Land Suitability Analysis for Crop Cultivation in A Newly Developed Area in Wadi Al-Natrun, Egypt

Osama R. Abd El-Kawy [1], Gamal M. Flous[1], Fawzy H. Abdel-Kader[1] and Ahmad S. Suliman[1]

ABSTRACT

The importance of the agriculture sector to the Egyptian economy along with the ever-increasing population emphasize the need for desert land reclamation as a vital key to narrow the food gap resulting from land degradation and the population growth. Therefore, the objective of this study is to provide the agricultural land use planning for an uncultivated land area (6539 ha) in the southwestern part of wadi Al-Natrun district, Egypt. In this research, 63 soil augers were sampled in the field based on a grid sampling strategy. The maps of soil characteristics and the soil mapping units were produced in GIS environment through the interpolation and overlaying processes. Land suitability assessment was performed using ALESarid-GIS model as a decision support system. Land suitability maps for different crops were produced. Results indicated that the soil salinity, exchangeable sodium percent, calcium carbonate content, and soil depth ranged from 0.33 to 59.1 dS/m, 1.49 to 63.58%, 0.47 to 67.1%, and 15 to 200 cm, respectively. The particle size distribution indicates the dominance of the sand to loamy sand soil texture. Eight soil mapping units were identified in the study area illustrating the spatial variability of the above mentioned soil properties. Prediction of land suitability by using ASLEarid indicated that six crops are the most suitable crops to grow in the study area. These crops are cotton, sunflower, cabbage, barley, sorghum, and watermelon. Results revealed that more than half of the study area is moderately (S2) to marginally (S3) suitable for each one of these crops. The output of this research would help decision makers plan the future desert land reclamation projects in Egypt.

Key words: Land suitability; ALESarid-GIS; land reclamation, wadi Al-Natrun.

INTRODUCTION

The agriculture sector is a key pillar for food security and employment in Egypt. It contributes significantly to the Egyptian economy since it represents about 11.5% of the GDP and 20% of the foreign exchange earnings (World Bank 2018). Additionally, it employs around 29% of the labor force (World Bank 2019; IFAD 2018). At the same time, the national agricultural production faces many challenges, either due to the continuous loss of the most fertile agricultural land by urban encroachment or as a result of soil salinization, causing a decrease in land productivity (Abd EL-Kawy et al. 2019; Hammam and Mohamed 2018; Afifi et al. 2013; Abdel Kawy and Ali 2012; Shalaby 2012; Belal and Moghanm 2011; Darwish and Abdel Kawy 2008; FAO 2005). Therefore, since the 1980s, the Egyptian governments have adopted strategies whose main objective is to narrow the food gap resulting from land degradation and the population increase, which estimated at 99.6 million in 2019 (CAPMAS 2019; MALR 2009). These strategies are based on the introduction of high-yield crop varieties and the addition of new agricultural areas through desert reclamation (MALR 2009). The Egyptian government has emphasized desert community development more than just land reclamation in order to overcome the problems of unemployment and congestion on the old agricultural lands in the Nile valley and the delta (El-Zoghby, 1999).

Establishment of a new agricultural area through desert reclamation requires deciding the best agricultural use for the new land area based on the concept of land evaluation, which refers to the process of estimating the potential of land for alternative kinds of uses (Dent and Young 1981). It is a tool for strategic decision making and a foundation for sustainable land use planning. In land evaluation, the land use planner matches land characteristics with the land use requirements, to determine the relative suitability of each land area for a specific land use. In a more operational sense, the degree of matching between the land mapping unit and the requirements of the land use is expressed by land suitability (FAO 1976). Land suitability is a prerequisite for sustainable land management and agricultural production.

A significant number of land evaluation models have been developed and computerized to provide a quantified method to match a land mapping unit with various proposed land uses, such as; the Land Evaluation Computer System, LECS (Wood and Dent, 1983), the Mediterranean Land Evaluation Information System, MicroLEIS (De la Rosa et al. 1992), the Automated Land Evaluation System, ALES (Rossiter and Van Wambeke 1997), The Land Evaluation Using an Intelligent Geographical Information System, LEIGIS (Kalogirou 2002), and The Agricultural Land

DOI: 10.21608/ASEJAIQJSAE.2019.67870
[1] Department of Soil and Water Sciences, Faculty of Agriculture, Alexandria University
Received December 01, 2019, Accepted December 27, 2019

Evaluation System for arid and semi-arid regions, ALESarid-GIS (Abd EL-Kawy et al. 2010). Despite the large number of the developed land evaluation systems, no standard model is automatically applicable to all conditions, because the biophysical conditions vary from region to region in the world (Rossiter 2003). So the land use planner must check that the context of the model matches that of the investigated area. Therefore, each one of the above mentioned systems has its own constraints for land suitability assessment. For example, the constraints of LECS are simplicity and it was developed for areas in Sumatra (Indonesia), while LEIGIS does not include climatic parameters and it is limited to five crops only (Nwer 2006). The limitation of MicroLEIS is that it is developed for land suitability assessment in the Mediterranean region only and it should only be applied in its original zone of calibration, extrapolation to other conditions is not calibrated (De la Rosa et al. 1992). MicroLEIS focus more on soil-inherent characteristics only (Wahab et al. 2013). Although the ALES system allows the land evaluators to build their own expert systems, it predicts the land suitability for major crops in tropical and subtropical regions only (Rossiter, 1990; Rossiter and Wambeke, 1997). The constraint of ALESarid-GIS is that it is dedicated for the arid and semi-arid regions only (Abd EL-Kawy et al. 2010).

The main objectives of this research are: 1) Establishment of the soil geodatabase for an uncultivated arid land area in the northwestern desert of Egypt, and 2) Assessment of land suitability for crop cultivation in this area, which would help in the planning of the intended desert land reclamation projects in the region.

