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LAND USE PLANNING AT MECHANICAL FARM SECTOR-WEST OF NUBARIA USING PARAMETRIC MODELS.

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ABSTRACT

Newly reclaimed areas cover several patches over different regions of Egypt, which have different specific characteristics related to climate, soils, hydrology, etc.... The mechanical farm, which extends over 10,000 feddans fares from south of Alexandria by 62 Km, could be considered one of the most important reclaimed areas at West of Nubaria affected by degradation due to water logging. The goals of this study are to; 1- classify soil types of the study area according to satellite image classification supported by traditional semi-detailed soil survey, and 2- evaluate resultant soil mapping units using parametric land evaluation. Land productivity indices and soil limitation factors which reflect degradation sources were assessed. Land suitability for different field, vegetable, forage and fruit crops was investigated to suggest optimum land use planning. Four soil mapping units were detected in the studied area varying in soil salinity, lime content, soil texture and profile depth. Wheat, Barley, Alfalfa, Sunflower, Cotton, Date palm and Olive were the optimum land use alternatives. Land evaluation was undertaken twice using current data and predicted information of soil salinity and water table after ten years (2017). Results showed a general trend of deterioration in both soil salinity and water table depth. The study recommends that current management practices should be modified regarding the need of improving drainage system and introducing subsoil plowing.

Spatial distributions of soil and evaluation maps were processed and visualized using GIS.

Keywords: Land Evaluation, Parametric models, Geographic Information Systems (GIS), Satellite image classification, Soil Salinity, Waterlogging, West Nubaria.

INTRODUCTION

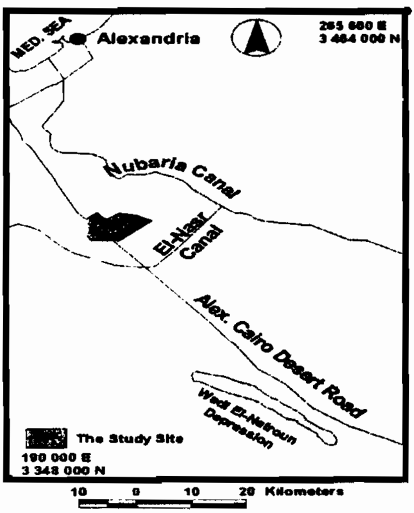
The central theme for sound agriculture policy should be more efficient land use with sustained higher yields, Wood *et al* (1998). The Egyptian strategy for agricultural horizontal expansion until year 2017 aims at adding about 4.32 million feddans in different regions, depending on land suitability and water resources availability, FAO (2001). During the past few years a number of projects have been carried out for reclaiming desert area at west of Nile Delta to increase the agriculture production and consequently feed rapidly growing population, Shokry, (1996). The Mechanical farm represents one of these projects which cover about 10,000 feddans at west of Nubaria, and stretched along 8 km on Alex.–Cairo desert road. The area was reclaimed in 1969 using irrigation network without paying enough attention to the water-salt balance which was affected by a rapid rise of ground water table and subsequently secondary salinization of the soils. The annual amounts of irrigation and drainage waters at the mechanical farm are 76 and 25 cubic meters, respectively. Elshal and Ismail (1979). Thus, the salts content in the root zoon at studied area increases yearly by 25-45 tons per hectare due to imperfect drainage, Elshal and Ismail (1979). Bourrfa and Zimmer (1994) showed that Water logging and salinization are both major problems, which increasingly hamper the development of the irrigated as well as the non-irrigated agriculture in the Mediterranean region, as a higher risk occurs as more efficient artificial drainage system will be needed. Land Evaluation aims generally to guide wisely the present land management and plan its future use. Parametric land evaluation aims to identify the main limiting factors for land productivity (LP) as well as identifying the different degrees of land suitability (LS) for several field, vegetables, forage and fruit, Khalifa (2004). Remote sensing could be a hermeneutic tool for water logging detection, Wright and Birnie (1986). Investigation of remote sensing revealed that the most important distinction between soil type's surfaces is in their reflectance, Hoffer (1978). Image classification procedures automatically categorize all image pixels into land cover classes or themes using a type of classification, such as unsupervised and supervised classifications (Lillesand and Keifer, 1994). Applications of GIS technology in soil survey indirectly impact land use and natural resource planning, Burrough (1986). Soil survey is often a layer in GIS applications, which range from land use and natural resource planning at local municipality levels to global resource inventory, Burrough and McDonnell (1998).

