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DETECTING LAND DEGRADATION PROCESSES USING GEO STATISTICAL APPROACH IN PORT SAID, EGYPT

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ABSTRACT: **The main objective of this study was to detect land degradation using parametric, geo-statistical and modelbuilder approach. There are five major land degradation processes (water and wind erosion, physical degradation, salinization and sodification) these were calculated by the Universal Soil Loss Equation (USLE) for assessment land degradation in the studied area. In order to understand the variation of land degradation types, graphical interpretation of parametric factors on land degradation were performed using geostatistics. Spatial models were developed using Arc GIS 9.2 software bachadge. The area was selected on the basis of being representative of most of the physiographic units of North Sinai and the eastern outskirts of Nile Delta. It is located in the two sides of Sues Canal between longitudes 32°3′5.93 and 32°33′18.90N and latitudes 31°22′11.30 and 30°54′0.12E, with a total area of 135,000 hectares (321,450 feddans). The results show that, soil degradation by water and wind erosion is slight (less than 0.02 and 2.63 t/ha/year respectively). It is slight to high degraded for physical degradation (from 0.01 to 7.5% per year). The present state of salinization in the area is slight to very high (from 0.1 to 31.43 dSm^{-1}/year). The present state of sodification in the area is slight to very high (from 0.47 to 7.07 %/year).**

Key words: Land degradation, USLE, geostatistics, model builder, Port Said

INTRODUCTION

Land degradation is the process which lowers the current and/or the potential capability of soil to produce goods or services. Land degradation is not necessarily continuous; it may take place over just a short period between two states of ecological equilibrium, FAO/UNEP (1978).The problem of land degradation in the world was studied initially at a world scale by an initiative of the United Nations Environmental Program (UNEP) and the International Soil Reference and Information Center (ISRIC). The study was developed from a soil resource perspective and as a human-induced phenomenon. The project was entitled: Global Assessment of Soil Degradation (GLASOD) and the objectives was to produce world map on the status of human-induced soil degradation (scale 1:1000000) (Oldeman, Hakkeling, and Sombroek, 1990). Abd-El-Gawad (1983) Detected that the soils of the north part of the Nile delta is supposed to suffer from salinity and alkalinity problems. This is due to their lower elevation as well as their location near the lake and their higher ground water tables. FAO (1983) Reported that waterlogging soils are not suitable for agriculture and they exist even in parts of the world where water excess is not a problem in Egypt for example about one-third of the Nile delta has a rather shallow water table of 80cm below the surface. Abd-El-Ghany (1996) on his study in the Nile delta showed that the soil salinity in1963 were ranging between 4-8 dS/m where it reaches more than 30 dS/m in 1996. Gad and Abdel-Samie (1998) Stated that the most active soil degradation processes in the Nile delta are salinization and physical degradation. El-Kassas (1999) and Abd el Kawey (2002) Summarized the main soil degradation types of irrigated lands in Egypt as salinization, alkalization, raising of ground water level, poor drainage, removal of top soil, urban land encroachment, sand dune moving and the reused drainage water in irrigation.

Five major of land degradation were calculated by Universal Soil Lose Equations (USLE) for promoting land degradation in the studied area. There are water erosion, and wind erosion, which are physical degradation indictors, Salinization and alkalization which are chemical degradation indictors.

According to FAO/UNEP (1978) the factors affecting of land degradation are: 1- Climatic, 2- Topographic, 3- Soil, 4- human activity. The first three, called natural factors are affect natural vulnerability or potential degradation. The fourth factor affects the actual degradation. However, it was reported that the level topography, as for chemical degradation is an important factor influencing this type of degradation, because it increases infiltration. Whereas slope aspect influence soil temperature and humidity. Oades and Waters (1991) detected that the silt and clay size particles are easily removed by wind or over land flow or move in suspension into a soil causing clogging of pores and seal formation. Resistance of a soil to erosion is therefore intimately linked to the proportion of clay and silt size soil compounds that resist dispersion/disaggregating. Singh (1995) reported that due to increasing human activities and climatic fluctuations in the last few decades, the degradation processes like wind erosion, water erosion, salinity, alkalinity and vegetation have depleted the biological productivity of four major land use systems of Indian desert.

The main objective of this study was detected the land degradation processes using parametric, geo-statistical and spatial statistical methods.

MATERIALS AND METHODS

Study Area

The study area is selected on the basis of being representative the most of physiographic units of North Sinai and the eastern outskirts of Nile Delta region (Figure1). It was geographically described, using a topographic maps (scale 1:100,000), published by the Land Survey Authority of Egypt (1990). The area is located in the two sides of Sues Canal between longitudes 32°3′5.93 and 32°33′18.90 and latitudes 31°22′11.30 and 30°54′0.12 , with total area 135008.14 hectars (321448 feddans), having an elevation from -3 meter under sea level to 13 m above sea level along the Aeolian deposits. The climatic data of the studied area, are describe by maximum temperature occurs in August as 30.9 C^{o} and minimum temperature occurs in January, as 11.2 C^{o}. The monthly precipitation reaches a maximum of 18.0 mm in December, while it becomes none in June, July and August. The annual rainfall is 73 mm. minimum evaporation occurs in January as 4.6 mm/day maximum evaporation occurs in September as 7.5 mm/day. The water resources in the studied area mainly depend on the Nile water flows to the area through El-Salam canal, crossing the western part by open canal pathing to the eastern part by two under-ground tubes under the bottom of the Suez Canal. El-Fayoumy (1968) found that the studied area is composed of Quaternary deposits Late Pleistocene to Holocen. The Holocene deposits included: Young fluvio- marine deposits, originally transported and deposited by both base of fluvio-marine alluvium, partly covered by Aeolian sand, the Aeolian sands are still of the river and the sea and composed of clay and silty clay interlayer with lenses of quartz sand, highly enriched with salt. The Pleistocene deposits include subdeltaic deposits, composed of medium and fine quartz sand resting either directly on the old fluvio-marine deposits or on their equivalent fluviatile deposits, named locally "Turtle Backs". The sediments are found through geological cross section between Ismailia and Port Said cities.