MATERIALS AND METHODS

The Site Description

The study area is an uncultivated desert land, which is located in the northwestern desert of Egypt. It lies between 29.6 E and 29.7 E and 30.4 N and 30.5 N (Fig. 1). It covers an area of approximately 65.39 km^2 (6539 ha). It is accessible through two highway roads, which are Al Dabaa-wadi Al-Farag regional road and Wadi Al-Natrun-Alameen road. El Dabaa-wadi Al-Farag road was established in 2017 for the development of new areas in the northwestern desert of Egypt, such as Wadi Al-Natrun and El Moghra regions. These infrastructures give the study area a priority for land reclamation and desert development. The study area is situated in the far southwestern part of Wadi Al-Natrun district, right in the zone of El Moghara region, where the Egyptian government planned to develop a new integrated society through desert reclamation of 71400 hectares (SDS-2030 2017).

The climatic data of Wadi EI-Natrun meteorological station for the last three decades indicate that the study area is generally characterized by hot dry summer and warm rarely rainy winter. The maximum summer air temperature reaches 36.2°C in August, while the minimum air temperature is 18.6°C in September. The maximum winter air temperature is 24.3°C in March, while the minimum is 7.8°C in January. Generally, the maximum mean temperature value is 28.45°C while the minimum mean value is 13.70°C. The maximum rainfall value is recorded on December (10.5 mm), while no rainfall values were recorded in July and August. According to Shata and El-Fayoumy (1970) the study area is located in an extremely arid region.

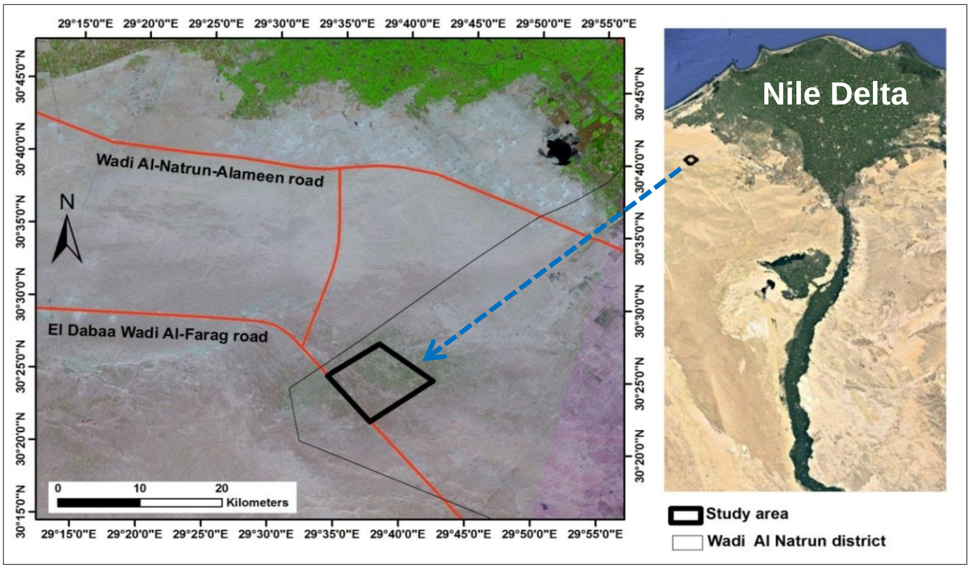

Fig 1. Location map of the study area on Google Earth (right) and Landsat 2018 image (left)

Geomorphologicaly, the study area extends over the Marmarica Tableland, which spreads towards the southwest of the northwestern coastal plains. The surface of the Tableland is covered by sand over limestone. Geologically, the study area is covered by extensive sedimentary exposures belongs to the Tertiary age (El Sheikh 2000; Gomaa, 1995). The groundwater in the study area is mainly controlled by the geological conditions, including lithology and geological structures. The main water bearing formation in the study area is El Moghra aquifer (Himida, 1970).

Field Work, Laboratory Analyses and Soil Mapping Units

The field work was carried out, during summer 2017, based on a one km-grid sampling strategy, where locations of 63 soil augers were assigned for soil sampling and georeferenced using GPS. Soil samples were collected at successive two depths (0-30 cm and 30-60 cm). The total soil depth at each location was assessed using the soil auger tool. Soil samples were laboratory analyzed with respect to the soil physical, chemical (in soil paste extracts) and fertility properties. Irrigation water samples were collected from three wells, which used for the irrigation and cultivation of newly reclaimed areas surrounding the study area. The collected soil and water samples were analyzed according to Page et al. (1982), Jackson (1973); and Richards (1954).

The laboratory results of soil samples were input into ArcGIS 10.2 (ESRI 2015) to produce the detailed soil maps of soil salinity, alkalinity, calcium carbonate and soil depth. The average weight value of each soil characteristic for the surface and subsurface soil layers was used for map production. Soil parameters with high spatial variability (i.e., a high coefficient of variance "CV%" as documented in the results' section) and high standard deviation were selected to produce the soil mapping units. These parameters represent the above mentioned maps. According to the soil survey manual (USDA 2017), the size of each soil unit and consequently the total number of units were justified based on the map scale.

Locations of ten soil profiles were identified on the resulted soil mapping units, where each soil unit was represented by one or more soil profiles to assign its soil taxonomy. Later in 2017, the identified soil profiles were dug, morphologically described in the field, sampled, laboratory analyzed, and consequently classified according to the American system of soil taxonomy (USDA 2014). In this system soil taxonomy are defined according to the morphological properties of the investigated soil profiles and the features associated with certain genetic factors such as, presence or absence of major diagnostic horizons, soil moisture and temperature regimes, parent material, soil texture, soil depth, and other specific soil physical and chemical properties.

