

# Potentialities of Agricultural Development for Some Soil Along Aswan-Toshka District

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## ABSTRACT

The proficient management of the available natural resources of Egypt is necessary in order to save food demands of the rapidly increasing population. In the processing of land use planning, estimating the agricultural land potentiality is important footstep where the agricultural resources are so limited. Toshka spillway area is one of the greatest promising area for horizontal agricultural extension where the fresh water is available. The main goal of the current study is to produce land priority map based on different thematic layers of some soil parameters that affect on or control the agricultural potentiality by designing a suitable GIS-based model for data integration with relevant logical condition of the area along Aswan Toshka District, south of Egypt. The parameters taken into consideration were slope, soil texture, soil depth, gravel content, calcium carbonate, soil salinity, and soil reaction. By using GIS environment, these parameters were interpolated in order to recognize their spatial variability by differentiating each property as sever, moderate, slight, and no limitations. Accordingly, The analysis showed that the soil depth, soil gravel, and soil reaction were the major limitation factors comparing with the other soil factors. The priority of Land Suitability Potential Index (LSPi) for Agricultural purpose was calculated by the contribution of the abovementioned parameters. The potentiality was categorized as not suitable, marginally suitable, moderately suitable, and highly suitable. These classes were attained by integrating the different thematic layers with corresponding weights in geographical information system (GIS). The output of study indicated that the study area can be mainly described as moderately suitable where it covers about 81.04 % of the total area, while highly suitable, marginal suitable and not suitable attained the lower converge 9.23, 9.01, and 0.72 %, respectively. The study concluded that any given area can be categorized into spatially distributed agricultural potential zones based on the soil characteristics and terrain properties by the profound assist of geographical information system (GIS).

**Key words:** Potentialities, Agricultural development, Toshka, GIS, Suitability index

## INTRODUCTION

Land resources in Egypt face pressures from continuing land degradation as well as increase of population. The population in Egypt is increasing very rapidly and its intensity has been twofold during the last decades, (Hamza and Mason, 2004). Accordingly, the

proficient management of the natural resources of Egypt is necessary for ensuring food supply and sustainability in agricultural development (El Baroudy, 2016). In the process of land use planning, land evaluation is an important footstep where resources (land, water and fund) are so limited especially in Egypt. In order to manage these resources in proper way, land suitability assessment is always conducted to assess which part of land is almost suitable or fit to a specific location (Bodaghabadi *et al.*, 2015). Land suitability evaluation process tend to recognize the main limiting factors of a particular crop yield for given area (Halder, 2013), where the requirements of land use are significantly met by the properties of the given land. Hence, the main object of land suitability potential evaluation is to predict the inherited land capability so as to support the land use specifically for long time without any hazard of damage. Moreover, it enables decision makers to put an efficient way to develop a crop management for increasing land productivity to meet the increase of human demands (Chen, 2014). In arid and semiarid region as Egypt, the availability of water and soil fertility status as well as other soil qualities limit crop productivity (Kerr *et al.*, 2002) and (Rockström *et al.*, 2003). Such these areas are characterized high evaporation rate as result of the high temperature which accordingly accelerates the decomposition rate of organic matter. Like this situation, the sustained land use planning, therefore, includes the decision of land use so that the available resources are put into use according to the determined potentiality (Rockström *et al.*, 2002). Various approaches of land evaluation have been developed, and each has a specific methodological procedure (Brink and Young, 1977; De la Rosa *et al.*, 2004; O'Geen, 2008; Hamad, 2016). The land evaluation systems are either qualitative, quantitative, or both. The qualitative ones are empirical assessment depending on the knowledge and the understanding of the study area. On the other hand, the quantitative ones are a factor-based land evaluation systems and involve more detailed land attributes by using parametric techniques that use either single or multiple parameters converted to an integrated index (Guo *et al.*, 2005). The Food and Agricultural Organization (FAO) suggested an approach for land suitability evaluation for crops in terms of suitability ratings varying from highly suitable

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Received OCTOBR 11, 2018, Accepted November 12, 2018

to not suitable based on terrain data and soil properties in addition to climatic data (Brink and Young, 1977). Sys and Verheye (1972) recommended a capability index, depending on various parameters, related to soil properties and, subsequently, an extent of capability indexes were proposed to designate soil limitations for crop production. With advances in information and communication technology, computer based decision support models have been developed towards land evaluation (De la Rosa *et al.*, 1992) and (Yen *et al.*, 2006).

Recently the geographical information system (GIS) and remote sensing (RS) have been applied to accomplish land evaluation through map analysis techniques (Kalogirou, 2002) and (Baja *et al.*, 2002). In addition, they provide a great promises for improving the convenience and accuracy of spatial data to be more productive assessment and enhance data access (El Baroudy, 2016). These techniques have been applied and used to determine the properties desired to define the land suitability (De la Rosa and Van Diepen, 2002), (Mokarram *et al.*, 2010), and (Hamzeh *et al.*, 2014).

Under the effort of Egyptian government for the horizontal and vertical agricultural expansion, the current study aim at providing a database of arable land in desert areas. In agricultural point of view, it should evaluate the productive potentiality of given land before using to assess the suitability areas. To attain that purpose, the main objectives of this research are: (i) to produce different thematic maps of some soil properties that affect on or control the agricultural potential through the conventional methods of soil survey, (ii) to categorize the thematic features based on their merit and demerit with respect to agricultural land potential, (iii) to design a suitable GIS-based model for data integration with relevant logical condition, and (iv) to prepare land priority map expressed by Land Suitability Potential Index (LSPI) through evaluating the limiting soil factors of the area along Aswan Toshka District.

## MATERIALS AND METHODS

### General occurrence and feature of the study area

The study area is located in the southern Egypt near Toshka lake. It lies between 22° 54' 06" to 23° 14' 29" N and 31° 37' 04" to 32° 00' 18" E, occupying an area of about 618 km<sup>2</sup> (148320 faddan), Fig (1). It is located some 250 km to the southwest away from Aswan City and some of 50 km from Abu Simble City. As for the climatic data, shown in Table (1) and Fig (2), the annual precipitation is lower than 1 mm/year. The average temperature ranges 9.2 to 25.3 °C in winter and from 42.3 to 44.1 °C in summer. The relative humidity recorded as average is fluctuating between 14 and 38 %. The average wind speed varies from 2.3 to 3.1 m/sec.

the study area is under hyperarid condition as indicated by the aridity index, being less than 0.05, (Middleton and Thomas, 1992). Geologically, the surface of this area is covered by different type of geological formation, Fig (2). According to Moneim *et al.* (2014), the Quaternary deposits are characterized mainly by sand sheets that covers of about 99300 faddan. Sabaya formation, representing the Lower Cretaceous, consists mainly of sandstone, ferruginous sandstone with thin bed of conglomerate. It covers an area of about 16314 faddan. Kiseiba formation covering around 30793 faddan, consists of shale and sandstone of Upper Cretaceous. The basement rocks occur as relic exposures of low relief and they consist of gneiss and magmatic gneiss that highly modified by weathering. This formation is occupies an area of about 1913 faddan.

In respect of geomorphology, the study area is considered as one geomorphic unit as mentioned by, (Moneim *et al.*, 2014) while DRC (2014) divided the area under consideration into four main units, Figure (2). The first landform is Karstified platform which covers the southern part of the study area. This landform appears as some rock exposures of Precambrian, cretaceous and/or Tertiary era. Some parts this of unit is affected by hydrothermal solutions. It occupies an area of about 39789 faddan. The second one encompasses both Mesas and Buttes, covering about 9000 faddan, particularly at the eastern, southeastern and western portion of the study area. This landform has been formed under the effect of structure (folding). Third, is pediplain covering an area of about 22141 faddan particularly at the northeastern and north part of the study area. It is a rocky surface that is considered the final form of erosional / depositional stage. Finally, sand sheets which cover very large area of about 77390 faddan and they belong to the depositional land forms. Because of the scarcity of rainfall, these sand sheets cover the shallow wadies and its terraces and alluvial fans, Figure (3).