Field Studies

Twenty nine soil profiles representing the different soil types were dug for the purposes of morphological description and soil sampling as well as detecting land degradation.

Laboratory Analyses

Include physical analysis (Particle size distribution was determined according to Dewis and Feritas (1991).) and *chemical analysis* include (Electric Conductivity EC (dS/m), Ca CO_3%, OM%, pH (1:2.5 suspention), exchangeable Na+, CEC meq/100g. soil, and gypsum content %) were determined according to Rowell (1995).

Land Degradation Assessment

The provisional methodology for soil degradation assessment (FAO/UNEP and UNESCO, 1979) aimed to investigate the purpose of identification, mapping and detecting the potential and present day land degradation. These methodologies were established in a "scale-independent" way to be applicable at regional, detailed and very detailed levels. The application of the parametric approach on different units resulted in estimating the risk of land degradation and the present day land degradation .The general form for the used parametric formula is:

D = f (C, S, T, V, L, M)

In which D = soil degradation, C = climatic factor, S = soil factor, T = topographic factor, V= natural vegetation factor, L = land use factor, M = management factor.

The values of the variables are chosen in such a way that the solving of the equation gives the numerical indication of the degradation rate. However, since the formula describes the processes only approximately, and the values assigned to each factor can themselves only are approximate in the present state of knowledge, the final results should not be regarded as absolute values for the soil loss or soil degradation. These values are merely giving an approximate indication of likely magnitude of degradation.

In order to understand the variation of land degradation types, graphical interpretation of parametric factors of land degradation were performed using geostatistics. A dataset of parametric factors of USLE for land degradation for each soil profile was created with their geo-referenced position in the field by using the ArcGIS 9.2 Before creating surface diagrams; the distribution of data was analyzed to get a better understanding of trends, directional influences and obvious errors. IDW and kriging were used for the creation of several maps for active land degradation types in the studied area. Prior to the creation of the maps, semi-variograms were produced for each type of land degradation. Cross validation was used to compare the prediction performances of the semi - variograms.

Spatial Modeling

GIS support land degradation by providing a good platform of data base storage, simple modeling and presentation of results and development of a user interface in combination with a GPS, controlling the navigation of degradation data. All spatial models were created using ArcGIS 9.2 a software from ESRI, using the Model Builder extension.

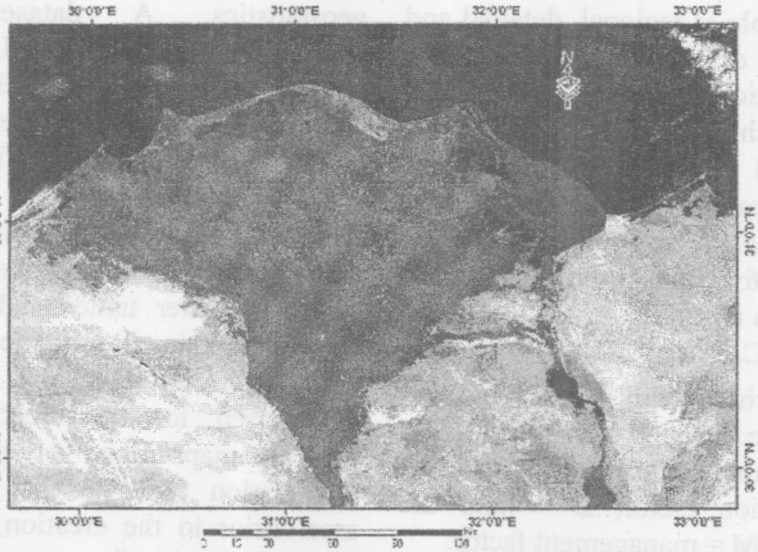


Fig.1.Location map of study area for land degradation assessment

Model Builder adds a new document to ArcGIS, (a model window analogous to view, layout and other document types existing in ArcGIS. Within the model document, users create models as process flow diagrams as in figure 2. The diagrams represent model processes. A process is defined as chained model nodes depicting input data, geo-processing function, and output or derived data. Each type of model node is represented as a distinctly shaped and colored icon.

Using the Model Builder in ArcGIS a model was developed for each of the respective land degradation. Once the land degradation variables of each model was determined by the USLE for each type, the shape files with the source data were modified to reflect the attributes that methods would be given consideration. All input shape files (land degradation types) were converted to discrete grid formats using the vector conversion function. Grid files are composed