Land Suitability Assessment

In this study, land suitability evaluation was performed using the ASLEarid-GIS model which has been developed by Abd El-Kawy et al. (2010). This system is integrated as an embedded model within the ArcGIS software package to facilitate the calculation of the suitability indices and classes for traditional crops (field crops, forage crops, vegetables and fruit trees) and provide their suitability maps. ASLEarid-GIS is based on the multi criteria analysis for predicting the geo-environmental suitability of land for cultivation of major crops in the arid and semi-arid regions. The integration of GIS and the expert system, ALSEarid, enables decision making with spatial data. ALESarid-GIS predicts crop suitability based on environmental factors at the site, such as the soil physical, chemical and fertility characteristics, the quality of water irrigation, and the potential climatic conditions (Abd EL-Kawy et al.2010). Table (1) shows the ratings used by ALESarid-GIS for land suitability assessment. The inverse distance weight as an interpolation GIS method was applied to create the land suitability maps for different crops using the suitability indices resulted from ALESarid.

Table. 1. Land suitability classes, ratings used by ALESarid-GIS (Abd Elkawy et al. 2010)

Class	Definition	Index (%)
S1	Highly suitable	80-100
S2	Moderately suitable	60-80
S3	Marginally suitable	40-60
S4	Conditionally suitable	20-40
NS1	Potentially suitable	10-20
NS2	Actually unsuitable	< 10

RESULTS AND DISCUSSION

Soil Characterization and Mapping

The descriptive statistics of the measured soil chemical and physical properties are listed in Table (2). Results of soil analyses indicated that soil salinity (EC) ranged from 0.33 to 59.1 dS/m with a mean value of 15.3 dS/m and a high coefficient of variance (CV= 103.18%). The total calcium carbonate content in the soil varied between 0.47% and 67.1% with a mean value of 10.43% and a high variability (CV=120.88 %). The exchangeable sodium percentage (ESP) ranged from 1.49 to 63.58% with high variations (CV=74.09 %) and a mean value of 21.67%. The soil depth of the investigated locations varied from 15 cm to 200 cm with an average value of 107.92 cm. The variability among the soil depth values was high (CV=75.8%). The results of the particle size distribution indicated that the soil samples are dominated by sand particles (64.93% - 98.95%), which reflect the dominant sand to loamy sand soil texture.

The spatial distribution of soil salinity (Fig 2) revealed that about 17% of the study area is characterized by low levels of soil salinity “non to slightly saline” (EC < 4 dS/m) and 37.4% is considered moderately saline (4 dS/m < EC < 8 dS/m). These levels of salinity (EC < 8 dS/m) mostly extend in the South part of the study area. The strongly saline soil (EC > 8 dS/m) is generally found in the North part of the area. On the other hand, more than half of the study area (51.5%) is considered a non-alkaline soil (ESP <15%), which mainly concentrates in the South and eastern parts of the study area (Fig 2).

About 39% of the study area is non to weakly calcareous soil ($CaCO_3$ < 10%), which occupies the South and southwestern parts (Fig 3). Approximately, 35 % of the area is calcareous soil (10 % < $CaCO_3$ < 15%) and 26% is very to extremely calcareous soil ($CaCO_3$ > 15%), these high levels of soil calcium carbonate content are distributed in the middle and North parts of the study area. For soil depth, the deep to very deep soil (soil depth > 100 cm) represents 52% of the area and generally concentrates in the Southern part of the study area. The soil depth less than 100 cm (very shallow, shallow, and moderately deep soil) mostly occupies the North and middle parts. It is clearly obvious that the south part of the study area is characterized by the low levels of soil salinity, alkalinity, and calcium carbonate content as well as the deepest soil.

Eight soil mapping units were identified in the study area, which summarized and depicted in Table (3) and Figure (4). Four soil parameters were used together to identify the soil mapping units, which are soil salinity, soil alkalinity, soil depth, and soil calcium carbonate content. These parameters are characterized by their high spatial variability (CV% > 74%). Although the CV values of clay and silt percent were high (Table 2), these parameters were not included in the production of the soil mapping units because the prevailing soil texture of all samples is “sand” to “loamy sand”. Results of soil mapping units (SMU) indicated that the largest units are SMU1 (25%), SMU4 (19%), SMU6 (14%), SMU7 (14%) and they all together represent more than two thirds (72%) of the study area (Table 3).

Table 2. Descriptive statistics of some soil chemical and physical properties

Statistical Parameters	pH	EC (dS/m)	$CaCO_3$ %	ESP	Soil depth (cm)	Clay %	Silt %	Sand %
Mean	7.88	15.30	10.43	21.67	107.92	5.58	4.83	89.59
Standard Deviation	0.36	15.79	12.61	16.06	81.80	4.01	3.76	7.08
Minimum	6.84	0.33	0.47	1.49	15.00	0.00	0.46	64.93
Maximum	8.85	59.10	67.10	63.58	200.00	17.76	20.31	98.95
CV%	4.61	103.18	120.88	74.09	75.80	71.75	77.91	7.90

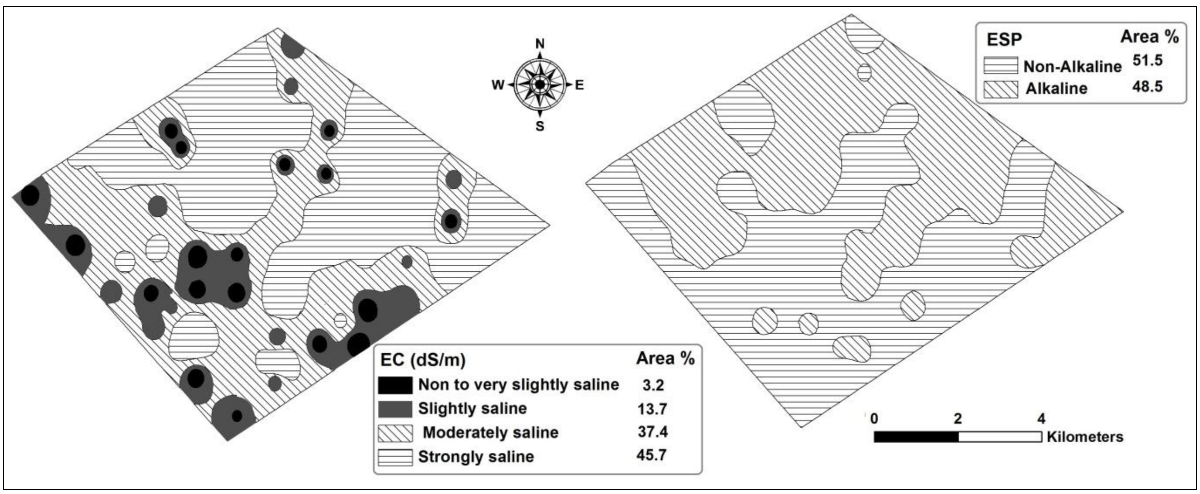

Fig 2. The spatial distribution of soil salinity (EC) and alkalinity (ESP) in the study area

