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Using Spatial Analyses to Study Land Capability, West of the Nile Delta, Egypt

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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 some areas west of the Nile Delta. 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 readability, 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, marginal, low and very low capability classes for agriculture represent 7.26, 22.45, 43.62, 21.11 and 5.56 % of the studied area respectively. The low capability classes in the area are mainly due to the shallow soil depth, coarse texture, poor drainage and the salts accumulation. Therefore, action measures of land management are essential for sustaining the agricultural land uses in this area.

Keywords: Land capability, landforms, GIS, Spatial analyses, West of Nile Delta.

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), (IFAD, 1990). By the year 1997 the total cultivated area in the West Delta fringes reaches to 445200 ha (GARPAD, 1997). The cost of reclamation of such regions varies from LE 7,000 to LE 23,000 per hectare of crop area for canals, pumping stations, main roads, electricity transmission facilities, utilities and related buildings (MALR, 1994). The soil capability mapping for this area is therefore, an essential action in order to maintain the sustainable development of effort and investment as well as the sustainable usage of these soils. The study area includes different landforms, *i.e.*, river terraces, levees, flood plain and alluvial windborn deposits (Sadek, 1984). The Pleistocene deposits in this area are of assorted size bordering the cultivated areas; they form a series of various elevation terraces (Wahab *et al.*, 1987). Land evaluation is assigned the indispensable task of translating the data of land resources into terms and categories, which can be understood and used by all those concerned with land improvement and land use planning. Interpreting soil qualities (LQ) and site information for the agricultural use and management practices is integrated using geographical information system (FAO, 1991 & 2007).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 land suitability for a specified kind of use (FAO, 1985); it is the ability of the land to fulfill specific requirements for the land utilization type (LUT) (Van Diepen *et al.*, 1991). Spatial analysis 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 (ESRI, 2001). 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 for evaluating the land capability, allow producing multi-thematic maps and outlining the limiting factors, accordingly suitable suggestions could be proposed to understand how to deal with these soils for sustainable agricultural use.

Material and Methods

The studied area extends between longitudes 30° 31′ 30″ and 30° 58′ 30″ east and latitudes 30° 12′ 20″ and 30° 40′ 02″ north (Fig. 1). Digital Elevation Model (DEM) of the studied area has been generated from the vector contour lines (Fig. 2); Arc- GIS 9.0 software was used for this function. Landsat ETM+ images (Fig. 3) and Digital Elevation Model (DEM) were grouped and processed in ERDAS Imagine 8.7 software to define the different landforms of the studied area (Dobos *et al.*, 2002 and Zink & Valenzuala, 1990). The extracted of data generate 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. Fourteen soil profiles were taken to represent different mapping units; the morphological description of these profiles was carried out according to the guidelines edited by FAO (1990). Representative disturbed soil samples have been collected and analyzed using the soil survey laboratory methods manual (USDA, 2004). 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, $CaCO_3$ content, texture class, soil depth, salinity, alkalinity and drainage condition. The thematic layers were matched to produce the land capability map; the land capability classes were defined using the rating and procedure after FAO, 1985 and 2007.

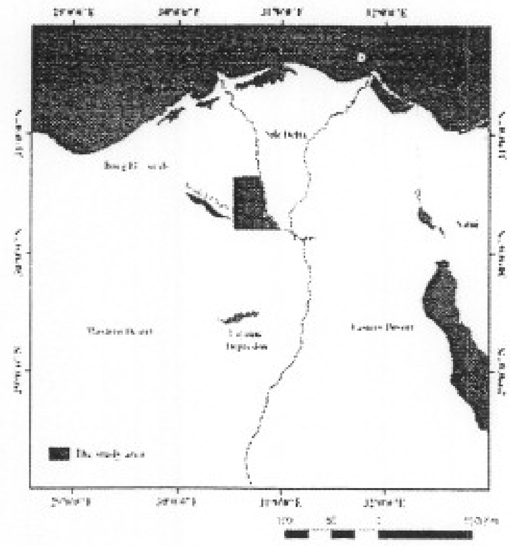


Fig. 1. Location of the studied area.

