

**ASSESSMENT OF THE ENVIRONMENTAL
SENSITIVITY TO DESERTIFICATION IN RELATION
TO LAND PRODUCTIVITY OF SOME SOILS AT
WEST EDFU, EGYPT**

Moamen M. El Kady¹ and Yasser A. Sayed²

¹Department of Pedology, Desert Research Centre, El-Matariya 11753, Cairo, Egypt

²Soils and Water Sci. Dept., Fac. Agric., Al-Azhar Univ., Assiut, Egypt

Corresponding author [e-mail: moamen.elkady@yahoo.com]

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ABSTRACT

Egypt is one of the territories that have been suffering from desertification and its unfavourable impact on socio-economy, food security, and gregarious stability. Thus, one of the main activities of Desert Research Centre is combating desertification in Egypt by assessing the sensitivity of the ecosystems to desertification and degradation vulnerability of land for resources conservation. Therefore, this paper aimed at appraising the environmental sensitivity to desertification in relation to land productivity of some soils at west Edfu, Egypt using the Desertification Sensitivity Index (DSI). The research area lies between 24°54'00" to 24°57'00"N and 32°43'30" to 32°49'30"E; 85 km². The results showed that the studied area was characterized by moderate soil quality with weak vegetation and hyper-arid climatic quality indices. Based on DSI, the investigated site could be identified as a sensitive area to desertification; with average and poor land productivity classes of grades III, and IV, respectively. The evaluated area is requiring particular soil management practices for best agricultural use and combating desertification.

1. INTRODUCTION

Desertification is a crucial environmental, social and economic issue to several countries altogether parts of the globe, especially in dry lands which cover about 41% of the Earth's surface and affect 38% of the cosmopolitan population (**Reynolds et al., 2007; Breckle et al., 2001**). **David and Nicholas (1994)** identified desertification that it means land degradation in arid, semiarid and dry sub-humid areas resulting essentially from climatic variations and unfavourable human impact.

Assorted investigations (**Khanamani, et. al., 2017; Tavares et al., 2015; Vasu et al., 2016**) have been conducted to assess the environmental sensitivity to desertification and its impact on productive

land in different regions of the Earth. These studies are greatly contributing to information related to the desertification process.

There are many factors that can contribute to desertification; these factors include soil, vegetation, climate, demographic and human activities, each of these factors has different variables determining it, (**Gad and Lotfy, 2006**). The most dominant degradation problems leading to desertification in arid regions like Egypt were represented in wind erosion and salinization (**Glantz, 1977; Quintanilla, 1981; Zonn, 1981**).

Gad and Lotfy, (2008) used remote sensing and GIS techniques in mapping the environmental sensitivity areas for desertification of Egyptian territory. They found that Egyptian territory is susceptible to very high-to-high desertification sensitivity, however the Nile Valley is moderately sensitive because of its vegetation cover. They concluded that action measures concerning to desertification appraisalment are essential for the sustainable agricultural projects located in the desert oases, wadis and interference zone.

Soils in west Edfu are promising for land reclamation projects due to their location nearby the urban areas and availability of groundwater resources for crop irrigation (**Abdalazem et. al., 2020**). So, one of the important steps to improve the employment of its natural resources is assessment of this soils for desertification sensitivity as a necessary stage prior to the agricultural use.

Based on that, this paper aimed at assessing the environmental sensitivity to desertification in relation to land productivity of some soils at west Edfu, Egypt using the Desertification Sensitivity Index (DSI).

2. MATERIALS AND METHODS

2.1 Study area location and general characteristics

The study area is located in west Edfu, Aswan governorate-Egypt, which lies between latitudes 24°54'00" and 24°57'00"N and longitudes 32°43'30" and 32°49'30"E, with an area about 85 km², (Fig. 1). According to **Egyptian Meteorological Authority (2011)**, the climatic regime is hot and characterized by moderate winter and very hot arid summer typically called a desert climate. There is almost no rainfall during the year (about 1 mm of precipitation). The average annual temperature is 26.8 °C in Edfu. The studied area could be classified as Hyperthermic temperature regime and Torric soil moisture regime (**Soil Survey Staff, 2014**).

