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ASSESSMENT AND MAPPING LAND DEGRADATION IN SOME AREAS OF NORTH NILE DELTA, USING NEW TECHNIQUES

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ABSTRACT: Land degradation is defined as a phenomenon or series of events that reduce the current and/or potential capability of soils. This research aims to monitoring the land degradation process for some soils located in Kafr El-Sheikh governorate from 2000 to 2020 years through assessing rate of the land degradation, contributing factors and degree using GIS techniques. Sentinel 2 image and digital elevation model (DEM) was used to extract physiographic map of the study area. The studied soils have a high risk of salinity, water logging, and compaction with account of 8.77, 40.67, and 31.25 % from the study area, respectively. Very high risk of sodicity is represent, 97.17% of the study area. The high Values of hazard are attributed to the excessive overflow irrigation practices, improper use of heavy machinery and the absence of conservation measurements.

Key words: Land degradation, remote sensing, GIS, North Nile Delta; Egypt

INTRODUCTION

Land degradation diminishes or eliminates the ability of soils to produce food. Excessive or inappropriate human activities (poor land management) induce soil salinization and loss of fertility. In certain areas, soil productivity has dropped by up to 50%. The last step of degradation is irreversible, then the soil deteriorates, (Brabant, 2008). According to El Baroudy (2014), land degradation is growing more severe and widespread in many regions of the world, with losing of around six million hectares from agricultural land each year due to this process.

Land degradation and desertification harm 2.6 billion people in over a hundred nations, affecting about 33% of the planet's land surface according to Damon et al. (2018). According to Nachtergaele et al. (2014) and IPBES (2014), the definition of "land degradation" has changed over the time. It has progressed from a focus on soil productivity to a complete understanding of ecosystem goods and services. According to Mantel et al. (2014), land degradation is an environmental phenomenon that affects dry lands and results in a loss of agricultural land's economic and biological quality. They went on to say that, there is a clear distinction between soil and land (the term land refers to an ecosystem that includes land, landscape, terrain vegetation, water, and climate). But there is no clear distinction between land degradation and desertification (desertification refers to land degradation caused by anthropogenic activities in arid, semiarid, and subhumid areas). There are a lot of methods to study land degradation, some of them depending on direct monitoring in the field and indirect methods such as remote sensing. Remote sensing is playing a vital tool in studying land degradation as it can observe a large area of earth with just one satellite image, so it is cost-effective and time-efficient to in comparison to field techniques. Gao and Liu, (2008) reported that, satellite

image can discover the land which suffer from different levels of land degradation. In addition, data which can extract from remote sensing may be used to identify and map hazards of land degradation and simulate soil loss as well (Geerken and Ilawi, 2004; Lu et al., 2007).

The most dynamic causes of land degradation in the Nile delta are Water logging, salinization, alkalization, and compaction (El Baroudy,2011). Furthermore, using of heavy machinery, unnecessary overflow irrigation and bad soil conservation and management are the main causes of human-induced land degradation in the area.

This research aims to monitoring land degradation process from 2000 to 2020 years through assessing rate, contributing factors and degree of land degradation in some soils in Kafr El-Sheikh governorate using remote sensing and GIS techniques.

MATERIALS AND METHODS

Investigated area

The investigated area included some soils located in Kafr El-Sheikh governorate restricted by longitudes 30◦15´ 00˝ and 30◦ 39´ 00˝ East and latitudes 31◦ 5´ 00˝ and 31◦ 29´ 00˝ North, covering an area of 984.64 km^2 (Fig, 1). According to Egyptian Meteorological Authority (2019), the maximum temperature is 36.16°C in August and the minimum is 8.02°C in January, with mean annual of 21.87°C. The average of rainfall is 1.93 mm per year and the heist amount was recorded in December. Evaporation levels range from 1.517 to 7.38 mm and the relative humidity is around 70 % in May. Land use/land cover Rice, sugar beet, maize, sesame and cotton are the main types of field crops grown in the study area, while the common types of orchards cultivated are guava, fig and palm trees. Vegetables represent small scattered areas such as beans, eggplant, melons, etc. The irrigation system is mostly surface irrigation, in which water is pumped from irrigation canals using furrow and basin irrigation.

