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EVALUATION OF LAND RESOURCES IN SOME AREA OF KAFR EL-SHEIKH GOVERNORATE, USING REMOTE SENSING (RS) AND GIS TECHNIQUES

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ABSTRACT: Evaluation of land resources is required to achieve their sustainable development and productivity. The study's aim was to evaluate the land capability and suitability for some main crops in some area of Kafr El-Sheikh governorate at the north of Nile Delta, Egypt utilizing of Remote Sensing and GIS techniques. The Applied System of Land Evaluation (ASLE) model was used for performing the land evaluation and produce its maps. Figure shapes of the study area were explanation using a Sentinel-2 image, digital elevation model (DEM) and field survey. Three main geomorphic unites were identified namely a) Flood Plain that is the largest unit occupying 72.96% from the study area and including River Terraces (High, Moderate and Low) and Basins (Overflow and Decantation Basins), b) Lacustrine plain and c) Marine plain. Samples from Eleven soil profiles were collected to represent different landform units of the study area, analyzed in the Laboratory. Results of land evaluation using ASLE model indicated that, the most of the studied area (73.25%) have Fair (C3) capability class. There are 24.87% from the area having C4 and the remaining (1.88%) have very poor class (C5). The evaluation of land suitability for the selected crops indicated that, wheat, barley and date palm are highly (S1) to moderately suitable (S2) for growing in the Most areas of the study area. Maize is moderately suitable (S2), while Onion and Citrus are moderately (S2) to not suitable (NS) in most of the studied area.

Keywords: Land capability evaluation, suitability, Remote Sensing, GIS, mapping unit.

INTRODUCTION

Land evaluation is defined as land's capacity to support a defined use. Related land characteristics are contrasted with the user's criteria for assessing the level of suitability. Different classes have diverse potential for production. Only the related soil qualities and their particular diagnostic factors are considered (Samuel et al., 2019). A sustainable assessment of natural resources is required to achieve food security (Shokr et al., 2021). Currently, Egypt's agricultural sector represents 38.2% of the man power and has ability to account for an even higher ratio (El Baroudy et al., 2020). The key problem in Egypt is growing population very rapidly in contrast to food production during the last three decades (Hamza and Mason, 2004; Abdelhamid et al., 2010 and El Baroudy et al., 2014). Thus, the natural resources efficient management in Egypt is very important for confirming food supplies and agricultural development sustainability (FAO, 1993 and Bodaghabadi et al., 2015).

Only 4% of the total Egypt land is cultivated, mainly in the Nile Delta and the slight the Nile Valley strip. To rise the cultivated area, Egypt started to reclamation of desert districts outside the Nile Delta and the Valley. About 210000 ha (519000 feddans) west of Nubaria canal have been identified as suitable for reclamation and 105000 ha (260000 fed.) as suitable, though the area is mostly calcareous (Abou-Hadid et al., 2010). The capability index is an expression of the natural fertility and can therefore be correlated with crop production under natural conditions.

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Land evaluation aims to guide wisely the current management of land and plan its using in the future. Parametric land evaluation aims to identify the major limiting factors for land productivity (LP) as well as the different degrees of land suitability (LS) for crops (Khalifa, 2004 and Mohamed et al., 2020). Land capability and suitability assessment as a requirement for sustainable agriculture is critical important, which determines current and future potential of any area (Tesfay et al., 2017). Land evaluation is land use prediction process whichو based on its characteristics, where different analytical models can be used in these estimates, varying ranging from qualitative to quantitative (Rossiter, 1996). Land capability evaluation is the property’s ability for usage in particular areas, including through different methods of management. The aim of land capability classification system is to research and document all related data to find a balance of agricultural measures and conservation (Sayed et al., 2016; Abd El-Aziz, 2018; Yousif, 2018 and 2019; El Baroudy et al., 2020).

Remote sensing (RS) imagery is an influential tool for studying the surface and cropping systems analysis (Sadeghi et al., 2015 and Rozenstein et al., 2016). This technology has been used to evaluate the measures required to define land suitability (El Baroudy, 2016). In addition, remote sensing (RS) and geographic information system (GIS) have been growing used during the last four decades for a lot of implementation fields including the land suitability assessment (Hamzeh, et al., 2014; El-Zeiny and Effat 2019; El Baroudy and Moghanm 2014; Hendawy et al., 2019; Mohamed et. al., 2019). The applied system for land evaluation (ASLE) computer program is used to evaluate land capability and suitability through determining soil physical, chemical properties and fertility (Ismail et al., 2001, Ismail et al., 2005).

The objectives of this study were to assess land capability and suitability for some potential crops of some areas in Kafr El-Sheikh governorate at north of the Nile Delta, Egypt using ASLE model integrated with RS and GIS techniques.

MATERAILS AND METHODS:

Study area location

The study area is bounded by longitudes 31°0′ 00″ and 31° 07′ 00″ east and latitudes and 31° 0′ 00″ and 31° 40′ 00″ in Kafr Elsheikh governorate at north of the Nile Delta, Egypt having an area of about 761.59 km^2 (Fig, 1). The important climatic characteristics for the area (temperature, rainfall, relative humidity, etc.) were obtained from Sakha Station. According to Egyptian Meteorological Authority (2019), the maximum temperature is 36.16°C in August and the minimum is 8.02°C in January, with mean annual of 21.87°C. The total of rainfall is 57.9 mm per year and the highest amount was recorded in December. Evaporation levels range from 65.1 to 198.4 mm and the relative humidity is around 81.95% in May.

Image processing

Landforms and digital soil mapping were created using a Sentinel-2 image obtained on 10/8/2019 under a clear sky circumstance with help of the DEM for the research region. The multi-spectral bands of Sentinel-2 image have a ten-meter spatial resolution for bands 2, 3, 4, and 8, respectively. The DEM was created by NASA's Topographic Radar (SRTM) with a spatial resolution of 30 meters. For image processing, SNAP and ENVI 5.4 were used, as well as spectral subset, radiometric calibration, atmospheric, and geometric adjustments. A projection system was assigned using the UTM Zone 36 N coordinate system and the WGS 84 datum (Shokr et al., 2021)

Identifying and mapping the Landform units

The multi-spectral Sentinal-2 image was placed over the DEM in Arc Scene to create a 3D view for identifying and mapping the landform units of the studied area (Fig, 2). This method could be enabled to separate the different landform units. Moreover, the satellite image and 3D DEM visual interpretation mode were helpful in the field work. The appropriate classification of landforms is given by field check. (Dobos et al., 2002).