Geologically, the Nubia formation of Cretaceous age (**Issawi, 1981**) which covers all the examined area and overlies the basement rocks, is mainly composed of sand and sandstone with clay and shale intercalations of irregular thicknesses (Fig.2). **El-Desoky and Sayed (2019)** classified the research area into three geomorphologic units

throughout interpreting satellite images and DTM techniques. These units are in the following; (i) Overflow basin, (ii) River terraces, and (iii) Decantation basin, Fig. (3).

2.2 Soil sampling and laboratory analyses

On the basis of geomorphological variation, seven soil profiles were selected, (Fig. 3) and described morphologically in accordance with norms of soil description, Soil Survey Manual (Soil Survey Division Staff 2012). Soil samples were collected and laboratory analyzed following the standard methods of **Burt (2014)**.

2.3 Land productivity appraisalment

The investigated area was appraised on basis of Riquier Land Productivity Index (RLPI) using the model produced by **Riquier et al. (1970)** into; (1) poor land productivity class (grade IV) which comprise the major part of the studied site, and (2) average land productivity class (grade III) which covers the rest of area, (**El-Desoky and Sayed 2019**), Table (1) and Fig. (4). Analytical data referred to that the studied soils were highly affected by degradation of salinization and alkalinization.

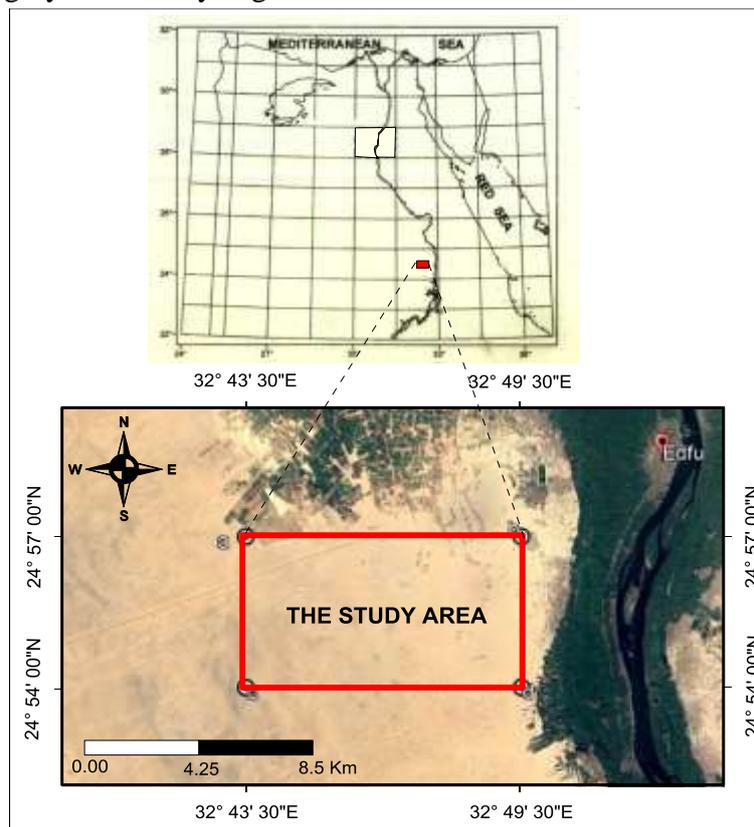


Fig. (1): Site of the studied area

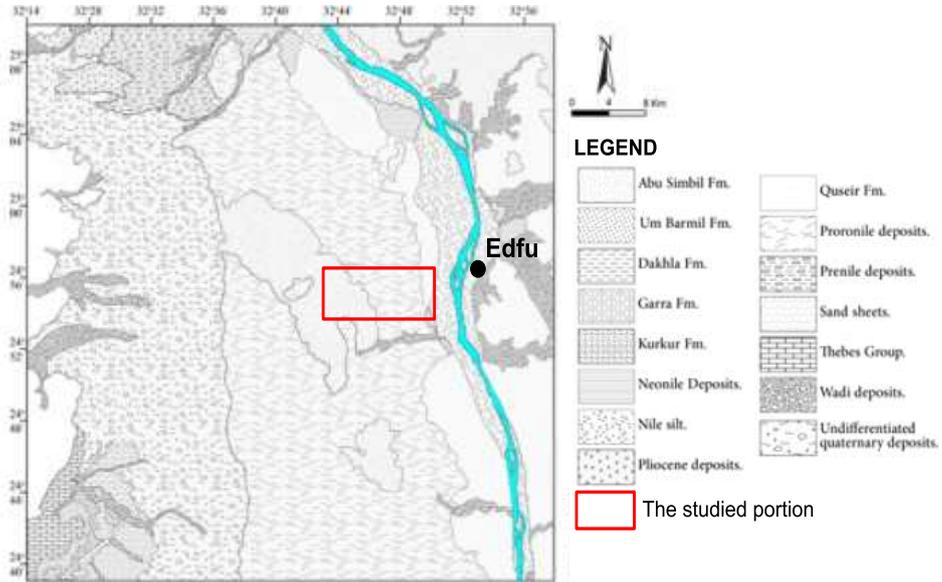


Fig. (2): Geology of the investigated portion, after Abdalazem et. al., (2020) and Issawi, (1981)

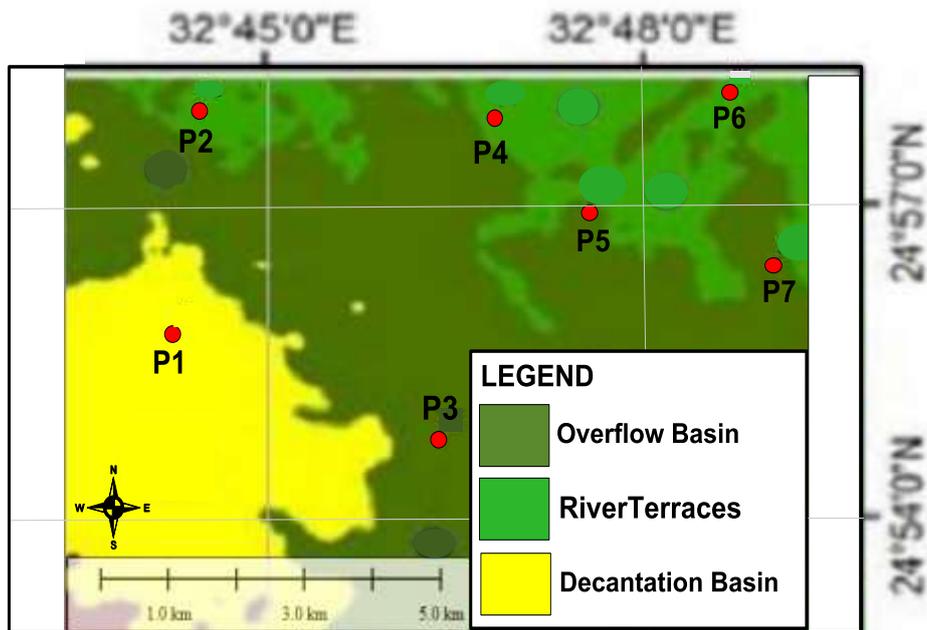


Fig. (3): Geomorphology of the studied area after El-Desoky and Sayed (2019), and locations of soil profiles