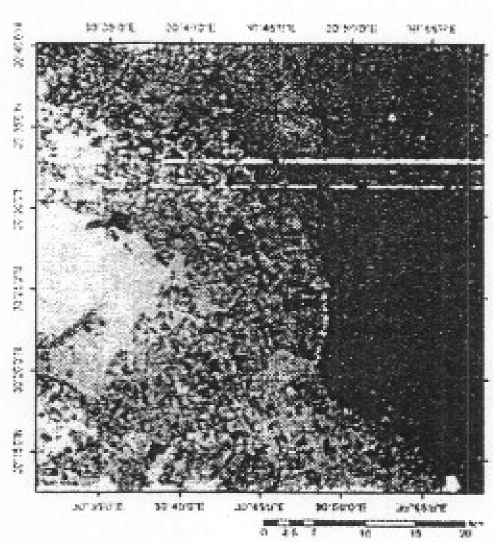


Fig. 2. Landsat ETM$^+$ image of the studied area (path 177 row 39).

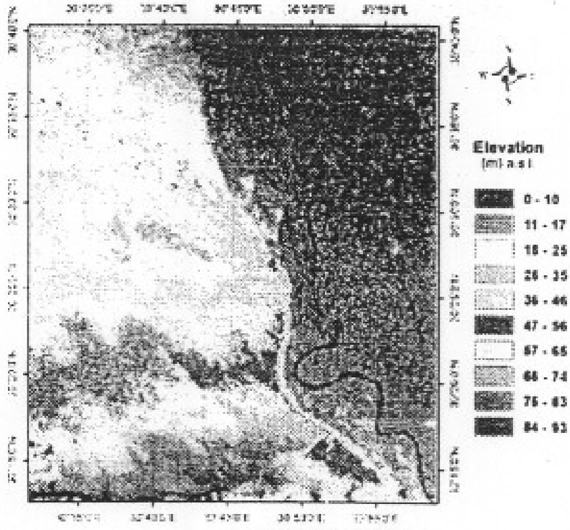


Fig. 3. Digital elevation model of the studied area.

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 indicate that the area includes the following:

Flood plain

This landscape exhibit an area of 336.56 Km^2, representing 19.83 % of the total area; it includes the landforms of river terraces of various elevation (145.36 Km^2), river levees (62.86 Km^2), overflow basin (59.19 Km^2) and decantation basin (50.99 Km^2). River stream and islands exhibit an area of 18.16 Km^2 (*i.e.*, 1.08 % of the studied area).

Aeolian plain

This landscape covers an area of 393.92 Km^2, representing 23.19 % of the total area. It includes the landforms of almost flat sand sheet (108.06 Km^2), gently undulating sand sheet (143.56 Km^2), undulating sand sheet (64.99 Km^2) and sand ripples (77.31 Km^2).

Old deltaic plain

This landscape covers an area of 967.81 Km^2; representing 56.98 % of the total area. The main landforms in this landscape are high terraces (277.38 Km^2), moderately high terraces (226.98 Km^2), low terraces (180.82 Km^2), complex terraces (93.48 Km^2), severely eroded terraces (127.62 Km^2) and terraces riser (61.53 Km^2).

Thematic layers

The attribute data of erodability, surface slope, $CaCO_3$ content, texture class, soil depth, salinity, alkalinity and drainage condition (Table 1) were compiled into the units of the digitized 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 5-12. 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 flood plain having no limiting factors, except some areas in the basins and river terraces which have a slight limitation due to soil depth and drainage condition. The soils of aeolian plain have moderate to high degree of limitation related to the erodability, $CaCO_3$ content, texture and salinity.

