Integrating Remote Sensing and Geographic Information System for Mapping Sensitivity to Land Degradation for Farafra Oasis, Western Desert, Egypt

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ABSTRACT

The imbalance between the rate of population increase and the cropland rate of increase is an important indicator of the need to add new lands through horizontal expansion, since vertical expansion has so far been characterized with a limited impact in Egypt. The horizontal expansion also helps provide more work opportunities, alleviate population pressure on the old cities and reduce loss of croplands to urban development. Moreover, it creates a new, developed social system in the new communities in a manner that enables them to establish a more effective agricultural sector. The study area covers about 3605 fed. named Abo-Monkar situated at El-Farafra Oasis, El-Wadi El-Gadid Governorate, Western Desert of Egypt. The present study aimed to: a) Identify the soil mapping units using remote sensing techniques. b) Characterize the properties of each soil unit. c) Evaluate each soil mapping unit for different crops (Capability and Suitability) to select the best crop pattern. d) Use remote sensing and geographic information system as a quantative method to map the environmentally sensitivity areas for desertification. Four main soil units were recognized in the study namely, slightly saline non calcareous sandy loam, slightly saline calcareous sandy, moderately saline non calcareous loamy sand, and highly saline non calcareous sandy covers 3.30, 25.63, 29.58, and 32.50% of the total area respectively. The index of water quality for irrigation is excellent (92.83%) for wells (1b, 2 and 4) and excellent for the other wells but must treated for the excess of Mn concentration. The land evaluation results for the study area shows that the capability class C2 and C4 cover about 28.93% and 62.08% of the total area respectively and the main limitations were the texture, soil salinity, and hydraulic conductivity. The suitability results show that the area is suitable for some crops (fruit trees, field crop and vegetables) but under specific management practices and the main limitations were soil texture, soil salinity, and hydraulic conductivity. Calculated Desertification Sensitivity Index (DSI) shows that the most of the study area (64 % of the total area) is very low sensitive to desertification; these soil units were slightly saline, calcareous, sandy and highly saline, non calcareous, sandy. The other two soil units which called slightly saline, non calcareous, sandy loam and moderately saline, non calcareous, loamy sand covered about 36 % of the total area was not sensitive to desertification.

Keywords: GIS, Land Evaluation, Remote sensing, Soil mapping units, Desertification sensitivity index (DSI).

INTRODUCTION

Egypt is classified as a low-income, food-deficit country (LIFDC). In 1999 the country imported 7.9 million tons of grains or 50 percent of its needs. The Government's strategic options for agriculture (up to 2017) include the following thematic elements: a) Achieve higher growth rate of 4.1 percent in the agricultural sector through vertical and horizontal expansion. b) Promote more efficient use of land and water, enhance agricultural research and extension, expand credit, and improve marketing cooperatives. c) Increase the value of exports by over two-fold (with respect to the current level), based on quality assurance and product safety, which are key to competitiveness under the World Trade Organization (WTO) policies and partnership agreements with the European Union (EU) and the United States. d) Develop livestock, poultry and fish resources to increase daily per capita animal protein consumption from 18 grams to 24 grams (Country Programmes 2001). There have been extensive introduction of new technologies and significant improvements in agricultural extension, marketing and credit. These efforts, together with area expansion through land reclamation, had contributed to an increase in agricultural production from 2.6 percent in the 1980s to 3.4 percent in the 1990s. The area available for cultivation increased from 2.6 million ha in 1982 to 3.3 million ha in 1995. In a given year, this area is used more than once; the average total cropped in a year amounts to 180 percent of the available area. Egypt's current Five-Year Plan envisages the development of 63,000 ha of new land area per year up to the end of 2001, of which 21,000 ha would be for the landless poor. The Government's land settlement policy, which has focused recently on the landless poor and the unemployed, has contributed to enhancing incomes and food security among the rural poor (World Food Programme, 2000).

Agriculture is the core and the main goal for any development strategies and increasing the total agricultural product by improving the quality and increasing the area of the cultivated land is the national target of Egypt in the last two decades. In the same time, deserts represent vast lands from the whole country area. These require continuous public and private reclamation efforts to change these lands from desert to productive lands (Aboelghar and Tateishi. 2002).

Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental changes. The advancement in the concept of vegetation mapping has greatly increased research on land use land cover change that providing an accurate evaluation of the spread and health of the world's forest, grassland, and agricultural resources has become an important priority (Opeyemi, 2006).

Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth system function, patterning and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

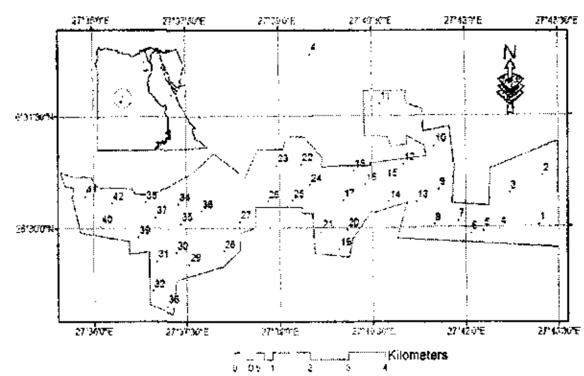
Environmental systems are generally in a state of dynamic equilibrium with external driving forces. Small changes in the driving forces, such as climate or imposed land use tend to be accommodated partially by a small change in the equilibrium and partially by being absorbed or buffered by the system. Desertification of an area will proceed if certain land components are brought beyond specific threshold, beyond which further change produces irreversible change (Tucker *et al.* 1991; Nicholson *et al.* 1998). For example, climate change cannot bring a piece of land to a desertified state by itself, but it may modify the critical thresholds, so that the system can no longer maintain its equilibrium (Williams & Balling, 1996). Environmentally Sensitive Areas (ESA's) to desertification around the Mediterranean region exhibit different sensitivity status to desertification for various reasons. For example there are areas presenting high sensitivity to low rainfall and extreme events due to low vegetation cover, low resistance of vegetation to drought, steep slopes and highly erodable parent material (Ferrara *et al,* 1999).