Table (1) Soil properties of the studied area

Profile No.	Slope %	Depth(cm)	Drainage Status	Texture	EC dS/m	pH (1:25)	OM %	CEC (cmol(+)/kg)	Gypsum %	CaCO ₃ %	ESP %
1	0.5-1	150	Poorly drained	sg_scl	57.7	7.8	0.52	20	1.84	10	19
2	0.5-1	150	Imperfectly drained	sg_sl	18.2	8.1	0.36	12	1.50	3	20
3	0.5-1	150	Imperfectly drained	gsl	8.8	8.4	0.22	10	0.48	1	25
4	0.5-1	150	Poorly drained	sg_scl	24.5	8.1	0.36	13	2.55	9	17
5	0.5-1	150	Imperfectly drained	gsl	161.9	7.9	0.56	13	3.87	1	19
6	0.5-1	150	Well drained	gls	54.8	8.4	0.36	9	1.97	1	18
7	0.5-1	150	Well drained	sg_ls	9.9	8.5	0.23	10	0.65	1	19

Abbreviations

Texture: sg_scl (slightly gravelly sandy clay loam); sg_sl (Slightly gravelly sandy loam); gsl (gravelly sandy loam); gls (gravelly loamy sand); sg_ls (slightly gravelly loamy sand)

EC: Electrical Conductivity

pH (1:25) pH measured in soil solution with (1g soil to 25ml water)

OM: Organic Matter

CEC: Cation Exchange Capacity

CaCO₃: Calcium Carbonate

ESP: Exchangeable Sodium Percentage

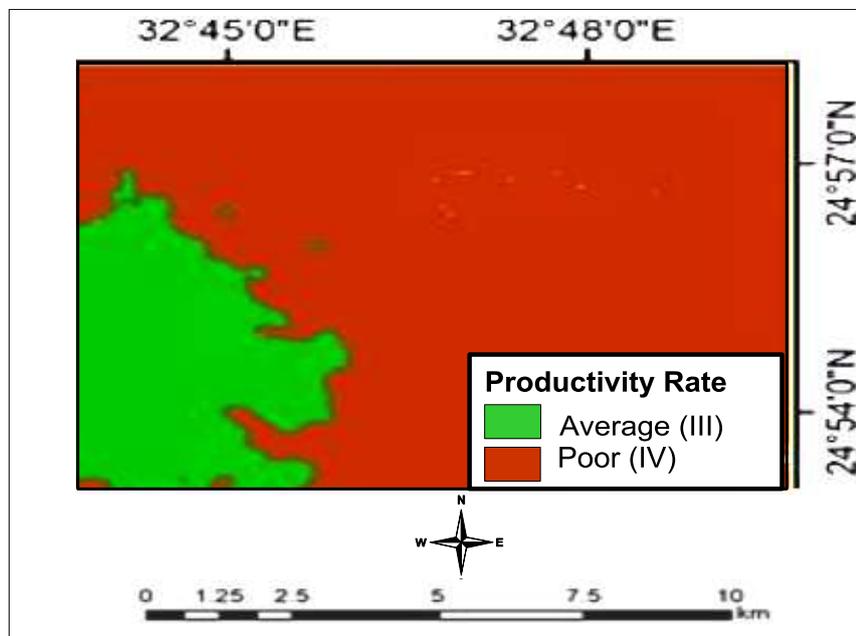


Fig. (4): Land productivity classes of the studied area after **El-Desoky and Sayed (2019)**

2.4 Assessment of the environmental sensitivity to desertification

The environmental sensitivity to desertification of the investigated portion was evaluated using the Desertification Sensitivity Index (DSI). The DSI was calculated according to the equation adopted from MEDALLUS methodology, **Basso et al., (2000)** and the investigation which is conducted by **Gad and Lotfy, (2008)** as follows;

$$DSI=(SQI * CQI * VQI)^{1/3}$$

Where SQI is the soil quality index, CQI is the climate quality index and VQI is the vegetation quality index. The SQI is based on rating the parent material, slope, soil texture, and soil depth. The SQI was calculated according to the following equation,

$$SQI=(I_p * I_t * I_d * I_s)^{1/4}$$

Where, I_p index of parent material, I_t index of soil texture, I_d index of soil depth, I_s index of slope gradient).