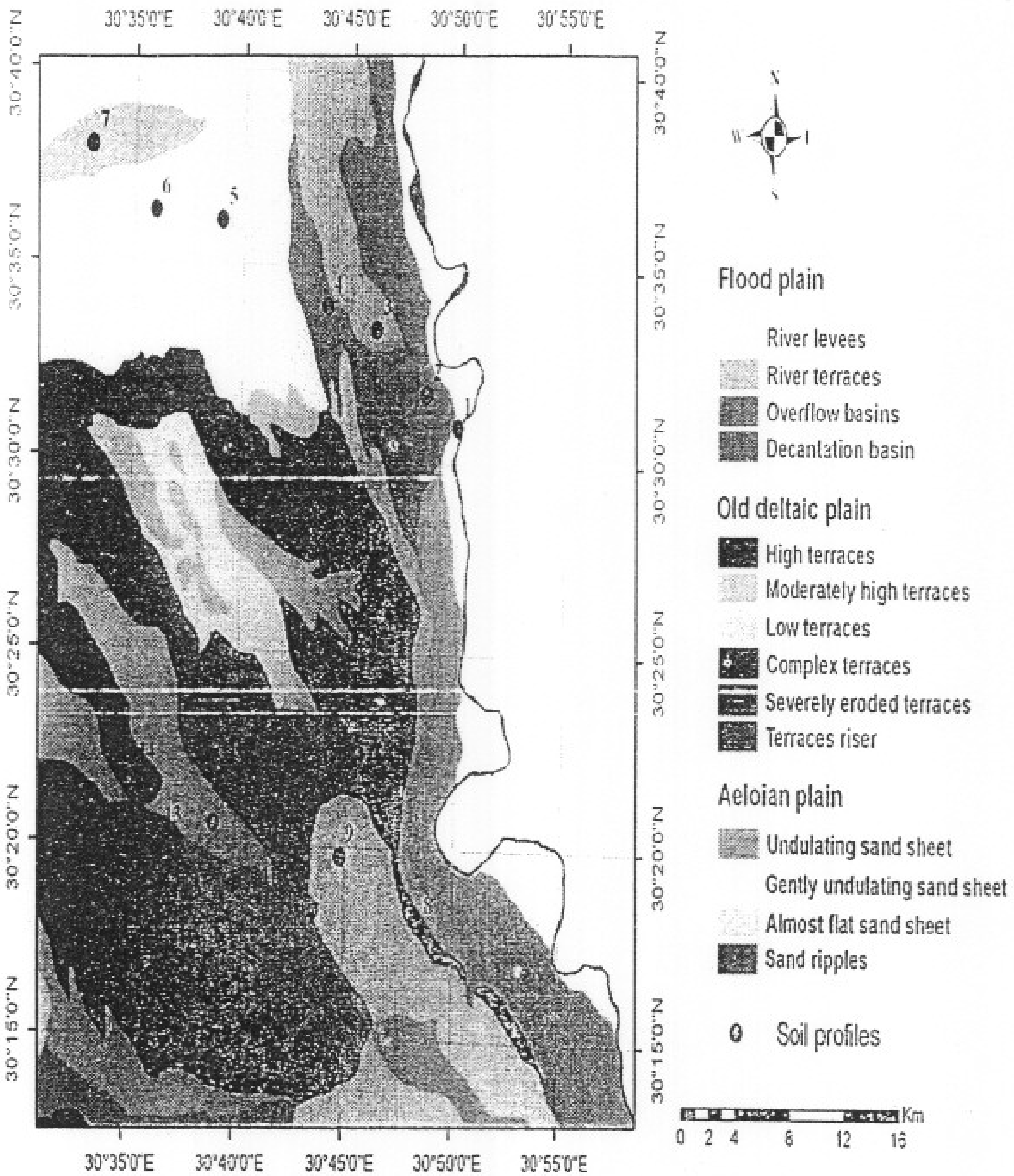


Fig. 4. Geomorphologic units of the studied area.

