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Assessment and Mapping of Desertification Sensitivity in Some of the Western Desert Oases, Egypt, Based on Remote Sensing and GIS

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Abstract

The United Nations convention to combat desertification, issued in September 1994, has defined desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities”. Studies regarding mapping the desertification risk in Egypt have already been carried out through the project of “Disaster preparedness” hosted by the Egyptian Academy of Scientific Research and Technology (1989-1992). Moreover, ambit of maps produced at regional scales was produced by different authors. Recently, different models were developed to scope on the quantitative approach of desertification assessment. The western desert oases are promising areas sustaining human activities, including agriculture. Thus assessment of desertification sensitivity in the oases may support decision making regarding the conservation and sustainability of these areas.

A number of three oases, located in the middle western desert of Egypt (i.e. Bahereya, Dakhla and Kharga) were investigated. ETM satellite images, geologic and soil maps were used as main sources for calculating the index of Environmental Sensitivity Areas (ESAI) for desertification. The algorism is adopted from MEDALLUS methodology as follows; ESAI = (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 VQI is computed on bases of rating three categories (i.e. erosion protection, drought resistance and plant cover). The CQI is based on the aridity index, derived from values of annual rainfall and potential evapotranspiration. Due to the homogenous hyper arid climatic conditions, dominating the western desert, the value of CQI was considered 1 in the studies oases. Arc-GIS 9 software was used for the computation and sensitivity maps production. The results show that the soils of the oases are characterized only by moderate and low quality indices, except the Kharga oasis which includes 24.4 % of its soils as high quality. The oases at the northern latitudes (i.e. Bahereya) attain larger areas of the soils characterized by moderate quality index than those of low one. Soils at the southern latitudes (i.e. Kharga and Dakhla) are characterized by more occurrences of low soil quality indices. The calculation of VQI showed a wide range between average in areas exhibited by Halophytic plants and weak to very weak in areas covered by Saharan vegetation and adopted cultivations. Concerning the climatic quality index (CQI), the oases are localized in the hyper arid zone, where evapotanspiration extremely exceeds the values of precipitation. Areas characterized by low desertification sensitivity represent 7.3% of the Bahereya oasis, while those of moderate sensitivity represent 92.7 and 0.8% of Bahereya and Kharga oases respectively. The whole Dakhla oasis is exhibited by sensitive and very sensitive environmental sensitive areas for desertification.

It can be concluded that implementing the maps of sensitivity to desertification is rather useful in the desert oases as they give more likely quantitative trend for frequency of sensitive areas. Land use can be adopted, on basis of the environmental sensitivity indices for desertification. The integration of different factors contributing to desertification sensitivity may lead to plan a successful combating. The usage of space data and GIS proved to be suitable tools to fulfill the needed large computational requirements. They are also useful in visualizing the sensitivity situation of different desertification parameters.

Keywords: Remote Sensing, GIS, Environment, Desertification, Oases, Egypt

Introduction

The word oases is commonly used to describe a place characterized by a sustainable life features, inserted among severe environmental conditioned areas. The Oasis can be defined as an isolated fertile area, usually limited in extent and surrounded by desert. They are depressions in the desert comprising springs, wells and trees, reflects the beauty, charm and diversity of nature. The term “*oases*” was initially applied to small areas in Africa and Asia typically supporting trees and cultivated crops with a water supply from springs and from seepage of water originating at some distance. However, the term has been expanded to include areas receiving moisture from intermittent streams or artificial irrigation systems. Thus the floodplains of the Nile and Colorado rivers can be considered vast oases, as can arid areas irrigated by humans. (http://www.answers.com/topic/oasis-technology?cat=technology).

In Egypt, there are not a few oases in the western desert. The most significant are Fayoum, Kharga, Dakhla, Paris, Frafrah, Bahereya, Siwa and the Qattara Depression. Egypt’s oases are just that: un-spoilt refuges from modern world, pockets of civilization in the dramatic setting of the desert.

