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LAND DEGRADATION ASSESSMENT IN EL-BUSTAN AREA - NUBARIYA REGION, EGYPT

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ABSTRACT

The studied area (El-Bustan areas I & II) is located in Nubariya region west of the Nile delta, between km 75 and km 85 of Cairo - Alexandria desert road. It occupies an area of about 44,322 feddans. The chosen area is one of the promising lands reclamation projects in Egypt. It is irrigated from El-Bustan El-Gddidah canal using drip and sprinkle irrigation systems.

Digital elevation model DEM was created depend on the contour point values map which derived from topographic map using Ordinary Kriging technique. The histograms operation of DEM value map was used to separate between the peaks of the histogram graph. There are different peaks representing the interval values, which were used together with geological map to determine and delineate the boundaries of the physiographic mapping units.

The studied area was covered by selected field observations (145 points) in a grid system with spacing of approximately (1000×1000) meters. Ordinary Kriging technique in Geographic information system (GIS) environment was applied to create soil maps for each property relevant to soil degradation such as; the effective soil depth, soil salinity, and soil bulk density. Land degradation degree, extent, and overall severity were estimated, using FAO, and Global Assessment of Desertification (GLASOD) approaches for two periods (1986-2001) and (2001-2011).

The results indicated that the agricultural investments during first period (1986–2001) causing of the waterlogging, salinity and compaction land degradation as a result of bad water management (i.e. applied the flooding irrigation system) in addition to the lack of information about the crops water requirements, irrigation scheduling, insufficient drainage system. These problems become less harm during the recent periods between years 2001 and 2011. This is due to applying new technology (e.g. drip and sprinkler irrigation), and risen farmers awareness by societies and services projects. Where as the compaction problem become more harm during second period in compared to first period resulted to continuous intensive agricultural applications under wet condition soil.

Keywords: Land degradation, Geostatistical analysis, Ordinary Kriging, GLASOD, West Nubaryia.

INTRODUCTION

Land degradation is one of the most serious ecological problems in the world. Land degradation is a manifestation of loss in certain intrinsic qualities or a decline in the land's capability to perform vital functions (both economic and ecological). From an agricultural standpoint, land degradation is reflected in declining productivity and utility (FAO, 1976). Land degradation is defined as "The temporary or permanent lowering of the productive capacity of land as a result of human activities" (UNEP, 1991).

Land Degradation Assessment in Dry Lands (LADA, 2002), reported that in Egypt there is 14.000 km2 (1% of the total area) of hydromorphy condition. Waterlogging and salinization are one of the land degradation types. It is the twin evils of the irrigated agriculture in arid and semi-arid areas, which reduce the productivity of agricultural lands adversely (Abbas et al., 2005; Bourrfa and Zimmer, 1994). It is estimated that about 45 million ha (19 %) of the total irrigated land worldwide is severely affected by induced waterlogging and associated salinization (Hoffman and Durnford, 1999).

The waterlogged soils in the western part of the newly reclaimed areas in the Baheira governorate in Egypt are created by clay horizon below the aeolian sand impeding drainage (Goossens et al., 1994). Excessive irrigation and bad drainage in New Reclaimed Areas (NRA) has led to high salt concentration in the soil and/or a rise of the ground water (Goossens et al., 1993).

The region of West Delta Egypt, lying west of Nubariya Canal, represents one of the most promising areas that include local reclaimed land of 558,500 feddans. About 70% of this area become reclaimed and are occupied by investors and joint venture Company's, public companies and small holders. (Abdel-kader et al., 2004).

El-Bustan areas I & II (44,322 fed) was designed to irrigate from El-Bustan El-Gddidah canal using drip and sprinkle irrigation systems. The wrong agricultural activities in this area causes some land degradation types represented by the waterlogging, salinity and compaction in some areas resulted to bad water management. This includes; 1) changing the irrigation system from modern to flooding irrigation with insufficient drainage system, 2) using drainage water with low quality for irrigation, 3) the lack of information about the water requirements for crops, 4) absent of irrigation scheduling in addition to some problems in the design of irrigation canals (Yacoub, 2003; Abde-Kader et al., 2004; El-Haris & Bahnassy, 2004; Yacoub et al., 2005; Darwish and Abdel Kawy, 2008; Abdel Kawy and Belal, 2009).

Remote sensing (RS) and Geographic Information System (GIS) techniques are useful tools for land use planning and land monitoring and management. These techniques also help to study the relationships between land use and land cover changes. This give better released the spatio-temporal variability of land degradation in certain areas. Abde-Kader et al., (2004) used Ordinary Kriging interpolation to characterize the status of the degradation process by the degree of soil degradation in West Nubariya Region, Egypt. Yacoub et al., (2005) identified that the waterlogging area using ETM spectral characteristics image in the West Delta in Egypt.

The objectives of this study are to: (1) Create digital elevation model (DEM) to obtain physiographic mapping units, (2) create thematic soil properties value maps that related to land degradation in the studied area using Ordinary Kriging technique, (3) Identify the degradation status of each soil mapping unit and define the extent and overall of land degradation severity for two different periods (1986-2001) & (2001-2011).

MATERIALS AND METHODS

1. Location:

The studied area is located in the western part of the Nile delta in Nubariya Region, between latitudes 30° 11' 36" N and 30° 43' 12" N, and longitudes between 30° 23' 19" E and 30° 40' 23" E. It occupies an area of about 44.322 feddans, divided into two settlement stages; El Bustan I and El Bustan II. It lies in the east of the Cairo-Alexandria desert road between 75 and 85 km from Alexandria city (Figure 1).

