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SPATIAL DISTRIBUTION AND DEGRADATION RISK ASSESSMENT OF SOME CULTIVATED ALLUVIAL SOILS OF AL-AZHAR UNIVERSITY, ASSIUT GOVERNORATE, EGYPT

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ABSTRACT: ***This research aims to characterize soils of Al-Azhar university of Assiut and mapping them on a large scale for more information. Moreover, assessment the risk of soil degradation for understanding the current situation of land uses and its management. The characteristics of the investigated soils ranged from 1.39 to 2.72%, 1.37 to 1.48 dSm^{-1}, 2.07 to 4.85% and slowly to very slowly permeable as weighted means for $CaCO_3$ content, salinity, sodicity and permeability condition, respectively. The soils could be divided into two mapping unites; (1) nearly level deep fine textured soils which is the major one, (2) nearly level deep moderately fine textured soils. High hazard of compaction covered the total area as a result of human activities along with very high values of physical degradation and low to moderate effects of chemical degradation threaten the studied soils. Anthropogenic factor had a clear impact on processes of land degradation and actual hazard in terms of inadequate soil management, intensive irrigation procedures, using heavy machinery and absence of conservation measures. The running situation of land degradation within the studied area is very serious and misses a correct land use planning and management.***

Key words: ***Land degradation, spatial distribution, alluvial soils, salinity, sodicity, compaction, Geographic Information System.***

INTRODUCTION

Capturing soil properties for interpreting and characterizing soil spatial distribution on a map up to date is urgently required for agricultural soil sustainability. Similar and dissimilar soils should be consistently and listed in map unit descriptions and databases to properly account for the complexity in a survey (Soil Science Division Staff, 2017). However, soil distribution and properties based upon user needs for a wise agricultural management at Nile alluvial soil of Assiut governorate were not yet fully took into account.

On the other hand, land degradation due to human misuse of agricultural soil is regarded one of the most serious issues worldwide. Where, about more than 5.5 million hectares of the global cultivated land becomes unproductive each year owing to different processes of soil degradation. From the agricultural point of view, land degradation is defined as being the actions in land that reduce sustainable crop production over time. In some cases the soil degradation occurs mainly as damage of physical properties by compaction or as spoilage of chemical properties by salt accumulations. However, wind and water erosion can be the main causes of land degradation with a probability of up to 85%. Soil degradation occur via a complicated interaction among climatic soil forming factors, anthropogenic and soil properties (Chartres, 1987; Asio *et al.,* 2009; Liberti *et al.,* 2009 and Brady & Weil 2013).

Investigation of soil distribution and land degradation can be done in various ways like direct field observation and remote sensing technique. Digital data of remote sensing is a suitable tool for monitoring risk of land degradation to different levels. In addition to, this advanced mean is impacted in characterization and mapping both of soil and land degradation spatially (Geerken & Ilawi, 2004; Lu *et al.,* 2007; Mathieu *et al.,* 2007; Chafer, 2008 and Gao & Liu, 2008).

The main objectives of this article are to: (1) Characterize soils of Al-Azhar University site, (2) Mapping of the pedological unites of the studied area, (3) Assess the risk of land degradation using remote sensing and GIS techniques.

MATERIALS AND METHODS

The studied area

The studied area represents Al-Azhar university site, Assiut, Egypt (longitudes 31°09′00″ and 31°11′00″E and latitudes 27°10′00″and 27°13′00″N). It lies 4 km northwest of Assiut city, between Nile river and El-Ibrahimya canal and covering an area of 6.1 km^2 (Fig. 1).

The area is characterized by a hot dry climate in summer with scanty winter rainfall and bright sunshine throughout the year. The meteorological data of Assiut station from 2009 to 2018 referred that the mean annual temperature is 22°C; the average annual rainfall is about 0.37 mm and the daily evaporation is about 6.75 mm/day. Geologically, the studied area was formed during Quaternary period where it constructed of the suspended colloids which were transported by the annual Nile flood. These suspended materials are the result of physical and chemical weathering of the igneous and metamorphic rocks forming the Ethiopian plateau (Kishk, 1972).