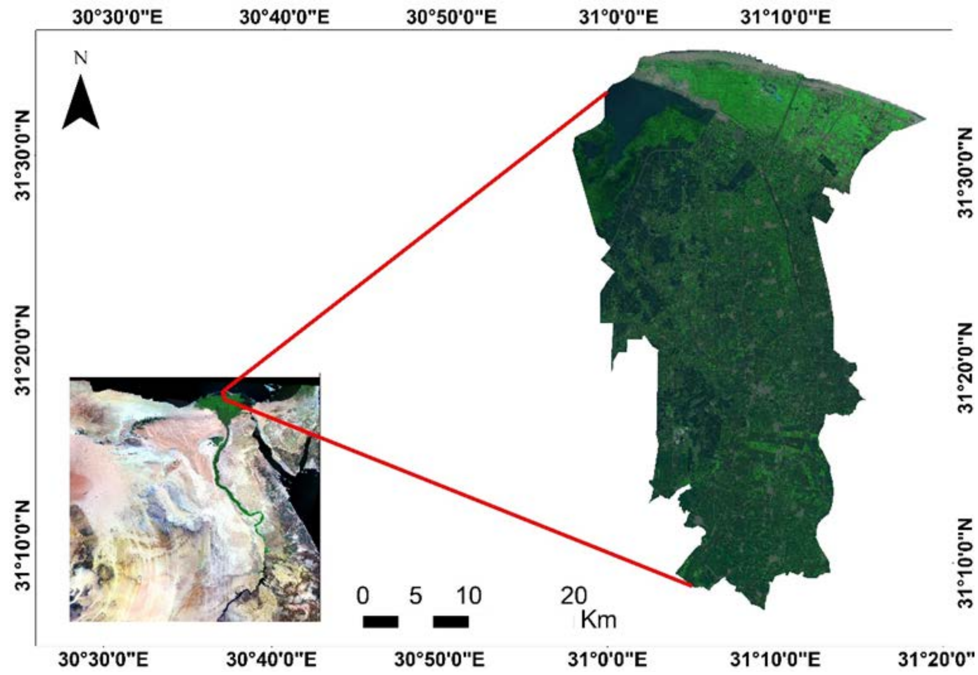

Fig (1): Location of the study area.

Digital image processing

With use of the DEM of the research region, landforms and digital soil mapping were created using a Sentinel-2 image obtained on 10/8/2019 under a clear sky circumstance. The multi-spectral bands of Sentinel-2 image have a ten-meter spatial resolution for bands 2, 3, 4, and 8, respectively. The DEM was created by NASA's Topographic Radar (SRTM) with a spatial resolution of 30 meters. For image processing, SNAP and ENVI 5.4 were used, as well as spectral subset, radiometric calibration, atmospheric, and geometric adjustments. A projection system was assigned using the UTM Zone 36 N coordinate system and the WGS 84 datum.

Producing of the Landform Map

The multi-spectral Sentinal-2 image was placed over the DEM in Arc Scene to create a 3D view for extraction classification of the landform units. Using this method could be enable to separate the different landform units. Moreover, the satellite image and 3D DEM visual interpretation mode were helpful in the field work. The appropriate classification of landforms is given by field check.

Field studies and laboratory analyses

A total of 21 soil profiles were dig to represent the whole soil mapping units. Morphological characteristics were described in details according to FAO (2006). Eighty soil samples were collected from the studied profiles, air-dried, grained and passed through 2 mm sieve. All of chemical analysis including electrical conductivity (EC), pH, exchangeable sodium percentage (ESP), total calcium carbonate, organic matter (OM), soluble cations and anions, cation exchangeable capacity CEC) and physical analyses (Soil bulk density and soil texture) were analyzed according (Burt, 2004). Soil classification were carried out using the American Soil Taxonomy (Soil Survey Staff, 2014).

Land degradation assessment

Assessment of degradation in this study relying upon comparison between data from El Baroudy (2000) and results from current study. The rates which used in this study are presented in Tables (1 and 2) according to (FAO/UNEP 1979).

Table (1): Classes and rates of Soil degradation (FAO/UNEP 1979).

Chemical degradation*	Salinization increase in EC per dS/m/year	Alkalinization increase in ESP/year
NS	<0.5	<0.5
M	0.5–3	0.5–3
H	3–5	3–7
VH	>5	>7
Physical degradation*	**Compaction/increase in bulk density per g/cm^3/year**	**Water logging/increase in water table in cm/year**
NS	<0.1	<0.1
M	0.1–0.2	1–3
H	0.2–0.3	3–5
VH	>0.3	>5

* NS= None to slight, M= Moderate, H= High and VH= Very high

Table (2): Criteria used to conclude the different degradation types degree (FAO/UNEP, 1979).