High to very high degree of limitation related to erodability, soil texture, slope, $CaCO_3$ content, soil depth, salinity and drainage condition exhibit the different landforms of old deltaic plain. 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 land uses; also it benefits the existing land users in determining the most appropriate management practices.

TABLE 1. Main land characteristics of the studied area.

Profile no.	Depth (cm)	Slope %	Erosion	Texture class	Drainage class	$CaCO_3$ %	EC dS/m	ESP
1	120	1.4	Non to Slight	SCL	Well	2.32	1.42	11.31
2	110	1.6	Non to Slight	SL	Well	0.91	0.86	12.82
3	100	2.1	Non to Slight	CL	Moderate	2.66	3.45	14.54
4	90	2.3	Non to Slight	SL	Moderate	6.84	7.39	14.83
5	150	3.3	Moderate	S	Well	8.31	3.52	16.31
6	100	2.7	Moderate	GS	Well	9.52	5.73	15.52
7	120	3.5	Moderate	S	Well	2.66	1.55	17.70
8	90	6.6	Moderate	S	Moderate	3.94	1.58	15.81
9	130	2.8	Slight to moderate	S	Well	1.57	3.69	11.44
10	120	3.4	Slight to moderate	SG	Well	12.76	9.56	19.53
11	130	4.2	Slight to moderate	S	Well	3.35	7.82	18.58
12	100	3.2	Moderate	SG	Moderate	5.14	9.62	18.15
13	60	3.4	Moderate	SG	Imperfect	8.12	6.41	19.86
14	45	4.6	Slight to moderate	GS	Imperfect	12.8	11.51	14.63

Soil capability assessment

The soil capability for agriculture of the studied area has been identified from the thematic layers (Fig.13). 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 7.19 % of the total area; it is associated with the river terraces and levees. The high capable soils (class II) dominate the decantation and overflow basins in the flood plain and low terraces of old deltaic plain, representing 22.22 % of the total area. The moderately capable soils (class III) are associated with the aeolian plain landforms and high terraces and sand ripples in the old deltaic plain, representing 43.17% of the area. The soils of terrace risers, moderate high terraces and severely eroded terraces have a low capability class (class IV) representing 20.89 % of the total area. The very low capable soils are associated mainly with the landforms of complex terraces in the west of the area, representing 5.51% of the total area. Suitable land management is essential for sustaining the agricultural land uses of 64.06 % (Classes III & IV) of the studied area.

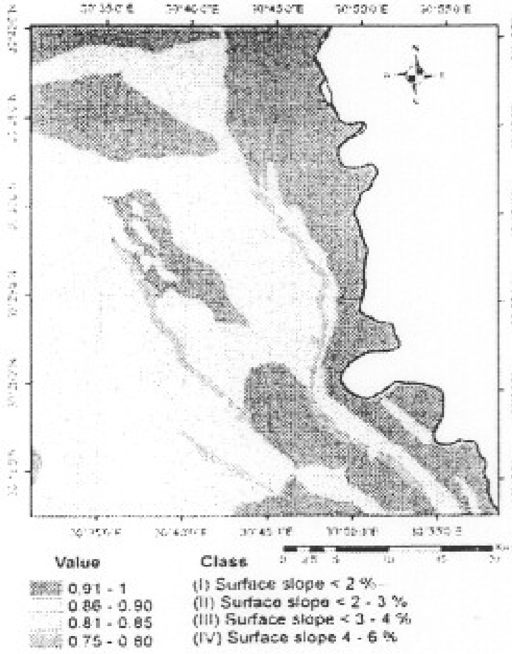


Fig. 5. Spatial distribution of erodability.