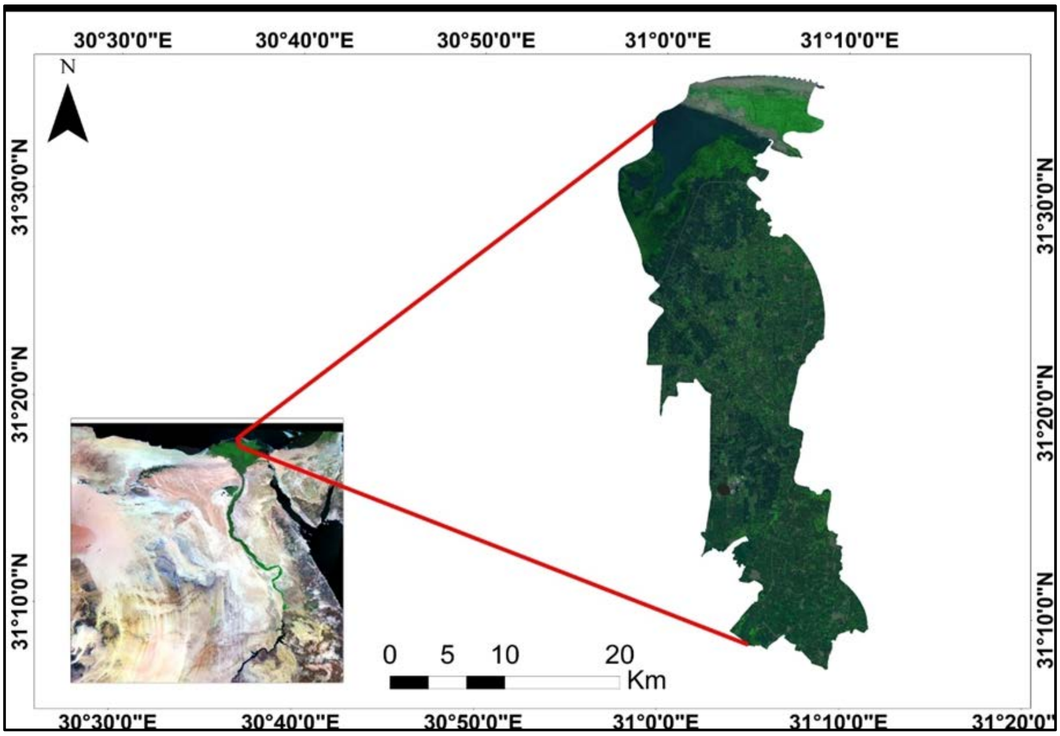


Fig 1: The investigated area location.

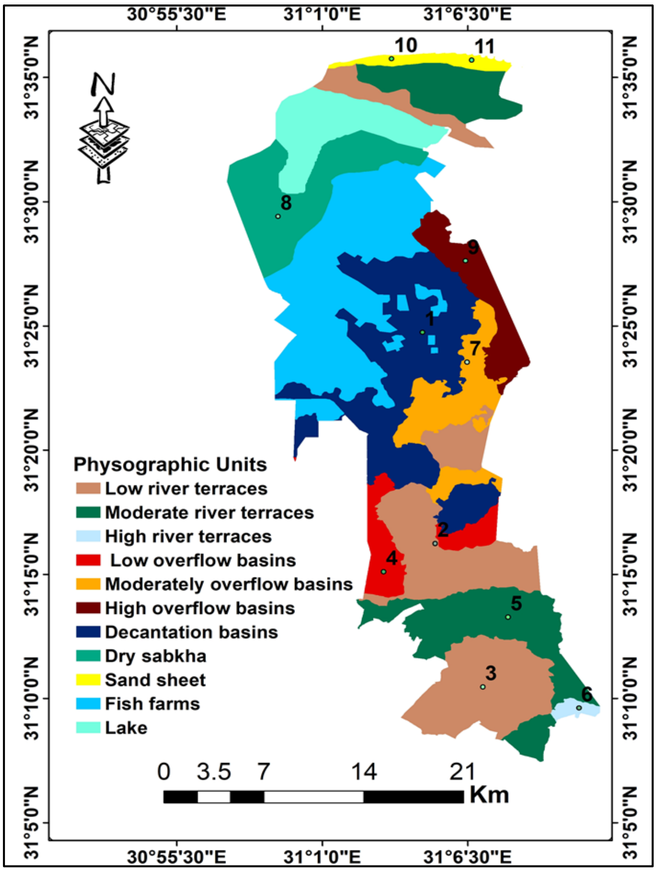


Fig (2): Geomorphological map of the study area and location of soil profiles.

Field work

Eleven soil profiles were dug to characterize the landform units of the study area as showed in Fig (2). The samples were air dried grained and passed through a 2 mm sieve before being sent to a laboratory for analyses to analyse soil chemical and physical properties according to Soil Science Division Staff (2017). The soils were classified according to Soil Survey Staff (2014).

Land evaluation

Land capability classification and land suitability for certain main crops were performed for the study area using the ASLE program developed by Ismail et al. (2005).