The objectives of the current research are to: (1) Classify soil types of the study area according to satellite image classification, (2) Evaluate resultant soil mapping units using a parametric model to assess land productivity, limiting factors, and land suitability for crops, (3) Estimate land productivity and land use planning according to expected deterioration in both soil salinity and water table after 10 years (2017)

STUDY AREA

1- Location of the Studied Area:

The mechanical farm is located at 62-km south of Alexandria. It bounded by latitudes 30° 45' 48" and 30° 50' 47 N and longitudes 29° 56' 07" and 30° 03' 9" E. The study area extends to cover a total acreage of 10,000 feddans, map (1).



Map (1) Location of the studied area.

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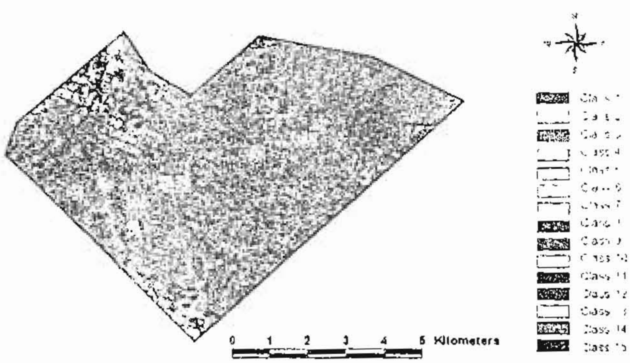
2- Geology and geomorphology:

The farm is a part of Pleistocene limestone sediments of old marine – lacustrine plains and older coastal beach ridges formed by successive high sea level, while the subsoil layers are coarse and gravelly sands of both deltaic and fluviomarine origin, Geological S. Auth. (1981). Recent and Holocene aeolian sand occupy the southern part of the area, so the studied area presumably considered as an area of interaction of mainly wind blown sand and marine sediments

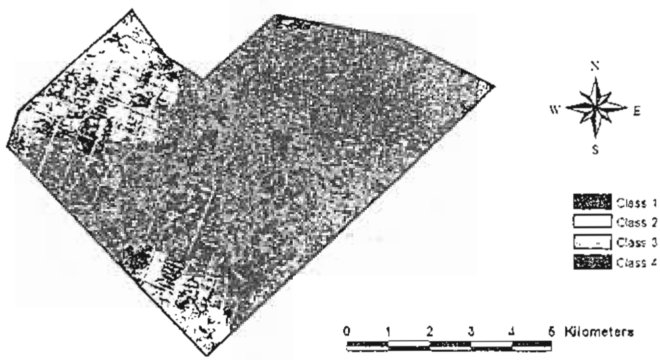
MATERIALS AND METHODS

1- Field work and RS processing:

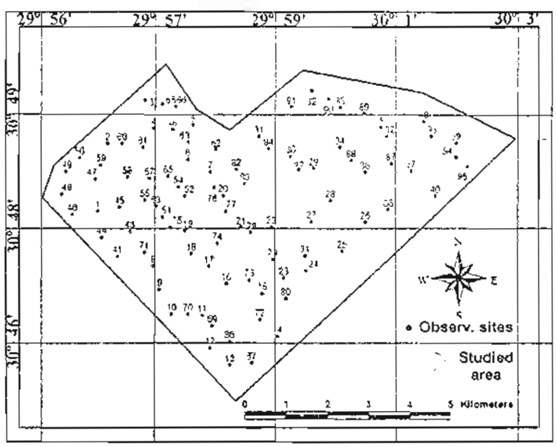
SPOT5 image of the studied area was classified through Isodata unsupervised classification into 15 spectral classes using IMAGINE 8.6 (map 2). Supervised classification was undertaken using selected surface soil data to classify the image into four main mapping units (map 3). A semi-detailed soil survey range (1 observation per 105 feddans) was carried out in 2007. A total of 95 soil observations were dug, described morphologically according to FAO (1998), and sampled (map 4). Four irrigation water samples were collected from El-Nubaria canal branches. Infiltration rate was measured in cm/hr.