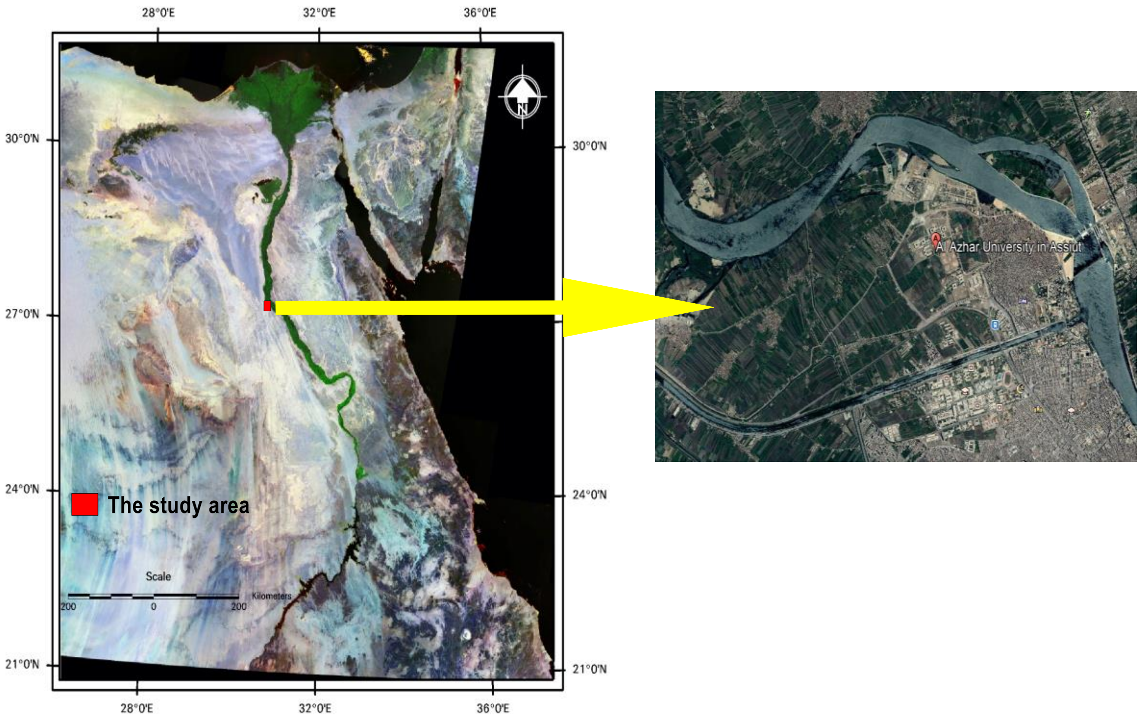

Fig. (1): Location of the studied area.

Digital elevation model (DEM)

The digital elevation model (DEM) of the studied area (Fig. 2) was extracted from the Shuttle Radar Topography Mission (SRTM) and processed in Global Mapper v17.0.5 software. ArcMap 10.2.2 was used to display and produce spatial distribution maps. Maps have been obtained by matching DEM with field investigations and analytical data of salinity, sodicity, bulk density, water table and soil depth.

Field studies and laboratory analyses

Field investigations, ground observation and laboratory data were conducted to identify the pedological units. A total of 11 pedons comprise 35 soil samples (Fig. 3) were taken representing the most dominant ground elevations of the studied area obtained from DEM (Fig. 2) for producing soil and land degradation assessment maps. A detailed morphological description of the pedons was formulated as outlined by Soil Survey Staff (1993) and FAO (2006). The soil samples were air-dried, ground and passed through 2 mm sieve. The collected samples were subjected to some chemical and physical analyses according to Page *et al.* (1982) and Klut (1986).

Land degradation assessment

Appraising the risk of land degradation was based on a simple model (Fig. 4) to establish a raster GIS depended on the equations provided by FAO/UNEP (1978 and 1979) and the feedbacks were assessed and confirmed with the pedological units.