### 2-Soil Sampling and Laboratory analysis

Through implementing a project carried out by Desert Research Center (2014), (DRC, 2014), soil Samples were conducted based on a survey grid where the distance between each two consecutive sites is 1 km, Figure (4). Accordingly, 618 soil profiles were digged and a detailed morphological description of the studied soil profiles was elaborated on the basis outlined by FAO guideline of soil profile description, (Jahn *et al.*, 2006). A number of 1574 representative soil samples have been collected from the soil profiles and analyzed for chemical and physical properties. In the laboratory,

all dried samples were ground to pass a 2 mm sieve, then subjected to standard soil characterization.

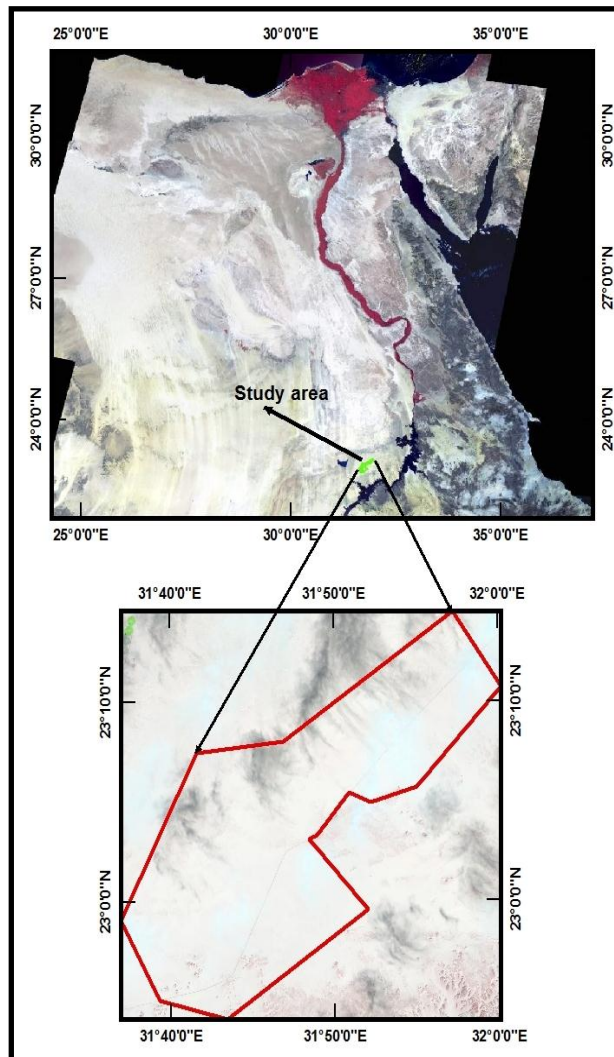


Figure 1. Location map of the study area

Table 1. Monthly average data of some climatic elements

Months	Temperature °C			Relative humidity %	Wind speed m/sec	Sunshine hours	Rainfall mm
	Maximum	Minimum	Average				
Jan.	24.6	9.2	16.9	37	2.5	8.0	0.1
Feb.	27.7	10.6	19.2	27	2.7	8.5	0.0
Mar	32.9	15.0	24.0	19	3.0	10.0	0.0
Apr	35.9	18.0	27.0	17	3.1	10.4	0.0
May	39.4	21.9	30.7	15	3.0	10.9	0.0
Jun	42.4	24.5	33.5	14	2.4	12.6	0.0
Jul	42.3	24.6	33.5	16	2.3	12.1	0.0
Aug	44.1	25.3	34.7	17	2.7	10.2	0.0
Sep	40.3	23.7	32.0	20	2.5	8.7	0.0
Oct	34.6	19.4	27.0	23	2.6	8.4	0.0
Nov	29.5	14.3	21.9	36	2.5	8.1	0.0
Dec	24.3	9.7	17.0	38	2.7	8.0	0.1

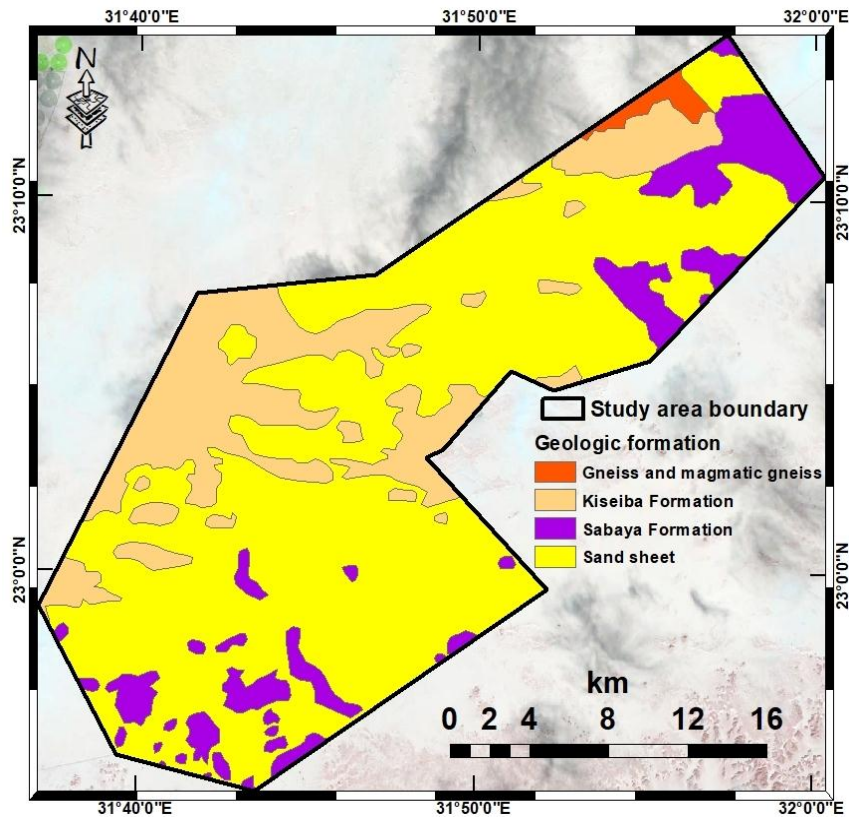


Figure 2. Surface geology of the study area, (Moneim et al., 2014).