The assessment of desertification sensitivity is rather important to plane combating actions and to improve the employment of natural resources. The merely quantitative aspect of desertification sensitivity demonstrates a clearer image of the risk state, thus, reliable priority actions can be planned. Remote sensing, in addition to thematic maps, may supply valuable information concerning the soil and vegetation quality at the general scale. However, for more detailed scales, conventional field observation would be essential. The Geographic Information System (GIS) is a valuable tool to store, retrieve and manipulate the huge amount of data needed to compute and map different quality indices to desertification. The Egyptian territory is susceptible to very high-to-high desertification sensitivity, however the Nile Valley is moderately sensitive because of its vegetation cover. Action measures are essential for the sustainable agricultural projects located in the desert oases, wadis and interference zone. It can be recommended that mathematical modeling should be developed for the operational monitoring of different elements contributing in desertification sensitivity. Multi scale mapping of ESA's are needed to point out the risk magnitude and causes of degradation in problematic areas (Gad and lotfy, 2006).

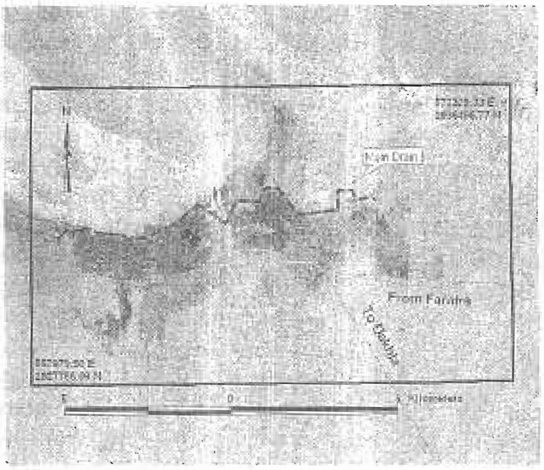
The object of this study to: a) Identify the soil mapping units using remote sensing techniques. b) Characterize the properties of each soil unit. c) Evaluate each soil mapping unit for different crops (Capability and Suitability) to select the best crop pattern. d) Use remote sensing and geographic information system as a quantitive method to map the environmentally sensitivity areas for desertification.

Area Study

Location: The Farafra Oasis is the smallest oasis located in Western Desert of Egypt, which extends from the Nile Valley in the East to the Libyan borders in the west, and from the Mediterranean in the north to Egypt's Southern borders. It is divided into: The Northern section, which includes the coastal plane, the northern plateau and the Great Depression, Natroun Valley and Baharia Oasis; and the Southern section, which includes Farafra, Kharga, Dakhla, and El-Owainat in the far south. Farafra Oasis, approximately mid-way between Dakhla and Bahariya. Farafra has an estimated 5,000 inhabitants living within its single village and is mostly inhabited by the local Bedouins. As shown in maps (1 and 2) the study area named Abu Monkar elongated between 27° 35' 26''E, 26° 28' 48'' Nand 27° 43' 38'' E, 26° 32' 34'' N.



Map 1: General location of the study area and soil profiles.



Map 2: The study area on ETM$^+$ satellite image year 2002.

The study site has a total acreage of 3605 Feddans. Generally, the soils are characterized by non calcareous sandy soil, Saline soil, and deep profile, and non calcareous. The main irrigation source is group of wells. There is no drainage network and the irrigation system was flood irrigation.

Climatology: Table (1) showed average climatologically data for ten years (1990-2000) for the study area collected from Farafra station 92m A.S.L. at 27.30° N and 27.58° E. The data shows that the study area is part of a hyper arid and hot desert area, which rarely receives any rainfall. The climate is extremely harsh. The summer maximum daily temperature can exceed 37.5°C while in winter daily sunshine warm weather and very low at night less than zero. The average evaporation ranges from 9 - 3 mm/ day. The relative humidity generally low, ranging from 47 % in winter and down to 23 % in the summer. The wind direction generally is blowing from the north-west.

Geology, Geomorphology and Topography:

According to the geomorphologic system of Egypt, the Farafra oasis lies within an oval shaped depression, which is bounded by scarps from the eastern, northern and western sides where, as it is open to the south. The longer axis of the depression is 102 km, whereas, its east west axis measured near the middle of the depression is about 90 km. The depression covers an area about 980 km^2. The floor of the depression is covered by the Dakhla Formation in southern part while northward it is covered by chalk of Maestrichtian age (Khoman chalk), and sand sheet with some sief dunes on top covers the eastern part of the depression. Northern part of Farafra. Erosion processes are mainly due to wind action temperature variation and occasional low rainfall. The general relief of the area is relatively low. The maximum height is about 353 m above sea level at El Quss Abu said south western part of the park, and the minimum reaches about 32 m above sea level at Wadi Hennis, Ain El Wadi and Wadi El Maqfi areas these areas are covered by wet sabkha

Methodology

Soil sampling design and analysis:

The fieldwork designed to define the soil characteristics. The total number of soil profiles was 42 that dug to a depth ranged from 120 to 150 cm. The soil profiles were geo-referenced to UTM coordinate system map (1). The soil samples were collected and analyzed for chemical, physical and fertility characterization according to Page et al. (1982) and Klute, (1986).

Table 1: Average climatologically data for the study area.