Map (2) Unsupervised classification for studied area spectrum.



Map (3) Supervised classification for studied area.



Map (4) Locations of soil observation sites.

2- Laboratory analysis:

Soil samples were air-dried, ground and passed though a 2mm sieve. Saturated soil paste was prepared and the saturated soil extract was obtained and analyzed for electrical conductivity (EC) in dS/m at 25^0C; soluble cations and anions; soil reaction (pH) of (1:2.5) soil water suspension according to Page *et al.* (1982). Organic matter % measured by Walkley and Black method, Jackson (1973); nitrogen %, phosphorus %, potassium %, calcium carbonate % and gypsum were determined according to Page *et al.* (1982); soil texture identified using FAO (1970).

3- Parametric land evaluation:

According to PLES-ARID (Parametric Land Evaluation System in Arid regions), Khalifa (2004), land productivity and suitability indices were calculated after some modification of rating slopes and limits as listed in FAO (2005), as well as using clay percentage to assess soil texture according to El-Fayoumy (1989). Evaluated parameters include; Soil physical parameters, Soil chemical parameters, Topographic parameters, Soil fertility parameters, Irrigation water parameters, Climatic parameters. Every property was evaluated and described as a percentage. The final index of land productivity and land suitability were calculated by multiplying the logarithmic mean of land properties groups. Suitabilities for different field, vegetables, forages, and fruits crops were obtained according to standard crop requirements.

4- Estimation of soil salinity and water table depth:

SALTMOD is an automated module for predicting the long-term hydro-salinity relationships in terms of soil moisture salinity, ground water and drainage water salinity, depth of water table, and the drain discharge in irrigated agricultural lands (SALTMOD user manual 1994). Soil salinity in the root-zone and water table level for ten years were predicted. Inputs include current salinity of the root zone, salinity of irrigation water, water table depth, the amount of water added, and the drainable porosity. Outputs were re-evaluated using PLES, and then results from both SALTMOD and PLES were linked with GIS for mapping the spatial distribution of different soil classes.

5- Geographical Information System (GIS):

Arc-GIS 9.2 (ESRI, 2006) software is used to create a digital vector database for the study site. The locations of soil observations were digitized. Each soil observation had a unique identifier linked to associated attribute data (soil analysis data) using the Database Management System (DBMS) of the GIS software. Soil mapping units were created by overlaying highly variable soil properties. Final outputs of current and potential evaluation maps were generated.

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RESULTS AND DISCUSSION

1- Statistical analysis:

Descriptive statistical parameters were analyzed for different land characteristics as seen in table (1). Higher C.V values belonging to EC, $CaCO_3$, and Profile depth, which used for soil mapping unit creation.

Table (1) Selected descriptive statistical parameters of some land properties in the studied area.

Properties	Min	Max	Range	Average	St. D.	C.V
Infiltration rate $cmhr^{-1}$	2.1	8.3	6.2	5.2	1.8	0.42
Calcium carbonate %	10.8	35.2	24.4	23	5.2	**0.78**
Sand %	40.5	78.9	38.4	59.7	5.2	0.52
Profile depth cm	75	150	75	112.5	3.5	**0.63**
Electric Conductivity dSm^{-1}	1.3	12.0	10.7	6.65	6.5	**0.88**
pH	7.5	8.3	0.8	7.9	0.9	0.35

2- Soil mapping units:

According to descriptive statistical analyses, the coefficient of variance (C.V) emphasized that EC, CaCO3, and profile depth are the most effective soil attributes which have high capability to distinguish between different soil mapping units. These properties in addition to soil texture were rated according to FAO (1998) to classify soils into four main units as seen in table (2) and map (5). Table (3) summarized soil properties for detected soil units

Table (2) Detected soil mapping units according to RS processing and lab. analyses.