Critical/Hazard type	Indicator	Unit	Hazard class			
			Low	Moderate	High	Very high
S	EC	dS/m	4	4-8	8-16	>16
A	ESP	%	10	10-15	15-30	>30
C	Bulk density	g/Cm^3	1.2	1.2-1.4	1.4-1.6	>1.6
WL	Water table level	Cm	150	150-100	100-50	>50

***Note: S= salinization, A= Alkalinity, C= compaction and WL= water logging**

RESULTS AND DISCUSSION

Geomorphology

Geomorphologic units may be acknowledged through interpretation of satellite image interpretation, which is consider the most common, flexible, and cost-effective progressive approaches. The major advantages of satellite images are providing ground observation with realism. The geomorphic units were identified using multiple maps and field surveys. The collected data show that, the flood plain is the dominant landscape in the investigated area. The found landforms are namely Flood plain that including river terraces (moderate, high and low), basins, decantation basins and overflow basins (low, moderate, high); Lacustrine plain including fish Farms and dry Sabkha, Marine plain including coastal sand dunes. These landforms have areas of 412.16 km^2 (42.80% from the total studied area), 224.54km^2 (23.32%), 121.65 km^2 (12.63%),191.38 km^2 (19.87 %) and 23.95 km^2 (2.49%) respectively (Table, 3 and Fig, 2).

Soils of the investigated area

According to field surveys and laboratory analyses, the soil texture classes of the investigated area differ between sandy and clay. Cation exchangeable capacity (CEC) ranged from 8.49 to 34.16 cmole/kg and strong correlated with clay content. The salinity values range from 0.82 to 35.61 dSm^{-1} thus, these soils varied between non saline to strongly saline. While, pH and ESP values varied between 8.12 to 8.77 and 2.62 to 18.80 respectively. The bulk density and soil depth of the study area ranged from (1.2 to1.6) and (120 to 150), respectively. The average of organic matter is (0.18%). The low value of OM is due to the high temperature in arid and semi-arid regions that leads to decomposition of fresh residuals. The average of $CaCO_3$ is 7.61. The high content in some sites is due to presence of shell pieces and blamed for the elevated values of the investigated profiles. According to Soil Survey Staff (2014), *Typic Torrifluvents, Vertic Torrifluvents, Typic Torriorthents, Vertic Torrifluvents, Vertic Natriargids, Vertic Haplosalids, Typic Haplosalids, Typic Torripssaments, and Typic Natrargids* are the main sub great groups found in the research area.

Land degradation caused by humans

To analyze human-induced land degradation in the study area, the land degradation type of different mapping unit was determined. To determine the rate of degradation, the current results were compared with data of the same area in year 2000. The current data show that, alkalinization, water logging, and compaction rate is ranged from non or slight to high, as yearly increase in EC is 0.29 dS/m and ESP is 1.42% (Table, 4). The interpolation maps of land degradation parameters were shown in Figs (3a, 3b, 3c

and 3d). The current values of electric conductivity, ESP, bulk density, and water table depth range between 0.82 to 35.61 dS/m, 26.96 to 48.76 %, 1.2 to 1.83 g/cm^3, and 70 to 175 cm, respectively. In the study region, soils with a high risk of salinity, water logging, and compaction are counted as 8.77, 40.67, and 31.25 % of study area, respectively. Very high risk of sodicity is represent, 97.17% of study area (Tables 5 and 6).

Table (3): Physiographic units of study area.

Landform	Map unit	Area (KM)^2	% of the study area
Low river terraces	RT1	290.66	30.18
Mod. River terraces	RT2	101.19	10.51
High river terraces	RT3	20.31	2.11
Overflow basins	OB1	25.19	2.62
Low overflow basins	LB1	43.29	4.50
Mod. overflow basins	LB2	53.18	5.52
High overflow basins	LB3	99.05	10.29
Decantation. basins	DB1	224.54	23.32
Fish Farms	FF1	109.75	11.40
Dry Sabkha	DS1	81.63	8.48
Coastal sand dunes	CD1	23.95	2.49