Month	Max. Temp. °C	Min. Temp. °C	Humidity %	Wind Speed Km/d	Sunshine hours	Solar Rad. MJ/m^2/d	ETo mm/d	Rain mm/month
Jan.	20.4	4.2	46.0	182.2	8.9	15.4	3.1	0.60
Feb.	22.7	5.5	39.0	216.0	9.5	18.4	4.2	0.20
March	26.5	9.0	30.0	250.6	10.5	22.5	5.9	0.10
April	31.4	13.5	24.0	266.7	10.9	25.3	7.7	0.40
May	34.5	17.0	23.0	275.6	11.9	27.8	8.8	0.00
June	37.6	20.3	23.0	284.3	13.5	30.3	9.9	0.10
July	37.3	21.3	26.0	257.5	13.4	30.0	9.3	0.00
Aug.	37.3	21.2	28.0	240.0	12.8	28.4	8.7	0.00
Oct.	34.9	19.2	33.0	257.5	12.0	25.4	7.8	0.00
Sept.	31.3	15.4	37.0	217.7	11.1	21.3	5.8	0.50
Nov.	25.7	10.5	45.0	200.0	9.4	16.4	3.9	0.80
Dec.	21.2	5.6	47.0	173.3	8.6	14.3	2.9	0.10
Average	30.1	13.6	33.4	235.1	11.0	22.9	6.5	0.23

Pen-Mon equation was used in ETo calculations

Water sampling and analysis:

Thirteen water samples were collected from different wells using for irrigation in the study area and analyzed for salinity, alkalinity, sodicity and Micronutrients to determine water quality according to Richards, (1954).

Terrain Analysis:

Two topographic map sheets at scale 1:500000 named El Dakhla and El Baharia were screen digitized using Arc GIS 9 software. Contour lines and spot height were digitized to generate Digital Elevation Model (DEM). Slope and aspect were derived using Arc GIS 9.

Land Evaluation:

Agricultural Land Evaluation System for arid region (ALES-Arid) is a new approach for land capability and suitability evaluation (Abdel Kawy, 2004). ALES-Arid is described as a land use decision support system, which is linked directly with integrated databases and coupled with GIS. Through ALES-Arid program, land evaluation algorithms were expressed in notation forms that can be understood by a calculating device. Optimization tools based on land evaluation models are considered very important to formulate decision alternatives. According to (Storie, 1964); six productivity classes were identified as shown in Table (2).

The calculation of capability index by ALES-Arid is an indication of land capability according to multiplication method. ALES-Arid evaluates the suitability for 32 crops (field crops, vegetables, forage crops, and fruit tress) to identify the optimum land use. Land suitability classes were identified using the matching between standard crop requirements (FAO, 1977, 1985; Sys, 1975; and Sys *et al.*, 1993a, 1993b) and land characteristic

Table 2: Productivity classes and ratings according to Storie, 1964.

Class	Description	Rating (%)
C1	Excellent	80 – 100
C2	Good	60 – 80
C3	Fair	40 – 60
C4	Poor	20 – 40
C5	Very poor	10 – 20
C6	Non-agriculture	< 10

Environmentally Sensitive Areas (ESA):

The identification of sensitive areas based on the hypotheses of MEDALUS project model (Giordane *et al.,* 2008). The model applies a geometrical average of some quality indices, in order to provide sensitivity diagnosis. It assumes that each index has only limited capacity of influence the final value of Environmentally Sensitive Areas (ESA) index and only when several parameters have a high score, an area can be assigned to high sensitivity class. The following three quality indices were computed; Soil Quality Index (SQI), Vegetation Quality Index (VQI), Climatic Quality Index (CQI). The methodology based on classification of each quality index obtained as geometric mean of available environmental and anthropogenic parameters. The available parameters are quantified in relation to their influence on the desertification process assigning score to each. The scores assigned to different parameters range between 1 (best value) and 2 (worst value). The final overall ESA index is obtained as a geometrical average of the quality indexes (European Commission, 1999). Figure (1) demonstrates the main flow chart of concepts and studied steps performed in the current study. The main input data for calculating theses indices include LANDSAT ETM image of the study area, topographic map of the study area, climatic data derived from the Ministry of Agriculture. GIS system (i.e. Arc GIS 9) was the main tools in indices computations and ESA's mapping.

1. Mapping Soil Quality Index (SQI):

Soil is the dominant factor of the terrestrial ecosystems in the arid and semi arid and dry zones, particularly through its effect on biomass production. Soil quality indicators for mapping ESA's can be related to water availability and erosion resistance (Briggs *et al*, 1992; Basso et al, 1998). A number of four soil parameters were considered at the current investigation (i.e. parent material, soil texture, soil depth and slope gradient). Weighting factors were assigned to each category of the considered parameters, on basis of OSS, 2003, which were adapted from Medalus project methodology (European Commission 1999). Tables (3 to 6) demonstrate the assigned indices for different categories of each parameter. The soil Quality Index (SQI) was calculated on basis of the following equation, and classified according to categories shown in Table (7).

$$SQI = (Ip * It * Id * Is)^{1/4}$$

Ip index of parent material, It index of soil texture, Id index of soil depth, is index of slope gradient)