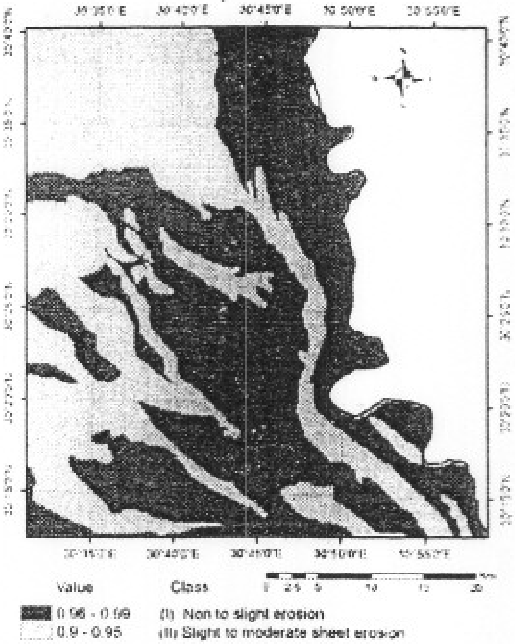


Fig. 6. Spatial distribution of surface slope.

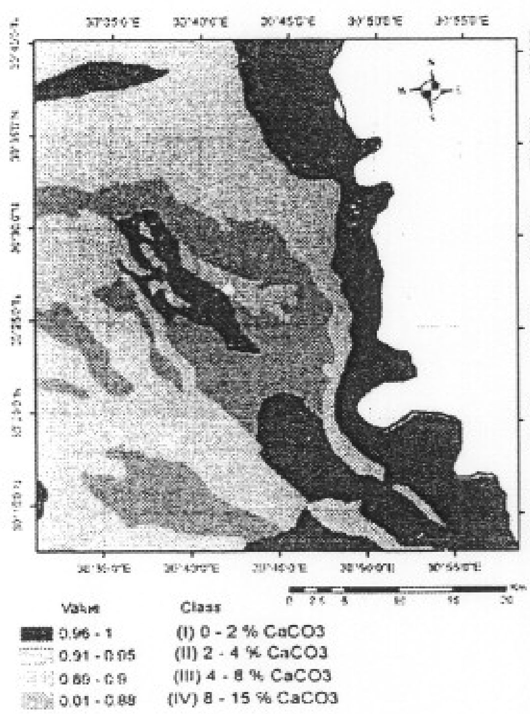


Fig. 7. Spatial distribution of $CaCO_3$ content.

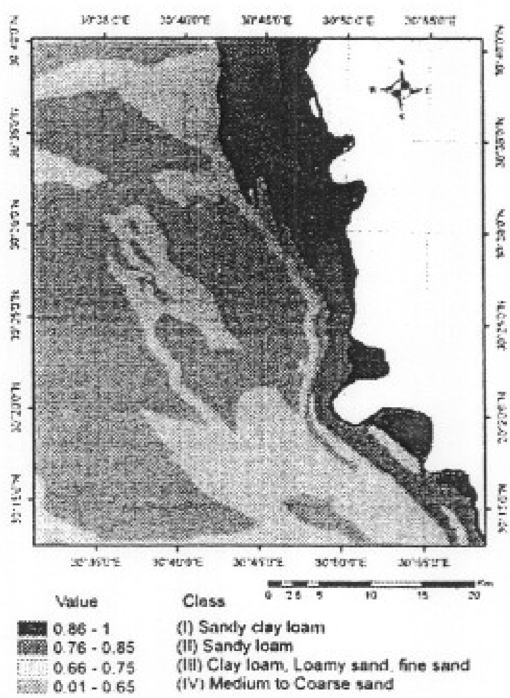


Fig. 8. Spatial distribution of soil texture.