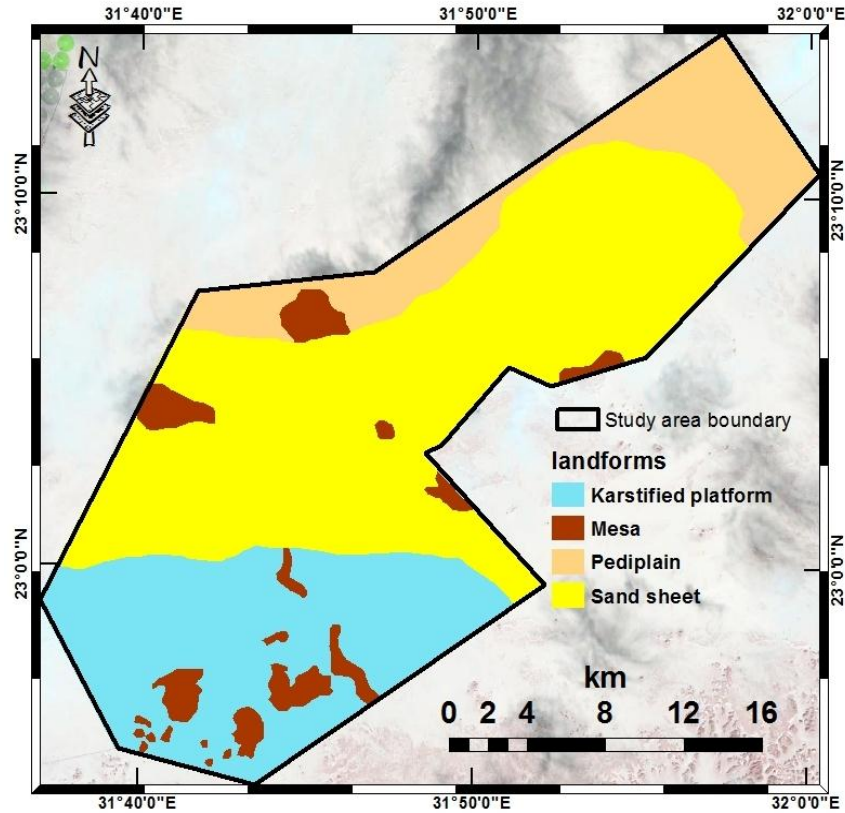


Figure 3. Landforms of the study area,(DRC, 2014).

The gravel percentage was calculated volumetrically (USDA, 2004). Particle size analysis was accomplished via hydrometer, with silt + clay and clay readings at 40 sec and 360 min, respectively, using a Model 152 H hydrometer and the method carried out by Bouyoucos (1962). Soil pH and electrical conductivity (EC) were determined via saturated soil water extraction 1:2.5 using EC/pH conductivity meter (Sonmez et al., 2008). Calcium carbonate content was determined via a pressure calcimeter (Sherrod *et al.*, 2002).

### 3- Database and methodology of land suitability

It should notify that, especially for the study area, the water quality and quantity are available due to the study area is near by the New Valley Project (Toshka spillway). In horizontal agricultural expansion projects like in Egypt, if the water quantity and quality are available, the soil depth, soil texture and slope as well as other soil properties play a vital role for that expansion. For detecting the potentiality of agricultural development at the current study area, the spatial

information regarding to the selected criterion i.e. slope, soil depth, soil texture, soil salinity, soil pH, and calcium carbonate content were used to present the suitability model. The slope as well as the elevation were derived from the digital elevation model version 3 downloaded from the USGS website <https://earthexplorer.usgs.gov/>. All the soil related data of each soil profile were converted to single values using the weighted mean by multiplying the parameter value of each layer by the layer thickness divided by the total depth of soil profile. Therefore the spatial variability map of each soil property were created for the study area using ArcMap 10.4.1, Topo To Raster option, spatial Analyst Tool. The obtained layer of each property was reclassified according to its limitation so (1) as sever, (2) as moderate, (3) as slight, and (4) as no limitation, Table (2).

**Table 2. The limitation of soil properties and their weight for the study area**

Soil layer	Category	Reclassification number	Limitation	Layer weight
Soil Depth (SD) cm	0-25	1	Sever	0.6
	25-50	2	Moderate	
	50-100	3	slight	
	100-150	4	No	
Soil texture (ST)	Sand	2	Moderate	0.2
	Loamy sand	3	Slight	
	Sandy loam	4	No	
Soil Gravel (SG) %	0 - 5	4	No	0.15
	5 - 15	3	Slight	
	15 - 40	2	Moderate	
	>40	1	Sever	
Soil slope (SL) %	0 - 1	4	No	0.02
	1 - 2	3	Slight	
Soil Carbonate (SC) %	0 - 2	3	Slight	0.01
	2 - 10	4	No	
	10 - 25	2	Moderate	
	> 25	1	Sever	
Soil Salinity (SS) dS/m	0 - 2	4	No	0.01
	2 - 4	3	Slight	
	4 - 8	2	Moderate	
	>8	1	Sever	
Soil Reaction (SR)	7.3 - 7.8	4	No	0.01
	7.8 - 8.4	3	Slight	
	8.4 - 9	2	Moderate	
	> 9	1	Sever	

Accordingly, suitable weights were assigned to each layer according to its effect on the productivity potentiality in agricultural point of view. They, therefore, were integrated and analyzed using the weighted aggregation method, ArcMap 10.4.1, Spatial Analyst Tool, Overlay, Weighted sum. In this method, the total weights of the final integrated layer map was derived as sums of the weights assigned to different layers, according to their suitability. The final obtained map displays the prioritized areas for land use as first priority, second priority, ....etc.

The equation used in GIS to assess the Land Suitability Potential Index (LSPI) for Agricultural purpose is:

$$\text{LSPI} = 0.6 (\text{SD}) + 0.2 (\text{ST}) + 0.15 (\text{SG}) + 0.02 (\text{SL}) + 0.01 (\text{SC}) + 0.01 (\text{SS}) + 0.01 (\text{SR})$$

The weighted value of each property was assigned by this numerical value based on the influence of each property on the use of soil under the study area circumstances. Therefore, it is found that the soil depth is the most important limiting factor of potential land use, so it was weighted by the highest value (60 %). Then it is followed by soil texture (20 %) and soil gravel (15 %), while the soil slope (2 %), calcium carbonate, soil salinity, or pH were weighted by the lowest weighted value (1 %) where they do not influence the Agricultural process in the study area.

## RERSULTS AND DISCUSSION

### 1- Soil mapping Units

Due the huge data of the study area, results related to descriptive statistical data are present in the supplementary Table (3) and Figure (5). These data were summarized based on the soil mapping unit which was designed according to the soil depth and soil texture categories mentioned by Soil Survey Staff (1993). Description of gravel, salinity, and soil reaction were defined according to Schoeneberger (2002). In such manner, the soil profiles were grouped according to soil

depth where depth ranges from 0- 50 cm represent shallow, 50-100 cm represent moderately deep, and greater than 100 cm represent deep soils. As for the soil texture, the sand and loamy sand texture represent the coarse-texture and sandy loams represent the moderately coarse-texture. Both of soil depth and soil texture were spatially mapped and then reclassified as shown in Table (3). After reclassification, they mathematically combined using PLUS spatial analyst tool, ArcMap 10.4.1, to get the final mapping units. Therefore, 6 soil mapping were obtained and statistically discussed.

#### 1.1- Shallow coarse-textured soils (SMU01)

This unit occupies an area of about 1820.09 faddan and could be distinguished into sand and/or loamy sand. The gravel content ranged from none to abundant (0.14 - 44.94 %). The surface slope of these units ranged from 0.13 to 1.19 % as flat to almost flat surface. The soils are slightly calcareous to strongly calcareous (0.31-20.78 %), non-saline to slightly saline (0.61 to 6.67) and showing neutral to moderately alkaline reaction (7.34 to 8.16). Reversely, the soil depth had the highest values of the standard deviation and standard error, while the soil pH and surface slope have gotten the lowest values, respectively. Base on the mean values of the characteristics studied, this unit could be related to "*Almost flat, Shallow, Gravelly coarse-textured, Strongly calcareous, Non-saline, Slightly alkaline*".

