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"Use of Spatial Analyses Techniques in the Assessment of Soil Capability for Agricultural Use in Wadi El Natrun, Egypt

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Abstract: The main objective of soil capability assessment for agriculture is to predict future conditions after development has taken place. It is necessary to forecast the benefits to farmers and the national economy and whether these will be sustained. The current study deals with spatial analyses techniques to evaluate the agricultural land capability in Wadi El Natrun Depression. The land surveying data, Digital Elevation Model (DEM) and satellite image were used in a Geographic Information System (GIS) to delineate the landforms of the area. The attribute data of erodability, surface slope, $CaCO_3$ content, texture class, soil depth, salinity, alkalinity and drainage condition were linked with the landform units of the area. The thematic layers of the attribute data were created in Arc-GIS 9.2 software using the spatial analyses function, and then these layers were matched together to produce the soil capability map. The results indicate that the soils of very high, high, moderate, low and very low capability classes for agriculture represent 3.92, 4.96, 34.87, 26.25 and 30.00 % of the depression respectively. The low capability classes in the area are mainly due to the shallow soil depth, poor drainage and the salts accumulation. Therefore, action measures of land management are essential for sustaining the agricultural land uses in this area.

Key words: Soil capability, landforms, GIS, spatial analyses, Wadi El Natrun.

INTRODUCTION

Wadi El-Natroun is a narrow depression located in the west of the Nile Delta, approximately 110 km northwest of Cairo between longitudes, 30º 02´ and 30º 29´ E and latitudes, 30º 16´ and 30º 32´ N (fig. 1). The total area of Wadi El Natrun is about 281.7 Km2 (i.e. 67608 feddans), extended in a NW-SE direction and 23 m below sea level. This area has always been confined as a possible area for reclamation and utilization due to its location and the presence of ground water in a suitable quality for irrigation. The origin of the underground water in Wadi El-Natroun is seepage from the Nile stream, due to its proximity and low level [1]. Most of the newly developed lands in the 1960s (420000 ha) were situated along the fringes of the Nile Delta. The West Delta region received the highest share of the land reclamation program (170000 ha). By the year 1997 the total cultivated area in the West Delta fringes reaches to 445200 ha [2]. Wadi El Natrun area considered as an extremely arid region where the mean annual rainfall, evaporation and temperature are 41.4 mm, 114.3 mm and 21ºC respectively [3].

Land evaluation is a vital link in the chain leading to sustainable management of land resources. It is assigned the indispensable task of translating the data on land resources into terms and categories, which can be understood and used by all those concerned with land improvement and land use planning. The different types and procedures in land evaluation are gradually being developed. Interpreting soil qualities (LQ) and site information for the agricultural use and management practices is integrated using geographical information system [4,5].The land quality (LQ) is a complex attribute of land which acts in a manner distinct from the actions of other land qualities in its influence on the suitability of land for a specified kind of use FAO, [6]; it is the ability of the land to fulfill specific requirements for the land utilization type (LUT) [7].

The spatial analysis was used in this study, it can be defined as the analytical techniques associated with the study of locations of geographic phenomena together with their spatial dimensions and their associated attributes [8]. Spatial analysis is useful for evaluating suitability, for estimating and predicting, and for interpreting and understanding the location and distribution of geographic features and phenomena. The use of spatial analyses techniques in evaluating the land capability, allow producing multi-thematic maps and outlining the limiting factors, accordingly suitable suggestions could be attained to understanding how to deal with these soils for sustainable agricultural use.