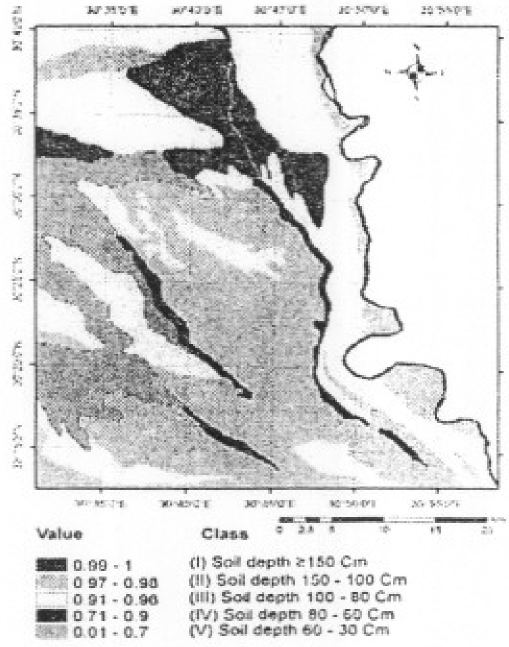


Fig. 9. Spatial distribution of soil depth.

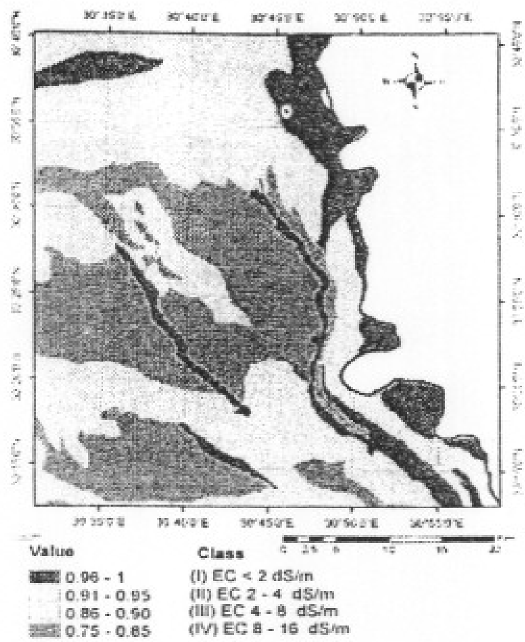


Fig. 10. Spatial distribution of soil salinity

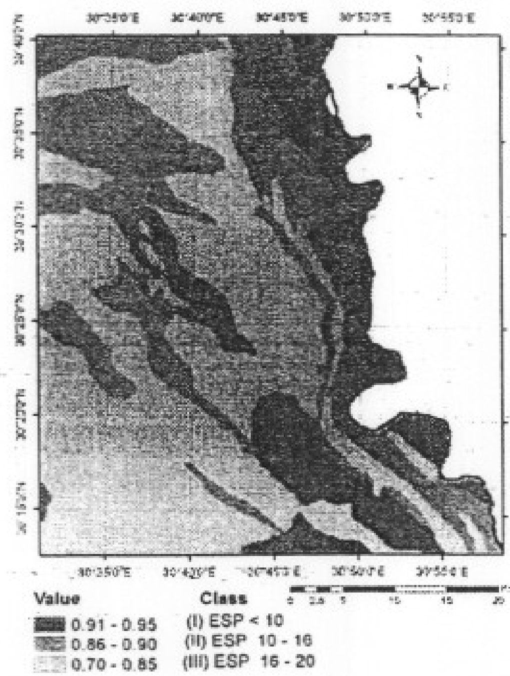


Fig. 11. Spatial distribution of soil alkalinity.