RESULTS AND DISCUSSION

Geomorphology

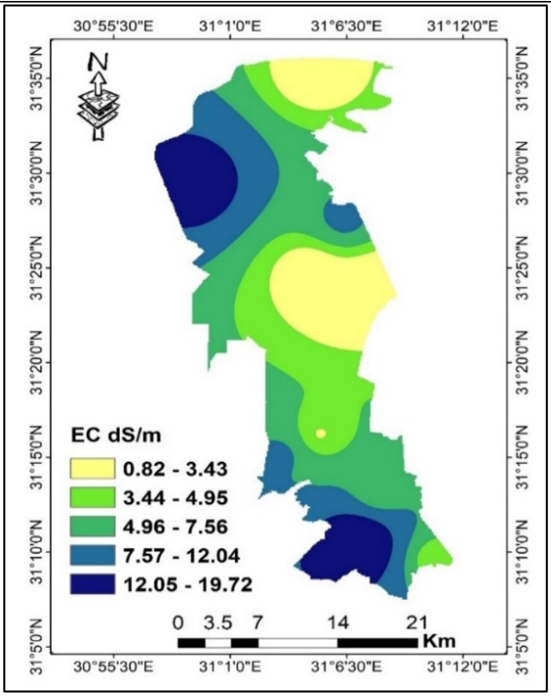
The interpretation of satellite image with the aid of Digital Elevation Model (DEM), and field observations indicated that, the study area has three main geomorphic units with different landforms besides water bodies (Lake) as presented in Table (1) and Fig (2). These geomorphic units are: 1) Flood Plain that is the largest unit occupying 72.96% from the study area and including River terraces (High, Moderate and Low), Overflow Basins (High, Moderate and Low) and Decantation Basins, 2) Lacustrine Plain including Fish Farms and Dry Sabkha, and 3) Marine plain including coastal sand Sheet. Area of these geomorphic units and their landforms (km^2 and %) are given in Table (1).

Physiochemical properties of the studied soils

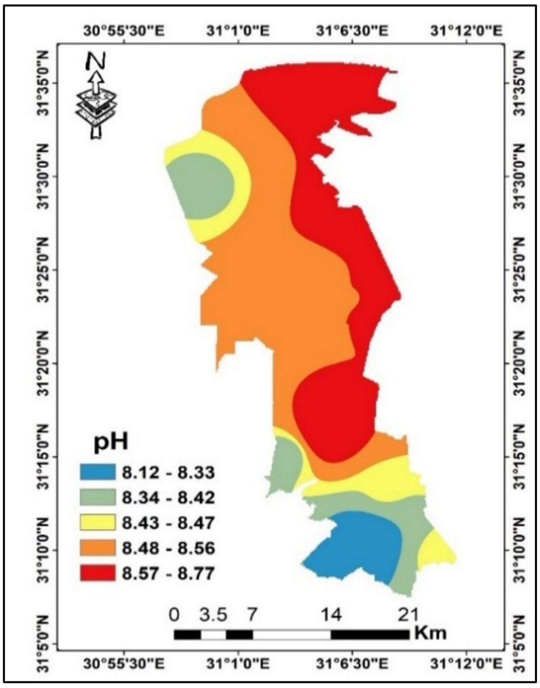
The main physical and chemical properties are illustrated in Fig, 3 (a, b, c, d, e, f and g). These results showed that, these soils are generally moderately deep to deep with mainly soft silt clay, silt loam, silt clay loam, clay loam and sandy loam texture grade. Calcium carbonate content ($CaCO_3$) varied from 0.83 to 8.08% with a general trend to decrease with depth. Soil samples was moderately alkaline as indicated by pH values, which varied between in 8 to 8.9 in some cases. The soils varied between non-saline to strongly saline as indicating from their EC values that varied between 0.58 to 34.30 dS/m. Exchangeable sodium percentage (ESP) ranged from 2.32 to 21.96 % and sodium adsorption ratio (SAR) values ranged from 0.36 to 19.42 in the horizons of the studied profiles. The analyzed soil samples showed that; the cation exchange capacity (CEC) ranged between 7.88 to 35.86 cmole/Kg. The high CEC in some profile is due to high organic matter and percentage of clay.

Table (1): Geomorphic units of the study area.

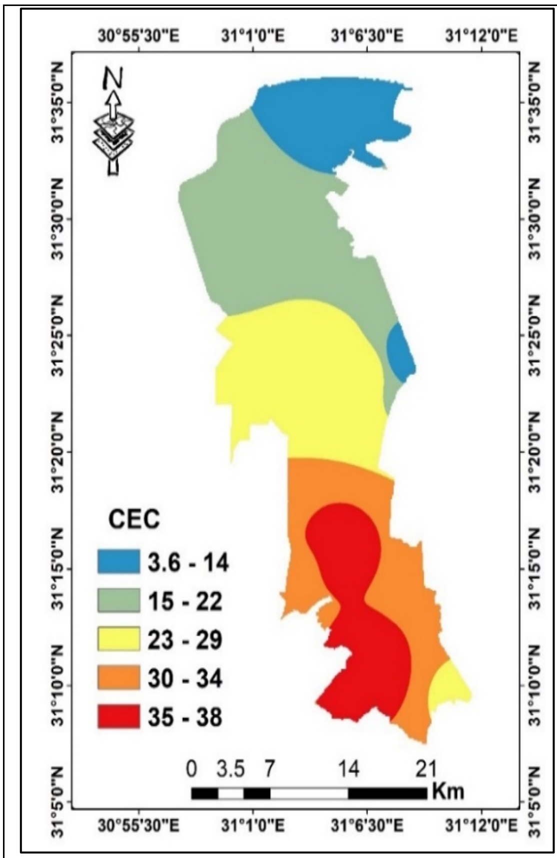
Geomorphic unit	Sub unit	Landform	Profile No.	Mapping unit	Area km^2	Area%
Flood plain	River Terraces	High	6	HRT	8.32	1.00
		Moderate	5	MRT	87.90	11.50
		Low	2,3	LRT	153.53	20.10
	Total				249.75	32.60
	Overflow Basins	High	9	HOB	71.69	9.41
		Moderate	7	MOB	53.18	7.00
		Low	4	LOB	43.29	5.68
	Total				168.16	22.09
	Decantation basins		1	DB	139.19	18.27
	Total of Flood plain				557.10	72.96
Lacustrine plain	Fish farms		-	FF	109.75	14.40
	Dry sabkha		8	DS	48.49	6.36
	Total of Lacustrine plain				158.24	20.76
Marine plain	Sand Sheet		10,11	SD	11.61	1.52
Water Bodies (lake)	-			L	34.63	4.54
Total					761.58	100