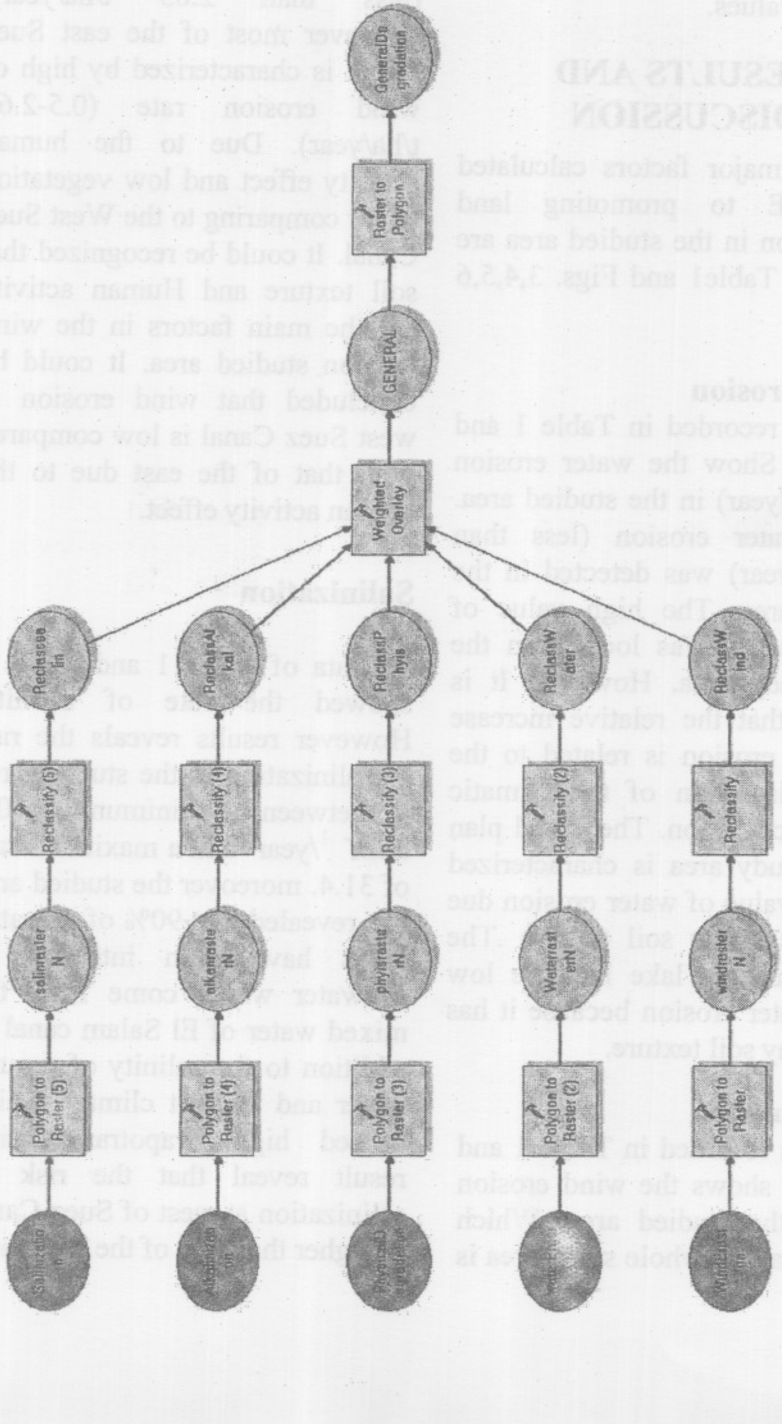


Fig. 2.Structural of spatial modeling for land degradation

of pixels, to which one can assign different values.

RESULTS AND DISCUSSION

Five major factors calculated by USLE to promoting land degradation in the studied area are shown in Table1 and Figs. 3,4,5,6 and 7.

Water Erosion

Data recorded in Table 1 and figure 3. Show the water erosion rate (t/ha/year) in the studied area. Slight water erosion (less than 0.02t/ha/year) was detected in the studied area. The high value of water erosion was located in the north study area. However, It is obvious that the relative increase of water erosion is related to the strong dissection of the climatic and soil condition. The costal plan in the study area is characterized by high value of water erosion due to it has sandy soil texture .The south Manzala lake has the low value water erosion because it has heavy clay soil texture.

Wind Erosion

Data recorded in Table 1 and Figure 4 shows the wind erosion rate in the studied area, Which reveal that the whole study area is subjected to slight wind erosion (less than 2.63 t/ha/year). However most of the east Suez Canal is characterized by high of wind erosion rate (0.5-2.63 t/ha/year). Due to the human activity effect and low vegetation cover comparing to the West Suez Canal. It could be recognized that soil texture and Human activity are the main factors in the wind erosion studied area. It could be concluded that wind erosion at west Suez Canal is low compared with that of the east due to the human activity effect.

Salinization

Data of Table 1 and figure 5 showed the rate of salinity. However results reveals the rate of salinization in the studied area is between a minimum of 0.2 dSm^{-1}/year and a maximum rate of 31.4. moreover the studied area has revealed that 90% of irrigated lands have been intruded by saltwater which come from the mixed water of El Salam canal in addition to the salinity of ground water and the hot climate which caused high evapotranspiration result reveal that the risk of salinization at west of Suez Canal is higher than that of the east and