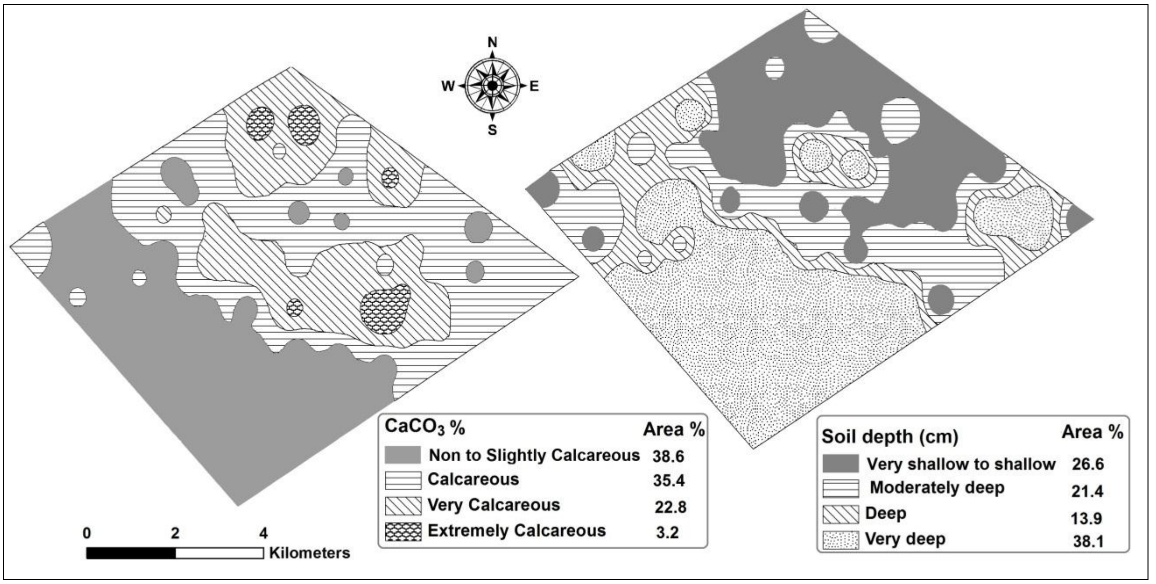

Fig 3. The spatial distribution of soil calcium carbonate and soil depth in the study area

Table 3. The soil mapping units (SMU) in the study area and their area percent (%)

Code	Soil Mapping Units (SUM)	Area %
SMU1	Non to slightly saline, moderately to very deep, Non alkaline, Weakly to moderately calcareous	25
SMU2	Moderately saline, Moderately to very deep, Non alkaline, Strongly to extremely calcareous	2
SMU3	Moderately saline, Very shallow to shallow, Alkaline, Weakly to moderately calcareous	8
SMU4	Moderately saline, Moderately to very deep, Alkaline, Weakly to moderately calcareous	19
SMU5	Strongly to extremely saline, Moderately to very deep, Alkaline, Weakly to moderately calcareous	12
SMU6	Strongly to extremely saline, Moderately to very deep, Alkaline, Strongly to extremely calcareous	14
SMU7	Strongly to extremely saline, Very shallow to shallow, Alkaline, Weakly to moderately calcareous	14
SMU8	Strongly to extremely saline, Very shallow to shallow, Alkaline, Strongly to extremely calcareous	6

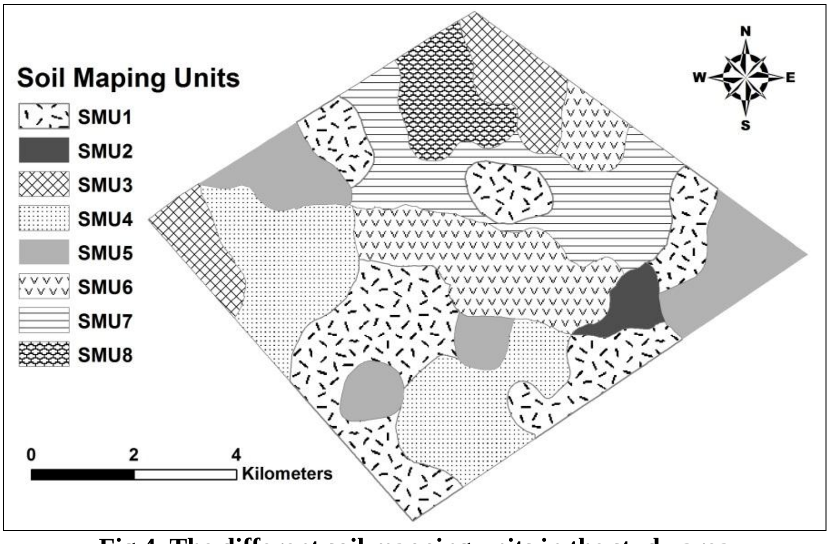

Fig 4. The different soil mapping units in the study area

According to the American system of soil taxonomy (USDA 2014), the investigated soil is weakly developed due to the prevailing dry climatic conditions. The only observed diagnostic horizons are *Calcic horizon*, *Salic horizon* and *Ochric epipedon*. Accordingly, the soil in the study area could be classified into four subgroups, which are *Lithic Torripsamment* (SMU3 and SMU7), *Typic Torripsamments* (SMU1, SMU4, SMU5, and SMU6), *Duric Haplocalcids* (SMU2), *and Duric Haplosalids* (SMU8).