#### 1.2- Shallow moderately coarse-textured soils (SMU02)

The soils of this unit, occupying an area of about 30276.13 faddan is mostly in the middle part of studied area particularly within the pediplain. soils have sandy loam texture and gravel content ranging between 0 to 29.04 %. The surface slope ranges from 0.12 to 0.98 % representing flat to almost surface. These soils are slightly calcareous to strongly calcareous where calcium

**Table 3. The methodology for getting the final soil mapping units' codes**

Soil Mapping Units	Reclassified Code		Combination code
	Soil texture	Soil depth	
SMU01 (Shallow coarse-textured soils)	10	1	11
SMU02 (Shallow moderately coarse-textured soils)	20	1	21
SMU03 (Moderately deep coarse-textured soils)	10	2	12
SMU04 (Moderately deep moderately coarse-textured soils)	20	2	22
SMU05 (Deep coarse-textured soils)	10	3	13
SMU06 (Deep moderately coarse-textured soils)	20	3	23
Where:	-Shallow:	< 50 cm depth	
-Coarse-Texture: Sandy and loamy sand soils	-Moderately deep:	50-100 cm depth	
-Moderately-Texture: Sandy loam soils.	-Deep:	100-150 cm depth	



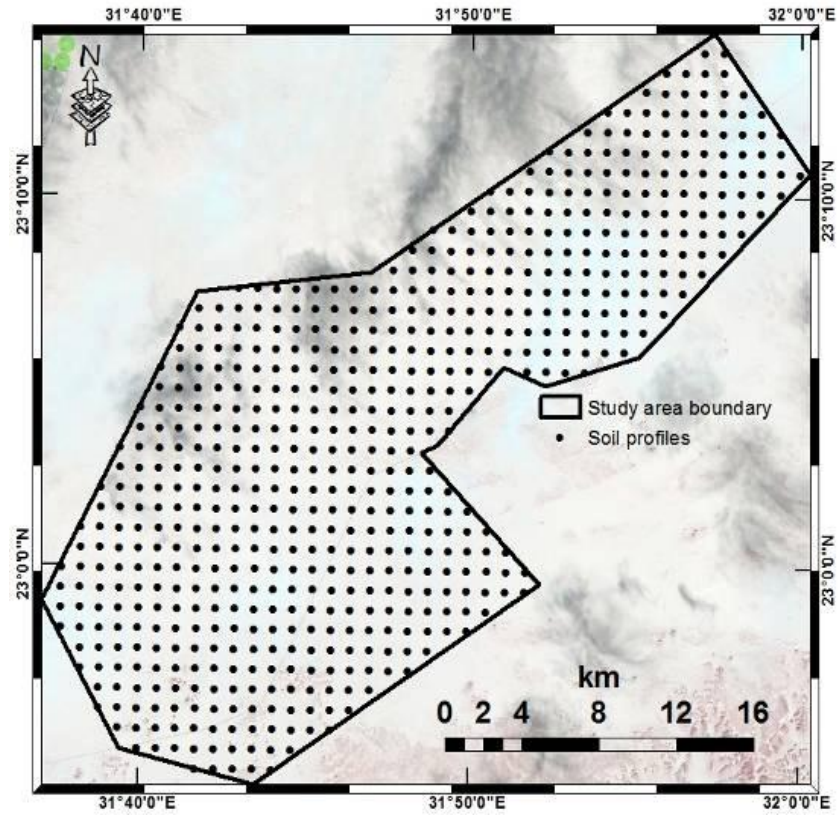


Figure 4. Soil profile covering the study area

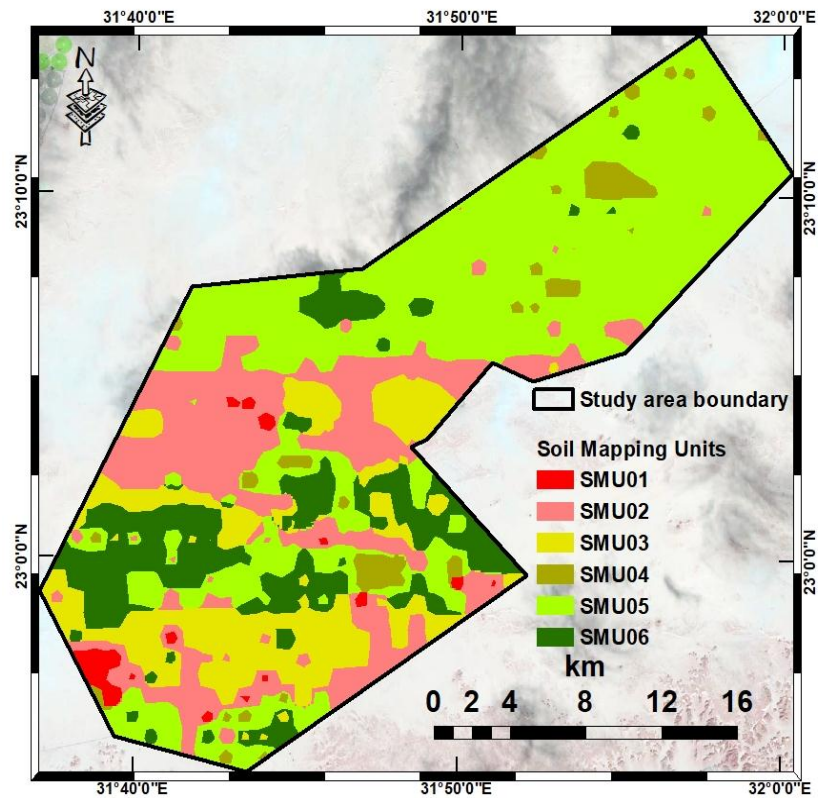


Figure 5. Soil mapping units in the study area





Continue.Table 4

SMU06 - Deep moderately coarse-texture soils (20551.33 faddan)									
<b>Mean</b>	128.74	15.06	0.38	10.36	19.39	70.25	4.08	1.26	7.96
<b>Standard Error</b>	1.81	1.08	0.02	0.38	0.60	0.71	0.37	0.08	0.03
<b>St. Deviation</b>	16.80	10.02	0.21	3.48	5.53	6.56	3.42	0.71	0.25
<b>Variance</b>	282.21	100.43	0.04	12.10	30.53	43.08	11.73	0.50	0.06
<b>Kurtosis</b>	-1.29	-0.31	1.64	0.96	0.01	0.52	9.46	8.42	1.28
<b>Skewness</b>	-0.04	0.73	1.33	0.26	0.44	-1.14	2.87	2.34	0.59
<b>Minimum</b>	100.01	2.60	0.05	1.07	8.84	52.01	0.85	0.22	7.39
<b>Maximum</b>	149.99	43.88	1.00	19.95	33.32	78.96	20.96	4.48	8.86
<b>Count</b>	86	86	86	86	86	86	86	86	86

carbonate content ranges from 1.32 to 15.89 %, non saline to very slightly saline (0.44 to 3.86 dS/m) and slightly to strongly alkaline (7.41- 8.62). According to the values of standard deviation and standard error, soils showed that the soil depth has the highest values, while the surface slope followed by pH have the lowest ones, respectively. Applying the mean values of the different soil properties indicated that the soils are “*Flat, shallow, Moderately coarse- textured, Moderately calcareous, Non-saline, Moderately alkaline*”

### 1.3- Moderately deep coarse-textured soils (SMU03)

This unit covers an area of about 22169.92 faddan, soils of which are either sandy or loamy sand with gravel content ranging from 0.52 to 52.72 %. The surface attained flat to almost flat slope (0.04 to 1.22 %). Similarly, soils vary from slightly calcareous to extremely calcareous (0.27-90.77 % as total carbonate content). The soil salinity is non-saline to strongly saline (0.20 to 16.14 dS/m) and slightly to very strongly alkaline where pH valued range from 7.41 to 9.65. With respect to the standard deviation and standard error, as the pervious unit, the soil depth has the highest values of while the surface slope and pH have gotten the the lowest values, respectively. By the mean values the studied paramters, the soils under consideration could be define as “*Flat, Moderately deep, Gravelly coarse-textured, Moderately calcareous, Very slightly saline, Moderately alkaline soils*”.