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MATERIALS AND METHODS

Digital Elevation Model (DEM) of the study area has been generated from the vector contour lines (Fig. 2); Arc- GIS 9.0 software was used for this function. Landsat ETM+ images and Digital Elevation Model (DEM) were grouped and processed in ERDAS Imagine 8.7 software to define the different landforms of the studied area [9,10]. The extracted of data generates a preliminary geomorphologic map which was checked and completed through field observation. A semi detailed survey was done throughout the investigated area in order to gain an appreciation on the soil patterns, the land forms and characteristic landscape. A number of 12 soil profiles (Fig. 3) were taken to represent different mapping units; the morphological description of these profiles was carried out according to the guidelines edited by FAO [11]. Representative disturbed soil samples have been collected and analyzed using the soil survey laboratory methods manual [12]. The obtained data were imported in a GIS database; the digital geomorphologic map was used as base map in the database. The spatial analyses function in ArcGIS 9.0 was used to create the thematic layers of Erodability, surface slope, CaCO3 content, texture class, soil depth, salinity, alkalinity and drainage condition. The thematic layers were matched to produce the soil capability map; the land capability classes were defined using the rating and procedure after [5,6].

RESULTS AND DISCUSSION

Base Map: The landforms of the studied area were delineated by using the digital elevation model, Landsat ETM+ and ground truth data of the studied area. The produced map, represents the landforms of the studied area, was imported in a Geo-database and considered as a base map (Fig., 4). The obtained data reveals that the main landforms in the depression are low elevated almost flat sand sheet (6.82 %), high elevated gently undulating sand sheet (30.31%), high elevated almost flat sand sheet (4.95 %), low elevated undulating sand sheet (17.31 %), high elevated undulating sand sheet (13.13 %), undulating sandy gravel plain (20.23 %) and wet sabkha (7.26 %).

Thematic Layers: The attribute data of surface slope, CaCO3 content, texture class, soil depth, salinity, alkalinity and drainage condition (Table 1) were compiled into the units of the digital geomorphologic map in a geographic information system. The incorporated attributes were used to obtain the thematic layers of spatial distribution of the above mentioned characteristics as shown in figures 5-10. The produced layers include information on the rating value, capability sub class, and distribution for each soil characteristics. The obtained data from the thematic layers indicate that the soils of low elevated almost flat sand sheet having no limiting factors, except some areas which have a slight limitation due to soil salinity.

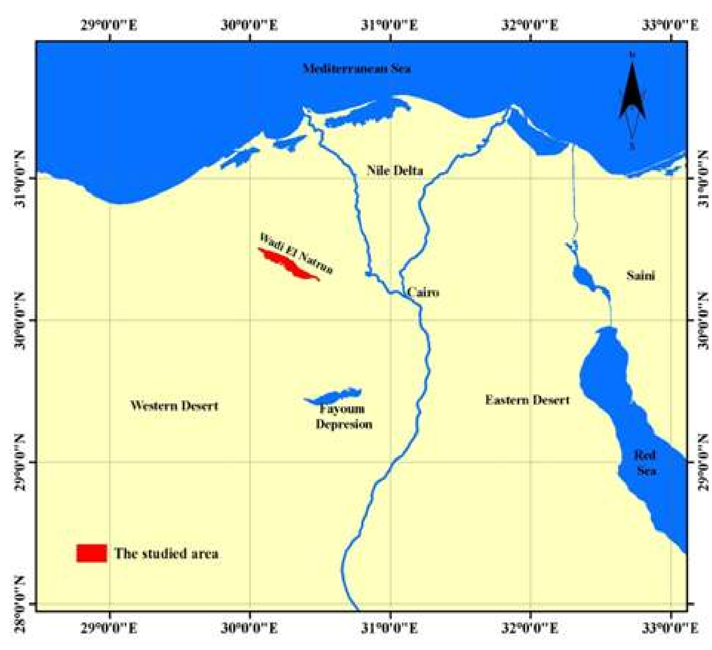

Fig. 1: Location of the studied area.