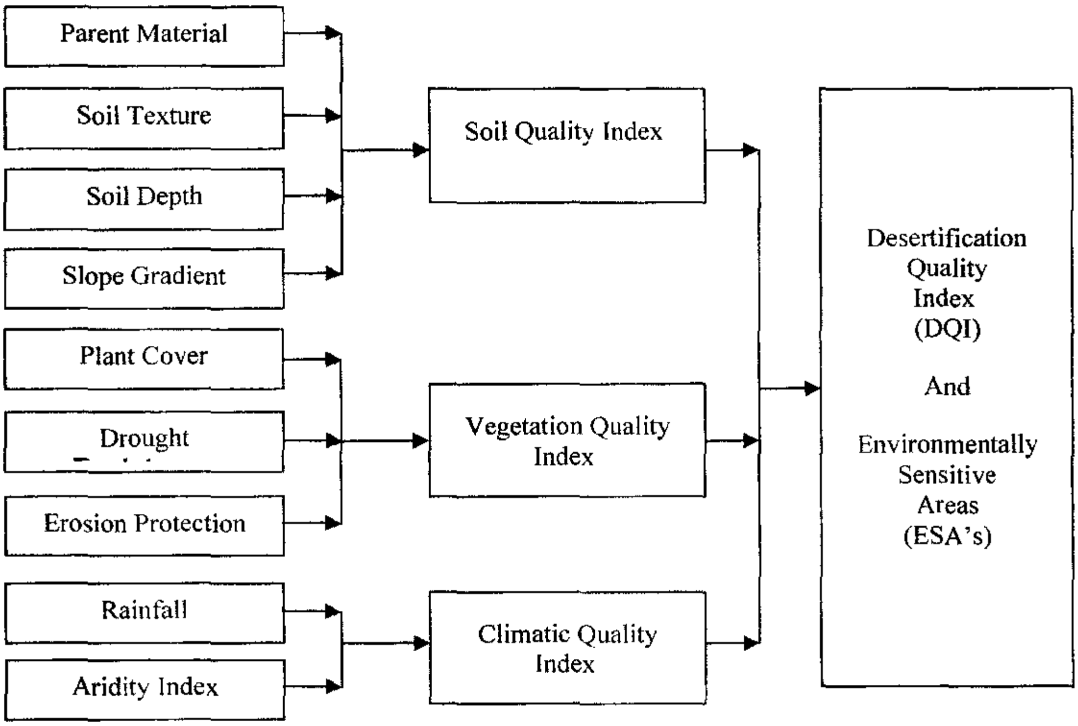


Fig. 1: Flow chart of mapping Environmentally Sensitive Areas (ESA's).

Table 3: Classes and assigned weighting index for parent material.

Class	Description	Score
1. Coherent: Limestone, dolomite, non-friable sandstone, hard limestone layer.	Good	1
2. Moderately coherent: Marine limestone, friable sandstone	Moderate	15
3. Soft to friable: Calcareous clay, clay, sandy formation, alluvium and colluviums	Poor	2

Table 4: Classes and assigned weighting index for soil depth.

Class	Description	Score
Very deep	Soil thickness is more than 1 meter	1.00
Moderately deep	Soil thickness ranges from <1m to 0.5 m	1.33
Not deep	Soil thickness ranges from <0.5m to 0.25 m	1.66
Very thin	Soil thickness < 0.15 m	2.00

Table 5: Classes and assigned weighting index for soil texture.

Texture classes	Description	Score	
		Areas dominated by water erosion	Areas dominated by wind erosion
Not very light to average	Loamy sand, Sandy loam, Balanced	1	1
Fine to average	Loamy clay, Clayey sand, Sandy clay	1.33	1.66
Fine	Fine Clayey, Clay loam	1.66	2
Coarse	Sandy to very Sandy	2	2

Table 6: Classes and assigned weighting index for Slope gradient.

Classes	Description	Score
< 6%	Gentle	1
6 – 19 %	Not very gentle	1.33
19– 35 %	Abrupt	1.66
>35 %	Very abrupt	2

Table 7: Classification of soil quality index.

Class	Description	Range
1	High quality	< 1.13
2	Moderate quality	1.13 to 1.45
3	Low quality	>1.45

2. Mapping Vegetation quality index (VQI):

Vegetation quality, according to Basso *et al* (2000) is assessed in terms of three aspects (i.e. erosion protection to the soils, drought resistance and plant cover). Adapted rating values for each of erosion protection, drought resistance and vegetal cover classes were adapted on basis of OSS (2003) as shown in Table (8). Vegetation Quality Index was calculated according the following equation, while VQI was classified on basis of the ranges indicated in Table (9).

$$VQI = (I\,Ep * I\,Dr * I\,Vc)^{1/3}$$

Where: IEp index of erosion protection, IDr index of drought resistance and IVc index of vegetation cover)

Table 8: Classes and assigned weighting index for different vegetation parameters

Class	Description	IEp	IDr	IVc
1	Perennial cultivation	1.00	1.00	1.00
2	Halophytes	1.33	1.00	1.33
3	Temporal and orchards, mixed with crop land	1.66	1.33	1.66
4	Saharan vegetation < 40%	2.00	1.66	1.00
5	Saharan vegetation > 40%	2.00	1.00	1.00

Table 9: Classification of vegetation quality index (VQI).

Class	Description	Range
1	Good	< 1.2
2	Average	1.2 to 1.4
3	Weak	1.4 to 1.6
4	Very weak	>1.6

3. Mapping Climatic quality index (CQI):

Climatic quality is assessed by using parameters that influence water availability to plants such as the amount of rainfall, air temperature and aridity, as well as climate hazards, which might inhibit plant growth (Thornes, 1995). Table (10) reveals the classification categories of climatic quality index according to OSS, 2003. The Climate quality index is evaluated through the Aridity Index (AI), using the methodology developed by Applied Meteorology Foundation "FMA" in accordance with the following formula. In the current study, rainfall and evapotranspiration data of the metrological station were used to calculate the CQI as follows;

$$CQI = P/EPT$$

Where: P is average annual precipitation and EPT is average annual Potential Evapotranspiration

4. Mapping Environmentally Sensitive Areas (ESA's) to Desertification:

Arc GIS9 software was used to map ESA's to Desertification (Kosmas *et al,* 1999) by integrating all data concerning the soil, vegetation and climate. Different quality indices were calculated and displayed as GIS ready maps from which class areas were deduced. The Desertification Sensitivity Index (DSI) was calculated in the polygonal attribute tables linked with the geographic coverage according to the following equation and classified according to Table (11);