#	Symbol	Soil Mapping Unit	Area (%)
1	A	Non saline calcareous loam deep soils	15.2
2	B	Slightly saline calcareous sandy loam deep soils	18.5
3	C	Saline slightly calcareous sandy clay loam mod. deep soils	41.2
4	D	Highly saline mod. calcareous sandy loam shallow soils	25.1

Table (3) Selected soil and water properties for represented soil profiles at different mapping units of the studied area.

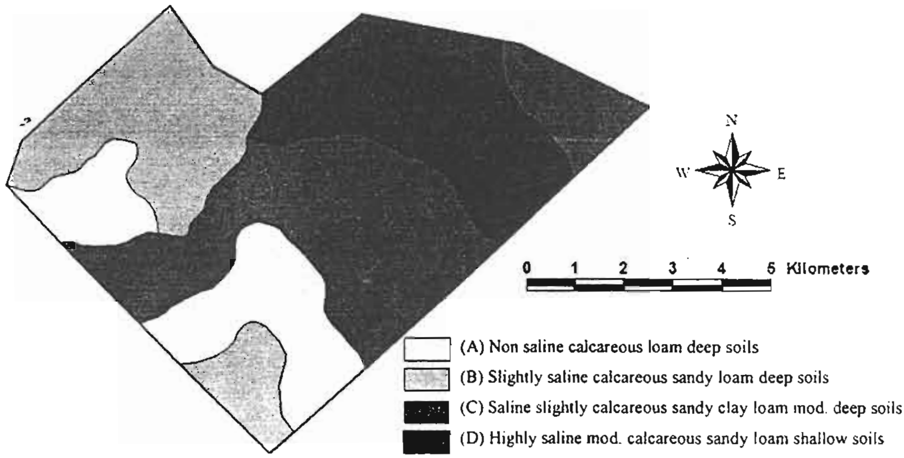
Depth	Physical properties						Chemical Prop.			Topo.	Soil fertility				Irrigation water			
to	IR	$CaCO_3$	Sand	Silt	Clay	Tex.*	EC	pH	ESP	Slope	O.M	N	P	K	EC	pH	SAR	B
cm	Cm/hr	%	%	%	%		dS/m			%	%	ppm			dS/m			ppm
Profile no. (1) Unit no. (1)																		
25	4.5	31.5	45.6	33.7	20.7	L	1.5	8.1	4.8	0.15	0.75	5.2	4.4	40.2	0.39	7.6	5.7	0.05
60		31.0	43.3	34.7	22.0	L	1.9	8.0	5.2		0.62	4.8	4.2	36.6				
100		31.9	46.1	32.5	21.4	L	1.3	8.0	4.4									
145		33.2	37.9	36.2	25.9	L	1.4	8.2	4.8									
Profile no. (4) Unit no. (2)																		
20	5.2	30.2	59.1	28.2	12.7	SL	1.9	7.9	5.2	0.20	0.54	4.3	4.1	36.2	0.40	7.5	7.2	0.04
50		33.5	52.8	32.1	15.1	SL	2.7	8.0	5.5		0.48	3.9	3.5	35.2				
80		30.5	68.0	18.1	13.9	SL	3.1	8.0	6.0									
130		32.4	58.8	31.0	10.2	SL	3.5	8.1	7.8									
Profile no. (35) Unit no. (3)																		
20	4.8	12.9	56.9	20.7	22.4	SCL	4.2	7.5	7.2	0.10	0.40	5.5	4.7	50.2	0.31	7.6	6.4	0.08
40		13.5	53.6	22.8	23.6	SCL	5.7	7.7	9.0		0.22	5.1	4.3	46.8				
70		14.0	51.1	18.9	30.0	SCL	5.9	7.6	9.0									
110		13.5	50.0	17.5	32.5	SCL	7.2	7.6	12.5									
Profile no. (81) Unit no. (4)																		
25	7.2	18.7	78.9	9.7	11.4	SL	8.5	7.8	14.3	0.10	0.45	4.0	4.5	35.2	0.43	7.8	8.2	0.02
60		20.4	70.0	21.5	8.5	SL	9.4	7.9	15.3		0.34	3.8	4.0	30.2				
75		25.8	70.1	21.2	8.7	SL	9.5	7.9	16.0									