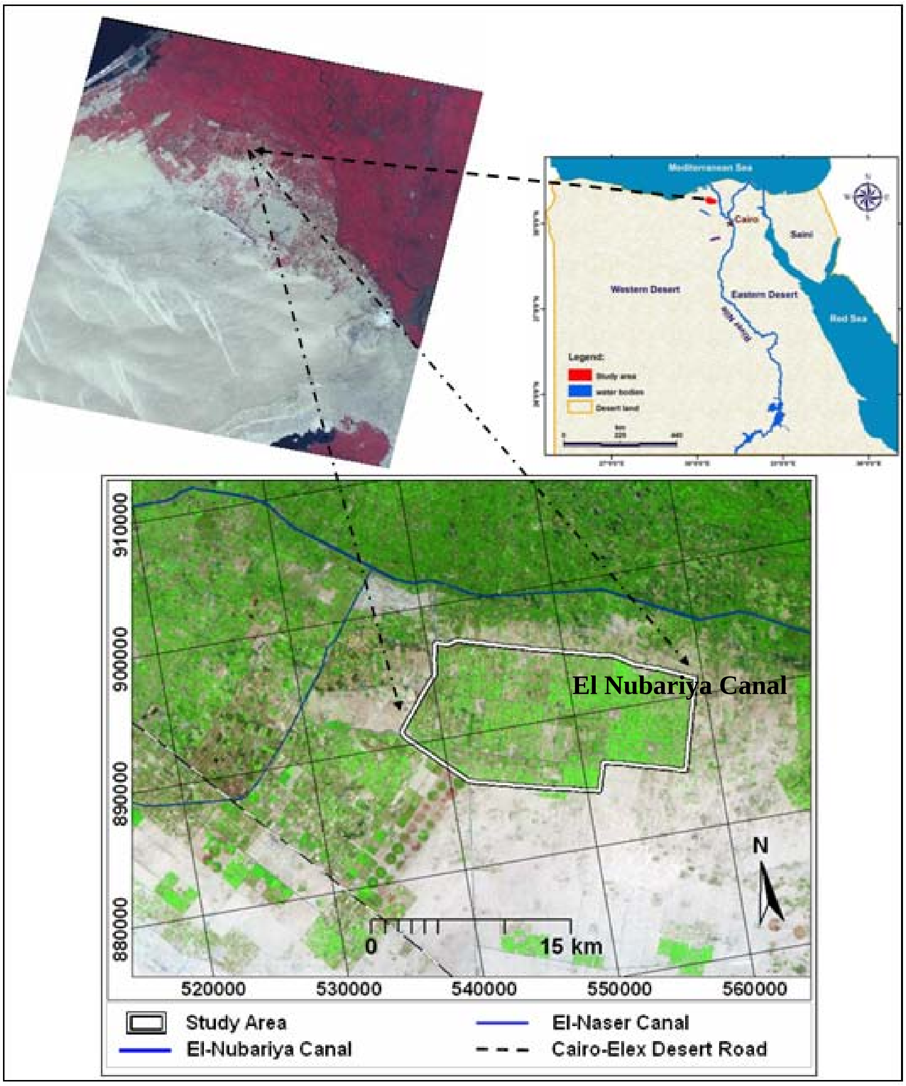


Fig.1. The location of studied area within Egypt

The studied area has a Mediterranean climate, characterized by rainy winter and prolonged hot in dry summer. According to meteorological data of Borg El Arab station (CNE, 2003) and Keys to Soil Taxonomy (2010). The soil moisture regime of the studied area is dominated by Torric or Aridic types, while the soil temperature regime is Hyperthermic.

2. Materials:

The following materials were used:

a) Topographic maps of Al-Nubariyyah (sheet NH36-I4a), Jabal Na'um (sheet NH36-I4b), Abu al-Matamir (sheet NH36-I4c), and Hawsh Isa (sheet NH36-I4d) at scale 1: 50,000, edition by Egyptian General Survey Authority 1996, based on aerial photographs of 1990-91 (EGPC, 1988).

b) Semi-detail soil survey reports of El-Bustan area, west Nubariya, done by the General Authority for Reclamation and Development Agricultural Projects, the General Department of Soil Studies (GARDAP, 1986) using 644 observation survey points.

c) Three types of observations were achieved and described in regular depth, 0-30, 30-60, and 60-150 by (Yacoub, 2003). This includes; 12 profiles (150 cm), 33 mini-pits (0-60 cm), and 147 auger observations.

d) The Integrated Land and Water Information System, ILWIS 3.7 (2007), was used as main GIS and RS software.

3. Methods*:*

a) DEM which was created after fitted the Semi-variogram model for contour points. Based on DEM histogram operation, auxiliary information, and geological map of Egypt with scale (1:500.000), (EGSA, 1996), Physiographic mapping units were assigned using the approach of Zinck, 1998.

b) The systematic random survey is one of common soil sampling methods (Boer *et al.*, 1996; Salehi *et al.*, 2003; Al-Shamiri & Ziadat, 2012). This method was applied to a randomly selected 145 field observations. These includes: 50 profiles (150 cm), 22 mini pits (60 cm), and 73 auger observations were achieved in the field due to a grid system with spacing of approximately (1000×1000) meter (Campbell *et al.*, 1986; Erian & Yacoub, 1999; Hengl *et al.,* 2003). Particle size distribution, soil texture, electrical conductivity, and other physical and chemical characteristics which representative profiles were described and estimated.

c) Geostatistical analysis for each period was carried out at two subsequence steps: (a) the calculation of the experimental semi-variogram and fitting a best model; and (b) applied Ordinary Kriging interpolation, which uses the semi-variogram parameters (Stein, 1998).

d) The parameters of the best fitting model for the variables were used to obtain the suitable Ordinary Kriging. The variables, which were not spatially related and gave total nugget, were interpolated by using the moving average method, which is the same as simple kriging method with total nugget.

e) MapCalc. Operation in ILWIS 3.7 (2007) was used to calculate the differences of the selected soil properties during two periods (1986 – 2001) and (2001-2011). The differences of each soil properties were negative or positive values depend on the type of the indicators. The positive values of the effective soil depth indicate that there is degradation in this area. But the positive values of the soil salinity, and bulk density indicates that there is an improvement in these areas and the negative value indicates that there is a degradation process.

f) According to FAO (1978) a common units of measurement for different processes could be the loss of soil production, in ton/ha/year or loss of benefit in monetary terms. Degraded areas were calculated for the total 10 years and also for each year.

g) The value maps of the selected soil properties for two periods (1986 – 2001) and (2001-2011), were rated by land degradation classes, then thematic maps were created and used to create land degradation severity level according the GLASOD approach (Oldeman, 1994; and Oldeman & Van Lynden, 1998).

h) The slicing operation was used to classify the differences and calculate the degradation status for the total 10 years and for each year. The extent area % and overall severity degradation were calculated by subtracted the status of each year from the status of the total 10 years, to get the percentage difference for each mapping unit.