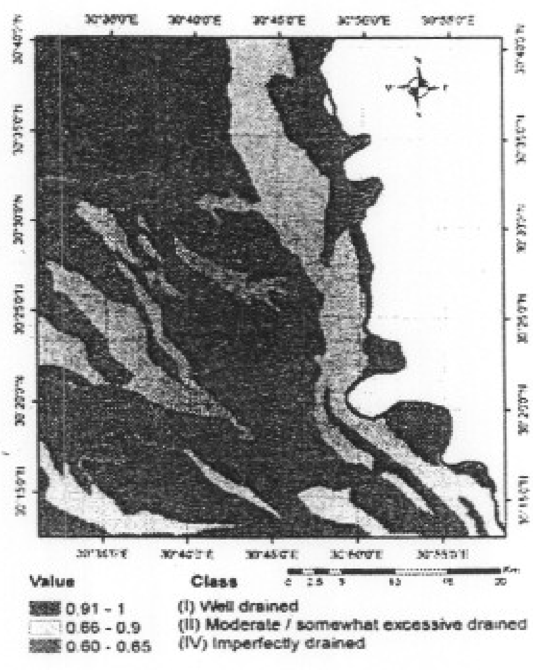
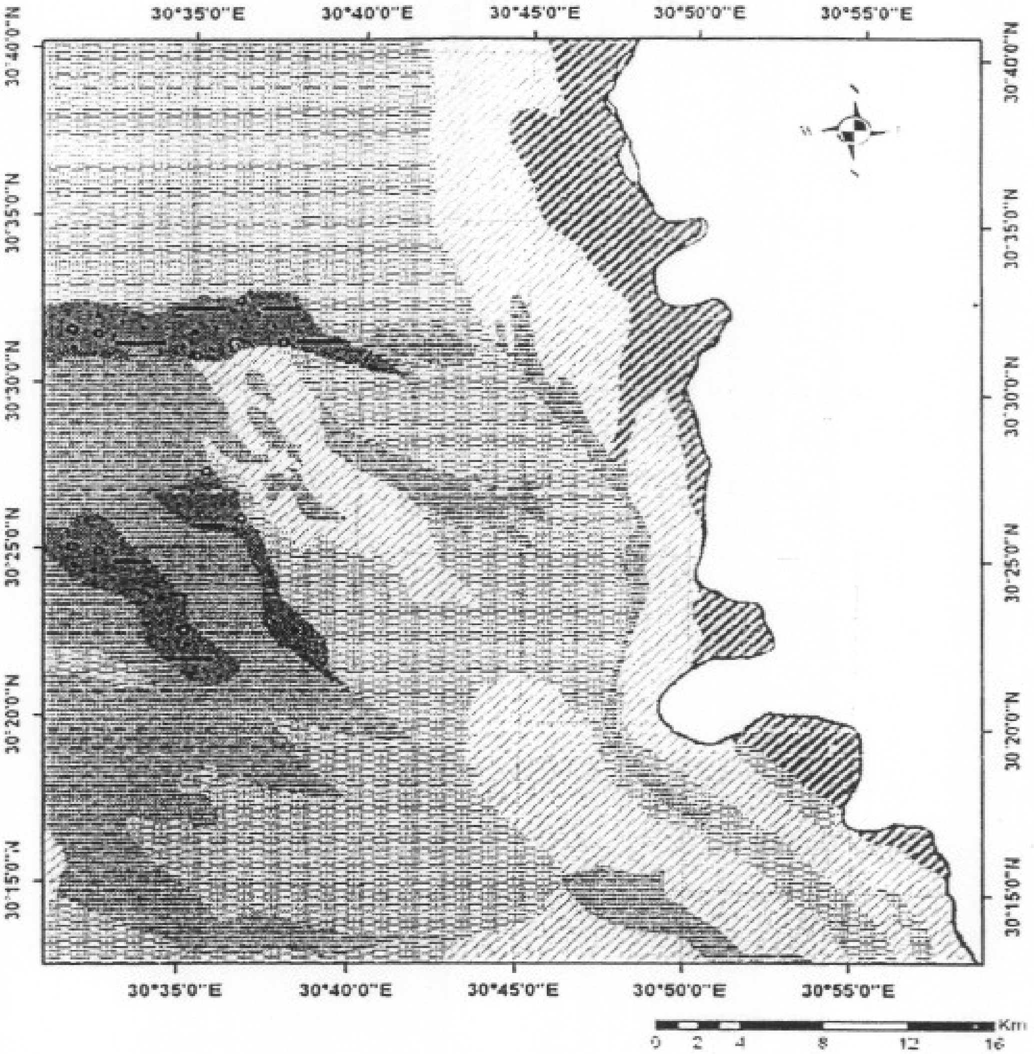


Fig. 12. Spatial distribution of drainage condition.