* Texture classes

L = Loamy

SL = Loamy Sand

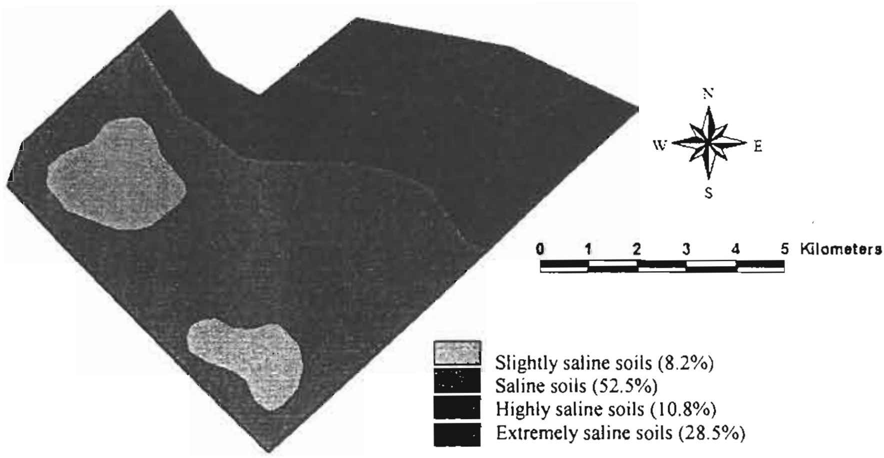
SCL = Sandy Clay Loam



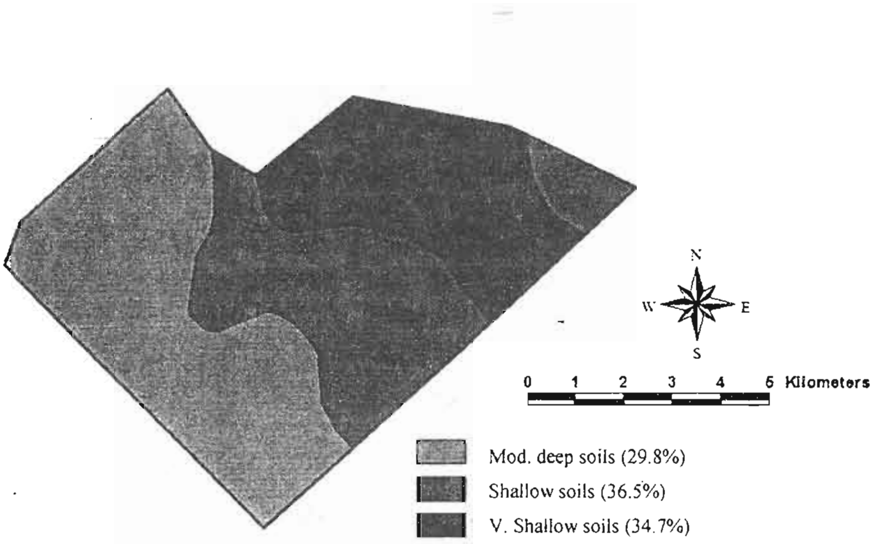
Map (5) Current soil mapping units of the studied area.

3- Prediction of soil salinity and water table:

Results indicated a general trend of deterioration in both soil salinity and water table depth. Salinity levels were shifted from a maximum of 10.4 dS/m for the current data (2007) to 19.5 dS/m after 10 years (2017), where extremely saline soils appear to occupy 28.5% from the total area (map 6). While, saline water table depth will be closer to the surface indicating water logging, where, very shallow unit of water table depth appears to occupy 34.7 % after 10 years (map 7). This general trend of deterioration is mainly due to the use of flood irrigation and the mal-maintenance of the drainage system.