RESULTS AND DISCUSSION

Ordinary Kriging and DEM Creation:

A total of 2075 contour points covers an area of 155,400 feddans, was larger than the studied area to avoid the error at the edge of the calculated map. The values of the contour point's map were ranged between 1 to 61 meters Above Sea Level (A.S.L) within average of 18.93 meters A.S.L. The standard deviation was 12 meters.

The parameters of the best fitting model were used to calculate the interpolation of the contour point values map. The goodness of the spherical model (R^2=0.99) was the best model and the parameters of this model were used to create DEM.

Physiographic Mapping Units

The DEM value map was used to delineate the boundaries of the physiographic mapping units after using the histograms operation in ILWIS 3.7. (2007) The stretched operation was used to separate between the peaks of the histogram, there were different peaks representing the interval values, which were used to determine the different geomorphic classes. Using the slicing operation with the selected interval values, the DEM value map can be transferred to a classified map. The geomorphic mapping units and geological map were integrated to create the physiographic mapping units as shown in (Table 1 and Figure 2).

Table1. The physiographic mapping units legend

Morphogenetic Environment	Landscape	Relief	Lithology	Landform	Unit	Phase	Unit	Main Soils	Area	%	Kind of mapping unit
Colluvial-Eolian Depositional	Plain (PL)	Flat (PL2)	Undifferentiated Quaternary deposits	Flat cover by thick sand sheet	PL211	---	---	Typic Torripsamments	3227	38.84	**1#**
						---	---	Typic Haplocalcids	5081	61.15	
						---	---	Aquic Torriorthents	1	0.01	
					Total				8309	18.75*	
				Flat cover by thin sand sheet	PL212	---	---	Typic Torripsamments	3900	40.71	**2#**
						---	---	Typic Haplocalcids	4310	44.98	
						---	---	TypicTorriorthents	810	8.45	
						---	---	Aquic Torriorthents	562	5.87	
					Total				9582	21.62*	
				Depression	PL213	---	---	Typic Torripsamments	299	21.13	**1#**
						---	---	Typic Haplocalcids	842	59.60	
						---	---	TypicTorriorthents	15	1.09	
						---	---	Aquic Torriorthents	257	18.18	
					Total				1413	3.19*	
		Sand Dunes (PL3)	Quaternary sand dunes	Longitudinal dune	PL311	Summit	PL3111	Typic Haplocalcids	56	100	**3#**
							Total		56	0.25**	
						Back slope	PL3112	Typic Torripsamments	62	29.08	**1#**
								Typic Haplocalcids	151	70.92	
							Total		213	0.94**	
						Foot slope	PL3113	Typic Torripsamments	5951	79.89	**3#**
								Typic Haplocalcids	1498	20.11	
							Total		7449	32.8**	
						Toe slope	PL3114	Typic Torripsamments	7452	49.71	**1#**
								Typic Haplocalcids	7540	50.29	
							Total		14992	66.01**	
					Total				22710	51.24*	
				Pyramidal dune	PL312	Top	PL3121	Typic Torripsamments	908	85.36	**3#**
								Typic Haplocalcids	156	14.66	
							Total		1064	46.63**	
						Slope	PL3122	Typic Torripsamments	1182	97.07	**3#**
								Typic Haplocalcids	36	2.93	
							Total		1218	53.37**	
					Total				2282	5.15*	
				Depression	PL313	---	---	Typic Torripsamments	26	100	**3#**
							Total		26	100**	
					Total				26	0.06*	
Total area									44322	100*	

*** % from total study area.** **** % from each mapping unit.**

1# kind of the mapping unit: Association. **2# kind of the mapping unit: Complex.**

3# **kind of the mapping unit Consociation**

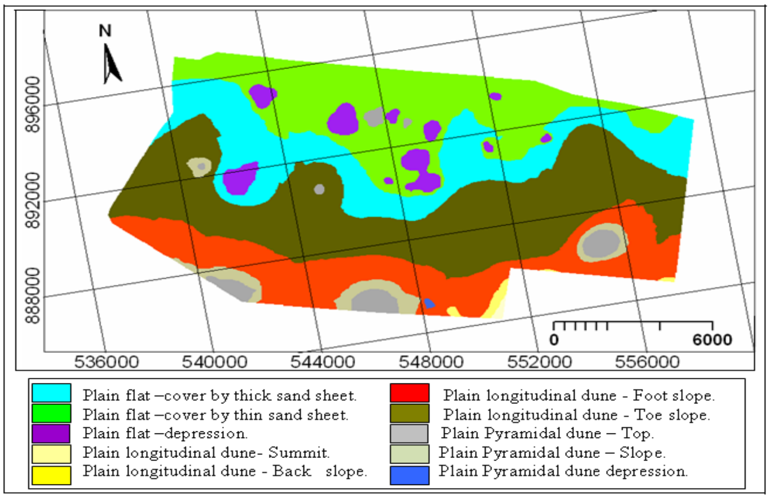


Fig.2: The physiographic mapping units of the studied area

Creation of the soil properties layers:

A total of 644 observation points were examined by (GARPAD, 1986), 192 observations points were selected by (Yacoub, 2003), and 145 observations points (50 profiles and 22 mini-pits) were collected and tested during the current study 2011. About 73 augers were used to check mapping units' boundary. The particle size distribution, soil texture, electrical conductivity, and other physical and chemical characteristics of the representative profiles are shown in Table 2.