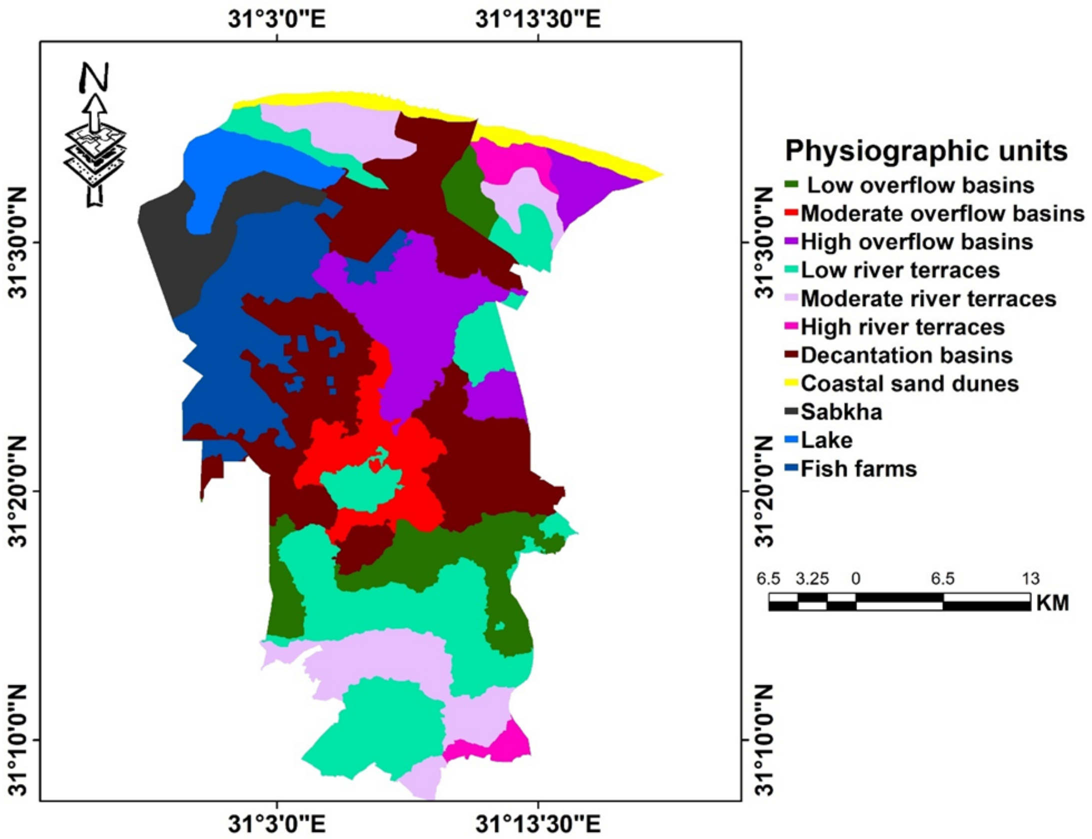

Fig (2): Geomorphological map of the investigated area.

Table (4): The annual rate of degradation in the study area.

Mapping unit	EC*	ESP	Bulk Density	Water log
RT1	NS	M	NS	H
RT2	NS	M	NS	NS
RT3	NS	M	NS	NS
OB1	NS	M	NS	H
LB1	NS	M	NS	M
LB2	NS	M	NS	M
LB3	NS	NS	NS	M
DB1	M	NS	NS	NS
DS1	M	M	NS	M
CD1	NS	M	NS	NS

*** NS= None to slight, M= Moderate, H= High**

Table (5): Monitoring of the main land characteristics in the studied area.

Profile no	Mapping unit	EC ds/m		ESP %		Water table(cm)		Bulk density (gm/cm^3)	
		2000	2020	2000	2020	2000	2020	2000	2020
1	RT1	7.55	13.39	20.19	48.76	110	175	1.39	1.83
2	RT2	3.94	2.65	13.23	37.14	135	120	1.36	1.38
3	RT3	8.87	0.82	20.13	35.14	90	90	1.39	1.6
4	OB1	6.63	7.7	24.87	37.31	85	150	1.39	1.4
5	LB1	3.76	7.27	10.79	36.81	150	98	1.39	1.44
6	LB2	3.76	4.96	10.79	31.05	150	125	1.39	1.3
7	LB3	7.8	2.74	23.16	31.82	150	105	1.35	1.2
8	DB1	19.77	6.9	25.41	31.03	106	103	1.36	1.34
9	DS1	66.86	35.61	31.45	47.83	80	110	1.37	1.6
10	CD1	4.79	1.86	11.53	26.96	85	70	1.36	1.6

Table (6): The rate of degradation in the study area.