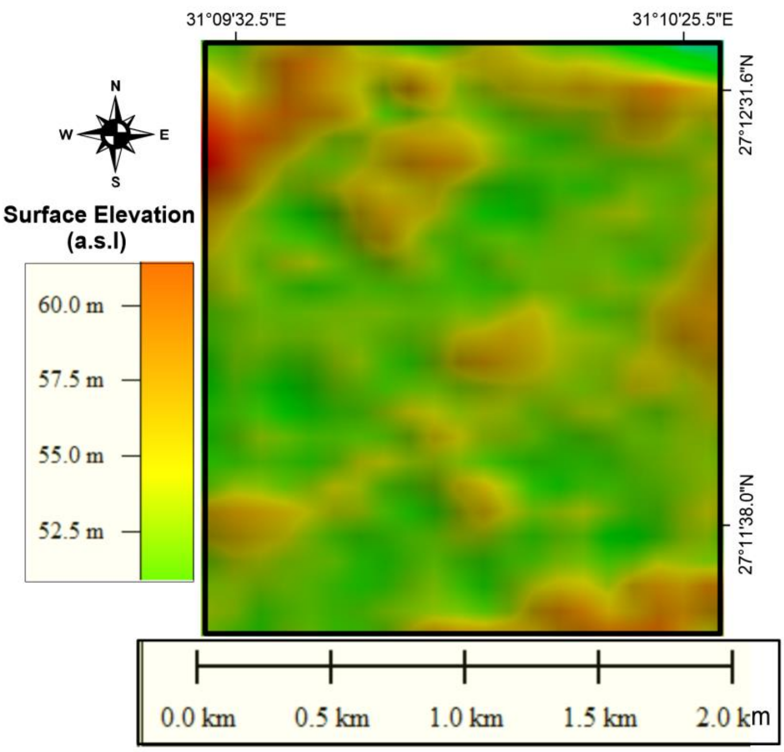

Fig. (2): The digital elevation model (DEM) as extracted from SRTM .

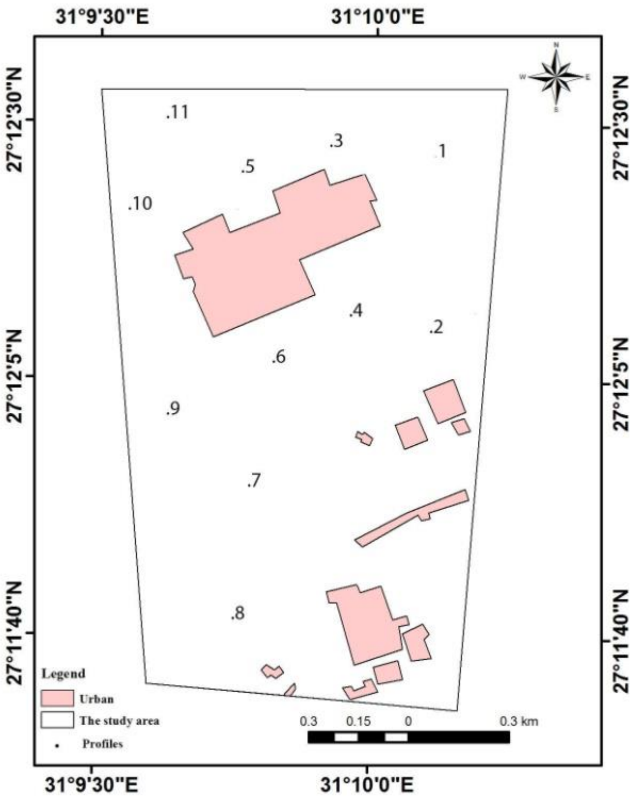

Fig. (3): Locations of the excavated pedons.

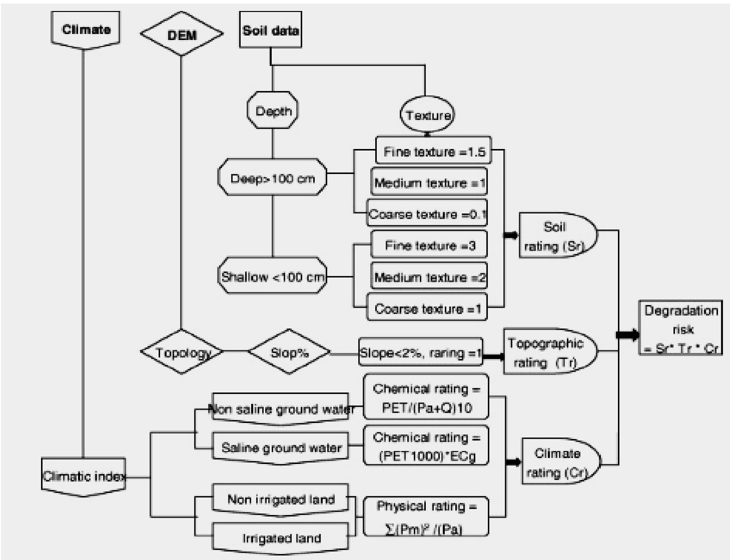

Fig. (4): Flowchart of the designed land degradation risk model.