Map (6) Estimated soil salinity of the studied area after 10 years.



4- Land Evaluation:

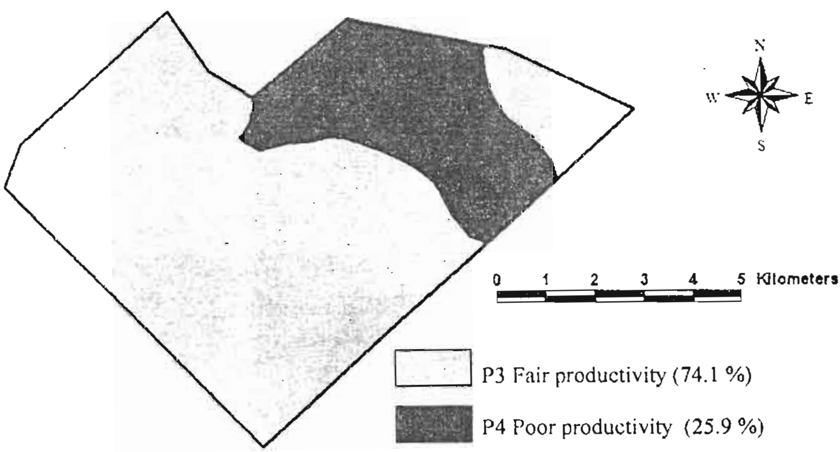
Two current land productivity classes (table 4) were recognized in the studied area, namely, class 3 which reflect faire land productivity over 74.1% of the total area and class 4 which reflect poor land productivity over 25.9% of the total area. Soil limitations were water table depth (WTD), carbonates (CO_3), texture (Tex.), salinity (EC), alkalinity (ESP), organic matter (O.M), nitrogen (N), phosphorus (P), and potassium (K).

Table (4) Current land productivity classes and related limiting factors in the studied area.

Soil Mapping Unit	Phys. index	Chem. index	Topo. index	Fertility index	Water index	Final index	Land Prod. index
A	57.09	87.69	92.23	18.4	86.8	58.4	P3
	C_3 P (CO3) F (O.M, N, P, K)						(Fair)
B	30.14	84.6	85.81	12.6	80.4	48.7	P3
	C_3 P (CO3, Tex.) F (O.M, N, P, K)						(Fair)
C	80.29	41.01	94.67	20.6	88.4	54.9	P3
	C_3 C (EC) F (O.M, N, P, K)						(Fair)
D	28.14	25.19	94.67	16.4	75.6	38.0	P4
	C_4 P (WTD, CO3, Tex.) C (EC, ESP) F (O.M, N, P, K)						(poor)

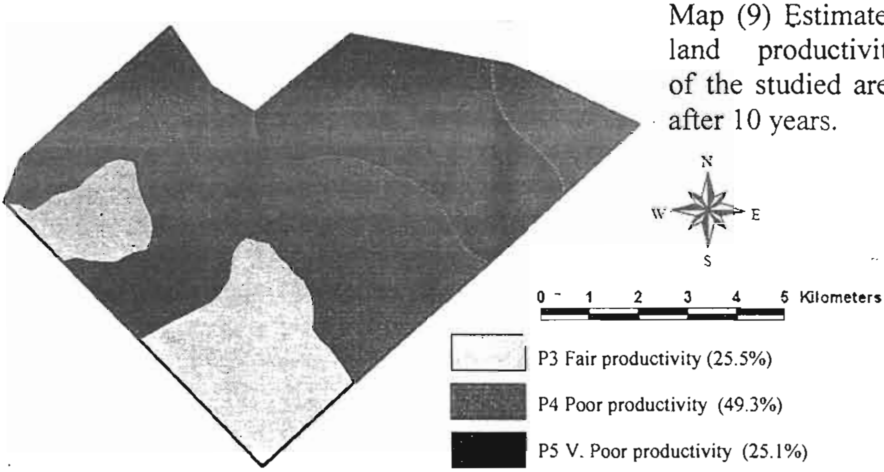
General degradation of land productivity occurs according to expected deterioration of soil salinity and water table depth after 10 years. Three land productivity classes were predicted; fair productivity (P3) occupying 25.5% of the studied area, poor productivity (P4) over 49.3%, and very poor productivity (P5) over 25.1% of the total area to be excluded from agrarian use. Maps 8&9 compare the current and predicted land productivity and emphasize on that expected degradation in land potentiality.