Table 10: Classification of Climatic quality index (CQI)

Class	Climatic zone	P/PET	CQI
1	Hyper Arid	< 0.05	2
2	Arid	0.05 – 0.20	1.75
3	Semi Arid	0.20 – 0.50	1.50
4	Dry Sub-Humid	0.50 – 0.65	1.25
5	Humid	>0.65	1

Table 11: Ranges and classes of desertification sensitivity index (DSI)

Classes	DSI	Description
1	< 1.20	Non affected areas or very low sensitive areas to desertification
2	1.20 < DSI < 1.30	Low sensitive areas to desertification
3	1.30 < DSI < 1.40	Medium sensitive areas to desertification
4	1.40 < DSI < 1.60	Sensitive areas to desertification
5	DSI > 1.60	Very sensitive areas to desertification

RESULTS AND DISCUSSIONS

Soil samples analysis:

Table (12) shows the statistical characterization of the sample properties. Data show that soiil salinity, Available Fe, available Zn, available Mn, organic matter content and sodium adsorption ration (SAR) have the highest coefficient of variation (C.V. %).

Irrigation water quality:

Table (13) shows the statistical characterization of the wells water samples properties. The highest coefficient of variation (C.V. %) were available Cu, total dissolve salts (TDS) and sodium adsorption ration (SAR). Water quality evaluation for irrigation using (ALES_Arid) model shows that all the samples had water quality index 92.83% except wells which had Mn concentration more than 0.20 mg/l. Because these water samples collected from the wells directly so that the high concentration of manganese can be treated through aeration/infiltration system. Map (3) shows the distribution of different water wells in the study area and the water quality index for each water well.

Soil mapping units:

The overlay of different soil attribute layers (Ec, CaCO3 and soil texture) in GIS environment showed that the study area have four main soil units, namely slightly saline non calcareous sandy loam, slightly saline calcareous sandy, moderately saline non calcareous loamy sand, and highly saline non calcareous sandy representing 3.62%, 28.16%, 32.50%, and 35.71%, respectively (map 4).

Table 12: Statistical characterization of soil properties.

Soil Property	Statistical parameters					
	Min	Max	Mean	Variance	St. Dev.	C.V.
Ec, dS/m	0.00	135.5	12.98	527.06	22.96	176.89
SAR	0.40	43.90	5.63	36.86	6.07	107.82
pH	6.73	9.11	8.12	0.20	0.45	5.54
$CaCO_3$, %	0.70	18.40	6.07	12.08	3.48	57.33
OM, %	0.02	1.61	0.31	0.10	0.32	103.23
Av. K, ppm	22.86	709.09	195.93	19183.33	138.50	70.69
Av. P, ppm	0.01	7.81	1.19	1.36	1.17	98.32
Av. Fe, ppm	0.36	68.94	7.41	137.84	11.74	158.44
Av. Zn, ppm	0.28	21.22	1.34	4.06	2.01	150.00
Av. Mn, ppm	0.06	15.10	2.09	7.87	2.80	133.97
Av. Cu, ppm	0.04	5.24	1.32	1.00	1.00	75.75
Clay, %	0.80	23.60	7.89	57.76	7.60	96.32
Silt, %	1.20	12.10	5.30	10.96	3.31	62.45
Sand, %	65.20	98.10	86.82	117.16	10.82	12.46
Sp, %θv	31.68	94.88	50.93	279.73	16.73	32.85
FC, %θv	4.93	30.57	12.55	45.36	6.73	53.63
PWP, %θv	0.72	16.84	5.57	16.39	4.05	72.71
AV. Water, mm/m	22.07	137.36	69.94	775.12	27.84	39.81
Ks*, m/d	0.11	5.17	2.50	3.88	1.97	78.80
Bulk Denisty, Mg/m^3	1.37	1.82	1.60	0.02	0.15	9.38

Table 13: Statistical characterization of water samples.

Soil Property	Statistical parameters					
	Min	Max	Mean	Variance	St. Dev.	C.V.
Ec, dS/m	0.18	0.47	0.22	0.01	0.07	31.82
SAR	0.50	2.30	0.73	0.20	0.44	60.27
pH	6.00	7.01	6.23	0.06	0.25	4.01
TDS, ppm	115.00	474.00	149.47	8113.27	90.07	60.26
Av. Fe, ppm	0.69	3.86	2.09	1.08	1.04	49.76
Av. Zn, ppm	0.01	0.05	0.03	0.00	0.01	33.33
Av. Mn, ppm	0.08	0.59	0.39	0.02	0.14	35.90
Av. Cu, ppm	0.01	0.12	0.04	0.00	0.03	75.00

Terrain analysis:

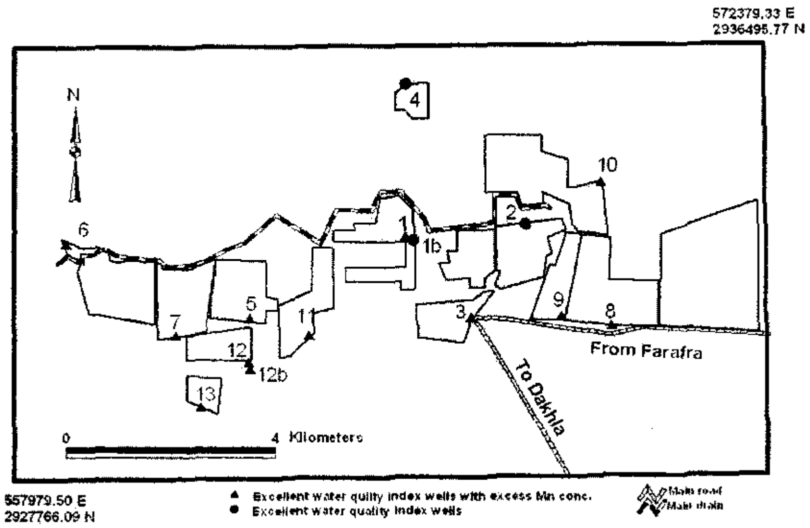
Digital Elevation Model (DEM) analysis indicated that the area study was located in one unit of the digital elevation model ranged from 83 to 167 m A.S.L. which is the lowest location for the surrounding area (map 5). The dominant slope class is flat (0 – 0.5%) and cover about 85% of the total acreage, while dominant slope directions (aspect) are north, northeast, and northwest representing about 50% of the total acreage.