### 1.4- Moderately deep moderately coarse-textured soils (SMU04)

The soils, encompassing around 5009.98 faddan, have sandy loam texture and the gravel content ranges from 0 to 63.66 %. The soil surface has a flat to almost falt slope and the soils are slightly to extremly calcareous (1.10-26.39). These soils are non-saline to moderately saline (0.19-11.64), and slightly alkaline to very strongly alkaline with pH values ranges from 7.36 to 9.69. As described in the previous unit, the soil depth has the highest values of standard deviation and standard error while surface slope and soil pH have the lowest values. The mean values of the determined soils parameters showed that these soils are “*Flat,*

*Moderately deep, Moderately coarse-textured, Moderately calcareous, Non-saline, Moderately alkaline*”.

### 1.5- Deep coarse-textured soils (SMU05)

This soil mapping unit covers an area of about 68492.63 faddan represented by sand and/or loamy sand with gravel content ranged from 2.63 to 48.25 %. The surface slope ranges from 0.03 to 1.38 %. These soils could be described as slightly to extremly calcareous where calcium carbonate content ranges from 0.19 to 20.27 %, on the other hand, the soil salinity and pH respectively are non-saline to strongly saline (0.23 to 30.61 dS/m) and slightly to strongly alkaline (7.39 to 8.62). Similar to the overmentioned, the soil depth and surface slope and pH have the highest and the lowest standard deviation and standard error values. The studied soils detected in this unit are related to *Flat, Deep, Gravelly coarse-textured, Moderately calcareous, non-saline, Moderately alkaline*.

### 1.6- Deep moderately coarse-textured soils (SMU06)

This unit encompasses an area of about 20369 faddan. The soils of this mapping unit have sandy loam texture with gravels ranged from 2.60 to 43.88 %. This units has flat to almost flat (0.5 -1.00 %) derived from surface slope. They are slightly calcareous to strongly calcareous as ranging from 0.85 to 20.96 %. The soil salinity, defined by EC values that ranges from 0.22 to 4.48 dS/m, is non-saline to slightly saline. The soil reaction indicated by pH values ranging from 7.39 to 8.86 is slightly to strongly alkaline. As mentioned in the unit before, the soil depth had the highest values of the standard deviation and standard error, reversely the surface slope and pH have gotten the lowest values, respectively. According to the mean values of soil properties, the soils are “*Deep, Gravelly moderately coarse-textured, Moderately calcareous, Non-saline, Moderately alkaline*”.

## 2- Study area data layers

The step followed in order to prepare land suitability maps was proceed from deciding what land to develop and when and how to develop. Accordingly the land suitability includes physical characteristics and

constrains (Bandyopadhyay *et al.*, 2009). In this study the suitability potential analysis attempted to be viewed as a prioritization of land for agricultural development. Therefore, multi-disciplinary study such as filed survey, ground truth, and remotely sensing has been undertaken to carry the potential land suitability to identify the areas to be used for agricultural purpose. In the study under consideration, the parameters used to determine the

priority map were put in the order of the most important according to the study area circumstances and they are shown previously in Table (2) and were mapped to get the spatial variability of each property' severity as soil depth (Figure. 6), soil texture (Figure 7), soil gravel (Figure 8), surface slope (Figure 9), calcium carbonate (Figure 10), soil salinity (Figure 11) and pH (Figure 12)

**Table 5. The limitation of soil properties represented by feddan and percentages**

Soil properties	Limitation	Area/ faddan	Percentage
Soil depth (SD)	Sever	5876	3.77
	Moderate	12203	8.07
	Slight	92731	62.87
	No	37509	25.29
	<b>Total</b>	<b>148320</b>	<b>100</b>
Soil Texture (ST)	Sever	3984	2.48
	Moderate	16544	11.03
	Slight	49952	33.76
	No	77840	52.73
	<b>Total</b>	<b>148320</b>	<b>100</b>
Soil gravel (SG)	Sever	1091	0.51
	Moderate	44887	30.31
	Slight	69295	46.92
	No	33047	22.26
	<b>Total</b>	<b>148320</b>	<b>100</b>
Soil slope (SL)	Slight	3045	1.61
	No	145275	98.39
	<b>Total</b>	<b>148320</b>	<b>100</b>
Soil calcium Carbonate (SC)	Sever	391	0.04
	Moderate	9770	6.42
	Slight	14420	9.58
	No	123739	83.96
	<b>Total</b>	<b>148320</b>	<b>100</b>
Soil Salinity (SS)	Sever	1328	0.67
	Moderate	6225	4.01
	Slight	20973	14.04
	No	119794	81.28
	<b>Total</b>	<b>148320</b>	<b>100</b>
Soil Reaction (SR)	Sever	1931	1.09
	Moderate	10553	6.95
	Slight	72314	48.97
	No	63522	42.99
	<b>Total</b>	<b>148320</b>	<b>100</b>