Desertification is the consequence of a set of important processes, which are active in arid and semi-arid environment, where water is the main limiting factor of land use performance in ecosystems (Batterbury and Warren, 2001). Environmental systems are generally in a state of dynamic equilibrium with external driving forces. Small changes in the driving forces, such as climate or imposed land use tend to be accommodated partially by a small change in the equilibrium and partially by being absorbed or buffered by the system. Desertification of an area will proceed if certain land components are brought beyond specific threshold, beyond which further change produces irreversible change (Tucker et al. 1991; Nicholson et al. 1998). Environmentally Sensitive Areas (ESA's) to desertification in desert oases exhibit different sensitivity status to desertification for various reasons. Low rainfall is generally the main constraint supporting severe desertification sensitivity. However, availability of ground water and preferable soil and landscape conditions may sustain a satisfactory vegetation cover causing drought resistance (Ferrara et al, 1999).

Location and Environment of study areas

In this study, a number of three oases desert (i.e. Bahereya, Dakhla and Kharga) located at the middle of western desert, Egypt, are considered (Fig. 1). The three oases belong, administratively, to the New Valley Governorate. Table (1) demonstrates the distances between the different oases and their distance from Cairo. Table (2) shows the mean maximum Minimum of temperature and humidity.

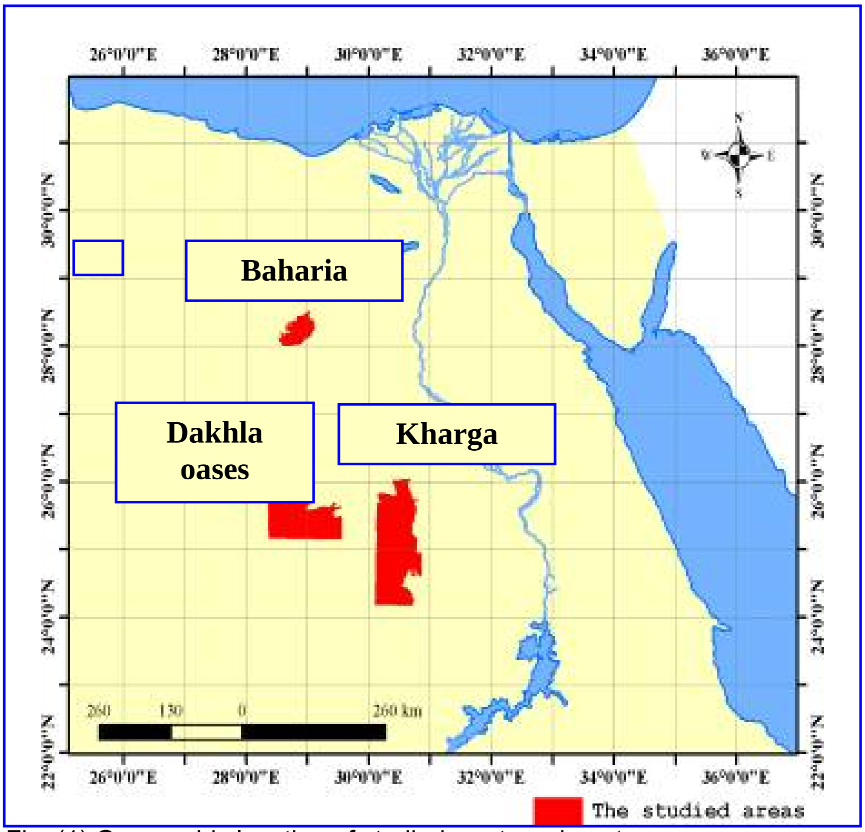

Fig. (1) Geographic location of studied western desert oases

Table (1) Distances between oases and to Cairo

	Cairo	Kharga	Dakhla	Bahereya
Cairo	0	602	739	402
Kharga	602	0	200	610
Dakhla	739	200	0	410
Bahereya	402	410	610	0