Table 1. Degradation rates and types

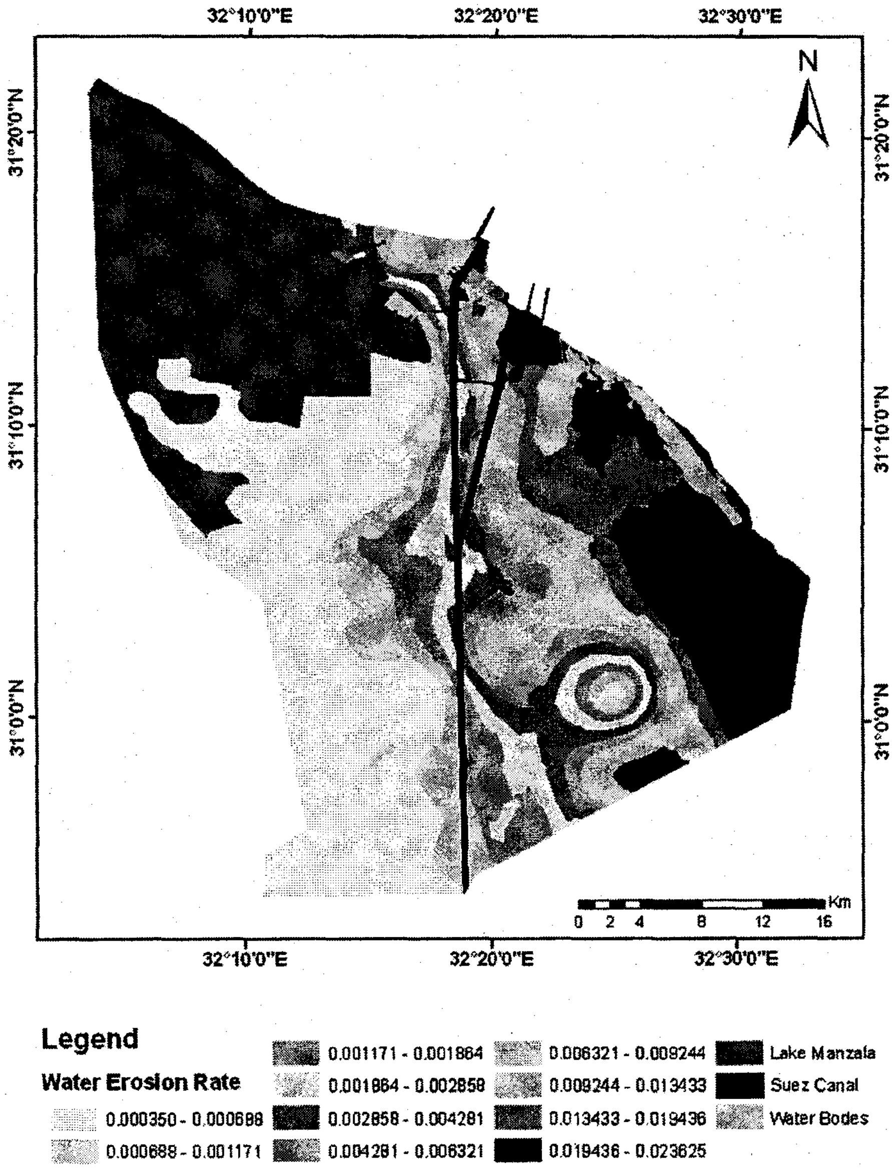
Profile No.	Q Water (t/ha/ year)	Q Water Rate	Wind (t/ha/ year)	Wind Rate	Q Physical degradation (%/year)	Physical degradation Rate	Sodificaiton (%/year)	Sodifica-tion Rate	Saliniza -tion (dSm⁻¹/ year)	Saliniza-tion Rate
1	0.00	Slight	1.49	Slight	7.50	High	0.47	Slight	0.10	Slight
2	0.00	Slight	1.49	Slight	7.50	High	0.47	Slight	4.93	High
3	0.01	Slight	0.53	Slight	0.01	Slight	4.71	Very high	0.99	Slight
4	0.01	Slight	0.53	Slight	1.00	Moderate	4.71	Very high	0.99	Slight
5	0.01	Slight	0.53	Slight	0.01	Slight	4.71	Very high	0.99	Slight
6	0.00	Slight	1.49	Slight	7.50	High	0.47	Slight	0.10	Slight
7	0.01	Slight	0.53	Slight	0.01	Slight	0.47	Slight	0.99	Slight
8	0.01	Slight	0.53	Slight	0.01	Slight	0.47	Slight	4.93	High
9	0.02	Slight	1.49	Slight	7.50	High	0.47	Slight	0.49	Slight
10	0.02	Slight	0.53	Slight	0.01	Slight	4.71	Very high	0.63	Slight
11	0.00	Slight	0.25	Slight	1.00	Moderate	0.30	Slight	1.85	Slight
12	0.01	Slight	2.63	Slight	0.00	Slight	7.07	Very high	18.49	Very high
13	0.00	Slight	0.39	Slight	0.01	Slight	7.07	Very high	31.43	Very high
14	0.00	Slight	0.79	Slight	0.01	Slight	7.07	Very high	31.43	Very high
15	0.00	Slight	0.13	Slight	0.01	Slight	0.87	Slight	27.73	Very high
16	0.00	Slight	0.13	Slight	0.01	Slight	4.58	Very high	27.73	Very high
17	0.00	Slight	0.53	Slight	0.01	Slight	4.71	Very high	0.63	Slight
18	0.02	Slight	1.49	Slight	7.50	High	0.47	Slight	0.25	Slight
19	0.02	Slight	1.49	Slight	1.50	Moderate	0.47	Slight	1.20	Slight

Q amount removal

Table 1. Cont.