Table2. The physical and chemical properties of chosen representative profiles of year 2011

Soil Map Unit	Profile No	Depth	Sand %	Silt %	Clay %	Texture	B. D g/cm^3	pH	EC ds/m	SP %	$CaCO_3$ %	O.M %
PL3113	**3**	0-30	89.9	4.9	5.2	Sand	1.7	7.8	1.2	20	5.7	0
		30-110	91.2	3.6	5.2	Sand	1.7	7.7	1	21	12.1	Nil
PL3114	**7**	0-25	86.3	6.4	7.3	L.Sand	1.64	7.3	2	23	5.7	0.12
		25-75	86	7.4	6.6	L.Sand	1.68	7.6	1.1	22	4.6	Nil
		75-120	85.4	8.1	6.5	L.Sand	1.66	7.7	0.5	21	4.6	Nil
PL213	**25**	0-30	72.2	20.3	7.5	S. Loam	1.61	8.01	2.37	28	24	0.5
		30-70	70.9	18.9	10.2	S. Loam	1.57	8.11	2.29	29	30	0
		70-120	58.3	27.5	14.2	S. Loam	1.49	8.15	3.52	27	20	0
PL211	**33**	0-20	82	10	8	L.Sand	1.62	8.0	2.4	22	3	0.6
		20-70	81	12	7	L.Sand	1.64	8.1	1.9	22	3	0.3
		70-110	68	20	12	S. Loam	1.54	8.0	3.8	22	9	0.44
PL212	**35**	0-30	61	20	19	S.Loam	1.37	7.3	1.4	38	4	1.3
		30-80	48	40	12	Loam	1.5	7.4	1.25	28	11	0.4
		80-120	49	38	13	Loam	1.49	7.3	1.24	28	11	0.38
PL3121	**41**	0-30	92.6	4.2	3.2	Sand	1.74	8.0	3.92	22	8.3	0
		30-120	88.6	6.1	5.3	Sand	1.7	7.8	3.18	20	7.1	0
		120-150	85.4	9.4	5.2	L.Sand	1.69	8.0	4.27	23	6.5	0
PL3122	**61**	0-25	90.5	3.2	6.3	Sand	1.67	7.3	0.8	23	4.6	00
		25-75	86.3	6.8	6.9	L.Sand	1.65	7.6	0.9	22	4.9	Nil
		75-150	89.4	5	5.6	Sand	1.69	7.8	1.6	21	4.7	Nil

Using the attribute operation, the effective soil depth, soil salinity, and bulk density point maps during years (1986, 2001 and 2011) were created. Table 3 shows the results and descriptive statistics of the soil properties point's maps during each period.

Table3. The descriptive statistics of the soil properties point's maps during each period

Soil Properties	Year	Descriptive statistics			
		Minimum	**Maximum**	**Mean**	**St.deviation**
Water-Table Depth (cm)	1986	80	230	131.86	26.54
	2001	35	150	140.36	22.39
	2011	80	150	142.92	14.86
Soil Salinity ds/m	1986	0.49	2.32	1.91	3.18
	2001	0.49	32.20	1.91	3.47
	2011	0.65	13.89	3.04	2.62
Bulk Density gm/cm^3	1986	1.57	1.72	1.65	0.05
	2001	1.46	1.75	1.61	0.08
	2011	1.37	1.74	1.65	0.09

The Ordinary Kriging Method was used to interpolate the soil properties which are spatial correlated. The variables which were not spatially related and gave total nugget were interpolated by using the moving average method. Table 4 shows the Kriging parameters and the Goodness of fit (R^2). Table 5 also shows that the results of applying Kriging of the soil properties raster's maps**.**

The Goodness of fit (R^2) was calculated to choose the most fitted model. In the case of effective soil depth, the most fitted models were Gaussian and Exponential in the year of 2001 and 2011 respectively. In the case of soil salinity, the most fitted models were Gaussian, Exponential and Spherical in the year of 1986, 2001 and 2011 respectively. Interpolation by Moving Average was applied in the case of effective soil depth in the year of 1986 and all bulk density layers because there are not spatially related between variables.

The slicing operation was used to create the rated classes of soil properties Figure (3). The rated classes and percents are summarized in Table 6

Dataset	Year	Semi-variograms model	Parameters				Goodness (R^2)
			Nugget	**Sill**	**Range**	**Limitation distance**	
Effective soil depth (cm)	1986	Moving Average applied because there are not spatially related between variables					
	2001	Spherical	250	600	4500	10000	-0.785
		Circular	280	600	4500	10000	-0.787
		Exponential	180	610	1600	10000	-0.835
		Gaussian	250	590	520	10000	-0.850
		Wave	300	560	1800	10000	-0.481
	2011	Spherical	0	290	1750	8000	0.902

		Circular	0	290	1500	8000	0.909
		Exponential	0	290	750	8000	0.924*
		Gaussian	0	290	750	8000	0.866
		Wave	50	260	500	8000	0.322
EC of the surface layer 60 cm (ds/m)	1986	Spherical	0.27	0.45	2000	10000	0.611
		Circular	0.26	0.45	2000	10000	0.614
		Exponential	0.25	0.45	750	10000	0.645
		Gaussian	0.25	0.45	340	10000	0.653*
		Wave	0.25	0.45	570	10000	0.607
	2001	Spherical	0.0	10.5	700	10000	-0.730
		Circular	0.0	10.5	700	10000	-0.720
		Exponential	0.0	10.5	350	10000	-0.733*
		Gaussian	0	10.75	350	10000	-0.723
		Wave	0.3	5.5	900	10000	-0.721
	2011	Spherical	1	8.35	2000	10000	0.740*
		Circular	1	8.35	2700	10000	0.669
		Exponential	1	8.35	800	10000	0.723
		Gaussian	1	8.35	1200	10000	0.692
		Wave	0.5	8	180	10000	0.636
of the surface layer 60 cm (gm/c	1986	Moving Average applied because there are not spatially related between variables					
	2001						
	2011						

Table 4. The Parameters of the Best-Fitted Models of Soil Properties, for three periods

*** The best fitting model for each variable.** **** B.D: Bulk density.**

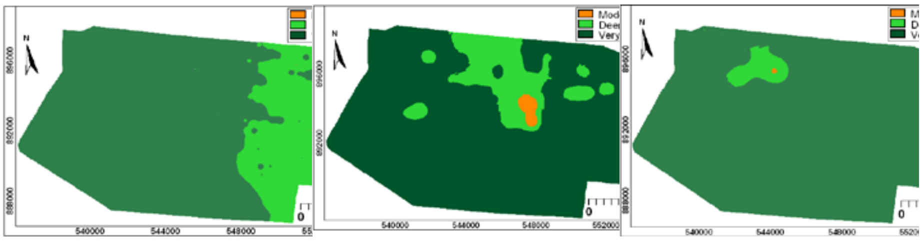
Table 5. Results of applying Ordinary Kriging and Moving Average of the soil properties raster's maps.