The criteria used to define and describe the degree and type of salinization, Alkalinization, compaction and water logging are shown in Table (1).

Table (1): The used criteria to determine the degree of different degradation types.

Critical/hazard type	Indicator	Unit	Hazard class			
			Low	Moderate	High	Very high
Salinization	EC	dS/m	4	4–8	8–16	>16
Alkalinization	ESP	%	10	10–15	15–30	>30
Compaction	Bulk density	g/cm^3	1.2	1.2–1.4	1.4–1.6	>1.6
Water logging	Water table	cm	150	150–100	100–50	<50

Risk of degradation is governed by various variables i.e., soil salinity, ground water salinity, exchangeable sodium percentage, surface slope, soil depth, soil texture, organic matter, monthly and annually precipitation, potential evapo-transpiration and irrigation water quantity. The impact of these factors can be identified by elaborating their effects on the physical and chemical degradation. The soil texture rating for chemical degradation risk in the deep profiles is 0.1, 1 and 1.5 for coarse, medium and fine texture, respectively. In the case of shallow profiles the utilized soil rating is 3, 2 and 1 for fine texture, medium and, coarse respectively. The climatic rating of chemical degradation is calculated according to FAO/UNEP (1978 and 1979) as follows:

$$CR_c = PET/(P_a+Q)10 \quad (1)$$

Where, CR_c is the climatic rating of chemical degradation risk

PET is the potential evapo-transpiration

P_a is the annual precipitation and

Q is the amount of irrigation water used in mm.

When using saline ground water, the climatic rating of chemical degradation risk was calculated using the following equation:

$$CR_c = (PET/1000)*EC_{gw} \quad (2)$$

Where, EC_{gw} is the ground water salinity.

The soil texture rating for physical degradation risk was calculated using the following equation:

$$SR_P = S/C \quad (3)$$

Where SR_p is the soil texture rating for physical degradation risk

S is the percentage of silt and

C is the percentage of clay.

The climatic rating of physical degradation risk was calculated using the following equation:

$$CR_P = \Sigma P^2_m/P_a \quad (4)$$

Where CR_p is the climatic rating of physical degradation risk

P_m is the monthly precipitation in mm and

P_a is the annual precipitation in mm.

RESULTS AND DISCUSSION

Soils of the studied area

Ground elevations of the studied area ranged narrowly between 54 to 61 m asl, where it reflected almost flat topography along with nearly level slope class (0.5-1%). Weighted means of $CaCO_3$ content, salinity, sodicity and permeability condition of the studied area ranged from 1.39% to 2.72%, 1.37 to 1.48 dSm^{-1}, 2.07 to 4.85% and slowly to very slowly permeable, respectively. The data showed that pedons of the investigated soils are deep (150 cm) and had a texture varied widely between sandy clay loam to clay (Table 2).

Table (2): Weighted means values of some physical and chemical properties of the studied pedons

Pedon No.	Elevation a.s.l (m)	Soil Depth (cm)	Slope (%)	EC (dS/m)	ESP (%)	Db (Mg/m^3)	$CaCO_3$ (%)	Permeability	Texture class
1	61	150	0.5-1	1.48	4.29	1.51	2.72	Very slowly permeable	SiC
2	60			1.44	3.65	1.48	1.81		C
3	59			1.41	3.52	1.50	1.69		C
4	57			1.41	4.09	1.49	1.91		C
5	55			1.37	4.85	1.46	1.98		C
6	56			1.43	4.05	1.49	1.39		C
7	57			1.41	4.52	1.50	1.96		C
8	57			1.40	3.63	1.47	2.35		SiC
9	54			1.39	3.41	1.49	2.17		SiC
10	60			1.46	3.75	1.50	2.40		C
11	61			1.40	2.07	1.62	2.17	Slowly permeable	SCL

Pedons could be classified into two pedological unites. The first was nearly level deep fine textured soils and occupied the majority of the studied area while the second was nearly level deep moderately fine textured soils, Fig. (5).

Soil degradation hazard assessment

The attribute data tables for salinity, alkalinity, bulk density were compiled into the digital soil mapping units and DEM in a geographic information system. The incorporated attributes were used to obtain the layers of spatial distribution of the above mentioned characteristics (Figure 6, 7 and 8). As water table depth is more than 150 cm for all the studied pedons, its spatial distribution map has been neglected. However, it has been put in the account with the other obtained data during assessment risk of degradation. The results showed that compaction was the main degradation hazard in the studied area.