EC dS/m
0.82 - 3.43
3.44 - 4.95
4.96 - 7.56
7.57 - 12.04
12.05 - 19.72
0 3.5 7 14 21 Km
30°55'30"E
31°1'0"E
31°6'30"E
31°12'0"E
31°35'0"N
31°30'0"N
31°25'0"N
31°20'0"N
31°15'0"N
31°10'0"N
31°5'0"N

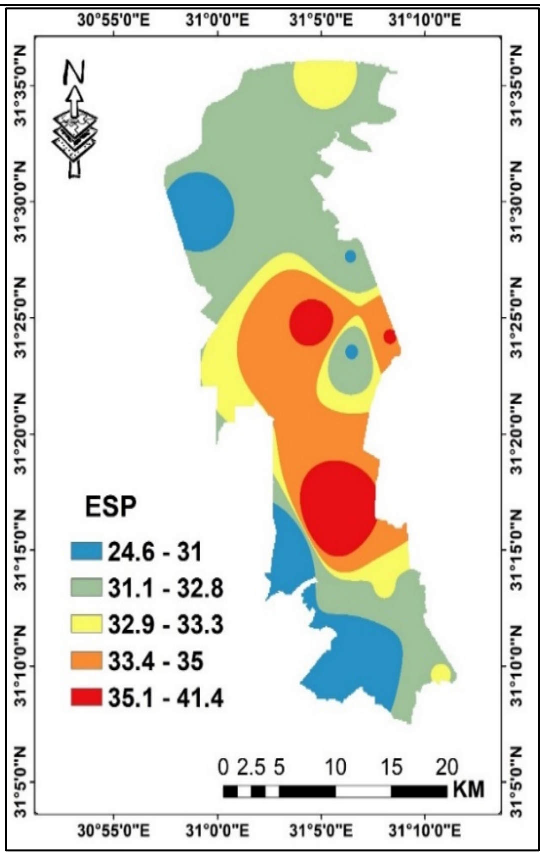
(a)


pH
8.12 - 8.33
8.34 - 8.42
8.43 - 8.47
8.48 - 8.56
8.57 - 8.77
0 3.5 7 14 21 Km
30°55'30"E
31°1'0"E
31°6'30"E
31°12'0"E
31°35'0"N
31°30'0"N
31°25'0"N
31°20'0"N
31°15'0"N
31°10'0"N
31°5'0"N

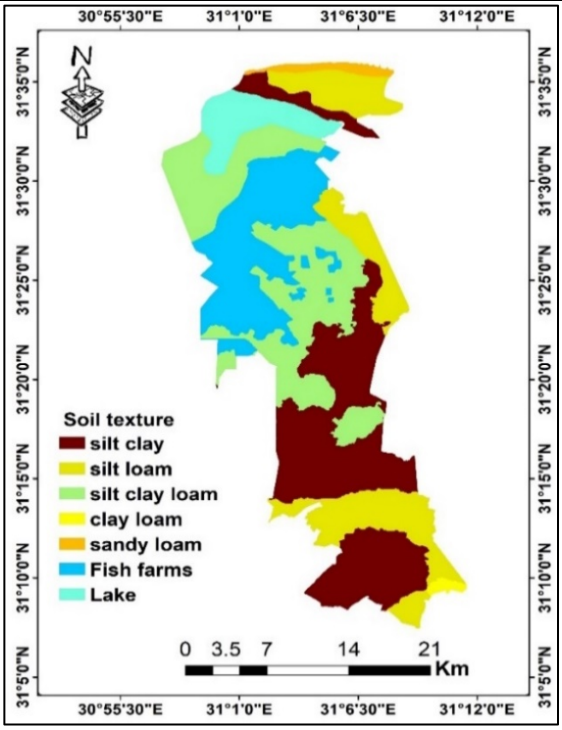
(b)


CEC
3.6 - 14
15 - 22
23 - 29
30 - 34
35 - 38
0 3.5 7 14 21 Km
30°55'30"E
31°1'0"E
31°6'30"E
31°12'0"E
31°35'0"N
31°30'0"N
31°25'0"N
31°20'0"N
31°15'0"N
31°10'0"N
31°5'0"N

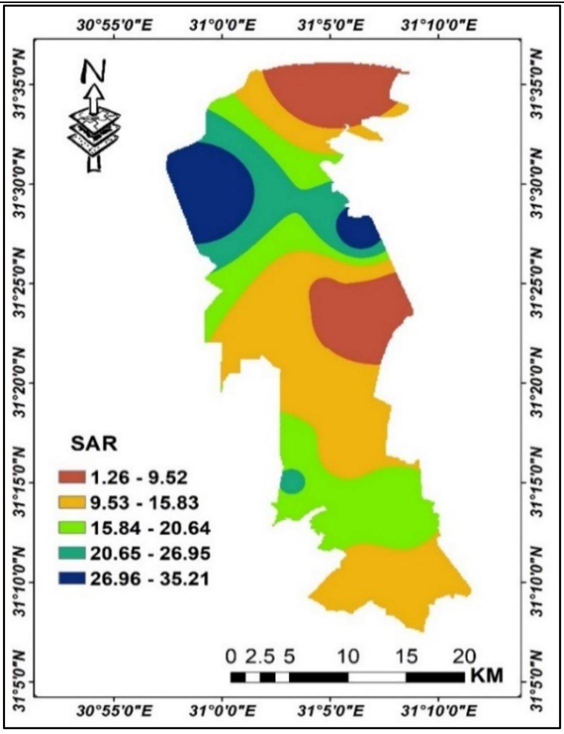
(c)


ESP
24.6 - 31
31.1 - 32.8
32.9 - 33.3
33.4 - 35
35.1 - 41.4
0 2.5 5 10 15 20 KM
30°55'0"E
31°0'0"E
31°5'0"E
31°10'0"E
31°35'0"N
31°30'0"N
31°25'0"N
31°20'0"N
31°15'0"N
31°10'0"N
31°5'0"N