Soil Properties	Year	Descriptive statistics				
		Minimum	Maximum	Mean	median	St.deviation
Water-Table Depth (cm)	1986*	90.1	219.8	134.9	134.45	20.6
	2001	66.5	150	108.39	108.4	24.07
	2011	81.4	150	117.62	117.75	18.88
Soil Salinity (ds/m)	1986	0.44	4.74	1.99	1.93	0.96
	2001	0.53	26.69	8.33	6.002	6.67
	2011	0.65	13.89	3.37	2.8	2.78
Bulk Density gm/cm^3	1986*	1.58	1.72	1.65	1.65	0.05
	2001*	1.46	1.75	1.61	1.61	0.09
	2011*	1.39	1.78	1.45	1.46	0.023

*** The layers which created using Moving Average approach**

Water-Table Depth

1986 **2001** **2011**



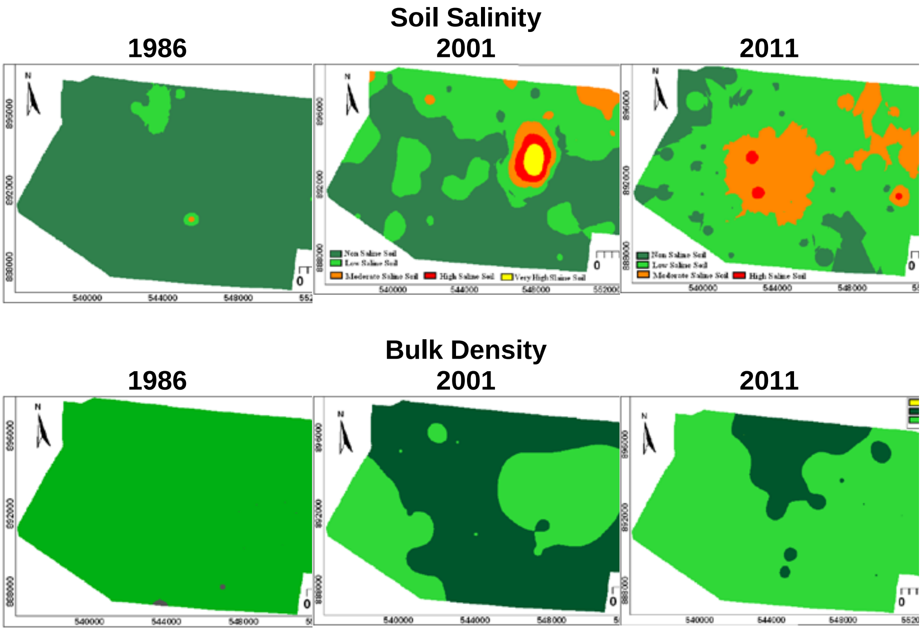


Fig.3. The soil properties classes for each period

Table 6. The soil properties classes (area and percents) for each period

Soil Properties	Class	Year					
		1986		2001		2011	
		Feddan	%	Feddan	%	Feddan	%
Water-Table Depth (cm)	Moderate soil depth	0	0	342	0.77	19	0.04
	Deep soil depth	16769	27.58	4972	11.22	1127	2.54
	Very Deep soil depth	27553	72.42	39008	88.01	43176	97.42
	Total	44322	100	44322	100	44322	100
Soil Salinity (ds/m)	Non Saline Soil	43157	97.37	27627	62.33	4559	10.29
	Low Saline Soil	1144	2.58	13969	31.52	31709	71.54
	Moderate Saline Soil	21	0.05	1733	3.91	7844	17.7
	High Saline Soil	0	0	606	1.37	210	0.47
	Very High Saline Soil	0	0	387	0.87	0	0
	Total	44322	100	44322	100	44322	100
Bulk Density gm/cm^3	Moderate Bulk Density	0	0	0	0	1	0.002
	High Bulk Density	74	99.83	31515	71.11	5862	13.23
	Very High Bulk Density	44248	0.17	12807	28.89	38459	86.77
	Total	**44322**	**100**	**44322**	**100**	**44322**	**100**

Land degradation assessment:

The data of 1986 were considered as value map for soil depth, soil salinity and soil balk density for (GARDAP, 1986) were carried out. Map Calc operation was used to calculate the differences of the effective soil depth, soil salinity and bulk density. The difference of each year was calculated too, according to the following formula:

Land degradation status for the total first period = the differences (value raster map) = (year 1986-year 2001)

Land degradation status per one year = the differences (value raster map) = ((year 1986-year 2001)/10).

Land degradation status for the total second period = the differences (value raster map) = (year 2001-year 2011)

Land degradation status per one year = the differences (value raster map) = ((year 2001-year 2011)/10).

The slicing operation according to (FAO, 1978) was used to assess land degradation status. The results of land degradation status due to water table depth, soil salinity, and compaction during the two periods show in Table 7.

Table 7. The results of land degradation status during two periods

Soil Properties	Status classes	1986- 2001		2001 – 2011	
		Feddan	%	Feddan	%
Water-Table Depth	non-severe areas	19285	43.51	19955	45.02
	slight severe	13157	29.69	18614	42.00
	moderate severe	1988	4.49	975	2.20
	high severe areas	4035	9.10	3779	8.53
	very high severe	5857	13.21	999	2.25
	Total	**44322**	**100**	**44322**	**100**
Soil Salinity	non-severe areas	2408	5.43	37075	83.65
	slight severe	22829	51.51	4155	9.37
	moderate severe	16275	36.72	1880	4.24
	high severe areas	1489	3.36	278	0.63
	very high severe	1321	2.98	934	2.11
	Total	**44322**	**100**	**44322**	**100**
Compaction	non-severe areas	4854	10.95	8895	20.07
	slight severe	32382	73.06	26616	60.05
	moderate severe	7086	15.99	8810	19.88
	high severe areas	0	0	1	0.002
	very high severe	0	0	0	0
	Total	**44322**	**100**	**44322**	**100**

Table 8. The Overall Severity Classes Due To Waterlogging (Pw) for the second period (2001-2011)

Mapping units	Severity Class	Severity total period classes		Severity each one year classes		Severity differences classes		Extent classes	GLASOD classes	Overall severity classes
		Feddan	%	Feddan	%	Feddan	%			