Land capability classes:

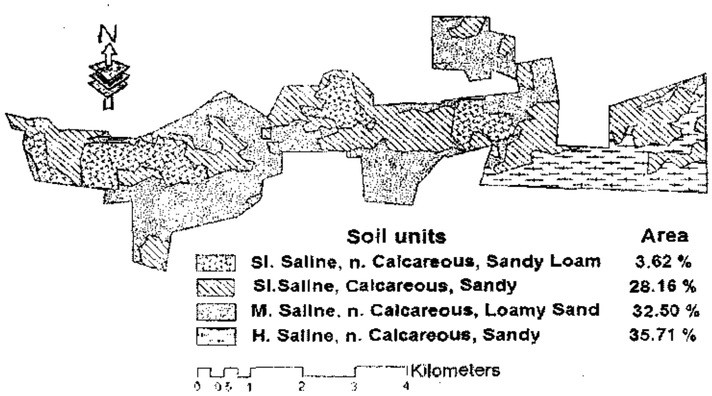
The (ALES_Arid) model provides prediction for general land use capability for a broad series of possible uses. According to the model prediction, most of the study area was classified as C4 (t, Kh, Ece), which indicated low capability due to soil texture, hydraulic conductivity and soil salinity as limiting factors. Table (14) illustrates the area and percentage of each land capability class in the study area. Map (6) shows the distribution of each land capability class in the study area.

Table 14: area percentage of land use capabilityclasses in the study area.

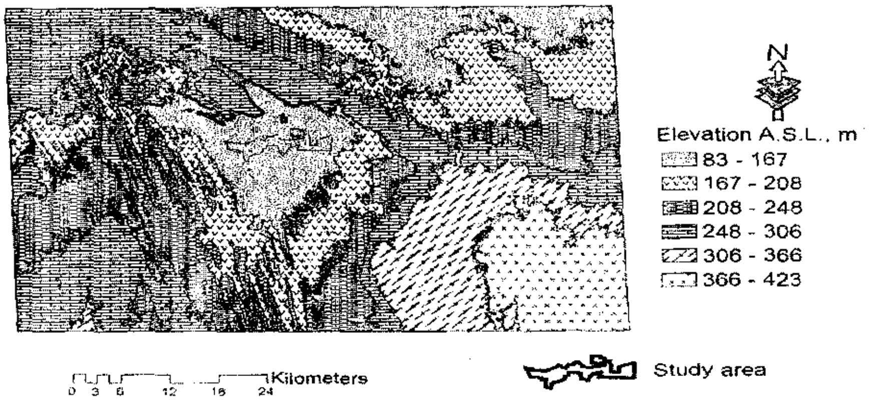
Land capability class	Area (%)
C_2, t	3.30
C_2, t,Kh	26.63
C_4, t, Ece	29.58
C_4, t, Kh, Ece	32.50
Ns_2	8.99
Total	100



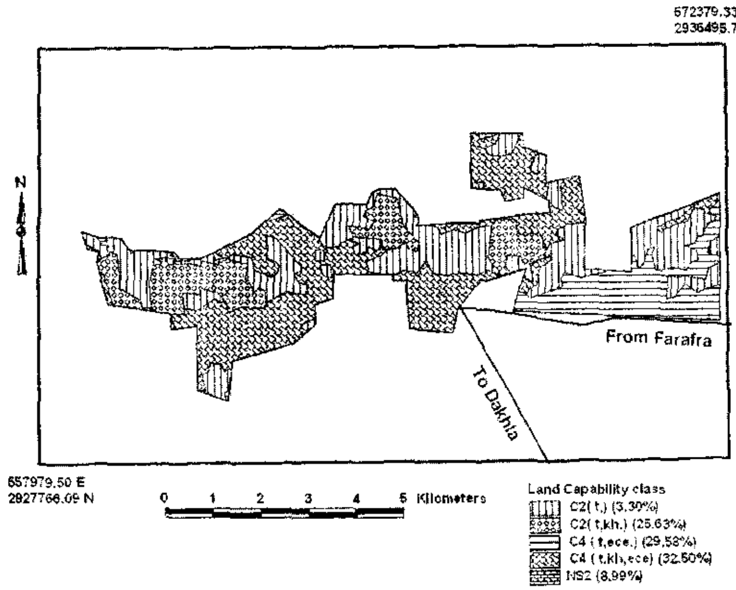
Map 3: Water wells quality and distribution in the study area.



Map 4: Soil mapping units of the study area.



Map 5: Digital Elevation Model (DEM) of the study area.



Map 6: Land capability for the study area.

Soil Quality Index (SQI):

According to the geologic map of Egypt, previous studies and field trip of the study area show that the dominant parent material was coherent limestone. The soil depth were evaluated in the field and shows that the soil characterized by deep soil depth. The mechanical analysis of the soil samples shows that the dominant soil texture classes were sandy, sandy loam and loamy sand. The slope gradient was classified, on basis of topographic maps and digital elevation model (DEM). Calculating the soil quality index reveals that the majority of the study area soil (64.0 %) are characterized by moderate quality concerned in two soil units called slightly saline, calcareous, sandy and highly saline, non calcareous, sandy (score=1.18) and the other two units represent 35.0% of the study area were high quality.