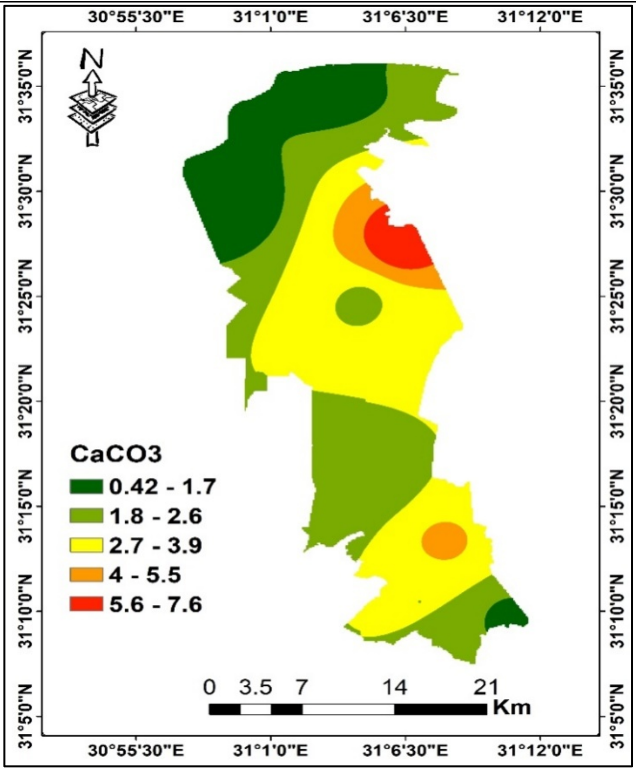
(d)



(e)



(f)



(g)

Fig (3): Spatial distribution of soil physiochemical properties: (a) EC (dS/m), (b) pH, (c) CEC, (d) ESP, (e) Soil texture, (f) SAR and (g) $CaCO_3$ %.

The dominant soil moisture regime in the study area is Aridic (Torric) with a Thermic soil temperature regime. The different investigated soils are classified up to subgroups level based on Soil Survey Staff (2014) as: *Typic Torrifluvents, Typic Haplosalids, Typic Torriorthents, Typic Torripssaments, Vertic Torrifluvents and Vertic Natriargids* (Fig, 4).

Land Evaluation

land evaluation was performed based on the soil physical and chemical characteristics for the studied area using the ASLE model (Ismail et al., 2005). This software can be help in assessing land capability indices and classification as well as land suitability for various crops. It is integrated with the ArcGIS software, and displayed the output results in simple maps that show the spatial distribution for each of capability classification and land suitability for chosen crops all over the studied area. The results could be discussed and mapped as follows.

Land Capability Classification

Outputs of land capability evaluation are illustrated in Table (2) and Fig (5). Accordingly, these results indicated that, the studied area have three capability classes namely: class of fair soil (C3), class of poor soils (C4) and class of very poor soils (C5) as follows:

Fair soils (C3): The soils of this class have capability indices (Ci) between 44.52 and 50.61% (Table, 2) and moderately severe limitations that restrict the range of crops and require special conservation practices. This class (C3) includes the soils of Moderate River Terraces, High River Terraces, Overflow Basins (High, Moderate and Low), Decantation Basins, high, and Dry Sabkha that occupied about 73.25% from the study area.

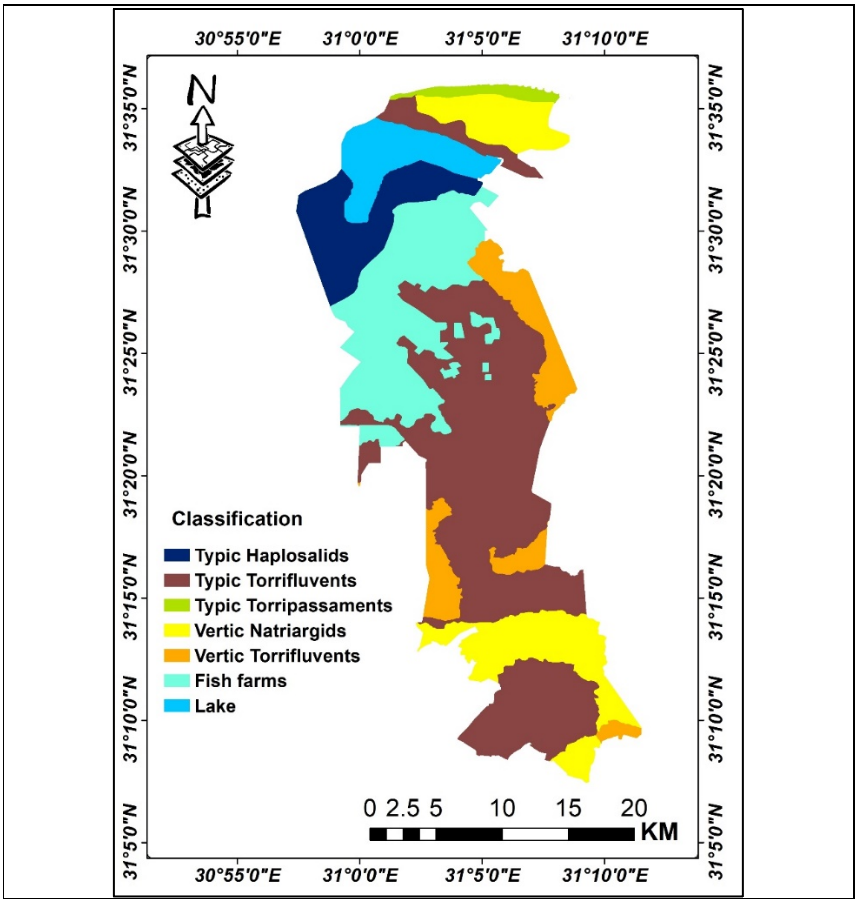


Fig (4): Distribution of soil classification in the study area.

Table (2): Land capability classification of the studied soil profiles.