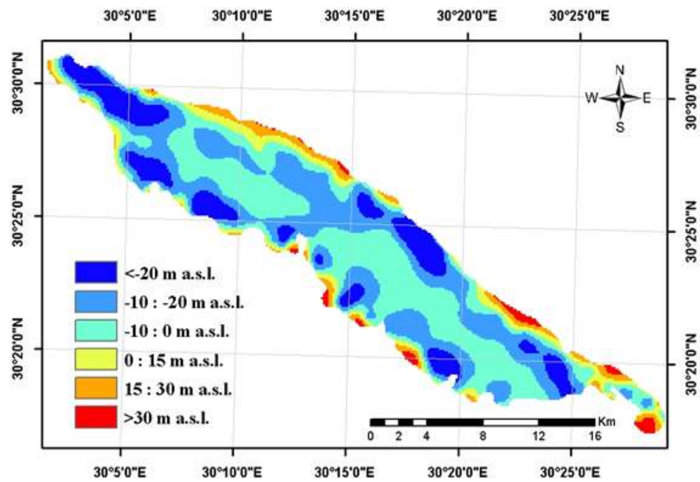

Fig. 2: Digital elevation model (DEM) of Wadi El Natrun Depression.

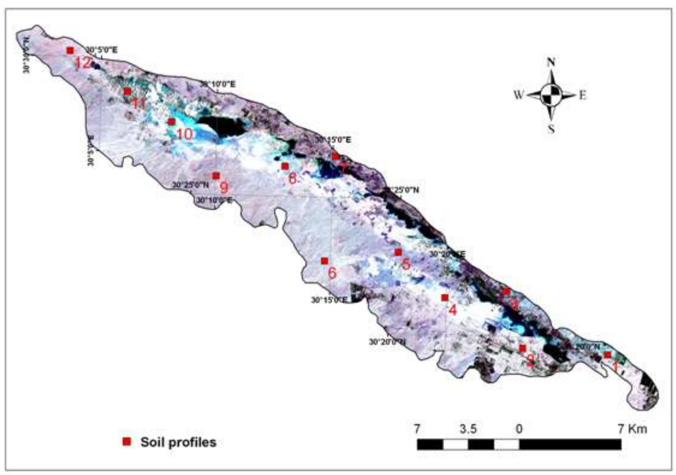

Fig. 3: Distribution of the studied soil profiles.

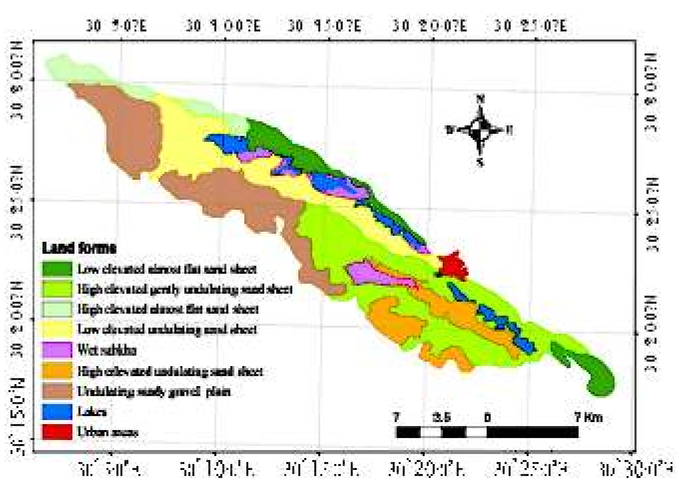

Fig. 4: Geomorphologic units of the studied area.

Table 1: Main land characteristics of the studied area

Unit	No.	Depth	Texture	EC	ESP	CaCO3	Slope %	Drainage
Low elevated almost flat sand sheet	1	150	Sandy	8.45	15.71	1.56	1.5	Well
High elevated gently undulating sand sheet	2	100	Sandy	9.12	18.48	1.35	6.6	Moderate
High elevated undulating sand sheet	3	120	Sandy	10.16	6.00	5.04	1.3	Well
High elevated undulating sand sheet	4	90	Sandy	10.81	12.69	12.08	1.4	Moderate
High elevated undulating sand sheet	5	100	Sandy	3.54	4.32	2.80	1.54	Moderate
Undulating sandy gravel plain	6	90	Sandy	5.98	5.58	2.28	4.2	Moderate
Low elevated almost flat sand sheet	7	90	Sandy	1.49	4.25	3.762	1.4	Moderate
Low elevated undulating sand sheet	8	70	Sandy	22.54	28.98	2.20	1.6	poor
Undulating sandy gravel plain	9	90	Sandy	31.01	26.15	2.87	5.3	Moderate
Low elevated undulating sand sheet	10	120	Sandy	8.73	24.01	1.15	2.1	Well
Undulating sandy gravel plain	11	100	Sandy	2.17	3.43	4.56	2.3	Moderate
High elevated almost flat sand sheet	12	150	Sandy	1.455	2.93	4.80	3.3	Well