Mapping unit	Salinization (EC) dS/m	Alkalization (ESP)%	Compaction (Bulk density g/cm^3)	Water logging (water table Cm)
RT1	H	VH	VH	L
RT2	L	VH	M	M
RT3	L	VH	H	H
OB1	M	VH	M	L
LB1	M	VH	M	H
LB2	M	VH	M	M
LB3	L	VH	L	M
DB1	M	VH	M	M
DS1	VH	VH	H	M
CD1	L	H	H	H

***Note: L= Low, M= Moderate, H= High and VH= Very high**

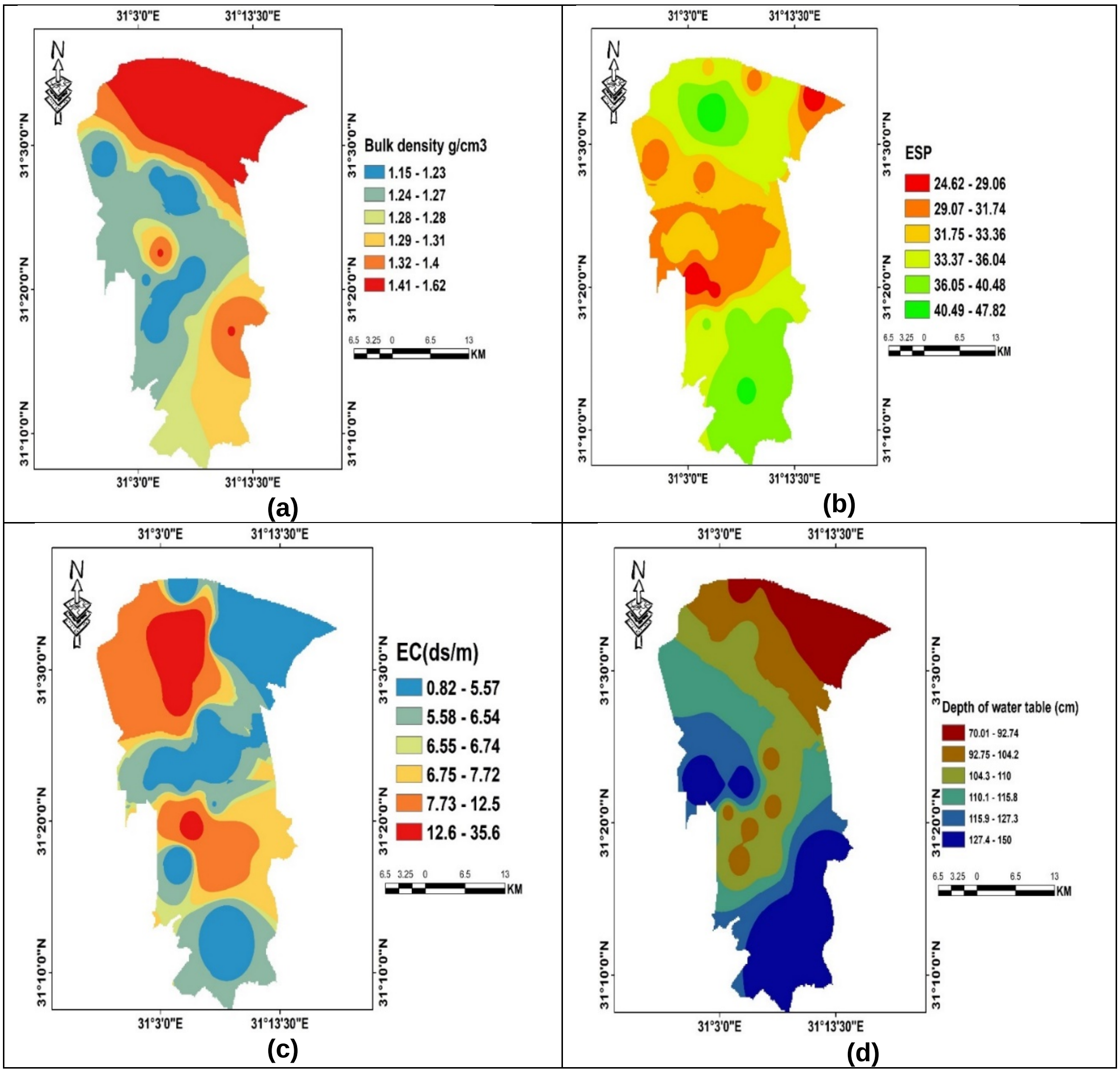

Fig (3): Spatial distribution of chemical and physical soil properties: (a): bulk density (g/cm^3), (b): ESP, (c): EC (dS/m), (d): depth (cm).