Profile No.	Capability index %	Capability Class
1	44.87	Fair (C3)
2	45.14	Fair (C3)
3	38.31	Poor (C4)
4	44.52	Fair (C3)
5	46.78	Fair (C3)
6	46.6	Fair (C3)
7	47.28	Fair (C3)
8	49.06	Fair (C3)
9	50.61	Fair (C3)
10	27.37	Poor (C4)
11	16.54	Very Poor (C5)

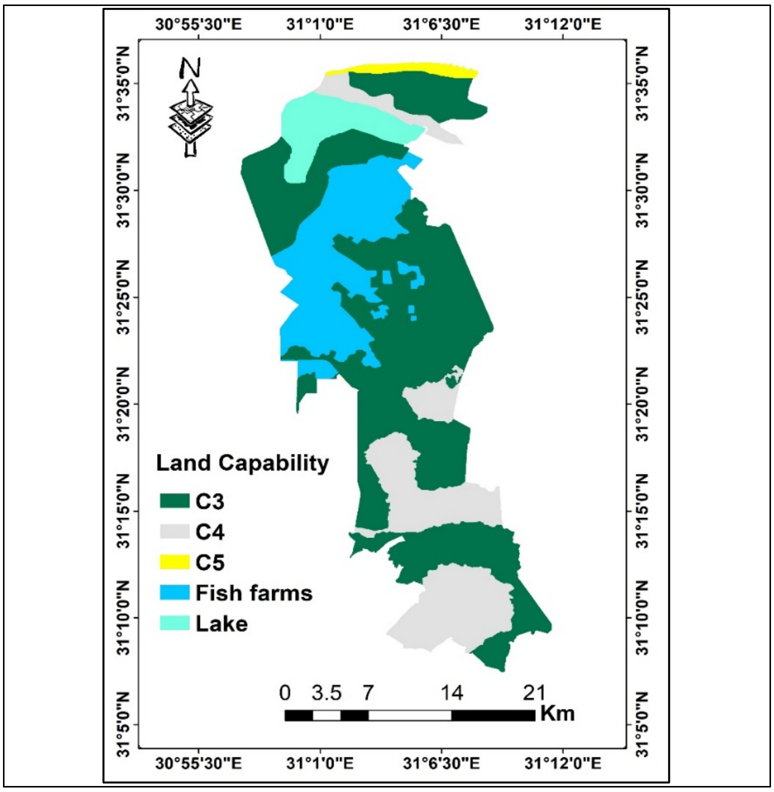


Fig (5): Land capability classes of the studied area.

Poor soils (C4): The soils of this class have capability indices (Ci) between 27.37 and 38.31% (Table, 2) and severe limitations that not generally provide the ecological conditions necessary for agricultural crops. These soils could be recommended for pasture or forestry as the only way of maintaining and recovering the productive capability of the resource and irrigation. The main limitations of these soils are salinity and sodicity. They may need very different management. This class includes the soils of low river terraces that cover about 24.87% from the study area.

Very poor soils (C5): The soils of this class have capability index (Ci) 16.54% (Table, 2) and very severe limitations mainly of sandy texture. These soils require very careful management and special conservation. This class includes soils of Sand Sheet that covers 1.88% from the study area.

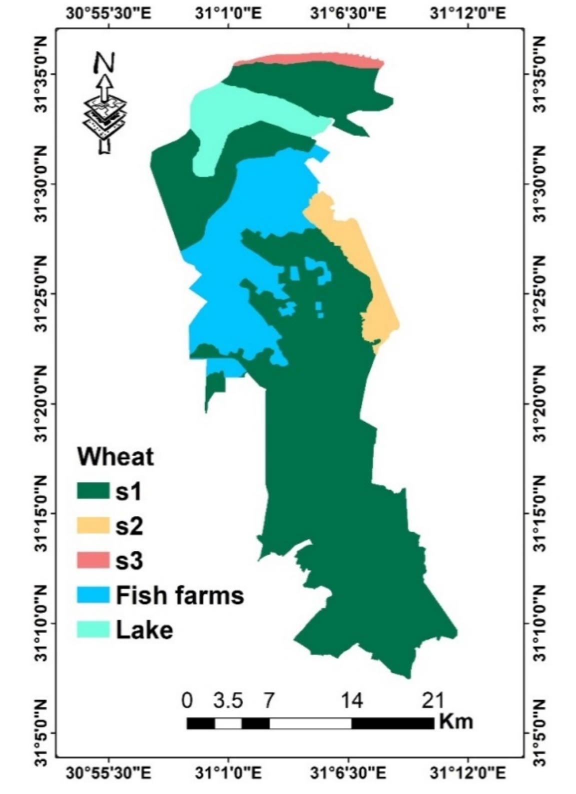
Land suitability for selected main crops

Seven main crops namely wheat, barley, rice, maize, onion, citrus and date palm were selected to assess and map their suitability for growing in soils of the studied area using ASLE model. The crops suitability is presented in Table (3) and illustrated in Fig, 6 (a, b, c, d, e, f and g). The results indicated that, the soils of low river terraces (LRT) are currently of highly suitable (S1) for wheat, barley, rice and date palm, suitable (S2) for maize only and marginally suitable (S4) for onion and citrus. The soils of moderate river terraces (MRT) are currently of highly suitable(S1) for wheat, barley and rice, suitable (S2) for maize and date palm, and marginally suitable (S4) for onion and citrus. The soils of high river terraces (HRT) are currently of highly suitable(S1) for barley wheat, rice, maize and date palm and marginally suitable (S4) for onion and citrus. The soils of low overflow basins (LOB) are currently of highly suitable (S1) for wheat, barley and rice, suitable (S2) for maize and date palm and currently not suitable (NS1) for onion and citrus. The soils of moderately overflow basins (MOB) are currently of highly suitable(S1) wheat, barley, rice and date palm, suitable (S2) for maize only and marginally suitable (S4) for onion and citrus. The soils of high overflow basins (HOB) are currently of highly suitable(S1) for wheat, barley and date palm, suitable (S2) for rice and maize and marginally suitable (S4) for onion only. Citrus was currently not suitable (NS1) in this landform. The soils of decantation basins (DB) are currently of highly suitable(S1) for wheat, barley, rice and date palm, Suitable (S2) for maize and marginally suitable (S4) for onion and citrus. The soils of dry sabkha (DS) are currently of highly suitable(S1) for wheat and barley, suitable (S2) for rice and date palm, moderately suitable (S3) for maize and Permanent not suitable (NS2) for onion and citrus. The soils of sand sheet are currently of moderately suitable (S3) for wheat and barley, currently not suitable (NS1) for maize and date palm and permanent not suitable (NS2) for onion and citrus.