Profile No.	Q Water (t/ha/ year)	Q Water Rate	Wind (t/ha/ year)	Wind Rate	Q Physical degradation (%/year)	Physical degradation Rate	Sodificaiton (%/year)	Sodificaiton Rate	Saliniza-tion (dSm^{-1}/ year)	Saliniza-tion Rate
20	0.02	Slight	1.49	Slight	1.50	Moderate	0.47	Slight	1.20	Slight
21	0.02	Slight	1.49	Slight	0.30	Slight	0.47	Slight	0.25	Slight
22	0.02	Slight	1.49	Slight	2.25	High	0.47	Slight	1.23	Slight
23	0.02	Slight	0.53	Slight	0.01	Slight	1.57	Moderate	2.46	Moderate
24	0.00	Slight	0.13	Slight	0.01	Slight	4.58	Very high	27.73	Very high
25	0.00	Slight	0.13	Slight	0.01	Slight	4.58	Very high	27.73	Very high
26	0.00	Slight	0.13	Slight	0.01	Slight	4.58	Very high	27.73	Very high
27	0.00	Slight	0.09	Slight	0.01	Slight	3.06	Very high	18.49	Very high
28	0.00	Slight	0.13	Slight	0.01	Slight	0.87	Slight	6.29	High
29	0.02	Slight	1.49	Slight	0.01	Slight	0.47	Slight	0.25	Slight

Q amount removal



Figu.3.Water erosion (t/ha/year) for study area by GIS

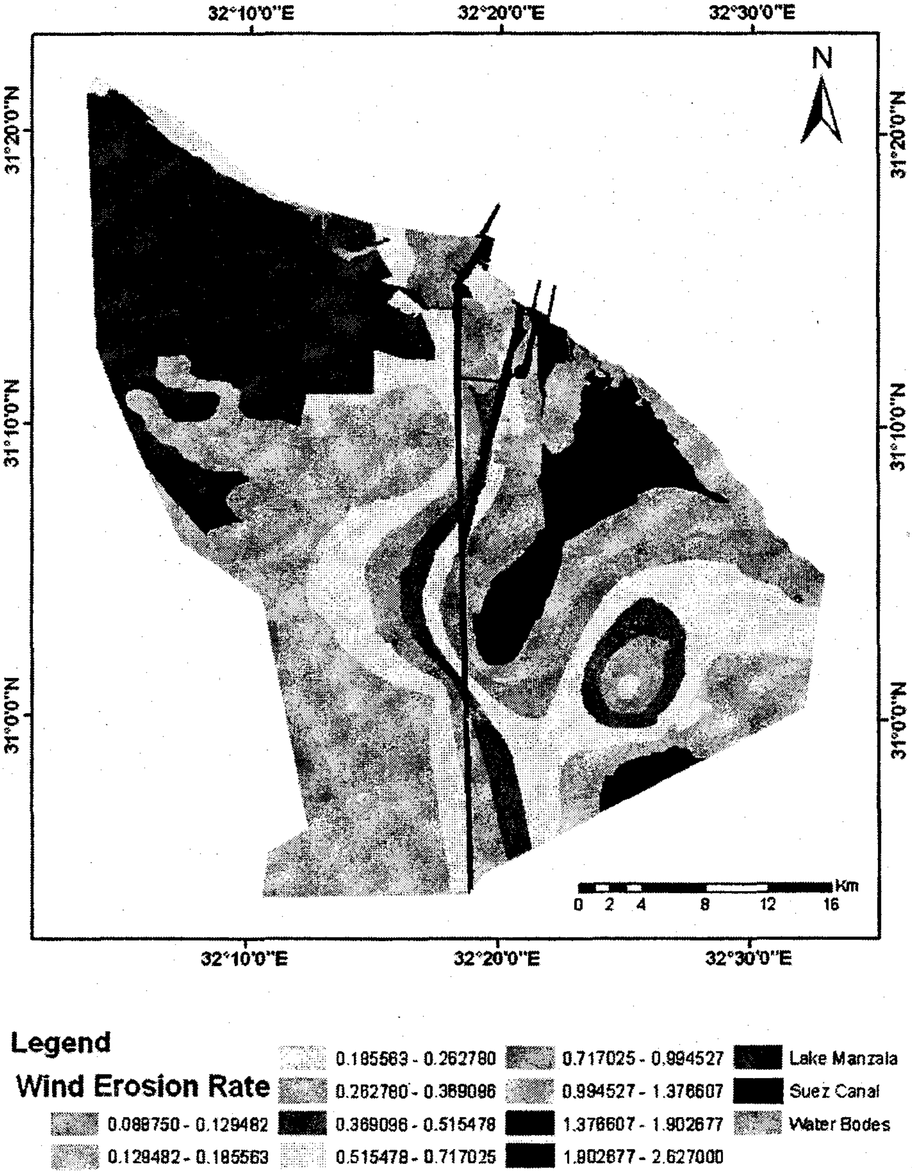


Fig.4.Wind erosion (t/ha/year) for study area by GIS.