The high hazard of compaction covered the total area as a result of human activities, inadequate soil management, using heavy machinery and human intervention in natural drainage systems. The soils are not affected by salinity, sodicity and water logging, where they were defined in relation to values of electrical conductivity (EC), exchangeable sodium percentage (ESP) and the depth of water table, respectively.

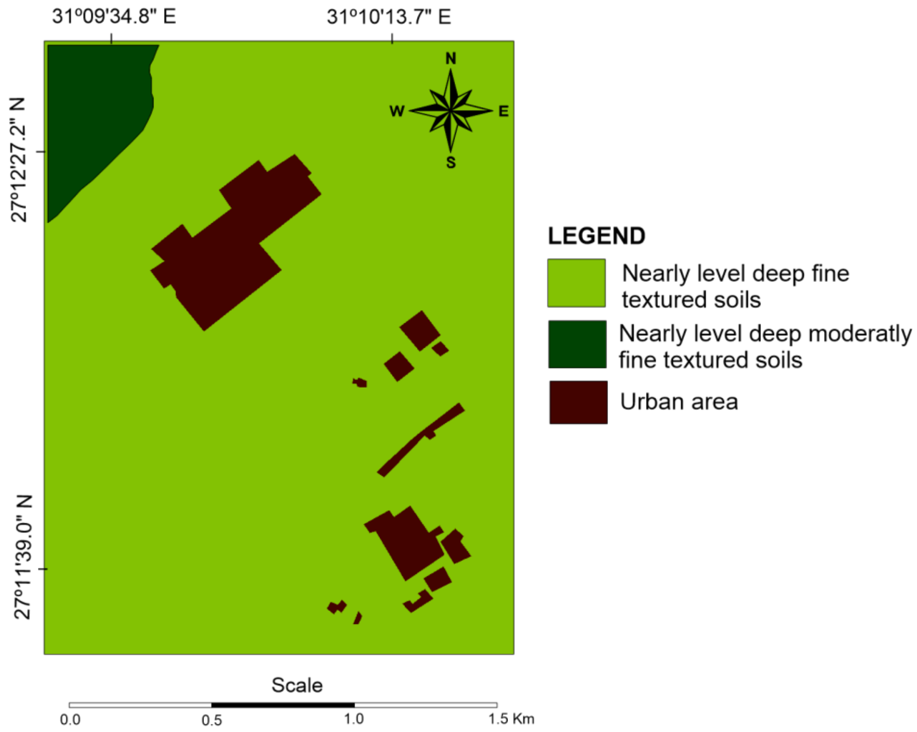

Fig. (5): Soil mapping unites of the studied area.