The VQI is computed on basis of rating three categories (i.e. erosion protection, drought resistance and plant cover). It was calculated according the following equation,

$$VQI=(I_{Ep} * I_{Dr} * I_{Vc})^{1/3}$$

Where: I_{Ep} index of erosion protection, I_{Dr} index of drought resistance and I_{Vc} index of vegetation cover.

The CQI is appraised based on the aridity index, derived from values of annual rainfall and potential evapo-transpiration which were extracted from **Egyptian Meteorological Authority (2011)**. The CQI was calculated according to the following equation,

$$CQI = P/PET$$

Where: P is average annual precipitation and PET is average annual potential evapo- transpiration. The Ranges and classes of DSI are illustrated in Table (2).

Table 2: Ranges and classes of desertification sensitivity index (DSI)

Classes	DSI	Description
1	>1.2	Non affected areas or very low sensitive areas to desertification
2	$1.2 < DSI < 1.3$	Low sensitive areas to desertification
3	$1.3 < DSI < 1.4$	Medium sensitive areas to desertification
4	$1.3 > DSI < 1.6$	Sensitive areas to desertification

3. RESULTS AND DISCUSSION

The Soil Quality Index (SQI) was evaluated based upon the indices of parent material, soil depth, soil texture class and slope. The geologic map was used to deduce the nature of parent material, where the results showed that the studied site is originated from soft to friable (i.e calcareous clay, clay, sandy formation, and alluvium materials). Field and laboratory analyses were used for assessing the other indices of soil depth, soil texture, and slope. The considered soils were deep (150 cm) and based of that, the soil depth index has nominated to take the score of "1". Soil texture index was classified as either "not very light to average" or "fine to average" where it has got a score (1-1.66). The slope gradient index showed homogeneous values and has given a score "1". Calculating the soil quality index (1.19-1.35), revealed that the studied soils are characterized by moderate soil quality, (Table 3).

The vegetation plays an essential role in erosion protection, drought resistance and soil capacity protection, (**Gad and Lotfy, 2008**). Based on the previous parameters, the VQI was appraised and showed that the estimated soils had weak vegetation quality index and sensitive to desertification, (Table 4). This is coming back to the Saharan vegetation which covers the investigated area with less than 40% and provides a low capacity to increase kinetic energy caused by the impact of soil erosion driving forces.

Table 3: Soil quality index (SQI) in the investigated area

Profile No.	Ip	It	Id	Is	SQI
1	2	1.66	1	1	1.35
2	2	1	1	1	1.19
3	2	1	1	1	1.19
4	2	1.66	1	1	1.35
5	2	1	1	1	1.19
6	2	1	1	1	1.19
7	2	1	1	1	1.19

Abbreviations: Ip-parent material index; It-soil texture index; Id-soil depth index; Is-slope gradient index; SQI-soil quality index

Data of climate (i.e. rainfall and evapo-transpiration) related to the studied area referred to that precipitation ranged between 0 to 1 percent annually while the average annual potential evapo-transpiration is relatively high. This qualified the research area to be affected by the hyper-arid climatic conditions. Accordingly, climatic quality index (CQI) has got a score equal to 2, (Table 4).