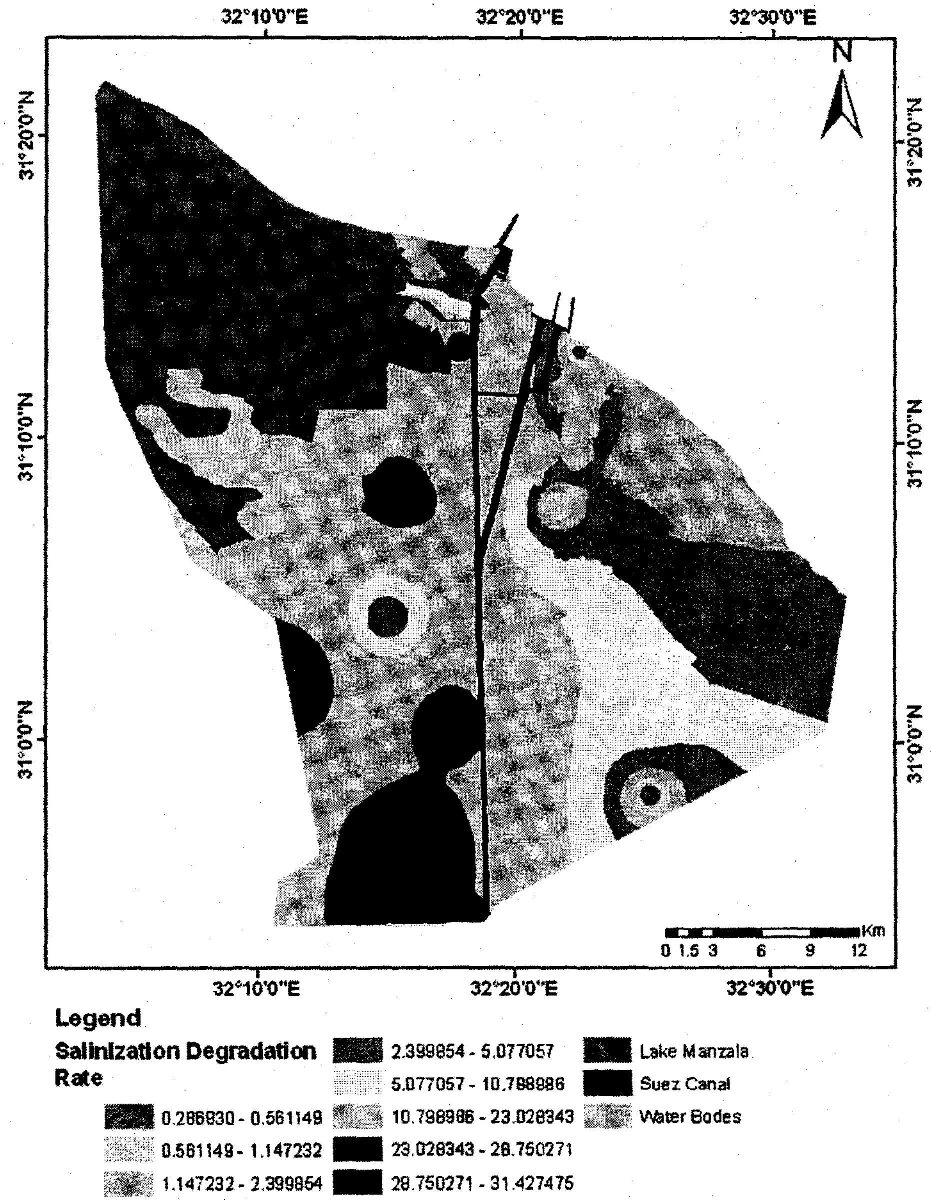


Fig.5. Salinization degradation (dSm^{-1}/year) for study area by GIS

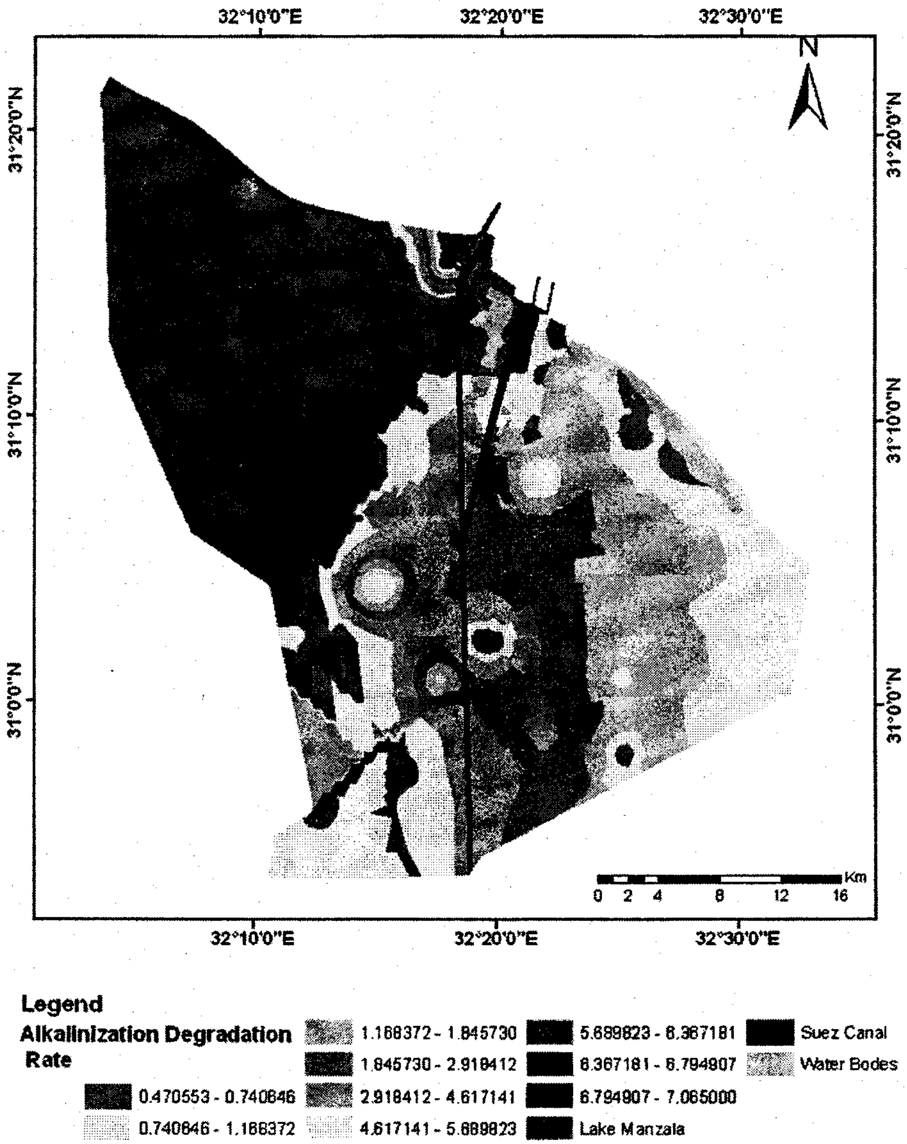


Fig.6.Sodification degradation for study area by GIS

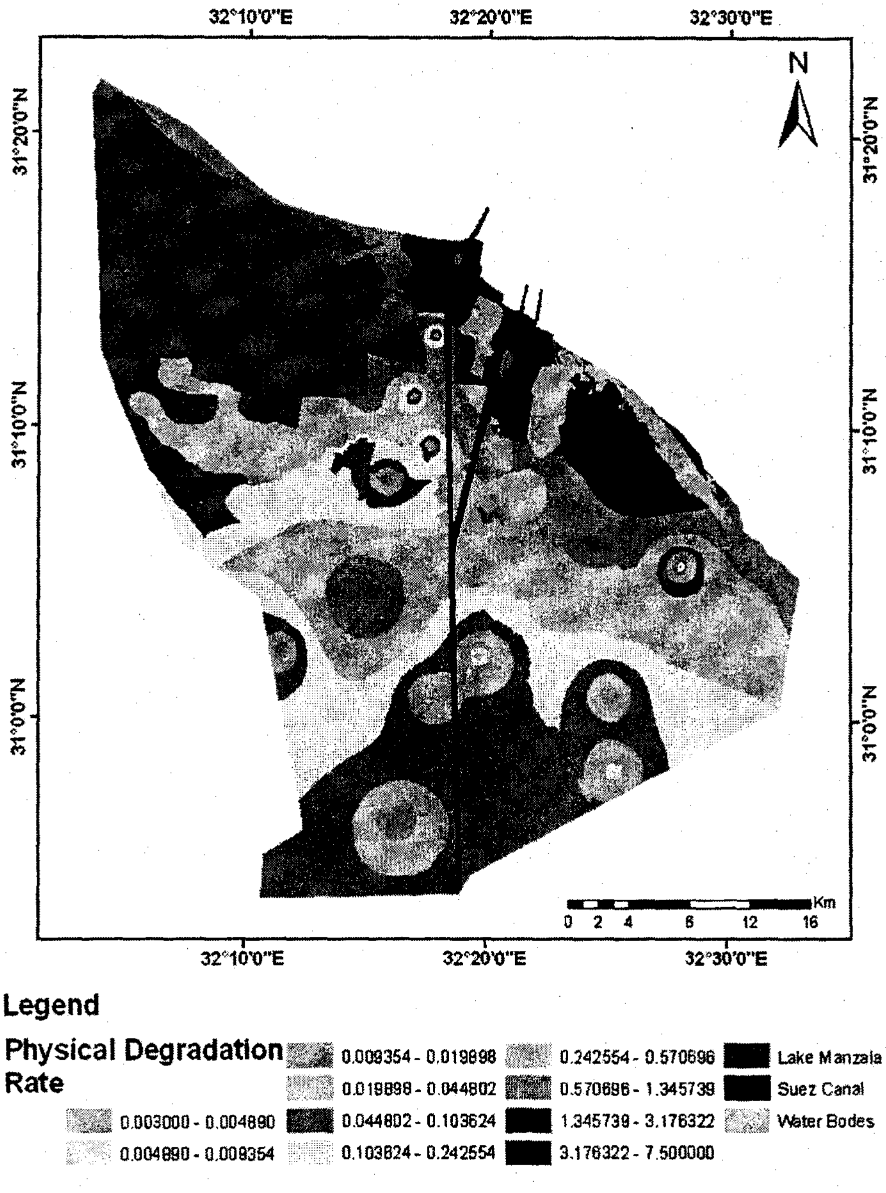


Fig.7.Physical degradation (g/cm^3/year) for study area by GIS

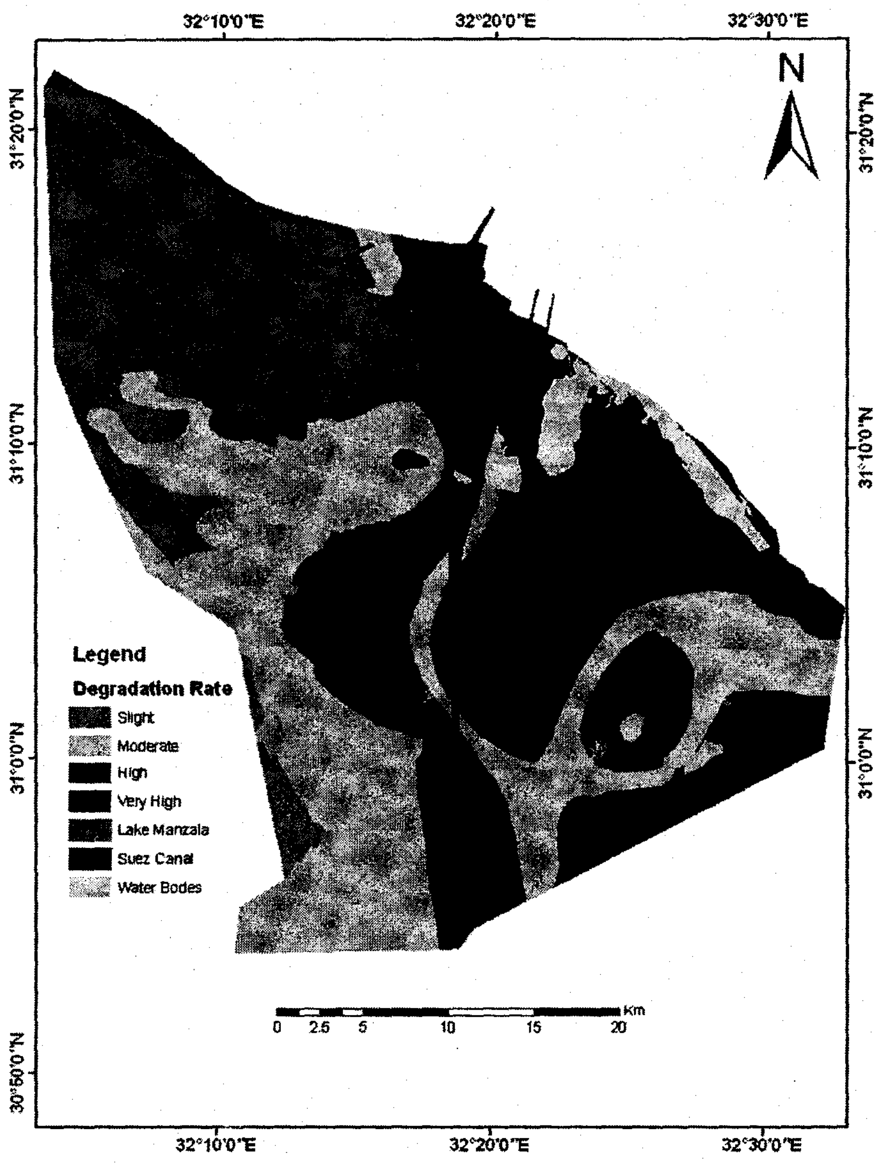


Fig.8. Overlay map of land degradation types in the studied area

that of coastal part of the studied area. However these estimations are based upon the calculated climatic index without considering the salinity of the ground water. It seemed that soil, topography and human activity will cause higher values of degradation by salinity. However the amount of salt, which might be brought to fields by normal irrigation practices, may be enormous. In fact, these results give a spotlight on the importance of good management for new cultivation projects in the area taking more care fore the use of appropriate irrigation and drainage techniques.

Sodification

Data present in Table 1 and Figure 6 show the rate of Alkalization in the studied area. Results reveal that alkalinity ranged between 0.47 and 7.06 %/year However the risk of sodification in west Suez Canal is higher than that of east and costal part of the studied area. These estimations are based upon the calculated climatic index without considering the alkalinity of ground water. Moreover soil topography and human activity will cause higher risk of degradation by sodification.