Analyses of the available water resources in the region of the study area revealed that water salinity varied from 3.41 dS/m to 3.92 dS/m with an average value of 3.59 dS/m, which considered slightly to moderately saline. The average pH value of water irrigation was 7.32. The concentrations of soluble sodium and chloride had average values of 30.32 meq/L and 31.83 meq/L, respectively, which considered high for sensitive crops.

Assessment of Land Suitability

By using ASLEarid-GIS as a decision support system, the agricultural land suitability assessment was performed based on the dominant land (soil, water, and climate) characteristics that limit the land suitability for crop cultivation. The area percentage of the land suitability classes for each crop is presented in Table (4). Land suitability was assessed for twenty three crops, which could be classified into three categories A, B, and C.

Discrimination among these categories was based on the area percentage of the land suitability classes. For the twenty three crops, it was obvious that the land suitability class S1 (highly suitable) was not predicted in the study area. This may be due to the harsh environmental (soil, water, and climate) conditions of such uncultivated area of the desert.

Category A involves the most six suitable crops that would be grown in the study area. The (S2+S3) class for each crop in this category is represented by more than 50% of the study area. This means that more than half of the study area is moderately (S2) to marginally (S3) suitable for all the crops, where (S2+S3) classes presents about 60%, 58%, 58%, 53%, 52% and 51% of the study area for cotton, sunflower, cabbage, barley, sorghum, and watermelon, respectively. It was clear that the land suitability classes NS1 (Potentially suitable) and NS2 (Actually unsuitable) were not predicted in category A.

The spatial extent of the land suitability classes for the most suitable crop (category A) is displayed in Figures (5, 6 and 7).

Table 4. The area percentage of the land suitability classes for different crops

Category	Crops	Area (%)						S2+S3	NS1+NS2
		S1	S2	S3	S4	NS1	NS2	(Area %)	(Area %)
A	Cotton	--	7.75	52.41	39.84	--	--	60.16	--
	Sunflower	--	5.04	53.17	41.79	--	--	58.21	--
	Cabbage	--	3.71	53.98	42.31	--	--	57.69	--
	Barley	--	0.34	52.67	47.00	--	--	53.00	--
	Sorghum	--	5.83	46.64	47.53	--	--	52.46	--
	Watermelon	--	6.80	43.81	49.39	--	--	50.61	--
B	Wheat	--	0.27	43.82	55.91	--	--	44.09	--
	Alfalfa	--	0.26	38.67	61.07	--	--	38.93	--
	Maize	--	2.18	33.53	64.03	0.26	--	35.71	0.26
	Pepper	--	0.48	31.49	67.61	0.42	--	31.97	0.42
	Potato	--	8.97	17.93	36.89	36.21	--	26.90	36.21
	Faba bean	--	0.50	20.47	77.31	1.73	--	20.97	1.73
	Sugar beet	--	0.18	20.75	79.07	--	--	20.93	0.00
	Soya bean	--	0.47	15.50	79.03	5.01	--	15.96	5.01
	Peanut	--	--	10.49	73.32	16.19	--	10.49	16.19
	Onion	--	--	2.79	95.83	1.37	--	2.79	1.37
C	Grape	--	--	6.73	40.00	25.78	27.50	6.73	53.27
	Date Palm	--	1.27	11.60	29.34	15.33	42.46	12.86	57.79
	Apple	--	0.77	12.16	27.82	15.60	43.66	12.92	59.26
	Olive	--	1.68	10.85	28.22	16.71	42.55	12.53	59.26
	Fig	--	1.26	10.36	28.42	16.79	43.17	11.62	59.96
	Banana	--	0.17	9.08	29.29	16.15	45.31	9.25	61.46
	Pea	--	--	1.10	34.89	63.77	0.25	1.10	64.02

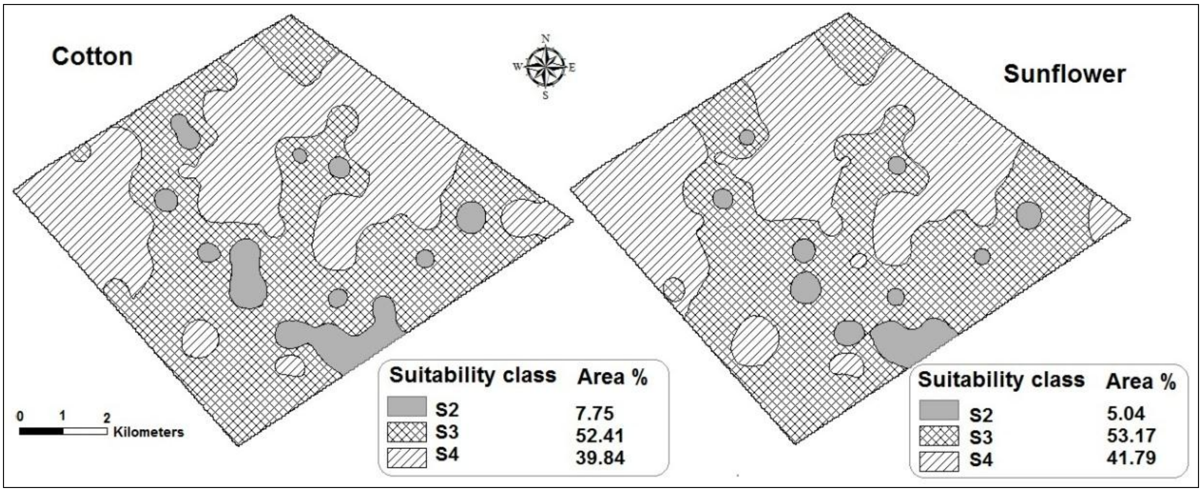

Fig 5. The spatial extent of the predicted land suitability classes for cotton and sunflower