Table (2) Mean Maximum Minimum of Temperatures and Humidity

Month / Oases	Climate	Jan.	Feb.	March	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Bahereya	Max. Temp.	21.5	23.6	22.7	28.2	34.9	36.0	36.9	37.5	35.3	30.3	26.7	21.9
	Min. Temp.	5.1	7.0	8.4	11.2	15.9	19.0	21.5	21.7	20.1	16.4	10.8	8.9
	Max Humid.	83	77	79	75	73	70	74	82	85	80	84	83
	Min. Humid.	44	41	41	33	28	31	31	35	36	41	46	51
Kharga	Max. Temp.	23.5	26.1	27.7	31.2	38.9	39.6	41.3	41.0	38.0	32.2	28.8	23.8
	Min. Temp.	5.6	7.8	11.2	14.7	21.0	24.3	23.7	25.0	22.0	18.7	11.4	9.0
	Max Humid.	70	62	54	45	37	40	39	42	49	60	58	68
	Min. Humid.	36	29	27	23	19	18	19	22	23	33	30	41
Dakhla	Max. Temp.	23.3	26.0	28.5	30.9	38.7	39.2	40.8	40.5	38.2	32.1	28.1	23.9
	Min. Temp.	4.4	6.3	10.1	12.5	18.3	21.4	22.1	23.6	20.4	16.7	9.4	7.8
	Max Humid.	55	46	47	38	36	38	38	38	44	52	59	56
	Min. Humid.	32	27	29	19	16	18	21	21	23	30	32	36

The Bahereya oases lies 360 km. south of west Giza and 180 km. west of Assyut with a moderate climate both in winter and summer. There are mountains, valleys, olive apricot trees, and 268 mineral and sulphur springs. At Al-Qaseer and Al-Baboouty there are Pharonic and Roman ruins. The Bahereya oases are known by the existence of iron oars

The Kharga oases is the capital of the New Valley Governorate, it lies 232 km. south of Assyout. It constitutes a natural excavation in the surface of the desert west of the Nile, elongating in in a N-S direction. Kharga oases are characterized by its numerous monuments, springs and touist sites such as ponds of fish in Bulaq village. The water temperature in Bulaq wells, south of Kharga, reaches 39°. The morphological features displayed in Kharga oases are distinguished into (1) the elevated plateau raised about 350 m. (2) the foothill slopes, and (3) the depression.

The Dakhla oases is the second provincial capital of the New Valley Governorate, lies 200 km. northwest of Kharga. It contains several wells in which the temperature reaches 43° C. Dakhla Oasis is a collection of fourteen different settlements, dominated on its northern horizon by a wall of rose-colored rock. Fertile cultivated areas growing rice, peanuts and fruit are dotted between sand dunes along the roads from Farafra and Kharga in this area of outstanding natural beauty.

The desert climate is recognizable in all oases, the difference in day and night temperature degrees are vast especially in winter. The difference in day and night humidity is also noticed, and more expressed in summer time.

Methodology

Two soil and vegetation quality indexes (SQI and VQI) were computed, the climatic quality index was neglected as the arid desert climate is similar in the studied oases.

Fig. (2) demonstrates the main flow chart of concepts and studied steps performed in the current study. The main input data for calculating these indices include a mosaic of LANDSAT ETM image and the geologic map of Egypt, produced by CONOCO, 1990. The satellite images were processed using the ERDAS IMAGINE 8.3 system. Different enhancement and classification techniques were tried to specify the optimal ones for the study purposes. Computational and map editing functions were performed using Arc GIS9 GIS system to find out the environmental sensitivity areas (ESA's).