Vegetation Quality Index (VQI):

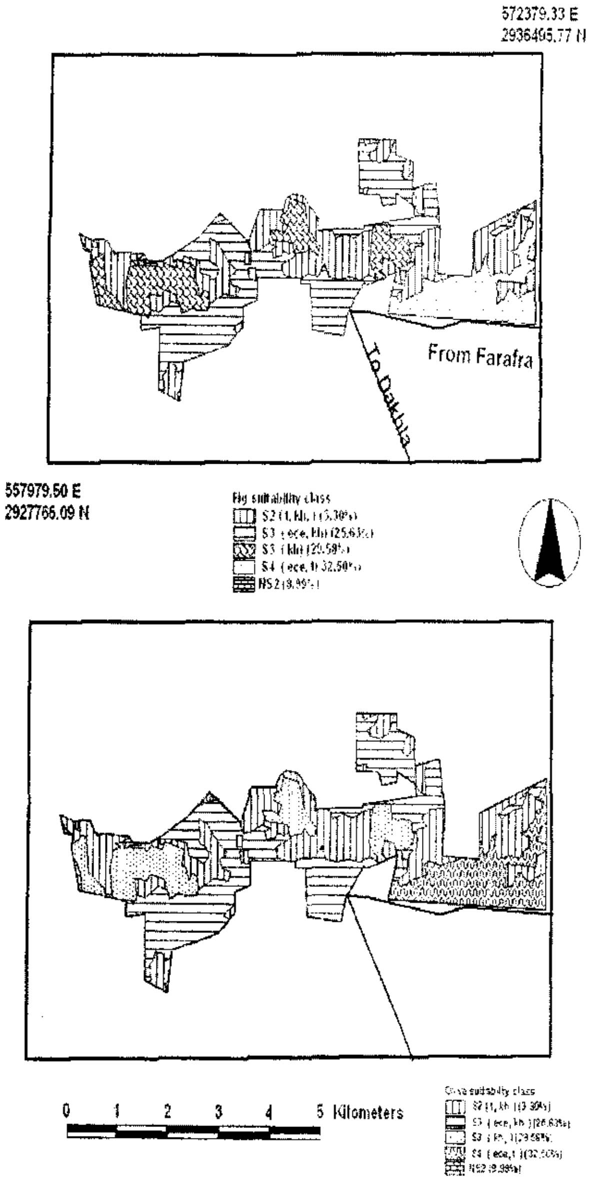
From the field trip and the questionnaire identifying that the study area vegetation pattern was temporal and orchards, mixed with crop land. Vegetation quality index of this class was given a score evaluating vegetation cover, erosion protection and drought resistance. Calculating the vegetation quality index, on basis of the previous parameters reveal that the area study of the vegetation cover is weak and sensitive to desertification.

Climate Quality Index (CQI):

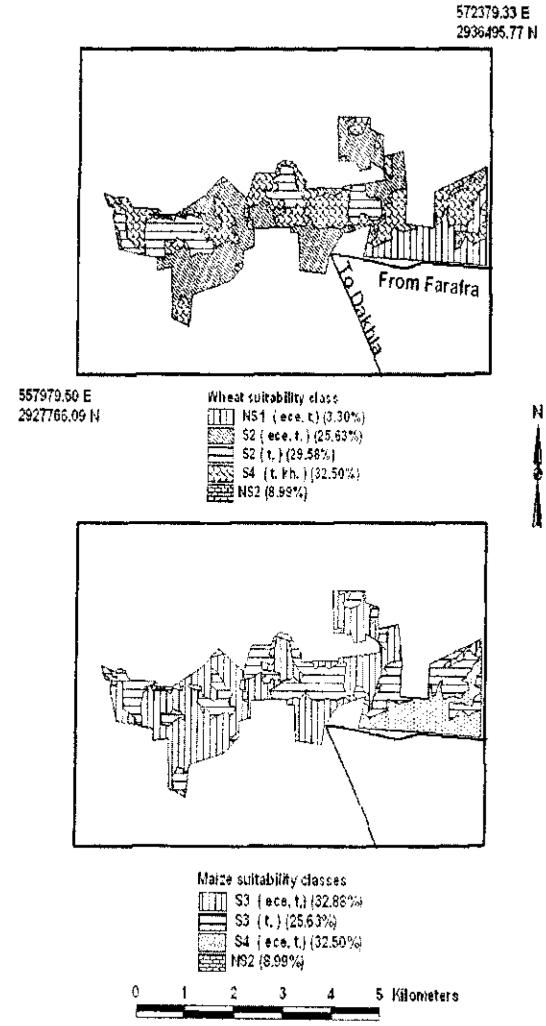
Climatic data (i.e. rainfall and evapo-transpiration) interpolation resulted in obtaining values for both parameters. The climatic sensitivity index was calculated and stored in a GIS. In the study area the average annual rainfall drops down to almost zero. The average annual potential evapo-transpiration is relatively high in the study area. The hyper arid climatic conditions characterize the study area region.

Environmentally Sensitive Areas (ESA's) to Desertification:

The three previous indices were driven together for the assessment of the environmentally sensitive areas (ESA's) to desertification, on basis of the calculated Desertification Sensitivity Index (DSI). It is clear that most of the study area (64 % of the total area) is very low sensitive to desertification; these soil units were slightly saline, calcareous, sandy and highly saline, non calcareous, sandy. The other two soil units which called slightly saline, non calcareous, sandy loam and moderately saline, non calcareous, loamy sand covered about 36 % of the total area was not affected areas.