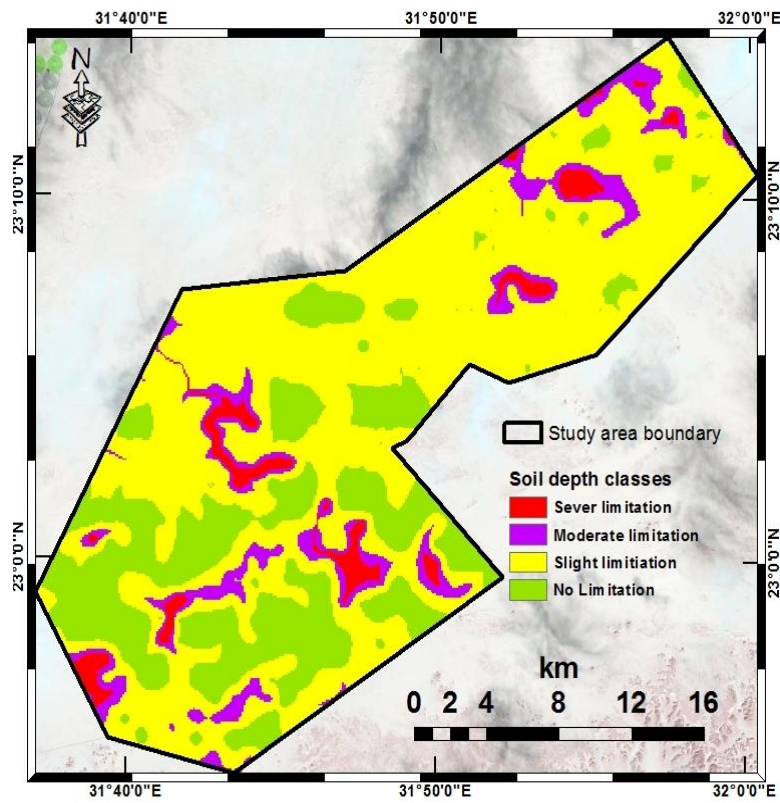


Figure6.Variability map of soil depth severity

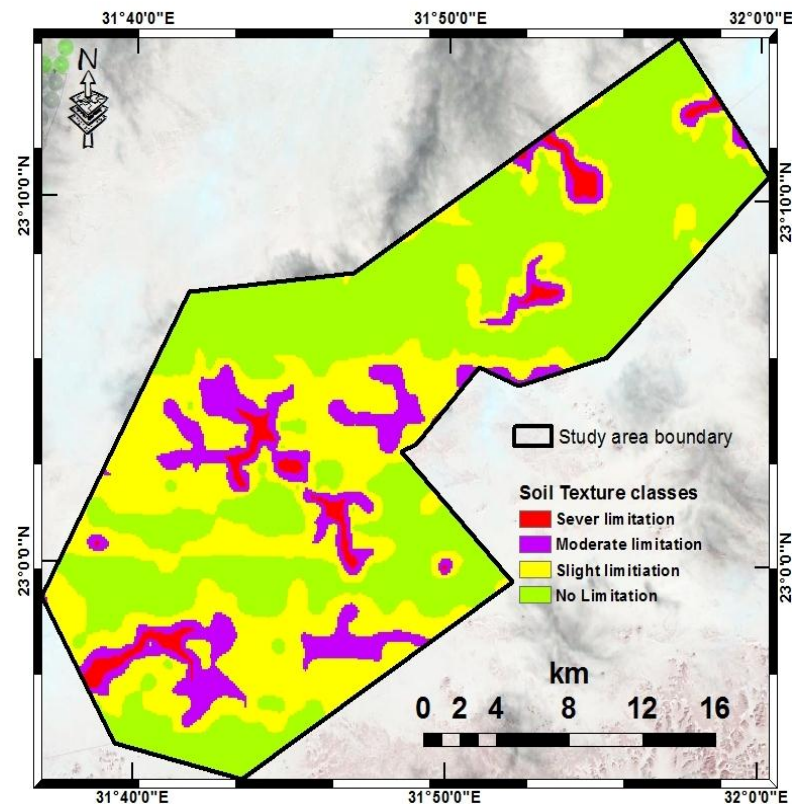


Figure7.Variability map of soil texture severity

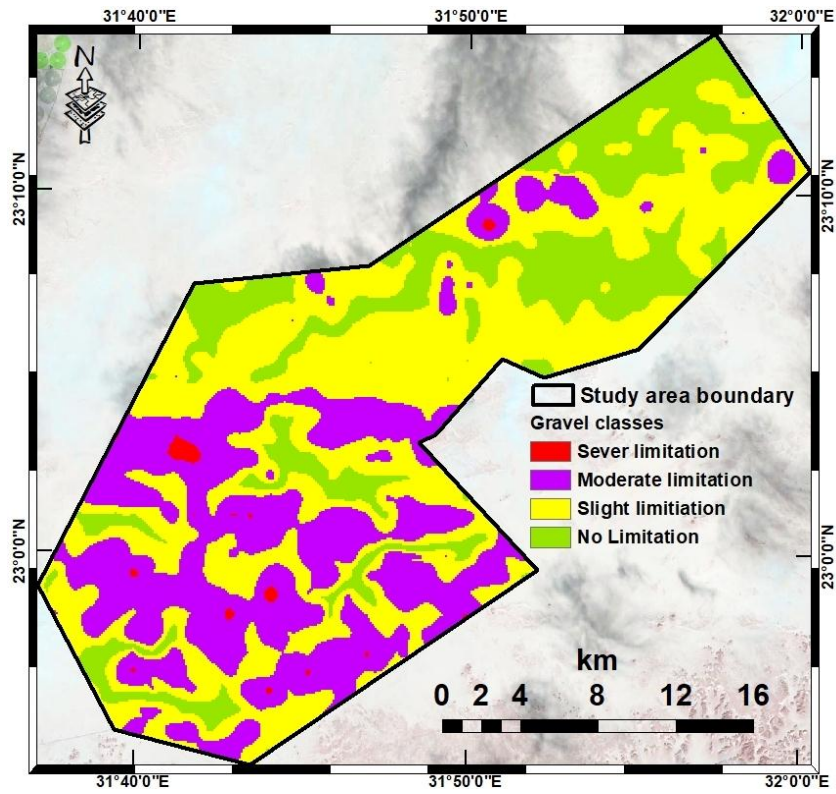


Figure 8. Variability map of soil gravels severity

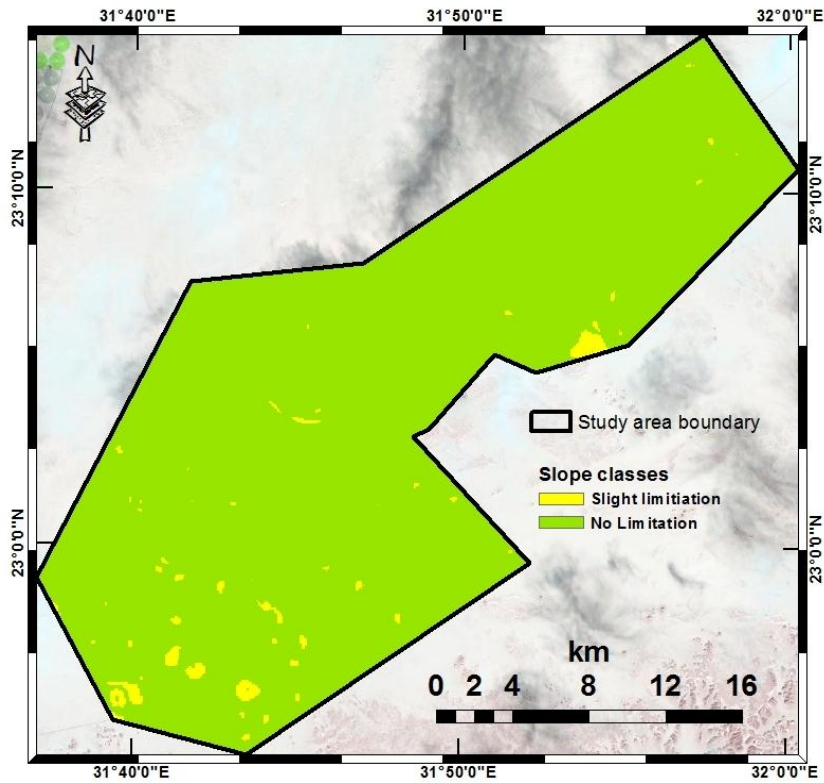


Figure 9. Variability map of soil surface slope severity



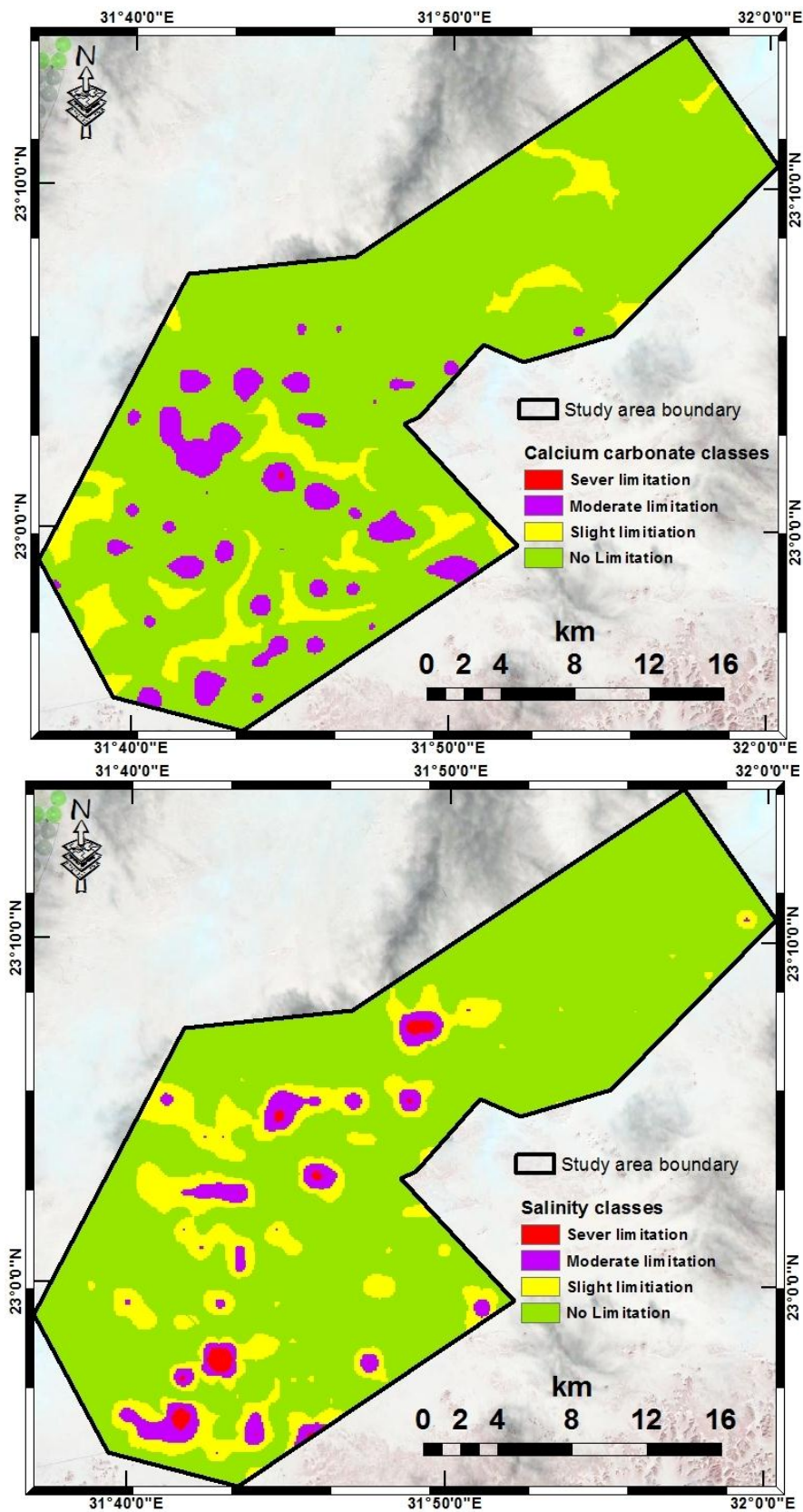


Figure11.Variability map of soil surface slope severity

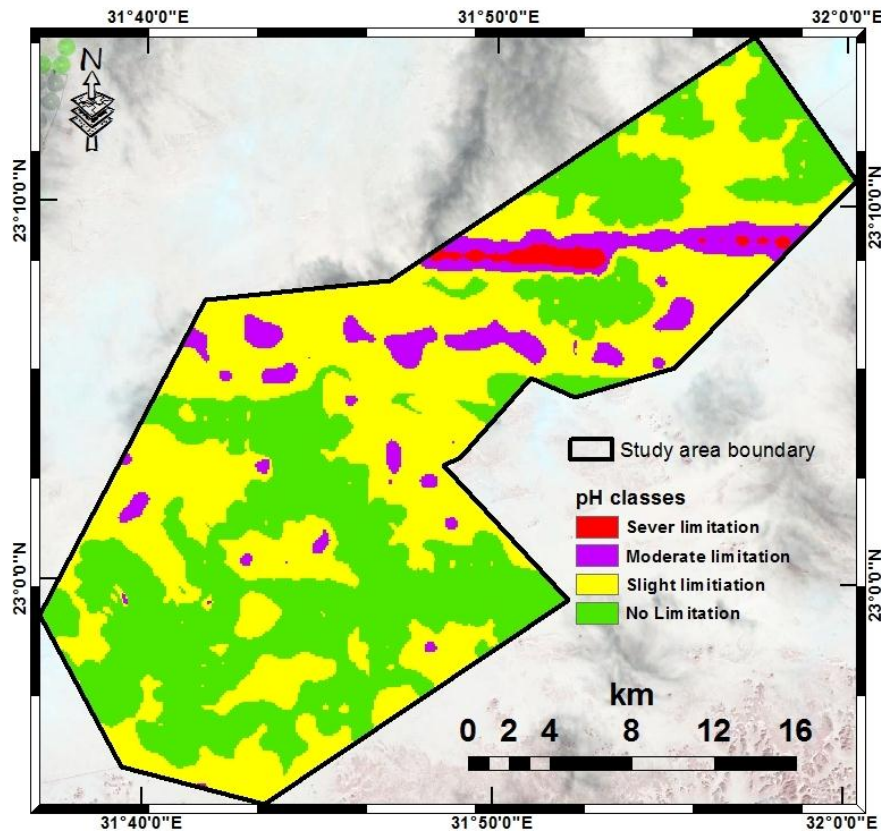


Figure 12. Variability map of soil pH severity

The thematic layers resulted from interpolation process were reclassified according to the limitation to reflect the importance or of each soil property and its effect on the potential land use as the current study. Showing the limitation that reflect the importance of each property in figures or numbers is a good and clear way for the interpretation of any phenomena. So, Table (5) present the area by feddan for each soil property based on its limitation. It is clear that the slight limitation category of soil depth (SD), soil gravel (SG) and soil reaction (SR) have gotten the wider area followed by “No limitation” except the soil gravel representing moderate limitation is the following order. On contrast, the “No limitation” of soil texture (ST), soil slope (SL), soil carbonate (SC), and soil salinity (SS) has the wider area followed by the slight limitation.

### 3- The Agricultural Potentiality Model

After categorization, all the created thematic layers by using interpolation method were incorporated with

each other in GIS environment by using the weighted overlay method using ArcGIS10.4.1 Figure (13). From the combined layers, Land Suitability Potential Index (LSPI) was delineated for agrarian purposes by gathering the classes into different suitability zones: not suitable, marginal suitable, moderately suitable, and highly suitable as shown in Table (6). Accordingly, the moderately suitable class covers the largest area (120205 feddan) representing about 81.04 % followed by the highly suitable class (13686 feddan) representing about 9.23 % and marginal suitable (13358 feddan) representing about 9.01 %, while the not suitable class recorded the lowest coverage area (1071 feddan) by about 0.72 %. By using the above mentioned model, the agriculturally-based land potential map was created and it is shown in Figure (14). The analysis shows that the study area is moderately suitable, Where, the soil depth, soil gravel, and soil reaction were the major limitation comparing with the other soil factors.