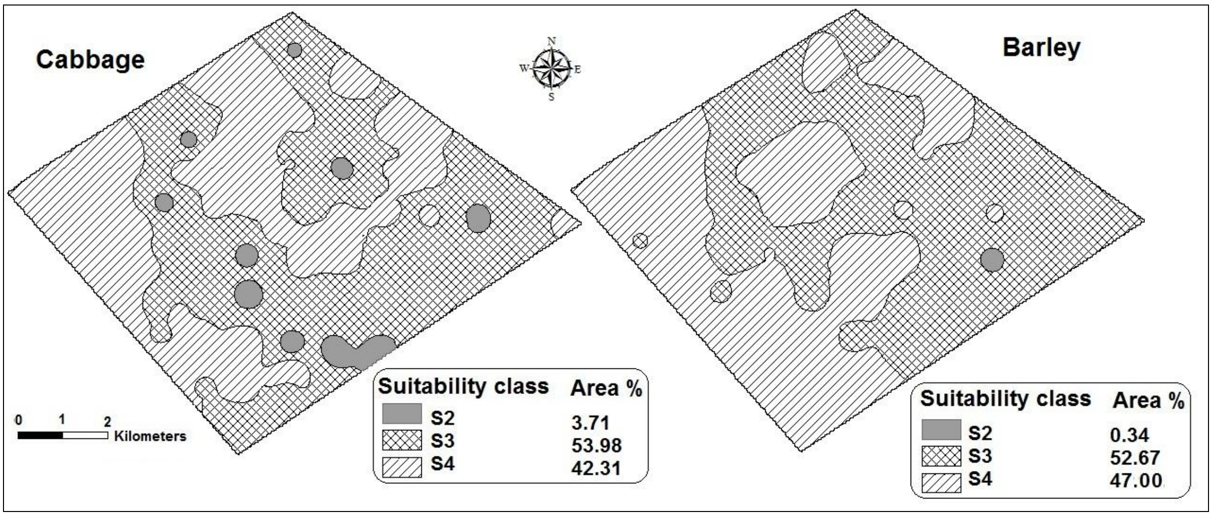

Fig 6. The spatial extent of the predicted land suitability classes for cabbage and barley

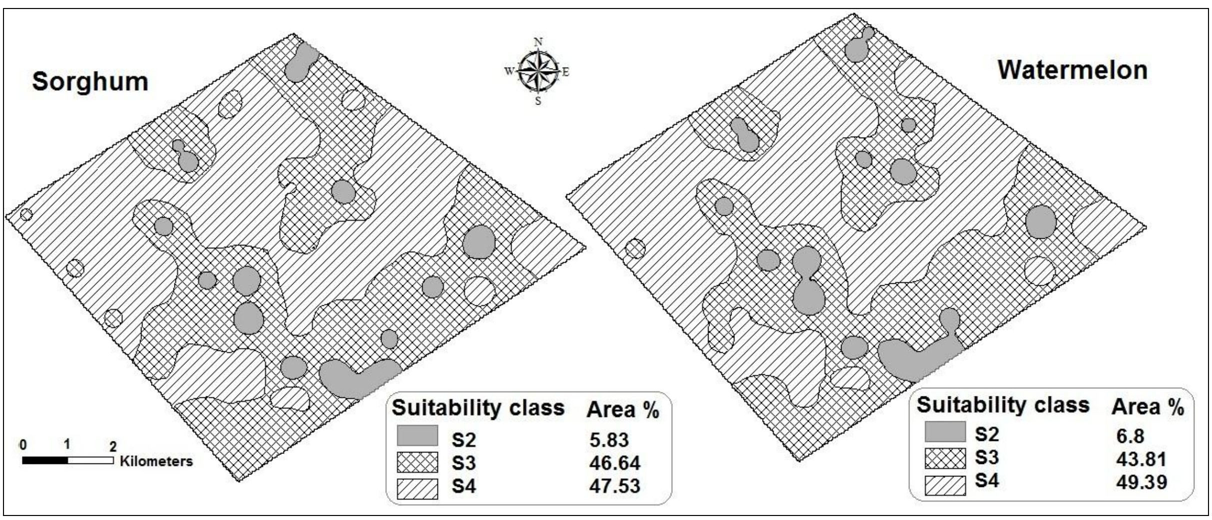

Fig 7. The spatial extent of the predicted land suitability classes for sorghum and watermelon

For category B, although there is a remarkable area percentage of the (S2+S3) class for the most crops, this percentage does not exceed 50% of the study area for all the crops. The crops of category B can be arranged based on the approximate area percentage of the (S2+S3) class as follows: wheat (44%), alfalfa (39%), maize (36%), pepper (32%), potato (27%), faba bean (21%), sugar beet (21%), soya bean (16%), peanut (10%), and onion (3%). The main limiting parameters for category A and B crops are the sand texture, soil salinity, soil permeability, and the sodium exchangeable percent.

Category C involves crops those area percentage of the land suitability classes (NS1+ NS2) represent more than 50% of the study area. It was clear that all of the fruit trees are listed in this category, where the shallow soil depth is the dominant limiting factor. Other limiting factors include the sand texture, soil salinity, soil permeability, and the sodium exchangeable percent.

CONCLUSION

In this research a soil geodatabase was established for land use planning of a newly developed area in wadi Al-Natrun, northwestern desert of Egypt. The harsh environmental conditions in the region of the study area, such as the extremely arid climate, resulted in high soil salinity and alkalinity levels, high calcium carbonate content and high variability in the soil depth. Since, only about 17% of the study area is characterized by low levels of soil salinity (EC < 4 dS/m) and the remaining area (about 83%) is characterized by the moderate to high levels of soil salinity (EC > 4 dS/m and up to 59 dS/m). At the same time, more than half of the study area (about 52%) is considered a non-alkaline soil (ESP <15%) and 61% is calcareous to extremely calcareous soil ($CaCO_3$% > 10% and up to 67.1%). The deep to very deep soil (soil depth > 100 cm) represents 52% of the study area and the remaining area is very shallow to moderately deep soil (< 100 cm). The dominant soil texture is sand to loamy sand. Eight soil mapping units were identified and mapped in the study area based on soil salinity, soil alkalinity, soil calcium carbonate content, and soil depth. The soils in the study area belong to four subgroups, which are *Lithic Torripsamment, Typic Torripsamments, Duric Haplocalcids, and Duric Haplosalids.* Analyses of the available water resources in the region of the study area indicate the slight to moderate levels of water salinity (average EC = 3.59 dS/m).