Table 4: Vegetation and climate quality indices in the investigated area

Profile No.	I _{Ep}	I _{Dr}	I _{Vc}	VQI	P/PET	CQI
1	2	1.66	1	1.49		
2	2	1.66	1	1.49	0.04	2
3	2	1.66	1	1.49	0.04	2
4	2	1.66	1	1.49	0.04	2
5	2	1.66	1	1.49	0.04	2
6	2	1.66	1	1.49	0.04	2
7	2	1.66	1	1.49	0.04	2

Abbreviations: I_{Ep}-index of erosion protection; I_{Dr}- index of drought resistance; I_{Vc}-index of vegetation cover; VQI-vegetation quality index; P/PET-precipitation/potential evapo-transpiration; CQI-climate quality index

The three former indices were driven jointly for the appeasement of the environmentally sensitive areas (ESA's) to desertification. On basis of the calculated Desertification Sensitivity Index (DSI), the investigated site could be classified as sensitive area to desertification, (Table 5) with average and poor land productivity classes of grades III, and IV, respectively. This means that the research area needs to particular soil management practices for best agricultural use and combating desertification, can be summarized in the following;

- (1) Designing recent irrigation systems along with agricultural drainage.
- (2) Increase organic matter inputs.
- (3) Use cover crops.
- (4) Rotate crops.
- (5) Manage Nutrients.
- (6) Adding the agricultural gypsum.

Table 5: Desertification Sensitivity Index (DSI) in the investigated area

Profile No.	SQI	VQI	CQI	DSI
1	1.35	1.49	2	1.58
2	1.19	1.49	2	1.52
3	1.19	1.49	2	1.52
4	1.35	1.49	2	1.58
5	1.19	1.49	2	1.52
6	1.19	1.49	2	1.52
7	1.19	1.49	2	1.52

4. CONCLUSIONS

This study aimed at assessing the environmental sensitivity to desertification in relation to land productivity of some soils at west Edfu, Egypt using the Desertification Sensitivity Index (DSI). In conclusion, the studied site had DSI varying from 1.52 to 1.58, indicating a sensitive area to desertification with average (III), and poor (IV) land productivity classes. This referring to that the research area needs particular soil management practices and applied safety environmentally techniques for best agricultural use and reducing the sensitivity for desertification.

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تقييم الحساسية البيئية للتصحّر، وعلاقته بإنتاجية بعض

الأراضي غرب ادفو، مصر

مؤمن محمد القاضي¹ ، ياسر عبد العال سيد²

¹ قسم البيولوجي ، مركز بحوث الصحراء ، المطرية ، القاهرة ، مصر

² قسم علوم الأراضي والمياه - كلية الزراعة- جامعة الأزهر - أسيوط

تعتبر مصر من احدى الدول التي عانت من التصحر وتأثيره السلبي على الاقتصاد الاجتماعي والأمن الغذائي والاستقرار المجتمعي ، ومن اجل هذا كان أحد الأنشطة الرئيسية لمركز بحوث الصحراء هو مكافحة التصحر في مصر من خلال تقييم حساسية النظم البيئية للتصحّر وتدهور الأراضي من أجل الحفاظ على الموارد.

لذلك هدفت هذه الورقة إلى تقييم الحساسية البيئية للتصحّر وعلاقته بإنتاجية الأراضي لبعض أنواع التربة في غرب ادفو ، مصر باستخدام دليل حساسية التصحر (DSI) ، هذا و تقع منطقة البحث بين "00' 54' 24° الـ" 00' 57' 24° شمالا ، "30' 43' 32° الى "30' 49' 32° شرقا وتغطي مساحة 85 كم².

وقد أظهرت النتائج أن المنطقة المدروسة تميزت بمؤشر جودة تربة من الدرجة المعتدلة ، وغطاء نباتي ضعيف ، وظروف مناخية شديدة الجفاف وبناءا على ذلك فان حسابات دليل الحساسية للتصحّر اشارت الى ان المنطقة المدروسة امكن تصنيفها بأنها منطقة حساسة للتصحّر ويصاحبها وحدتين من درجات تقييم الانتاجية للأراضي وهما وحدة الدرجة المتوسطة والآخرى وحدة الدرجة الفقيرة ، مما يتطلب استخدام نظم ادارة معينة للتربة من اجل التقليل من اخطار التصحر بها وافضل استغلال ممكن للزراعة.