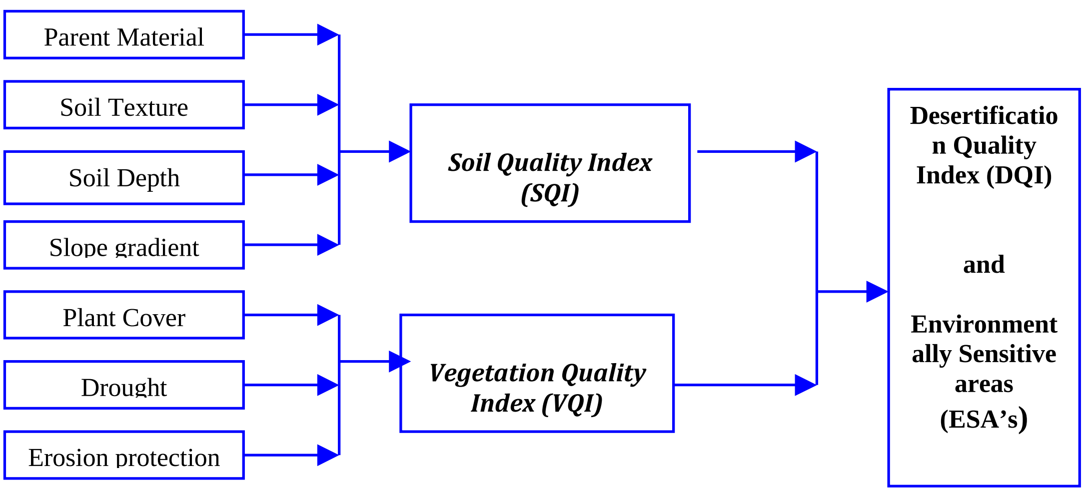

Fig. (2) Flow chart of mapping Environmentally Sensitive Areas (ESA's)

1 Mapping Soil Quality Index (SQI)

Soil is the dominant factor of the terrestrial ecosystems in the arid and semi arid and dry zones, particularly through its effect on biomass production. Four soil parameters, related to water availability and erosion resistance, were considered (parent material, soil texture, soil depth and slope gradient) following Medalus project methodology (European Commission 1999). Weighting factors were assigned to each category of the considered parameters, on basis of Gad and Lotfy (2007). The soil Quality Index (SQI) was computed on basis of the following equation, and classified according to categories shown in table (3).

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

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)

Table (3) Classification of soil quality index

Class	Description	Range
1	High quality	>1.13
2	Moderate quality	1.13 to 1.45
3	Low quality	> 1.46

2 Mapping Vegetation quality index (VQI)

Vegetation quality was evaluated according to Basso et al (2000) in terms of three aspects (i.e. erosion protection to the soils, drought resistance and plant cover). The TM satellite images mosaic covering the studied oases (Fig. 2) is the main material used to map vegetation and plant cover classes. Rating values for erosion protection, drought resistance and vegetal cover classes were adapted on basis of OSS (2004). Vegetation Quality Index was calculated according the following equation, while VQI was classified on basis of the ranges indicated in table (4).

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

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

Table (4) Classification of vegetation quality index (VQI)

Class	Description	Range
1	Good	< 1.2
2	Average	1.2 to 1.4
3	Weak	1.4 to 1.6
4	Very weak	> 1.6

3 Mapping Environmentally Sensitive Areas (ESA's) to Desertification

ArcGIS9 software was used to map ESA's to Desertification (Kosmas et al, 1999) by integrating all data concerning the soil and vegetation. Different quality indices were calculated and displayed as GIS ready maps from which class areas were deduced.

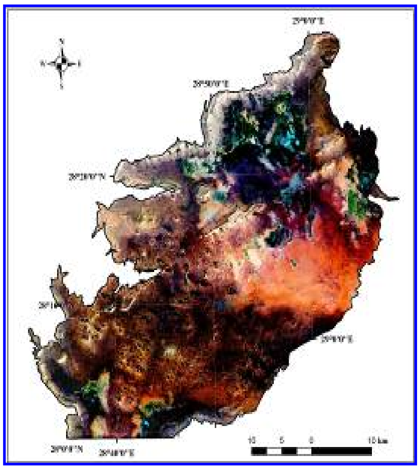

Fig. (2) LANDSAT image of Baharia oasis

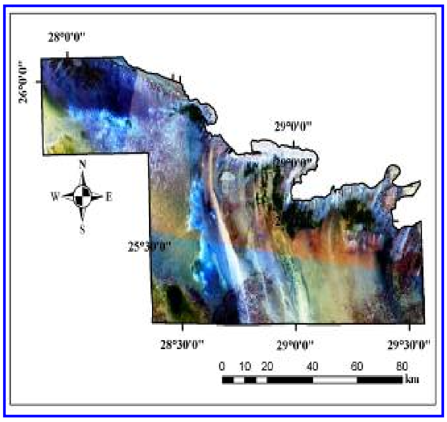

Fig. (3) LANDSAT image of Dakhla oasis

Fig. (4) LANDSAT image of Kharga oasis

Desertification Sensitivity Index (DSI) was calculated in the polygonal attribute tables linked with the geographic coverage on basis of the following equation;

$$DSI = (SQI * VQI)^{1/2}$$

Classification of (DSI) was done according to the values shown in table (5).