PL3121	**Non**	377	35.14	377	35.14	0	0	**Non sever**	**Non sever**	**Non sever**
	Slight	409	38.12	696	64.86	-287	-26.05	**Non sever**	**Non sever**	**Non sever**
	Moderate	33	3.08	0	0.00	33	3.08	**Infrequent**	**2.1**	**Slight-Pw**
	High	212	19.76	0	0.00	212	19.76	**frequent**	**3.3**	**High-Pw**
	V. High	42	3.90	0	0.00	42	3.9	**Infrequent**	**4.1**	**Medium-Pw**
	Total	**1073**	**100**	**1073**	**100**	**0.00**	**0.00**			
PL3122	**Non**	436	35.74	436	35.74	0	0	**Non sever**	**Non sever**	**Non sever**
	Slight	553	45.33	784	64.26	-231	-18.93	**Non sever**	**Non sever**	**Non sever**
	Moderate	53	4.34	0	0.00	53	4.34	**Infrequent**	**2.1**	**Slight-Pw**
	High	158	12.95	0	0.00	158	12.95	**frequent**	**3.3**	**High-Pw**
	V. High	20	1.64	0	0.00	20	1.64	**Infrequent**	**4.1**	**Medium-Pw**
	Total	**1220**	**100**	**1220**	**100**	**0.00**	**0.00**			
PL211	**Non**	4897	58.89	4899	58.91	-2	-0.02	**Non sever**	**Non sever**	**Non sever**
	Slight	1947	23.41	3417	41.09	-1470	-17.68	**Non sever**	**Non sever**	**Non sever**
	Moderate	97	1.17	0	0.00	97	1.17	**Infrequent**	**2.1**	**Slight-Pw**
	High	888	10.67	0	0.00	888	10.67	**frequent**	**3.3**	**High-Pw**
	V. High	487	5.86	0	0.00	487	5.86	**Infrequent**	**4.1**	**Medium-Pw**
	Total	**8316**	**100**	**8316**	**100**	**0.00**	**0.00**			
PL212	**Non**	6983	72.75	6983	72.75	0	0	**Non sever**	**Non sever**	**Non sever**
	Slight	874	9.10	2616	27.25	-1742	-18.15	**Non sever**	**Non sever**	**Non sever**
	Moderate	187	1.95	0	0.00	187	1.95	**Infrequent**	**2.1**	**Slight-Pw**
	High	1265	13.18	0	0.00	1265	13.18	**frequent**	**3.3**	**High-Pw**
	V. High	290	3.02	0	0.00	290	3.02	**Infrequent**	**4.1**	**Medium-Pw**
	Total	**9599**	**100**	**9599**	**100**	**0.00**	**0.00**			
PL213	**Non**	1385	97.67	1385	97.67	0	0	**Non sever**	**Non sever**	**Non sever**
	Slight	30	2.12	33	2.33	-3	-0.21	**Non sever**	**Non sever**	**Non sever**
	Moderate	2	0.14	0	0.00	2	0.14	**Infrequent**	**2.1**	**Slight-Pw**
	High	1	0.07	0	0.00	1	0.07	**Infrequent**	**2.1**	**Slight-Pw**
	V. High	0	0.00	0	0.00	0	0			
	Total	**1418**	**100**	**1418**	**100**	**0.00**	**0.00**			
PL3111	**Non**	45	100	45	100	0.00	0.00	**Non sever**	**Non sever**	**Non sever**
	Total	**45**	**100**	**45**	**100**	**0.00**	**0.00**			
PL3112	**Non**	199	100	199	100	0.00	0.00	**Non sever**	**Non sever**	**Non sever**
	Total	**199**	**100**	**199**	**100**	**0.00**	**0.00**			
PL313	**Non**	0.00	0.00	0.00	0.00	0.00	0.00	**Non sever**	**Non sever**	**Non sever**
	Slight	25.	100	25	100	0.00	0.00	**Non sever**	**Non sever**	**Non sever**
	Total	**25**	**100**	**25**	**100**	**0.00**	**0.00**			
PL3113	**Non**	2126	28.62	2124	28.59	2	0.03	**Non sever**	**Non sever**	**Non sever**
	Slight	4677	62.96	5305	71.41	-628	-8.45	**Non sever**	**Non sever**	**Non sever**
	Moderate	153	2.06	0	0.00	153	2.06	**Infrequent**	**2.1**	**Slight-Pw**
	High	438	5.89	0	0.00	438	5.89	**common**	**3.2**	**Medium-Pw**
	V. High	35	0.47	0	0.00	35	0.47	**Infrequent**	**4.1**	**Medium-Pw**
	Total	**7429**	**100**	**7429**	**100**	**0.00**	**0.00**			
PL3114	**Non**	3755	25.04	3758	25.06	-3	-0.02	**Non sever**	**Non sever**	**Non sever**
	Slight	9845	65.64	11240	74.94	-1395	-9.3	**Non sever**	**Non sever**	**Non sever**
	Moderate	448	2.99	0	0.00	448	2.99	**Infrequent**	**2.1**	**Slight-Pw**
	High	836	5.57	0	0.00	836	5.57	**common**	**3.2**	**Medium-Pw**
	V. High	114	0.76	0	0.00	114	0.76	**Infrequent**	**4.1**	**Medium-Pw**
	Total	**14998**	**100**	**14998**	**100**	**0.00**	**0.00**			
Total				**44322**						

The results of land degradation status due to water table depth during the two periods show that there was an improvement process in the studied area where the water table depth becomes deeper. The percentage of moderate, high severe and very high severe areas decrease from 26.80% to 12.98%. However, land degradation status due to soil salinity during the two periods showed that soil salinity decreases. The percentage of moderate, high severe and very high severe areas decrease from 43.06% to 6.98%. Also, the results of land degradation status due to compaction during the two periods showed that soil compaction increases. The percentage of moderate severe, high severe and very high severe areas increase from 15.99% to 19.88%.

Degradation Severity Extent

The physiographic mapping units were crossed with the severity degradation of the total period and per of each year to create the extent areas of waterlogging, salinity and compaction degradation. The difference between the resulted crossing maps was used to obtain the percentage of occurrence in each physiographic mapping unit. GLASOD classes were used to transfer the status and the extent occurrence to overall degradation severity. Table 8 shows the result of crossing and the overall severity classes of the waterlogging (Pw) for the second period (2001-2011).