Results of land suitability investigation indicated that Wheat, Barley, Alfalfa, Sunflower, Cotton, Date palm and Olive were the optimum land use alternatives in the study area. Land suitability classes of recommended crops are class 2 (S2) for moderate suitability over 17.5% of the area, class 3 (S3) for marginal suitability over 73.1% of the area, and class 4 (NS1) for current non suitable for all crops except for Barely and Date palm over 9.4% of the total studied area as shown in map (8) for current optimum land use planning.



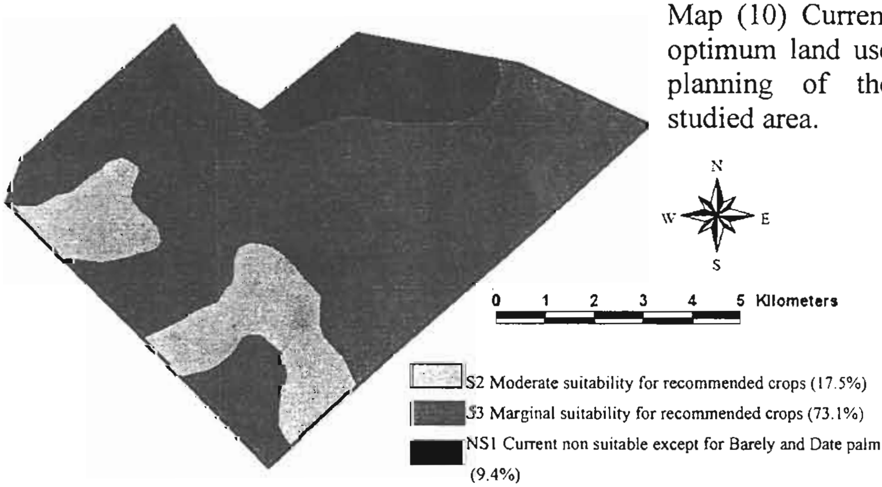
Map (8) Current land productivity of the studied area.

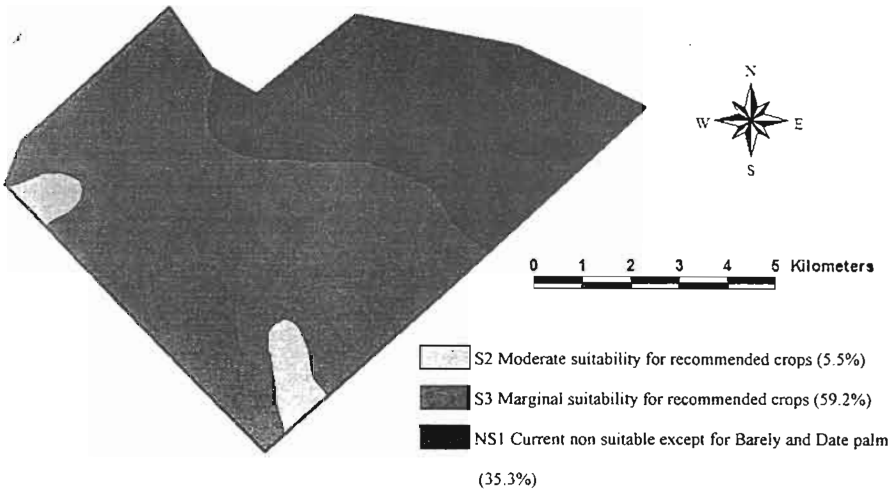
Map (9) Estimated land productivity of the studied area after 10 years.