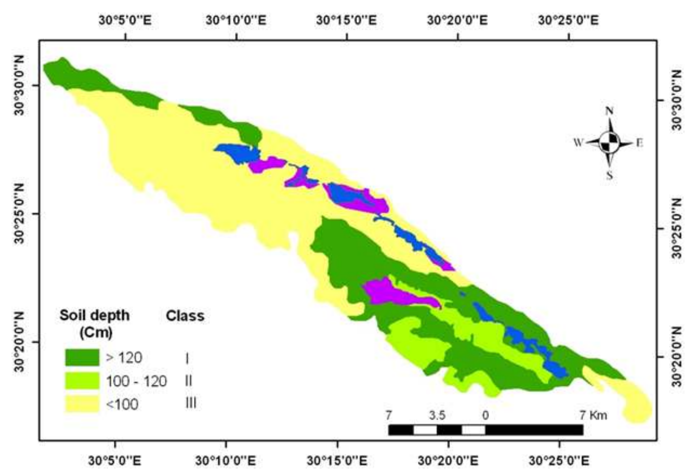

Fig. 5: Spatial distribution of soil depth.

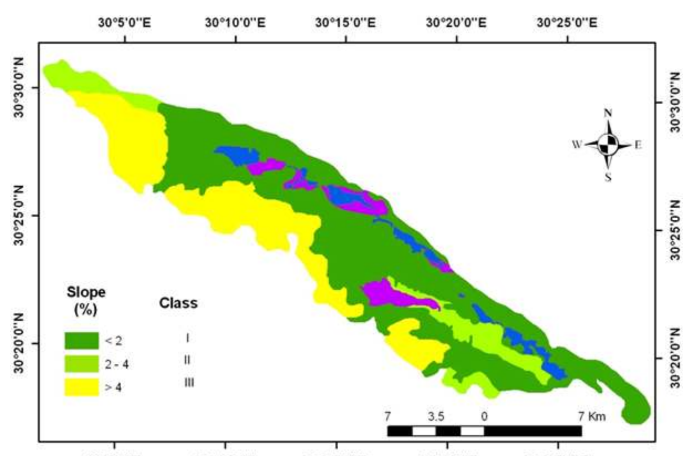

Fig. 6: Spatial distribution of surface slope.

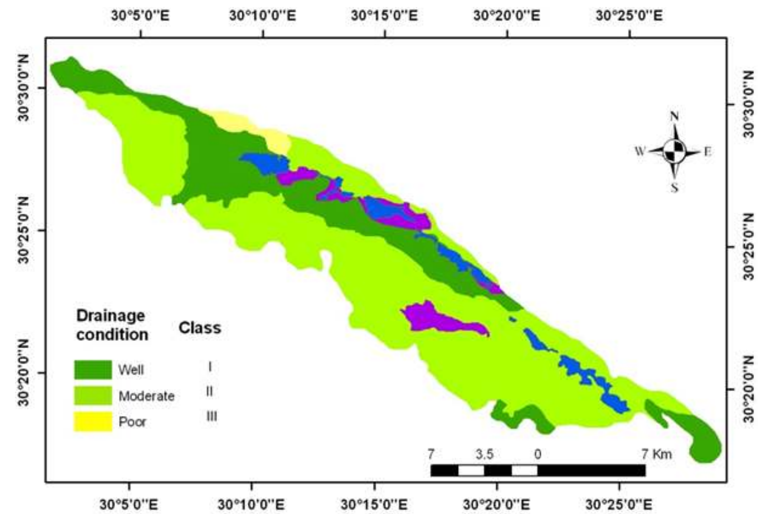

Fig. 7: Spatial distribution drainage condition.