Physical Degradation

Data of Table 1 and Figure 7 show the present approximate state of physical degradation in t/ha/year for the study area, calculated by studied area is subjected to slight to high physical degradation (from 0.01 to 7.5 %/year). Most the south to middle of the studied area is characterized by slight to a moderate class of physical degradation. On the other hand, the middle and the north parts are characterized by moderate to high. Moreover it could be stated that climatic and soil factors were the dominant factors which effect on the risk of physical degradation in the studied area.

Overall Land Degradation

Arc GIS Model Builder was used to develop a final overlay map for land degradation types in the studied area.

The over all of land degradation types in the studied area shown at Figure 7. The maps resulting from the interpolation techniques were introduced into a GIS and their values reclassified.

Conclusion

It is obvious to state that the studied area considered the hope of future agriculture expansion in Port Said Governorate, these area exposed to different degradation processes. So special management planning of agriculture warning and prevention system for natural disasters are urgently needed. Thus, detailed and very detailed studies must be performed to evaluate this area in order to establish a good planning for this area.

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تحديد تدهور الأرض باستخدام طريقة الإحصاء المكانية Geo statistical في بورسعيد- مصر

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الهدف الرئيسي من هذه الدراسة هو تحديد تدهور الأرض باستخدام parametric approach ، والإحصاء المكانية والنمذجة الفراغية وتم حساب خمس عمليات رئيسية لتدهور الأرض باستخدام المعادلة العامة لتدهور التربة (USLE) وهي (النحر بالمياه – التعرية بالرياح – الملوحة – القلوية – التدهور الطبيعي) .منطقة الدراسة المختارة ممثلة لمعظم الوحدات الفيزيوجرافية لشمال سيناء والجزء الشرقي لمنطقة شرق الدلتا وتقع منطقة الدراسة بين خطى طول ١٨,٩٠ ٣٣` ٣٢° و ٥,٩٣ ٣` ٣٢° شمالاً ودائرتي عرض ١١,٣٠ ٢٢ ` ٣١ ° و ٠,١٢ ٥٤` ٣٠° شرقاً ويبلغ مساحة منطقة الدراسة١٣٥,٠٠٠ هكتار(٣٢١,٤٥٠ فدان). ولفهم الاختلافات ما بين أنواع التدهور تم تفسيرها فوتوغرافيا على أساس العوامل المحددة لعمليات التدهور بواسطة الإحصاء المكانية والنمذجة الفراغية،وتم استخدام برنامج ArcGIS Model Builder في تطوير المنتج النهائي للخريطة العامة لأنواع التدهور في المنطقة ،وكان معدل نحر التربة بالمياه ضعيف (٠,٠٢ طن /هكتار /سنة) والتعرية بالرياح ضعيفة(٢,٦٣ طن /هكتار /سنة) والملوحة والقلوية تتدرج من ضعيفة إلى مرتفعة جدا والتدهور الطبيعي من ضعيف إلى مرتفع