The use of the GIS integrated land suitability analysis systems, such as ALISarid-GIS, helped in the assessment and mapping of land suitability for crop cultivation in the study area. Land suitability analysis by ALISarid-GIS indicated that six crops are considered the most suitable to grow in the study area. The land suitability class S1 (highly suitable) was not predicted for any crop in the study area. About 60%, 58%, 58%, 53%, 52% and 51% of the study area is moderately to marginally suitable for cotton, sunflower, cabbage, barley, sorghum, and watermelon, respectively. On the other hand, the land suitability for crop cultivation such as, wheat, alfalfa, maize, pepper, potato, faba bean, sugar beet, soya bean, peanut, and onion is considered moderately to marginally suitable for about 44%, 39%, 36%, 32%, 27%, 21%, 21%, 16%, 10%, and 3% of the study area, respectively. The land suitability for all fruit trees is considered potentially suitable to actually unsuitable for more than 50% of the study area, this mainly was due to the shallow soil depth.

The main limiting parameters for crop cultivation are the sand texture, soil salinity, soil permeability, and the sodium exchangeable percent. The shallow soil depth is the dominant limiting factor for growing fruit trees.

REFRENCES

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

Abd EL-Kawy, O.R., H. A. Ismail, H. M. Yehia and M. A. Allam. 2019. Temporal detection and prediction of agricultural land consumption by urbanization using remote sensing. The Egyptian Jour. of Remote Sensing andSpaceSci.https://www.sciencedirect.com/science/article/pii/S1110982318304757

Abdel Kawy, W. A. and R.R. Ali. 2012. Assessment of soil degradation and resilience at northeast Nile Delta, Egypt: The impact on soil productivity. The Egyptian Jour. of Remote Sensing and Space Sci. 15, 19–30

Afifi, A.A., M.A. Elsemary and M.A. Wahab. 2013. Urban sprawl of greater Cairo and its impact on the agricultural land using remote sensing and digital soil map. Jour. Appl. Sci. Res. 9 (8): 5159–5167.

Belal, A.A.and F.S. Moghanm, 2011. Detecting urban growth using remote sensing and GIS Techniques in Al Gharbiya Governorate, Egypt. Egypt. Jour. Remote Sens. Space Sci. 14: 73–79.

CAPMAS. 2019. Central Agency for Public Mobilization and Statistics (CAPMAS). https://www.capmas.gov.eg

Darwish, Kh. and W. A. Abde l Kawy. 2008. Quantitative Assessment of Soil Degradation in some Areas North Nile Delta, Egypt. International Jour. of Geology. 2(2): 17-22.

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

Dent, D. and A.Young. 1981. Soil survey and land evaluation. London, Allen and Unwin. 278 pp.

El Sheikh A.R. 2000. Hydrogeological of the Area North and west of Wadi El Natrun. M.Sc. Thesis, Faculty of Sci., Minufiya University, Cairo, Egypt.

El-Zoghby, S.M. 1999 Sustainable planning of desert land reclamation projects in Egypt as related to drought management: an integrated strategy. Paper presented at the International Conference on Integrated Drought Management, arranged by UNESCO. 20-22 September. Pretoria, South Africa.

ESRI. 2015. Environmental Systems Research Institute. What's new in ArcGIS 10.3.1 for Desktop. http://desktop.arcgis.com/en/arcmap/10.3/main/get-started/whats-new-in-arcgis-1031.htm

FAO .1976. A framework for land evaluation. Soils Bulletin 26. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

FAO .2005. Salinization and drainage in the Nile Delta. Food and and Agriculture Organization. Irrigation in Africa in figures: AQUASTAT Survey.

http://www.fao.org/nr/water/aquastat/countries_regions/africa/box.pdf

Gomaa, M.A.A. 1995. Comparative Hydrological and Hydrogeochemical Study on some aquifers, West of Nile Delta, Egypt. Ph.D. Thesis, Ain Shams University.

Hammam, A.A. and E. S. Mohamed. 2018. Mapping soil salinity in the East Nile Delta using several methodological approaches of salinity assessment. The Egyptian Jour. of Remote Sensing and Space Sci. (in press) https:// www.sciencedirect.com/ science/article/pii/ S1110982318301339

Himida, I. H. 1970. The Nubian Artesian Basin, its Regional, Hydrogeological Aspects, Paleohydrogeological Reconstruction. Jour. of Hydrology. 9: 89-116.

IFAD. 2018. Middle East and North Africa An Agricultural Policy Review of Egypt. https://www. ifad.org/ documents/38714174/41131195/An+agricultural+policy+review+of+Egypt+First+steps+towards+a+new+strategy.pdf/44178715-9244-8497-bd74-1d5d84ecb9c8

Jackson, M.L. 1973. Soil chemical analysis. Advanced course Ed.2. A Manual of methods useful for instruction and research in soil chemistry, physical chemistry of soil, soil fertility and soil genesis. Revised from Original Edition .1958.

Kalogirou, S. 2002. Expert systems and GIS: an application of land suitability evaluation . Computers, Environment and Urban Systems, Vol. 26 (2-3): 89-112.