By the same method, the other studied soil properties within the both periods (1986-2001) and (2001-2002) were estimated. Table 9 and Figure 4 summarize the overall severity classes due to different studied properties

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Table 9. The overall severity classes due to the different properties (areas and percents)

Soil Properties	Overall severity class	1986- 2001		2001 – 2011	
		Feddan	%	Feddan	%
Water-Table Depth	Non sever	32684	73.74	38563	87.01
	Slight-Pw	809	1.83	974	2.20
	Medium-Pw	2395	5.40	2262	5.10
	High-Pw	3177	7.17	2523	5.69
	V. High-Pw	5257	11.86	0	0
	Total	**44322**	**100**	**44322**	**100**
Soil Salinity	Non sever	25358	57.21	41423	93.46
	Slight- Cs	64	0.14	614	1.39
	Medium- Cs	3335	7.52	1894	4.27
	High-Pw Cs	15147	34.17	0	0.00
	V. High- Cs	418	0.94	391	0.88
	Total	**44322**	**100**	**44322**	**100**
Compaction	Non sever	36233	81.75	14075	31.76
	Slight-Pc	995	2.25	21454	48.40
	Medium-Pc	6597	14.88	5162	11.65
	High-Pc	497	1.12	3631	8.19
	V. High-Pc	0	0.00	0	0.00
	Total	**44322**	**100**	**44322**	**100**

Waterlogging (Pw)

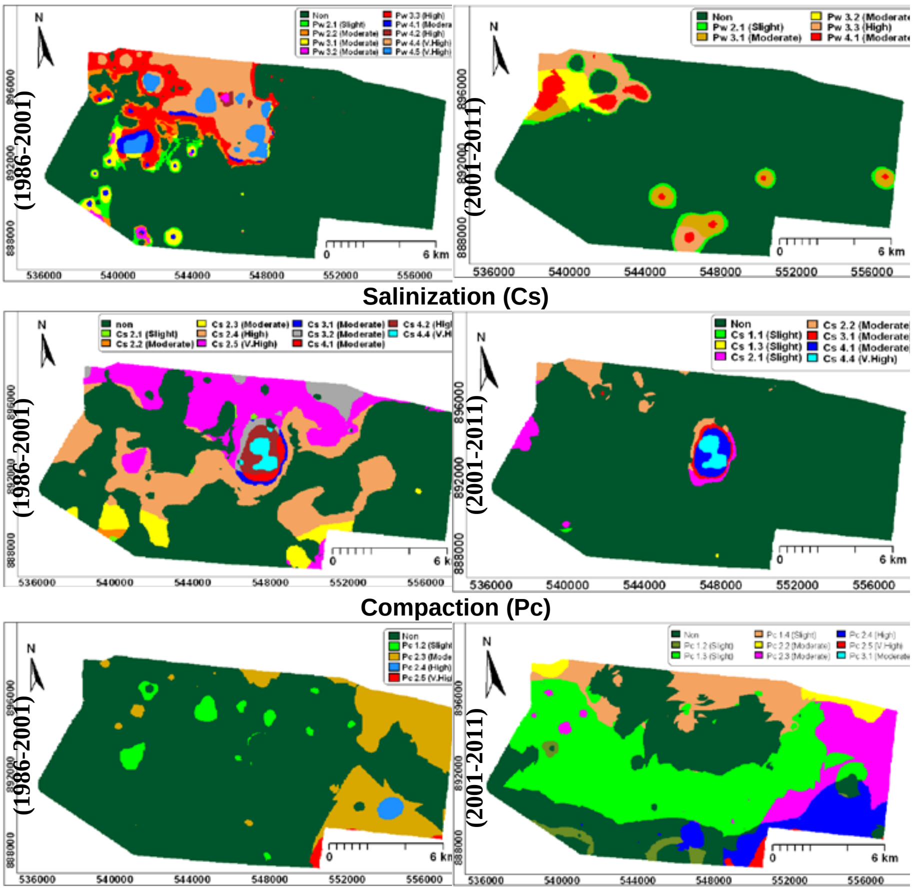

Fig.4: The Overall Severity Classes distribution within the studied area

Figure 5 summarizes the overall severity classes due to the studied soil properties during the two periods. The results showed that there was an improvement process in the water table depth especially in non severe and very high (pw) classes where the differences were 13.27% and 11.86% respectively. In the case of soil salinity the percentage of non severe was increased from 57.21% to 93.46% Where as the medium (Cs), and high (Cs) classes decreases from 7.52% to 4.27%, and from 34.17% to zero value, respectively.

The overall severity classes due to the soil compaction were showed that soil compaction increases in every classes in exception of slight (Pc) class which increase from 2.24% to 48.40%.