Areas impacted by salinity, sodicity, compaction, and water logging were shown in Table (7). Soils having EC values < 4 dS/m increased by 0.46% while, soils lying in the range of 4-8, 8-16 dS/m and >16 dS/m were decreased by15.75%, 51.75% and 19.87% of the study area, respectively. Exchangeable sodium percentage (ESP) is used to express the alkalinity in this study. The data revealed that areas of ESP values ranged between10-15 % and 15-30 % were decreased by 27.48% and 52.04% of the study area respectively. On the other hand, soils having ESP values >30 % were increased by 79.52% of the study area. In regards to soil compaction, areas having bulk density values of 1.2-1.4 g/cm^3 and 1.4-1.6 g/cm^3 were decreased by 29.76% and 0.41% respectively. While those having bulk density >1.6 g/cm^3 were increased by 30.18%. Water table level is the indicator of water logging. The areas affected by water table in the range of 50-100cm and100-150 cm were increased by18.38% and 10.6% of the study area respectively. Whereas, those having water table more than 150 cm were decreased by 28.98% of the study area.

Table (7): Distribution of land degradation in the studied area.

	Range	Area in Yr. 2000		Area in Yr. 2020		Difference	
		Km^2	%	Km^2	%	Km^2	%
Salinization EC dS/m	<4	240.06	24.93	244.49	25.39	4.43	0.46
	4-8	270.09	28.05	121.66	12.63	-148.43	15.42
	8-16	16.78	2.11	515.19	53.50	498.41	51.75
	>16	436.03	28.35	81.63	8.48	-354.4	19.87
Alkalization ESP	<10	--	--	--	--	--	--
	10-15	264.65	23.01	--	--	- 264.65	27.48
	15-30	525.14	54.53	23.95	2.49	- 501.19	52.04
	>30	173.18	17.99	939.03	97.51	765.85	79.52
Bulk density gm/cm^3	<1.2	--	--	--	--	--	--
	1.2-1.4	789.79	82.01	503.14	52.25	286.65	29.76
	1.4-1.6	173.19	17.98	169.17	17.57	4.02	0.41
	>1.6	--	--	290.66	30.18	290.66	30.18
Water logging (water depth cm)	>150	385.92	40.07	106.81	11.09	-279.11	28.98
	150-100	375.85	39.03	477.96	49.63	102.11	10.6
	100-50	201.21	20.89	378.20	39.27	176.99	18.38
	<50	--	--	--	--	--	--
Study area	$962.97km^2$						

Conclusion

The most widely utilized methods and techniques in the detection and mapping of soil degradation are remote sensing data and geophysical surveys. The studied soils are threatened by low to high levels of water logging, compaction, salinity, and alkalinity. The high values of hazard are attributed to the excessive overflow irrigation practices, improper use of heavy machinery and the absence of conservation measurements. The studied soils are characterized by a low rate of degradation for different types of human induced factors due to the low changes in the land characteristics during the period between 2000 to 2020.

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تقييم ورسم خرائط تدهور الأراضي في بعض مناطق شمال دلتا النيل، مصر

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الملخص العربى

يُعرَّف تدهور الأراضي بأنه ظاهرة أو سلسلة من الأحداث التي تقلل من القدرة الإنتاجية الحالية و / أو المحتملة للتربة، ويهدف هذا البحث إلى تتبع عملية تدهور الأراضي من عام 2000 إلى عام 2020 من خلال تقييم معدل تدهور الأراضي، والعوامل المسببة ودرجة التدهور وذلك باستخدام تقنيات نظم المعلومات الجغرافية، ولقد تم استخدام صورة نموذج الارتفاع الرقمي، وصورة القمر الصناعي Sentinel 2 لإنتاج الخريطة الفيزيوجرافية لمنطقة الدراسة.

شكلت التربة ذات المخاطر العالية للملوحة ومستوى الماء الأرضي والكثافة الظاهرية النسب 8.77 و40.67 و31.25٪ من منطقة الدراسة على التوالي، وتمثل الاراضي ذات النسبة العالية جدا من مخاطر الصودية نسبة 97.17٪ من منطقة الدراسة، ويمكن أن تُعزى القيم العالية للمخاطر إلى ممارسات الري بالغمر المفرطة، والاستخدام غير السليم للآلات الثقيلة، وغياب نظم صيانة التربة.

<u>أسماء السادة المحكمين</u>

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