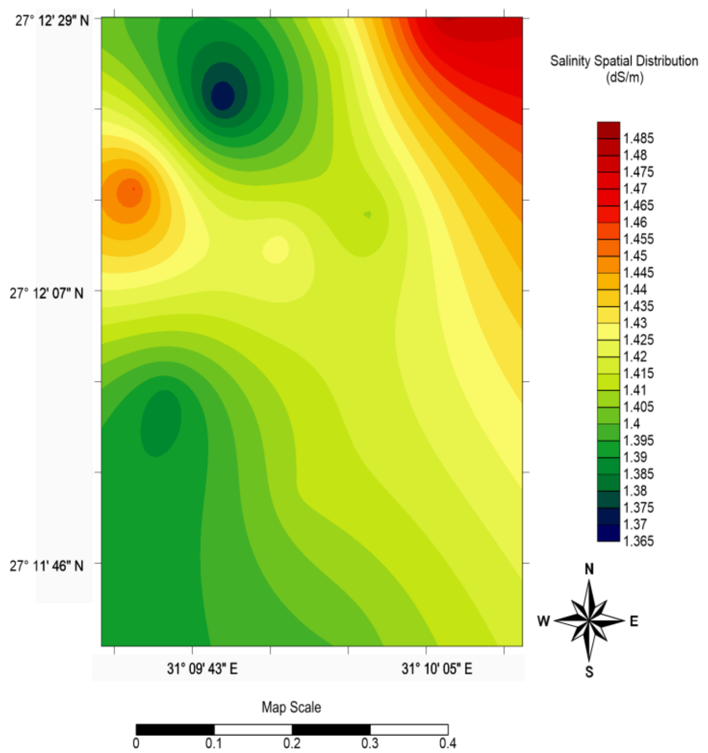

Fig. (6): Spatial distribution of soil salinity at the studied area

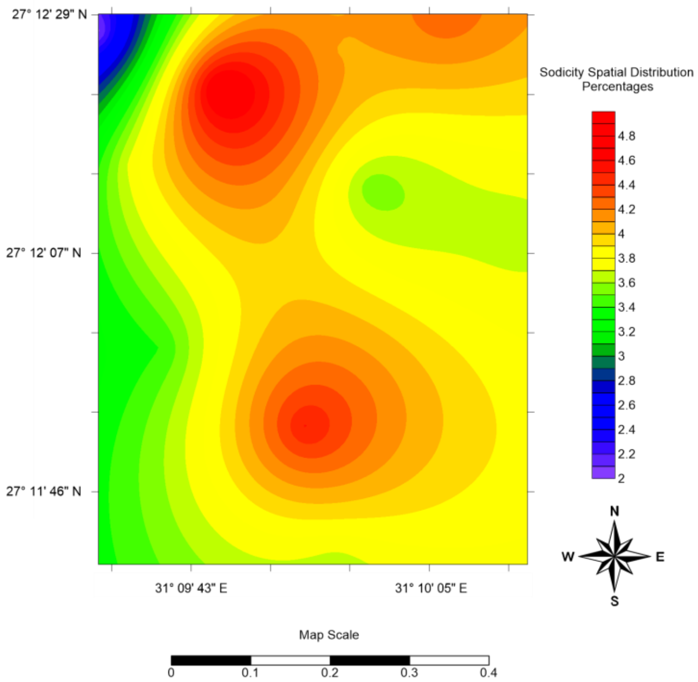

Fig. (7): Spatial distribution of soil sodicity at the studied area.

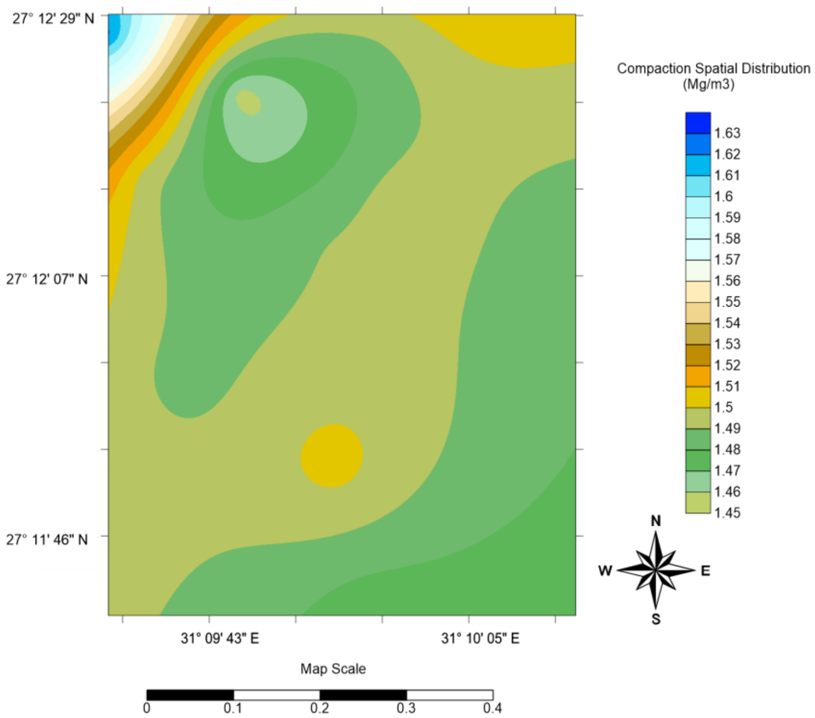

Fig. (8): Spatial distribution of soil compaction at the studied area.

Assessment of chemical and physical degradation

Analysis of DEM data indicated that the slope gradient of the research area varied between 0.5% and 1%, which has a slight effect on natural vulnerability. Thus the topographic effect on natural vulnerability was considered as 1.0 within the investigated area. The feedbacks reflected that risk of chemical degradation was categorised as low in all the representative pedons of the studied area, except the soil of profile no. 9 that show moderate class of degradation. While, assessment risk of physical degradation displayed that all of the investigated area threatened by very high risk values (Table 3). The very high values of hazard can be attributed to inadequate soil management, intensive irrigation farming, using heavy machinery and absence of conservation measures as human activities. This of course, lack to a convenient land use management for soil resources.