Table (5) 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
5	DSI > 1.6	Very sensitive areas to desertification

Results and discussions

1 Soil Quality Index (SQI)

Table (6) and Figs. (5, 10 and 15) show the classification of the soil parent material in the Bahereya, Dakhla and Kharga oases regarding their sensitivity to desertification. The results show the variability of parent material nature of the three studied oases. While the moderately coherent Marine limestone and friable sandstone characterized by moderate sensitivity class cover 93.4% of the Bahereya, its frequency in Kharga oases reaches only 17.8%. The Dakhla oases parent material splits between the coherent (51.2%) and the soft to friable (48.8%) attaining good and poor sensitivity classes respectively. The Kharga oasis is dominated (55%) by poor parent material which is more sensitive to the desertification processes. It may be outlined that the southern oases include more sensitive parent material that the southern ones.

The slope gradient, as shown in (table 7 and Figs 6, 11 and 16) was classified, on basis of topographic maps and digital elevation model (DEM). The majority (88.5%) of the Bahaereya Oasis, situated northwards is characterized by a gentle slope class, inducing less sensitivity to desertification process. The slope gradient in Kharga oases mostly ranges between not very gentle to a very abrupt covering areas representing 37.3 to 18.9% of its terrain respectively. An area representing 24.4% is characterized by a gentle sloping landscape. In general, it can be outlined that oases inserted in the table land of the western desert, as Kharga, attain more rugged landscap causing more sensitivity to most desertification processes.

Table (6) nature of parent material and assigned scores of the studied oases

Parent Material classes	Oases	Area (sq km)	Area %	Score	Class
Coherent: Limestone, dolomite, non-friable sandstone, hard limestone layer.	Bahereya	91.3	4.7	1.0	Good
	Dakhla	4844.8	51.2		
	Kharga	3268.23	27.2		
2) Moderately coherent: Marine limestone, friable sandstone	Bahereya	1803.2	93.4	1.5	Moderate
	Dakhla	0.0	0.0		
	Kharga	2144.28	17.8		
3) Soft to friable: Calcareous clay, clay, sandy formation, alluvium and colluvium	Bahereya	35.9	1.9	2.0	Poor
	Dakhla	4617.78	48.8		
	Kharga	6606.19	55.0		

Table (7) Distribution of slope classes and assigned scores in the studied oases

Slope class	Slope %	Oases	Area (sq km)	Area %	Score
Gentle	< 6%	Bahereya	1708.2	88.5	1.00
		Dakhla	4022.10	42.51	
		Kharga	2928.50	24.4	
Not very gentle	6 to 18 %	Bahereya	130.9	6.8	1.33
		Dakhla	287.35	3.04	
		Kharga	4495.50	37.3	
Abrupt	18-35%	Bahereya	0.0	0.0	1.66
		Dakhla	5153.12	54.46	
		Kharga	2331.98	19.4	
Very abrupt	> 35 %	Bahereya	91.3	4.7	2.00
		Dakhla	0.0	0.0	
		Kharga	2262.72	18.9	

Table (8) and Figs. 7, 12 and 17 show that the soils in the three oases are mostly characterized either by a very shallow depth or very deep one. The Bahereya oases, in particular, include 45.1% of its soils characterized by a very shallow depth.

The soil texture was assessed on basis of the geomorphology, deduced from the ETM satellite mosaic. Table (9) and Figures (8, 13 and 18) show that the most sensitive coarse textured soils dominates the Dakhla and Kharga oases, covering 77.8 and 75.6% respectively. The rest of the soils are characterized by very light to average soil texture. The soils of Bahereya oases are dominated (95%) by fine to average texture which characterizes them by less sensitivity to desertification. It could be outlined that vicinity of Kharga and Dakhla oases from the great sand sea and their vertical location as interior oases in the western desert were important factors for the dominance of most sensitive soil textural classes.