Symbol	Description	Area %
I	Very highly capable soils, having no limiting factors it needs to very low grade of liability	7.19
II	Highly capable soils, slightly limited by effective soil depth, drainage condition and erodability it needs to low grade of liability	22.22
III	Moderately capable soils, moderately limited by surface slope, soil texture, salinity, $CaCO_3$ content and erodability, it needs to medium grade of liability	43.17
IV	Low capable soils, highly limited by soil texture, effective soil depth, salinity and alkalinity, it needs to high grade of liability	20.89
V	Very low capable, strongly limited by surface slope, salinity, effective soil depth and drainage condition, it needs to very high grade of liability	5.51

Fig. 13. Land capability Classes 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 soil of old deltaic plain have low capability classes compared with those of aeolian and flood plain. An area of 5.51 % of the total area is currently not suitable for agricultural use, while 64.06 % of the area needs to high grade of liability for sustaining the agricultural land uses.

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استخدام بعض تحليلات وبيانات الاراضي الاساسيه فى تقييم القدرة الانتاجية الزراعية لبعض اراضى غرب دلتا النيل ،مصر

رأفت رمضان على و جميل وهيب عجيب
قسم الاراضى واستغلال المياة - المركز القومى للبحوث – القاهرة – مصر.

إن الهدف الرئيسى لتقييم القدرة الانتاجية للاراضى الزراعية هو معرفة حالة التربة بعد عمليات الاستصلاح حيث ان ذلك من العوامل الاساسية لمعرفة مدى تحقيق المنفعه الاقتصادية للمزارعين وبالتالى تحقيق التنمية المستدامة. وتعنى الدراسة الحالية باختيار بعض التحليلات الارضيه الاساسيه كاحد ادوات نظم المعلومات الجغرافية فى تقييم القدرة الانتاجية لبعض الاراضى حديثة الاستصلاح بغرب دلتا النيل. وبالاعتماد على بيانات الحصر الميدانى للاراضى والنظام ثلاثى الابعاد مع صور الاقمار الصناعية من نوع لاندسات المحسنة الماخوذة عام 2003، تم التعرف على الوحدات الجيومورفولوجية بالمنطقة، حيث تم تحويلها الى الصوره الرقمية وقد تم ربط العوامل الاساسية لتقييم القدرة الانتاجية للتربة (القابلية للنحر، درجة ميل السطح، نسبة كربونات الكالسيوم، قوام التربة، عمق القطاع الارضى، الملوحه، القلوية وحالة الصرف) مع الوحدات الجيومورفولوجية المختلفة داخل نظام المعلومات الجغرافى.

استخدم برنامج Arc-GIS 9.2 لانتاج الخرائط المعلوماتية المختلفة (خرائط القابلية للنحر، ميل السطح، نسبة كربونات الكالسيوم ....) وباستخدام تقنيات التحليل المكانى تم ربط هذة الخرائط للحصول على خريطة القدرة الانتاجية لاراضى المنطقة. وقد اشارت النتائج المتحصل عليها الى ان المنطقة تشتمل على اراضى ذات قدره انتاجية عالية جدا بنسبة 7.26 وعالية بنسبة 22.45 واراضى هامشية بنسبة 43.62 واراضى ضعيفة القدرة الانتاجية بنسبة 21.11، اما الاراضى ضعيفة الانتاجية جدا فتمثل 5.56٪ من اجمالي مساحة المنطقة المدروسة. وتعزى القدرة الانتاجية المنخفضة بالمنطقة الى ضحالة العمق الفعال للتربة والقوام الارضى الخشن وسوء الصرف بالاضافة الى تراكم الاملاح. وهذا يدعو الى القول ان هناك اجراءات عملية متعلقة بادارة التربة (تحسين الصرف ، اضافة المادة العضوية واتباع نظم الرى الحديثة) ومن الضرورى اتباعها لتحقيق الاستدامة الزراعية بهذة المنطقة.