Conclusion

It can be concluded that soils of the studied area were categorized into two unites; (1) nearly level deep fine textured which covered most of the investigated area and (2) nearly level deep moderately fine textured soils. High hazard of compaction covered the total area as a result of human activities along with very high values of physical degradation and low to moderate effects of chemical degradation threaten the investigated area. Inadequate soil management, intensive irrigation farming, using heavy machinery and absence of conservation measures can be the main causes of very high values of hazard.

Table (3): The computed chemical and physical degradation risks in the studied area.

Pedon No.	Chemical degradation					Physical degradation				
	SR	TR	CR	Risk	Class	SR	TR	CR	Risk	Class
1	1.50	1.00	0.001	0.001	Low	1.00	1.00	16.88	16.90	Very high
2	1.50	1.00	0.001	0.002	Low	0.87	1.00	16.88	14.63	Very high
3	1.50	1.00	0.001	0.001	Low	0.75	1.00	16.88	12.71	Very high
4	1.50	1.00	0.001	0.001	Low	0.81	1.00	16.88	13.66	Very high
5	1.50	1.00	0.000	0.001	Low	0.78	1.00	16.88	13.24	Very high
6	1.50	1.00	0.001	0.001	Low	0.86	1.00	16.88	14.51	Very high
7	1.50	1.00	0.001	0.001	Low	0.93	1.00	16.88	15.62	Very high
8	1.50	1.00	0.001	0.002	Low	0.94	1.00	16.88	15.90	Very high
9	1.50	1.00	1.471	2.206	Moderate	0.95	1.00	16.88	16.05	Very high
10	1.50	1.00	0.001	0.002	Low	0.81	1.00	16.88	13.63	Very high
11	1.50	1.00	0.000	0.001	Low	0.72	1.00	16.88	12.20	Very high

SR, soil rating; TR, topographic rating; CR, climatic rating; Risk = SR*TR*CR; risk < 2 (class = 1 low), risk = 2–4 (class = 2 moderate), risk = 4–6 (class = 3 high), risk > 6 (class = 4 very high).

Anthropogenic factor had a clear impact on processes of land degradation could be reflected in view of degradation risk and the actual hazard. The current scenario of land degradation in the investigated area is very alarming and requires suitable land use planning and management.

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التوزيع المكاني لبعض الأراضي الرسوبية لمزرعة جامعة الأزهر بأسيوط ، مصر ، وتقييم حساسيتها للتدهور

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الملخص العربى

هذا البحث يهدف إلى تحديد صفات أراضى جامعة الأزهر بأسيوط ورسم خرائط لها على نطاق واسع للحصول على مزيد من المعلومات بالإضافة إلى معرفة محددات تدهور هذه الأراضى لفهم الوضع الحالى لأستخدامات التربة وكيفية إدارتها. وقد أظهرت النتائج أن هذه الأراضى غير جيرية حيث أن محتوى التربة من كربونات الكالسيوم الكلية يتراوح بين 1.39 - 1.72% وأن قيم ملوحة التربة تراوحت من 1.37-1.48 ديسيمنز/م وكانت هذا الأراضى غير صودية (2.07-4.8%)، بينما كانت نفاذيتها بطيئة جداً إلى بطيئة.

يمكن تقسيم هذه الأراضى إلى 2 وحدة خريطية 1- أراضى عميقة ذات قوام ناعم تغطى معظم المنطقة المدروسة 2- أراضى مستوية تقريباً ذو قطاع أرضى عميق ذات قوام متوسط النعومة. وتعانى منطقة الدراسة من خطر التضاغط بصورة كبيرة نتيجة لأنشطة الانسان المختلفة والتى تؤدى الى تدهور الصفات الطبيعية للتربة بشكل كبير مما يستتبعه تدهور ملحوظ على صفات التربة الكيمائية.

وكان العامل البشرى له أثر واضح فى عملية تدهورالتربة وتعرضها لمخاطرة فعلية من خلال سياسة زراعية غير مناسبة، ورى مزرعى غزيربالغمر ، واستخدام الآلآت الثقيلة وغياب وسائل المحافظة على التربة. لذلك فإن الوضع الحالى للأراضى محل الدراسة ينذر بتدهور خطير للغاية ويفتقر إلى التخطيط الجيد وإستغلال الأرض بصورة صحيحة.

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