Land suitability evaluation for crops was carried out using estimated data of salinity and water table depth. The suitability degraded from classes S2 (17.5 %) and S3 (73.1 %) and S4 (9.4 %) for the current data to S2 (5.5 %), S3 (59.2 %) and NS1 (35.3 %) after 10 years as seen in map (9) for estimated land use planning. This deterioration is associated mainly with the degradation of soil properties, especially salinity levels, drainage and consequently soil profile depth. Maps 8 and 9 compare the spatial distribution of the different classes of current and estimated land use at the Mechanical farm.

Map (10) Current optimum land use planning of the studied area.





Map (11) Estimated land use of the studied area after 10 years.

The current study recommends some modifications have to be undertaken in the current management practices, these are:

1- Leaching regime of irrigation water is urgently needed to control the root zone salinity at the desired level. Thus, the total irrigation norms should contain surplus quantity of water to allow sufficient leaching.

2- Improving current imperfect drainage system, where drains bottom should be maintained at a 25 to 50 cm below the critical water level to insure the necessary hydraulic head for ground water movement to the drains (Elshal, 1979). Consequently, 150-200 cm and 200-250 cm are the optimum depths of ground water and drains bottom, respectively.

3- Introducing sub soiling will improve water movement to the network of sectional drains.

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الملخص العربى

تخطيط استغلال الأراضي بقطاع المزرعة الآلية – غرب النوبارية باستخدام النماذج متعددة المتغيرات.

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تنتشر المساحات المستصلحة من الأراضى بكافة أرجاء القطر المصرى، ولكل منها خصائصه المميزة وفقا لطبيعة المناخ السائد والتربة وهيدرولوجية المنطقة وغيرها من العوامل. ومنطقة المزرعة الآلية التى تمتد على مساحة 10.000 فدان جنوب الإسكندرية بـ 62 كم تعد من أهم مناطق الإستصلاح التى تعانى من إرتفاع الماء الأرضى المالح بالقرب من السطح. ويهدف البحث إلى توصيف الإختلافات الأرضية السائدة بالمنطقة بإستخدام التحليل الطيفى لصورة القمر الصناعى الممثلة للمنطقة تكاملا مع عمليات حصر التربة النصف تفصيلى التى أجريت بالمنطقة وذلك للخروج بالوحدات الأرضية السائدة بها. وأستهدف البحث إجراء تقييم كمى لتربة الوحدات الأرضية للوقوف على قدرتها الإنتاجية ومحددات إستغلالها زراعيا والتى تعكس مظاهر التدهور التى إعترت المنطقة، بالإضافة لتحديد درجات الملائمة الزراعية لكافة محاصيل الحقل والخضر والعلف والفاكهة وذلك لرسم سيناريو الإستغلال الأراضى الأمثل. أستخدم برنامج تقييم الأراضى متعدد المتغيرات (PLES) لإجراء التقييم بعد إجراء بعض التعديلات الخاصة بالحدود والمعدلات التقيمية. وقد أستخدمت تقنيات نظم المعلومات الجغرافية (GIS) فى عرض النتائج ورسم الخرائط المختلفة. هذا وقد أمكن تمييز أربعة وحدات (أنواع) أرضية مختلفة بالمنطقة تتباين فيما بينها فى خصائص ملوحة التربة – نسبة الجير – قوام التربة – عمق قطاع التربة. وأكدت النتائج على أن محاصيل القمح – الشعير – البرسيم – عباد الشمس – القطن – نخيل البلح – أشجار الزيتون هى أفضل البدائل بالمنطقة. وقد أجرى التقييم مرتان الاولى باستخدام البيانات الحالية والأخرى بإستخدام المعلومات المتوقعة والناتجة من استخدام برنامج (SALTMOD) لتقدير الملوحة وعمق الماء الأرضى بعد 10 سنوات، حيث توقعت الدراسة حدوث تدهورا ملحوظا فى كلا الصفتين، وأوصت بضرورة الإهتمام بالاحتياجات الغسيلية للأملاح وزيادة مياة الرى المضافة بالإضافة إلى تحسين نظام الصرف والإهتمام بحرث باطن التربة.