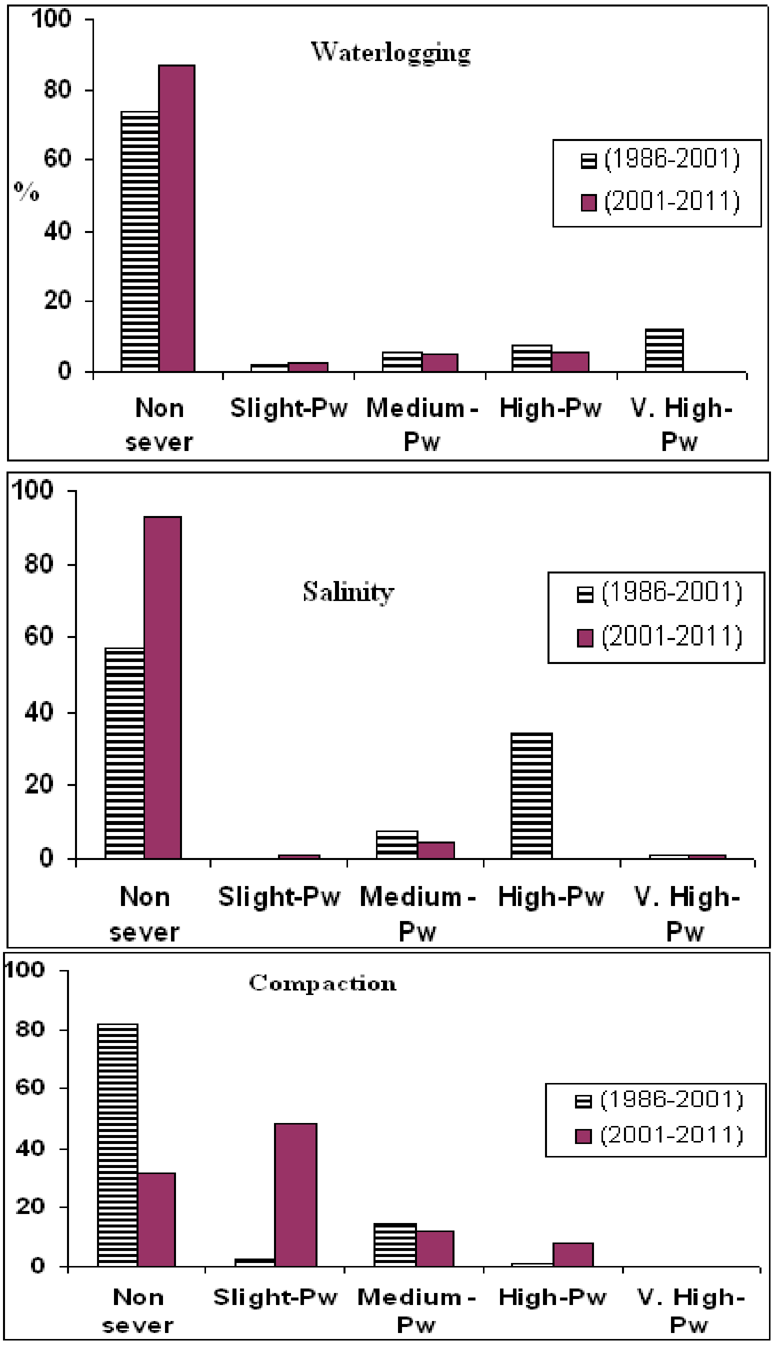

Fig.5: The different between overall severity classes due to the studied soil properties.

CONCLUSION

The geostatistical interpolation tools in GIS package are useful in assessing the spatial- temporal variability of major land degradation types. The GIS environments also enable us to identify the degradation severity in quantitative form. This allows to monitoring the land degradation and overcome their hazard in the appropriate time. The land degradation rate during the first period between years 1986 and 2001, might be due to flooding irrigation with inadequate drainage, roughly land uses, and the bad activities applied resulted to farmers awareness absent.

Several development and services projects are aims in agricultural technology transfer (modern irrigation systems) and training the farmers to apply and use this technology in the study area. This lead to reduce and overcome waterlogging and salinity caused. The study results are indicated to clearly decreasing in the degraded areas due to waterlogging and salinity during the second period between years 2001 and 2011. The severity classes during this period also become lesser than similar classes during the first period, especially (high and v.high severity classes in the case of waterlogging) and (moderate, high and v.high severity classes in the case of salinity). The study results are indicated also to clearly increasing in the degraded areas due to compaction during the second period between years 2001 and 2011. The severity classes during this period also become more than similar classes during the first period, especially (non sever area, slight and high severity classes). This is resulted to use fertilizers especially organic fertilizers and continuous intensive agricultural applications under wet condition soil.

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تقدير تدهور الأراضي في منطقة البستان – النوبارية – مصر

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تقع منطقة الدراسة في النوبارية بغرب الدلتا بين 57كم – 85 كم على طريق القاهرة الاسكندرية. وتشغل منطقة الدراسة مساحة قدرها 44322 فدان تقريبا. وتم اختيارها كونها منطقة استثمار واعدة ضمن أراضي الاستصلاح الجديدة في مصر.

تم بناء نموذج الارتفاعات الرقمية Digital Elevation Model (DEM) اعتماداً على قيم خطوط الكنتور المشتقة من الخريطة الطبوغرافية للمنطقة باستحدام طريقة المعالجة الإحصائية المكانية المعروفة باسم Ordinary Kriging. ولقد مثلت الوحدات الفيزيوغرافية باختيار القيم الرقمية لفواصل الرسم البياني الخاص بنموذج الارتفاع الرقمي إلى جانب الخريطة الجيولوجية للمنطقة.

اعتمدت الدراسة على تغطية المنطقة من خلال (145) نقطة دراسة أرضية ومعالجتها باستخدام نظم المعلومات الجغرافية للربط بين النتائج المتحصل عليها من اسلوب التحليل الاحصائي الجغرافي ونتائج التحليل لخواص التربة الفيزيائية والكيميائية المرتبطة بعمليات التدهور والتي شملت العمق الفعال للتربة ودرجة الملوحة والكثافة الظاهرية. وأجريت حسابات تدهور التربة (Status, Extent and Overall severity) بناءً على الخواص المذكورة باستخدام طريقة الـ FAO والـ GLASOD ، وذلك للفترتين الزمنيتين (1986-2001م) و (2001-2011م).

أشارت النتائج إلى أن الاستثمار الزراعي في المنطقة خلال الفترة (1986-2001) أدى إلى تدهور التربة وفقا للغدق والملوحة ، وكان ذلك بسبب الإدارة السيئة للمياه والتربة، كاستخدام طريقة الري بالغمر وضعف المعرفة بالاحتياجات المائية للمحاصيل المزروعة وعدم جدولة عمليات الري مع عدم وجود نظام صرف مثالي. ولكن هذه المشاكل أصبحت أقل خطورة وانحسرت المساحات المتدهورة في فترة الدراسة الثانية (2001-2011) وكان ذلك نتيجة لتطبيق التكنولوجيا الجديدة (مثل الري الحديث بالرش والتنقيط) وتحسين نظام الصرف ، وكذا رفع درجة وعي المزارعين في المنطقة بالتطبيقات الزراعية الحديثة عن طريق مشاريع التنمية الحديثة والجمعيات التعاونية ومشاريع المراقبة الزراعية.

من ناحية أخرى فإن مشكلة تضاغط التربة استمرت وتفاقمت في الفترة الثانية مقارنة بالفترة الأولى نتيجة لاستمرار استخدام الميكنة الزراعية وإجراء عمليات خدمة التربة في الظروف الرطبة.

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