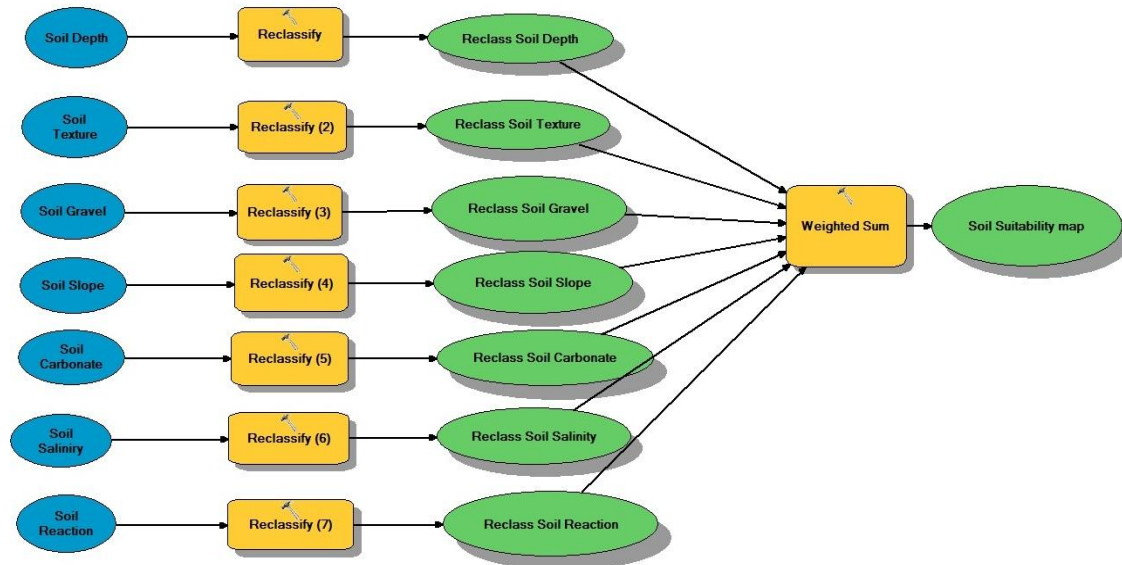


Figure 13. Schematic methodology of land suitability analysis in ArcGIS Modelbuilder

Table 6. The final agricultural potentiality and their covering area and percentage

classes	Area/ faddan	Percentage
Not suitable	1071	0.72
Marginal suitable	13358	9.01
Moderately suitable	120205	81.04
Highly suitable	13686	9.23
Total	148320	100

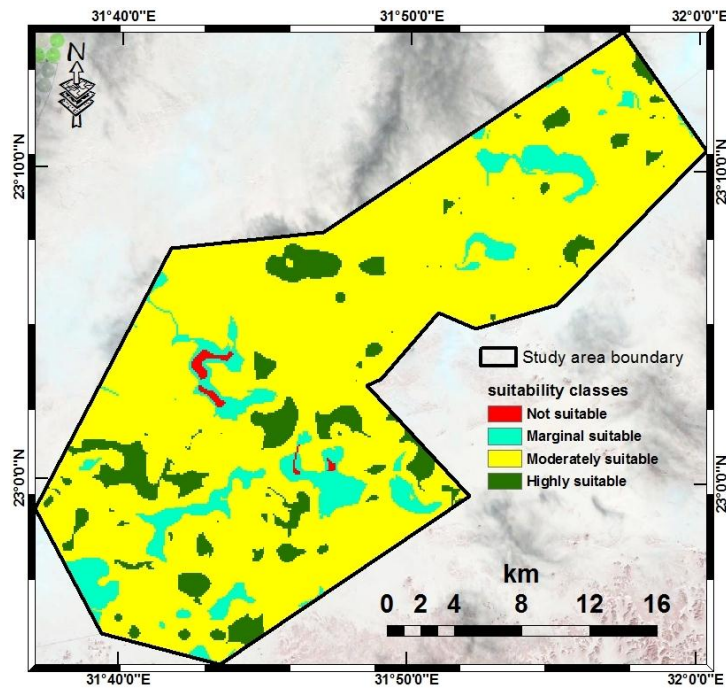


Figure 14. The agricultural potentiality map of the study area

## CONCLUSION

From the overmentioned information, estimating the land evaluation potentiality is one of the most important steps in agricultural planning. When the irrigation water is available, studying the soil characteristics, especially the most limiting factors, in detail plays a vital role in agricultural expansion. Geographical information system (GIS) provides the possibility to interpolate each soil parameter in order to assess its spatial variability. Therefore, it determines the most promising area that could be created from interpreting soil quality classes as severe, moderate, slight, or no limitation. By using the Modelbuilder toolset of GIS programme, the spatial variability of the studied soil parameters could be overlaid together to evaluate the land suitability potential based on the weight of each parameter according to the study area circumstances.

In the current study, the Land Suitability Potential Index was clearly computed as  $LSPI = 0.6 (SD) + 0.2 (ST) + 0.15 (SG) + 0.02 (SL) + 0.01 (SC) + 0.01 (SS) + 0.1 (SR)$ , where SD is soil depth, ST is soil texture, SL soil slope, SG is soil gravel, SC soil carbonate, SS is soil salinity, and SR is soil reaction. Accordingly the soil of study area is moderately suitable representing about 81.04 % of the total area, where the soil depth, soil gravel, and soil reaction were the major soil limitation.

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## الملخص العربي

### إمكانات التنمية الزراعية لبعض الأراضي بإمتداد منطقة أسوان - توشكا.

عبدالصمد عبدالستار علي الضبع و أسماء عبده شطا و محمد يحيى دراز

أساس حديثها إلي شديدة الخطورة، ومعتدلة، وطفيفة، وبلا خطورة. وبناء علي ذلك، أظهرت الدراسة أن عمق التربة و محتوى التربة من الحصى وتفاعل التربة كانت هي أهم المحداث الرئيسية بالمقارنة بعوامل التربة الأخرى. وقد تم حساب أولوية المؤشرات المحتملة لملاءمة الأراضي للأغراض الزراعية بمساهمة المعايير المذكورة أعلاه. وقد صنفت الأراضي وفقا للإمكانات إلي غير صالحة، هامشية الصلاحية، متوسطة الصلاحية، و عالية الصلاحية. وقد تحققت هذه الفئات بإجراء التوافق الموضوعي للطبقات المختلفة مع ما يقابلها من أوزان في نظام المعلومات الجغرافية (GIS). وأوضحت مخرجات الدراسة ان منطقة الدراسة يمكن وصفها أساسا بأنها متوسطة الصالحة حيث انها تغطي حوالي ٨١,٠٤ ٪ من المساحة الاجمالية، في حين أنها عالية الصالحة وهامشية الصالحة وغير صالحة حيث بلغت النسبة حوالي ٩,٢٣ ، ٩,٠١ ، و ٠,٧٢ ٪ ، علي التوالي. وخلصت الدراسة إلي انه يمكن تصنيف اي منطقة بعينها في مناطق زراعية محتملة موزعة مكانيا إستنادا إلي خصائص التربة وخصائص التضاريس و من خلال مساهمة نظم المعلومات الجغرافية.

إن الإدارة الجيدة للموارد الطبيعية المتاحة في مصر ضرورية ومطلوبة للحصول علي الإمدادات الغذائية من أجل تلبية مطالب الزيادة السريعة في عدد السكان. وعند التجهيز و البدء في تخطيط استخدام الأراضي، يعد تقدير إمكانات الأراضي الزراعية خطوه هامه في المجالات التي تكون فيها الموارد الزراعية محدوده جدا. تعتبر منطقه مفيض توشكي واحده من أكبر المناطق الواعده للتوسع الزراعي الأفقي حيث تتوفر المياه العذبة. ويتمثل الهدف الرئيسي للدراسة الحالية في وضع خريطة لأولويات الأراضي إستنادا إلي طبقات مواضيعيه مختلفه لبعض مؤشرات التربة التي تؤثر علي الإمكانات الزراعية أو تتحكم فيها عن طريق تصميم نموذج مناسب يستند إلي نظم المعلومات الجغرافية لتكامل البيانات مع الحالة المنطقية ذات الصلة بالمنطقة الواقعة علي جزء من المنطقة الممتدة من أسوان إلي توشكي. المؤشرات التي أخذتها الدراسة في الاعتبار هي الانحدار، قوام التربة، وعمق التربة، ومحتوي التربة من الحصى، و كربونات الكالسيوم، وملوحة التربة، وتفاعل التربة. وباستخدام نظام المعلومات الجغرافية، تم إستيفاء هذه المؤشرات من أجل التعرف علي تنوعها و توزيعها المكاني من خلال تمييز كل خاصية علي