Map 7a: Land suitability classes for fig and olive.



Map 7b : Land suitability for wheat and maize.

CONCLUSION

Land use planning in the study area should be carried out in a precautious way to avoid the impact of being a low-lying area, and the impact of being drained by the surroundings. A main drain should be installed to protect the area, and wind breaks should be planted to prevent wind erosion. Manganese oxides should be get rid of in order not to affect the irrigation water quality. A road network connecting the study area to main cities and towns should be paved to guarantee the sustainable agricultural development, as the study area is not sensitive to desertification and land degradation. It is recommended that the quantitative approach for determining the sensitivity for desertification should be adopted and applied to the areas where desertification and environmental deterioration is expected.

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الملخص العربى

تكامل تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية لرسم خرائط المناطق الحساسة بيئيا للتصحر لبعض مناطق واحة الفرافرة – الصحراء الغربية – مصر

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إن إختلال التوازن بين معدلات الزيادة السكانية ومعدلات إستصلاح الاراضى الزراعية فى حد ذاته مؤشر هام على الحاجة لإضافة أراضى جديدة من خلال عمليات التوسع الزراعى الأفقى حيث أن عمليات التوسع الزراعى الراسى فى مصر اصبحت محدودة جدا. والهدف الرئيسى من عمليات التوسع الزراعى الأفقى هو زيادة الإنتاج لتلبية الحاجة إلى الغذاء والأعلاف والالياف امواجهة الزيادة السكانية المستمرة. كما إنه يساعد على توفير المزيد من فرص العمل والتخفيف من الضغط السكانى على المدن القديمة وتقليل الخسائر فى الأراضى الزراعية نتيجة عمليات الزحف العمرانى كنتيجة لعمليات التنمية الحضرية. وعلاوة على ذلك فانه ينشئ مجتمعات عمرانية جديدة تمكن من إنشاء قطاع زراعى أكثر فاعلية وقادر على جذب الإستثمارات وإعادة هيكلة الإنتاج الزراعى من خلال إدخال محاصيل غير تقليدية لتحقيق الأهداف التصديرية وتشجيع مشاريع التصنيع الزراعى. تغطى منطقة الدراسة مساحة تقدر بحوالى ٣٦٠٥ فدان وتسمى أبو منقار وتقع بواحة الفرافرة بمحافظة الوادى الجديد بالصحراء الغربية – مصر. وتهدف الدراسة إلى أ) التعرف على الوحدات الأرضية المختلفة الموجودة بمنطقة الدراسة وذلك من خلال تحليل صور الأقمار الصناعية المتاحة (التقسيم الموجة والغير موجة) وكذلك الزيارات الحقلية. ب) تحديد خصائص كل وحدة ارضية موجود بمنطقة الدراسة من خلال التحليل المعملى لعينات التربة. ج) تقييم كل وحدة ارضية لتحديد أفضل انواع المحاصيل التى يجود زراعتها فى هذه الوحدة الأرضية عن طريق برامج تقييم الاراضى (تقييم القدرة الإنتاجية وتقييم الملائمة) المختلفة وذلك فى بيئة نظم المعلومات الجغرافية. د) استخدام التكامل بين كلا من نظم المعلومات الجغرافية والإستشعار عن بعد كطريقة كمية لرسم وتحديد المناطق الأكثر حساسية بيئيا لعمليات التصحر بمنطقة الدراسة. وقد وجد خمس وحدات ارضية اساسية بمنطقة الدراسة وهى

a) Slightly saline non calcareous sandy loam,
b) Slightly saline calcareous sandy,
c) Moderately saline non calcareous loamy sand,
d) Highly saline non calcareous sandy
e) Stony soil.

وتغطى مساحات تقدر بحوالى ٣,٣٠% و ٢٥,٦٣% و٢٩,٥٨% و ٣٢,٥٠% و٨,٩٩% من إجمـالى مـساحة منطقـة الدراسة على التوالى. ومن خلال تقييم مياه الابار لتقييم صلاحيتها للاستخدام فى عمليات الرى ان الابار ارقام (1b و٢ و٤) مياها ذات جودة ممتازة للرى ودليل الصلاحية يقدر بحوالى ٩٢,٨٣% اما بالنسبة لباقى الأبار الموجودة بمنطقة الدراسة فانها جيدة للرى ولكن تعانى من زيادة فى تركيز عنصر المنجنيز لذلك لأبد من عمل الإجراءات اللأزمة للتخلص منه عن طريقـة تهوية المياه لحدوث عمليات التاكسد والترسيب لأكاسيد المنجنيز. ومن خلال نتائج عمليات تقييم الاراضى وجـد أن منطقـة الدراسة تنقسم الى قسمين اساسيين من حيث تقييم القدرة الانتاجية وهما C2 , C4 ويغطوا مساحة تقدر ٦٢,٠٨% و ٢٨,٩٣% من اجمالى المساحة الكلية على التوالى وكانت المعوقات الأساسية هى قوام التربة وملوحة التربة والتوصيل الهيدروليكى. ومن خلال تقييم ملائمة الأراضى لبعض المحاصيل وجد أن منطقة الدراسة تصلح لزراعة بعض المحاصيل التى تتحمل المعوقـات الأساسية الموجودة وكذلك باستخام طرق إدارة معينة. ومن خلال حساب دليل حساسية الترب للتصحر وجد إن معظم منطقـة الدراسة أى ٦٤% من المساحة الكلية حساسيتها منخفضة جدا للتصحر وهذه الوحدات كانت slightly saline, calcareous, sandy and highly saline, non calcareous, sandy. أما باقى الوحدات والتى تمثل ٣٦% من اجمالى المساحة تعتبر مناطق غير حساسة أو متاثرة بالتصحر.