Table (8) distribution of soil depth classes and assigned scores in the studied oases

Class of soil depth	oases	Area (km^2)	%	Score
Very shallow (> 0.25 m)	Bahereya	91.3	4.7	1
	Dakhla	4271.7	45.1	
	Kharga	4594.7	38.2	
Shallow (0.25 to 0.50 m)	Bahereya	17.8	0.9	1.33
	Dakhla	0.0	0.0	
	Kharga	0.0	0.0	
Deep (0.50 – 1.00 m)	Bahereya	18.1	0.9	1.66
	Dakhla	881.4	9.3	
	Kharga	4313.2	35.9	
Very deep (> 1m)	Bahereya	1803.2	93.5	2.0
	Dakhla	4309.5	45.6	
	Kharga	3110.8	25.9	

Calculating the soil quality index (SQI) as shown in table 10 and figs 9,14 and 19 reveal that only the Kharga oasis include 24.4% of its soils characterized by high quality which may have least sensitivity to desertification. The moderate quality soils exhibit 94.4, 42.5 and 1.5% of Bahereya, Dakhla and Kharga oases respectively. These soils are located at the middle part of the oases characterized by lowest altitude and deep soil profiles. The majority of the oases soils range between the moderate and low quality.

Table (9) Distribution of soil texture classes and assigned scores in the studied oases

Class	Description	Oases	Area (km^2)	%	Score
Very light to average	Loamy, Sandy, Sandy-loam, balanced	Bahereya	5.27	0.3	1.00
		Dakhla	2101.9	22.2	
		Kharga	2928.5	24.4	
Fine to average	Loamy clay, Clayey-sand, Sandy clay	Bahereya	1833.9	95.0	1.33
		Dakhla	0.0	0.0	
		Kharga	0.0	0.0	
Average	Clay, Clay-Loam	Bahereya	0.0	0.0	1.66
		Dakhla	0.0	0.0	
		Kharga	0.0	0.0	
Coarse	Sandy to Very sandy	Bahereya	91.3	4.7	2.00
		Dakhla	7360.7	77.8	
		Kharga	9090.2	75.6	

Table (10) Areas of different categories of Soil Quality Index (SQI) classes

Class	Description of soil quality	Range of SQI	Oases	Area (Km^2)	%	Score
1	Good Quality	< 1.2	Bahereya	0.0	0.0	
			Dakhla	0.0	0.0	
			Kharga	2928.5	24.4	1.11
2	Moderate Quality	1.2 to 1.4	Bahereya	1821.3	94.4	1.6818
			Dakhla	4023.7	42.5	1.2
			Kharga	182.3	1.5	1.28
3	Low Quality	1.4 to 1.6	Bahereya	109.2	5.6	1.2447
			Dakhla	5438.9	57.5	1.0
			Kharga	8907.9	74.1	1.68
4	Very Low Quality	> 1.6	Bahereya	0.0	0.0	
			Dakhla	0.0	0.0	
			Kharga	0.0	0.0	

