www.researchgate.net/publication/357016787_Tracking_Changes_in_Soil_Fertility_at_North_Nile_Delta_Egypt_Using_GIS_Techniques [accessed Nov 17 2023].

Wright, G.H. (1939). Soil Analysis: A Handbook of Physical and Chemical Methods. 1st Edit., Marby Co., London.

Yousif, I.A.H. (2018). Land Capability and Suitability Mapping in Some Areas of North-Western Coast, Egypt. J.Soil Sci. and Agric. Eng., Mansoura University, 9(3):111 – 118.

Yousif, I.A.H. (2019). Soil Suitability Assessment Using MicroLEIS Model: A Case Study in Wadi El-Heriga, North Western Coast Zone, Egypt. Egyptian Journal of Soil Science, 59(3):209 – 221. DOI: 10.21608/ejss.2019.12598.1272

رسـم خرائط خصــائص التربة وتقييم الأراضــي للأغراض الزراعية، منطقة العلمين، الســاحل الشمالي الغربي، مصر

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الملخص

يعد تقييم الأراضـي أداة ضـرورية لاسـتصـلاح وزراعة الأراضـي الجديدة. يمثل السـاحل الشـمالي الغربي أحد المواقع الواعدة للتنمية الزراعية المستدامة في مصر. ولذلك كان الهدف الرئيسـي من هذا العمل هو تقييم الأراضـــي للأغراض الزراعية في منطقة الدراســـة باســـتخدام نظام تقييم الأراضـي الزراعية للمناطق القاحلة وشبه القاحلة بنظام (ALES-arid). وتم جمع وتحليل عينات التربة السطحية (0 – 30 سم) وتحت السطحية (30 – 60 سم) من أربعة وعشرين موقعاً (إجمالي العينات 48 عينة)، بالإضــافة إلى عينة واحدة من مياه الري من ترعة الحمام. تم اسـتخدام تقنيات نظم المعلومات الجغرافية لإنتاج خرائط لخصـــائص التربة وتقييم الأراضـــي. أظهرت النتائج أن قوام التربة كان طينياً رملياً، وتراوحت درجة الحموضـــة للتربة من 7.9 إلى 8.5، وكانت نســـبة كربونات الكالســـيوم $CaCO_3$ مرتفعة. وفيما يتعلق بتقييم الأراضـــي فقد احتلت صـــف القدرة المتوسطة (C3) كامل مساحة الدراسة. وكانت العوامل المحددة التي تؤثر على تقييم الأرض هي المحتوى المنخفض لمحتوى الطين وللســـعة التبادلية الكاتيونية، وارتفاع قلوية التربة. وفيما يتعلق بتقييم صــلاحية التربة لاثني عشــر محصــولاً، كانت منطقة الدراســة مناسـبة بدرجة عالية (S1) للبرسـيم الحجازي (71%) والطماطم (68%). مناسـبة إلى حد ما (S2) للشـعير (100%) والقمح ودوار الشمس والبصل (75%). مناسبة بشكل هامشي (S3) للفول البلدي (75%)، والذرة الرفيعة (64%)، والذرة، وفول الصـويا، والفول السـوداني، والبطاطس (68%). إن اسـتخدام خرائط تقييم الأراضـي يمكن أن يساعد صناع القرار فيما يتعلق بمشاريع استصلاح الأراضـي الجديدة.