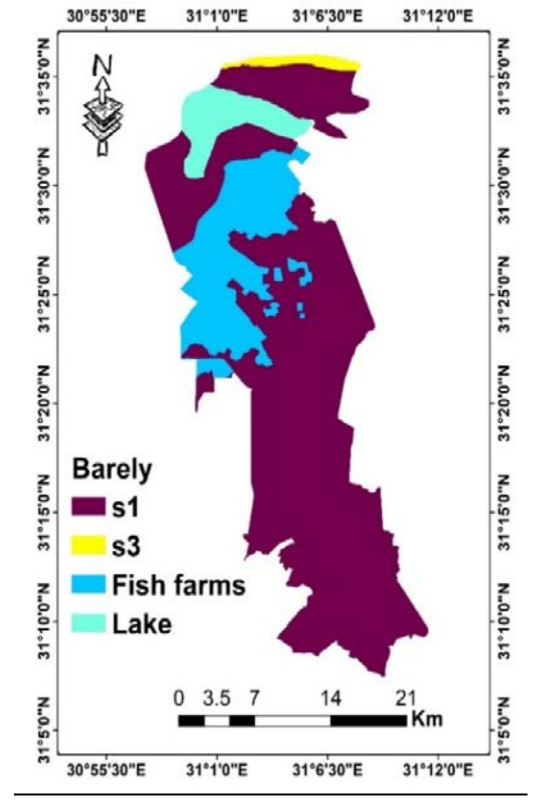
Table (3): Land suitability of the study area for certain crops.

Crop	Crop suitability in the different mapping units								
	LRT	MRT	HRT	LOB	MOB	HOB	DB	DS	SS
Wheat	1	1	1	1	1	1	1	1	3
Barley	1	1	1	1	1	1	1	1	3
Rice	1	1	1	1	1	2	1	2	5
Maize	2	2	1	2	2	2	2	3	5
Onion	4	4	4	5	4	4	4	6	6
Citrus	4	4	4	5	4	5	4	6	6
Date palm	1	2	1	2	S	1	1	2	5

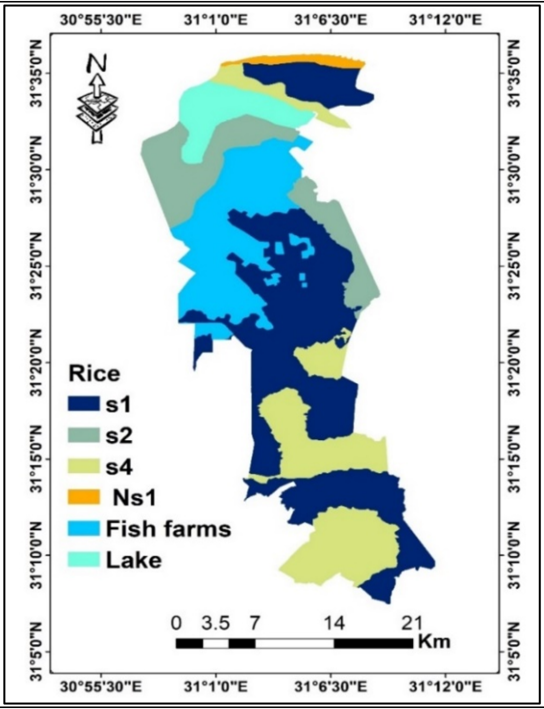
1= S1 (highly suitable), 2= S2 (suitable), 3=S3 (moderately suitable), 4= S4(marginally suitable),
5=NS1 (currently not suitable), 6= NS2 (permanent not suitable)



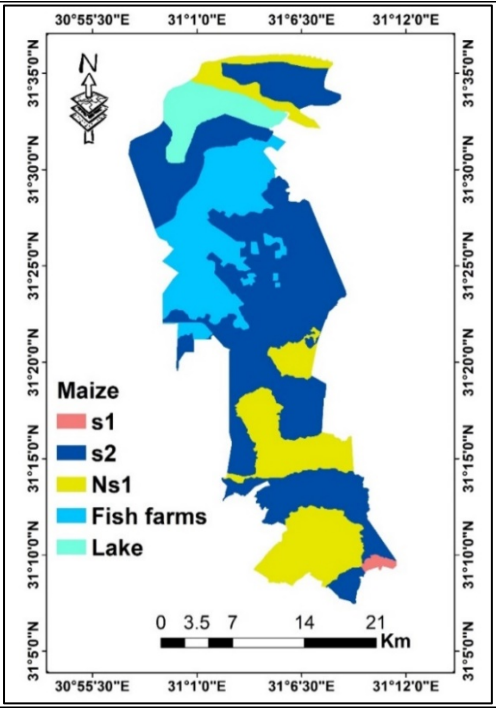
(a) Land suitability for wheat.



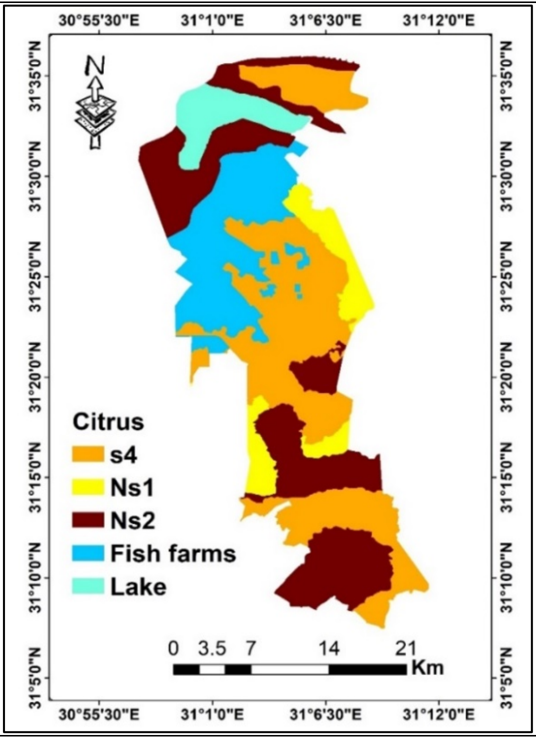
(b) Land suitability for barely.