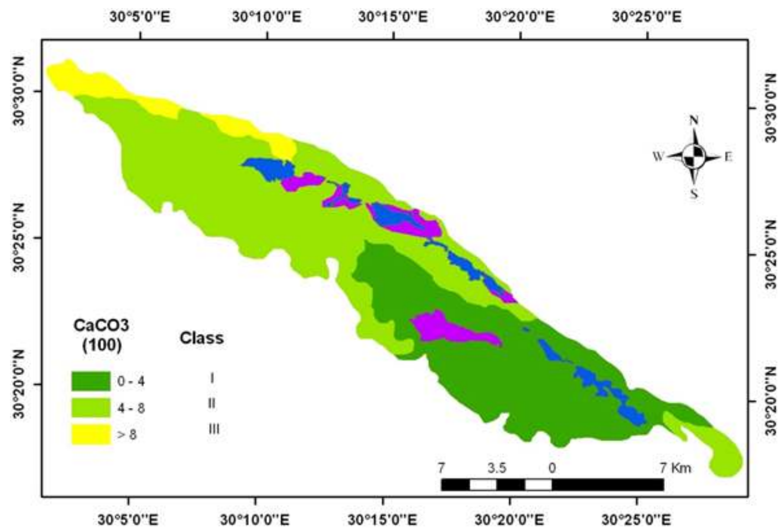

Fig. 8: Spatial distribution of $CaCO_3$ %.

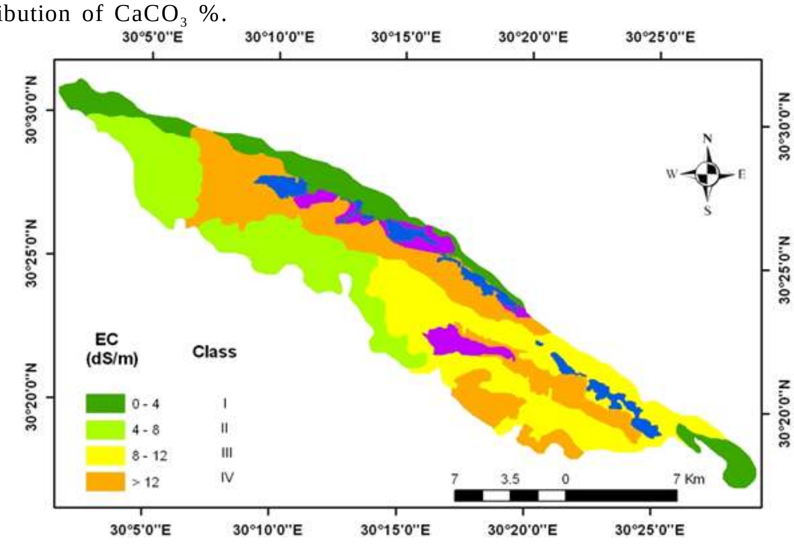

Fig. 9: Spatial distribution of soil salinity.

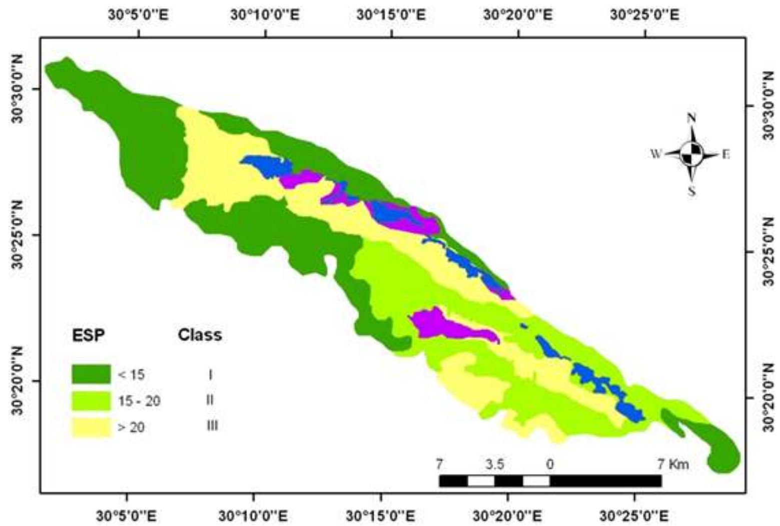

Fig. 10: Spatial distribution of soil salinity.