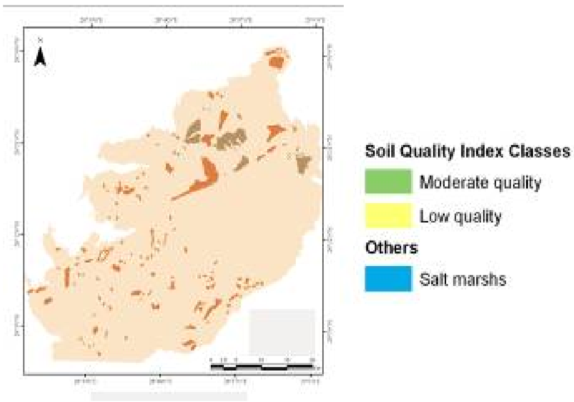

Fig. (5) Parent Material classes of Baharyia oases

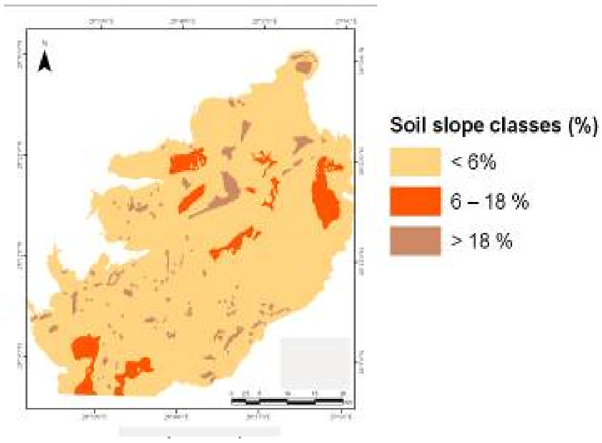

Fig. (6) Slope classes of Baharyia oases

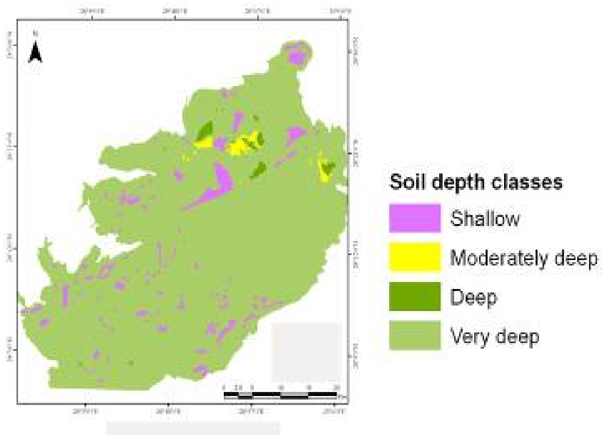

Fig. (7) Soil depth classes of Baharyia oases

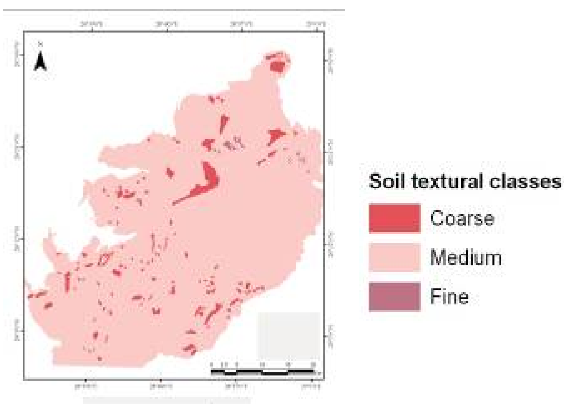

Fig. (8) Soil texture classes of Baharyia oases

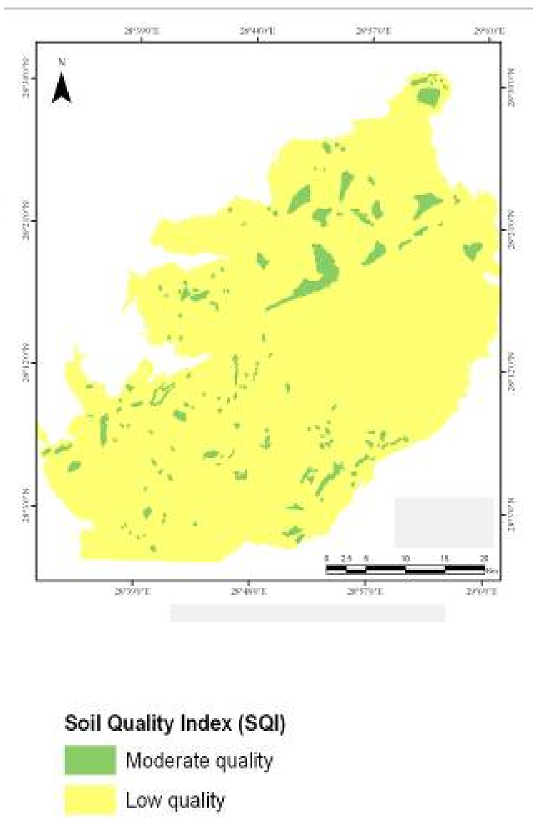

Fig. (9) Soil Quality Index classes of Baharyia oases