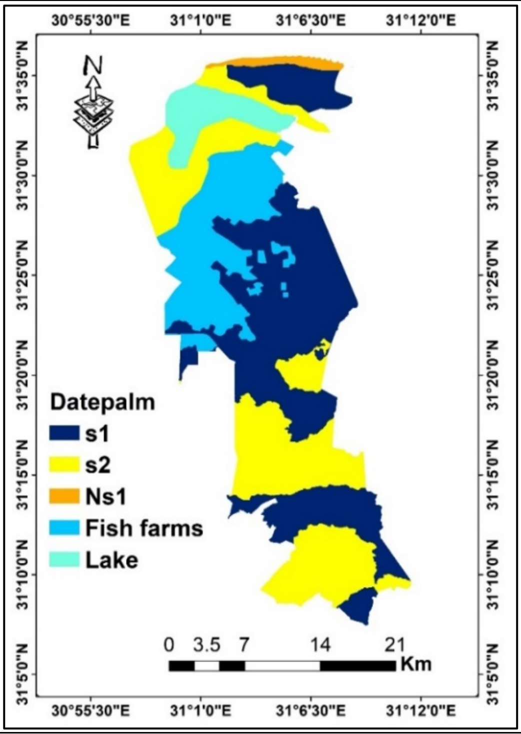
(c) Land suitability for rice.



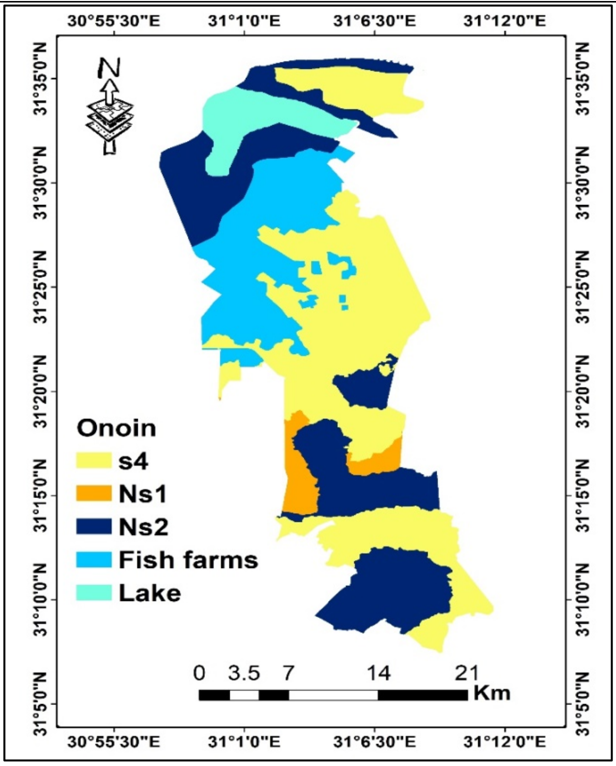
(d) Land suitability for maize.



(e) Land suitability for citrus.



(f) Land suitability for Date palm.



(g) Land suitability for onion

Fig (6): Land suitability maps for the different chosen crops in the study area.

Conclusion

GIS is a useful tool for storing, retrieving, and manipulating numerous amounts of data needed to map different soil parameters. Land capability and suitability evaluation is enabling optimum crop development and maximum productivity. To achieve the aim of studied was using ASLE program through determining soil physical, chemical and fertility properties. Results indicate that the studied area varied from fair to very poor according to final class by ASLE model. On the other hand, land suitability for the selected field crops can be grown in these soils, where land suitability was classified into Six classes: Also, ASLE program can be used by decision makers for future land using plans.

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تقييم الموارد الأرضية في بعض مناطق محافظة كفر الشيخ، مصر، باستخدام على تقنيات الاستشعار من البعد ونظم المعلومات الجغرافية

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الملخص العربي:

يتطلب تطوير وتحقيق الاستدامة في انتاج الموارد الأرضية المتاحة تقييم قدرتها وملاءمتها الانتاجية، ولذلك كان الهدف من هذه الدراسة هو تقييم القدرة الانتاجية والملائمة المحصولية لبعض مناطق محافظة كفر الشيخ في شمال دلتا النيل بمصر باستخدام تقنيات الاستشعار من البعد ونظم المعلومات الجغرافية، ولقد استخدم نظام التقييم الرقمي ASLE في اجراء هذا التقييم وإنتاج الخرائط الموضحة لنتائجه.

ولقد تم التعرف على وانتاج خرائط الأشكال الأرضية باستخدام صورة قمر صناعي Sentinel-2 ونموذج الارتفاع الرقمي، والحصر الحقلي، حيث اتضح أن المنطقة تتميز بوجود ثلاث وحدات رئيسية هي أ) السهل الفيضي الذي يعتبر أكبر الوحدات شاغلاً ٧٢,٩٦٪ من مساحة المنطقة، متضمناً الشرفات النهرية متعددة الارتفاعات والأحواض النهرية، ب) السهل البحيري، ج) السهل البحري، بالإضافة إلى الكتلة المائية للبحيرة، ولقد تم حفر أحد عشر قطاعاً أرضياً لتمثل الوحدات الأرضية المختلفة بمنطقة الدراسة، وجمعت منها عينات التربة اللازمة للتحاليل المعملية.

أظهرت نتائج تقييم القدرة الإنتاجية باستخدام برنامج ASLE أن ٧٣,٢٥٪ من منطقة الدراسة من الدرجة المقبولة C3، و٢٤,٨٧٪ من الدرجة الفقيرة C4، و١,٨٨٪ من الدرجة الفقيرة جداً C5، كما أظهرت نتائج ملاءمة المحاصيل المختارة أن القمح والشعير ونخيل البلح عالية إلى متوسطة الملائمة في معظم أراضي المنطقة، وأن الذرة متوسط الملاءمة، في حين أن البصل والموالح تتراوح بين متوسطة إلى غير ملائمة الصلاحية في معظم أراضي المنطقة.