MALR 2009. Ministry of Agriculture and Land Reclamation. Sustainable Agricultural Development Strategy towards 2030.ARE.http://farmalr.gov.eg/pdf/en/Full%20SADS2030.pdf

Nwer, B.A.B. 2006. The Application of Land Evaluation Technique in the North-East of Libya. Faculty of Environment. Cranfield University, Silsoe

Page, A. L., R. H. Miller and R. Keeny. 1982. "Methods of soil analysis. Part2. Chemical and microbiological properties. Agron. Monograph No. 9, ASA, Madison, WI, USA.

Richards, R.L. (ed.). 1954. Diagnosis and improvement of saline and alkaline soils. Agriculture Handbook No. 60, U.S Govt. Printing Office, Washington, USA.

Rossiter, D.G. 1990. ALES: a framework for land evaluation using a microcomputer. Soil Use & Management .6: 7–20.

Rossiter, D. G. 2003. Biophysical models in land evaluation. Article 1.5.27 in Theme 1.5 *Land Use and Land Cover*, .Verheye, W.H. (ed.), in *Encyclopedia of Life Support Systems (EOLSS)*, developed under the auspices of the UNESCO. Oxford: EOLSS Publishers. http://www.eolss.net

Rossiter, D.G. and A.R. Van Wambeke. 1997. ALES version 4.65 users manual. Cornell University, Ithaca, NY, USA. 280p.http://www.itc.nl/personal/rossiter/Docs/ALES_V4.65_Manual.pdf

SDS- 2030. 2017. The Sustainable Development Strategy: Egypt's Vision 2030. https://planipolis.iiep.unesco.org/sites/planipolis/files/ressources/egypt_vision_2030.pdf

Shalaby, A. 2012. Assessment of urban sprawl impact on the agricultural land in the Nile Delta of Egypt using remote sensing and digital soil map. Int. Jour. Environ. Sci. 1 (4): 253–262.

Shata, A. A. and I. F. El Fayoumy. 1970. Remarks on The Regional Geological Structure of The Nile Delta. Sympos. Hydrology of Deltas, UNESC. I: 189 – 197.

USDA. 2017. United States Department of Agriculture. Soil Survey Manual. Washington, D.C.

USDA. 2014. United States Department of Agriculture. Keys to Soil Taxonomy. Twelfth Edition. Washington, D.C.

Wahab, M.A., M.A. El Semary, R.R. Ali and Kh. M. Darwish. 2013. Land Resources Assessment for Agricultural Use in Some Areas West of Nile Valley, Egypt. Jour. of Applied Sci. Research. 9(7): 4288-4298.

Wood, D.R. and F.J. Dent. 1983. LECS: A land evaluation computer system. Manual 5: Methodology. Ministry of Agriculture, Bogor, Indonesia.

World Bank. 2018. World Bank Data: Agriculture, forestry, and fishing, value added (% of GDP). https://data.worldbank.org/indicator/ NV.AGR.TOTL.ZS?locations=EG

World Bank. 2019. World Bank Data: Employment in agriculture (% of total employment) (modeledLOestimate),https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=EG.

الملخص العربي

تقييم مدى ملائمة التربة للزراعة بالمحاصيل المختلفة بمنطقة تحت التنمية بمركز وادى النطرون، مصر

أسامة راضى عبد القوى، جمال مصطفى فلوس، فوزى حسن عبد القادر، أحمد سعيد سليمان

يعتبر القطاع الزراعى فى مصر أحد أعمدة الاقتصاد المحلى، وفى ضوء الزيادة السكانية المستمرة الى جانب نقص الارضى المزروعة سواء بالبناء عليها اونتيجة لتدهورها بسبب تملح التربة، تزداد الحاجة الى اضافة أراضى زراعية جديدة عن طريق استصلاح واستزراع الصحراء. لذلك، تهدف هذه الدراسة إلى التخطيط الزراعى لأرض غير مزروعة بمركز وادى النطرون بمصر، عن طريق اقتراح افضل المحاصيل ملائمة للزراعة بمنطقة الدراسة. خلال الحصر الميدانى تم تجميع عينات التربة من ٦٣ جسة اوجر استنادًا إلى الأستراتيجية الشبكية المنتظمة لاخـذ العينات. تم إنتاج الخرائط التفصيلية للتربة وكـذلك خريطة وحدات التربة باستخدام برامج نظم المعلومات الجغرافية. تم تقييم مدى ملائمة الأراضي للزراعة بالمحاصيل المختلفة باستخدام برنامج ALESarid-GIS كأحد أنظمة دعم أتخاذ القرار. تم إنتاج خرائط ملائمة الأراض للزراعة بمختلف المحاصيل. أوضحت النتائج وجود تباين ملحوظ فى قيم ملوحة التربة (٠,٣٣ – ٥٩,١ ديسيسمنز/م) ونسبة الصوديوم المتبادل (١,٤٩ إلى ٦٣,٥٨٪) ومحتوى التربة من كربونات الكالسيوم (٠,٤٧ إلى ٦٧,١%) وعمق التربة (١٥ إلى ٢٠٠ سم). كما أوضحت نتائج التوزيع الحجمى لحبيبات التربة سيادة القوام الرملى والقوام الرملى اللومى. تم تحديد ثمانية عشر وحدة أرضية بمنطقة الدراسة تظهر مدى التباين المكانى فى خصائص التربة. أيضا أوضحت نتائج ملائمة التربة للاستخدام الزراعى أن ستة محاصيل هي الأنسب للزراعة بمنطقة الدراسة. هذه المحاصيل هي القطن وعباد الشمس والكرنب والشعير والسورجم والبطيخ، حسب الترتيب الموضح. أيضا أظهرت النتائج أن أكثر من نصف مساحة الدراسة تعتبر متوسطة الملائمة (S2) إلى هامشية الملائمة (S3) بالنسبة للمحاصيل سالفة الـذكر. يمكن الاستناد الى نتائج هـذا البحث في اتخاذ القرارات المتعلقة بالتخطيط الزراعى لمنطقة الدراسة وكـذلك المشاريع المستقبلية لاستصلاح الأراضي بشمال الصحراء الغربية بمصر.