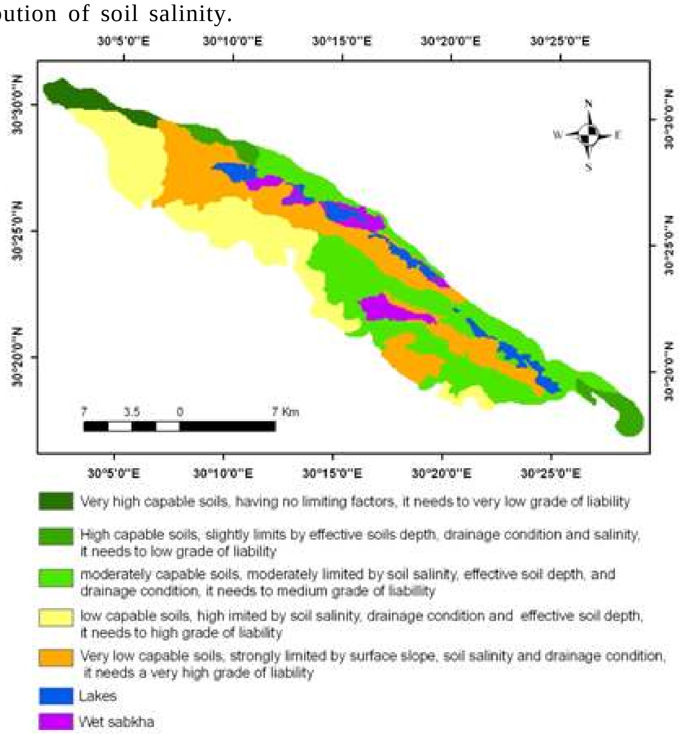

Fig. 11: Land capability Classes of the studied area.

The soils of high elevated gently undulating sand sheet have moderate to high degree of limitation related to the salinity, and alkalinity. High to very high degree of limitation related to erodability, slope, CaCO3 content, soil depth, salinity and drainage condition exhibit the rest of landforms in the depression. These results are of great importance as they show the distribution of the constraints of productivity all over the region. This is particularly important when planning for optimal land uses, also it benefits the existing land users in determining the most appropriate management practices.

Soil Capability Assessment: The soil capability of the area has been identified from the thematic layers (Fig. 11). The soil capability was divided to five categories according the rating values (ranges from 0 to 1), whereby the soil capability tend to increase when the rating value is closed to 1. It became clear that the very high capable soils (class I) represent 3.92 %

of the total area; it is associated with the low elevated almost flat sand sheet. The high capable soils (class II) dominate the High elevated almost flat sand sheet, representing 4.96 % of the total area. The moderately capable soils (class III) are associated with the High elevated gently undulating sand sheet, representing 34.87 % of the area. The soils of Undulating sandy gravel plain have a low capability class (class IV) representing 26.25 % of the total area. The very low capable soils are associated mainly with the landforms of Low elevated undulating sand sheet in the middle of the area, representing 30.00 % of the total area. Suitable land management is essential for sustaining the agricultural land uses of 56.25 % (Classes III & IV) of the studied area.

Conclusion: The use of spatial analyses allows producing multi thematic layers of land characteristics, which offer a great source of data for the land use planners. The spatial distribution represents the correlation between the soil characteristics and landforms, with more detailed data, that can be use in extrapolation of soil characteristics in the different landforms. The spatial distribution of soil capability in the area indicates that an area of 30.00 % of the total area is currently not suitable for agricultural use, while 56.25 % of the area needs to high grade of liability for sustaining the agricultural land uses. Actions measures are essential for the sustainable agricultural projects located in Wadi El Natrun especially in the middle southern parts which are susceptible to moderate or high salt accumulation and poor drainage.

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