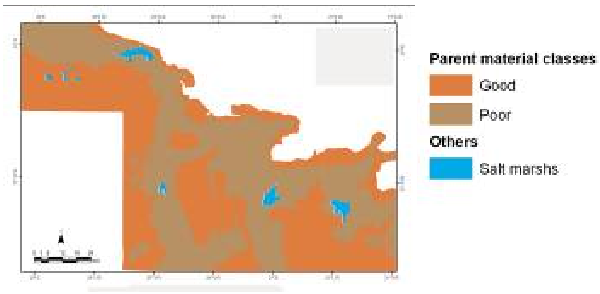

Fig. (10) Parent Material classes of Dakhla oases

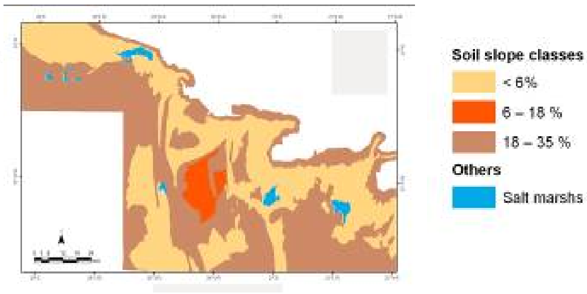

Fig. (11) Slope classes of Dakhla oases

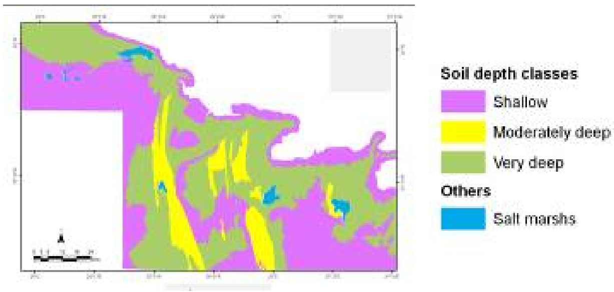

Fig. (12) Soil depth classes of Dakhla oases

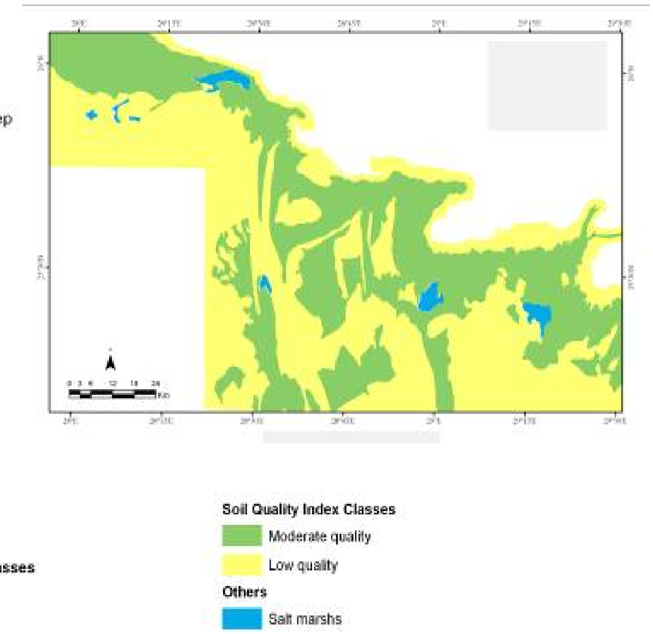

Fig. (14) Soil Quality Index classes of Dakhla oases

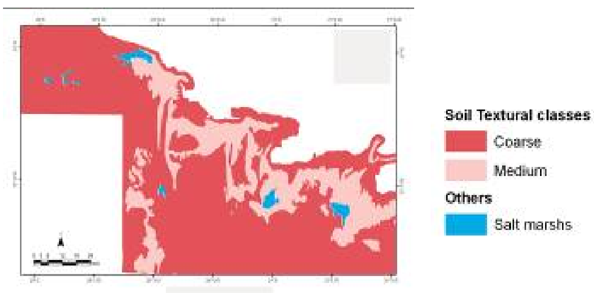

Fig. (13) Soil texture classes of Dakhla oases

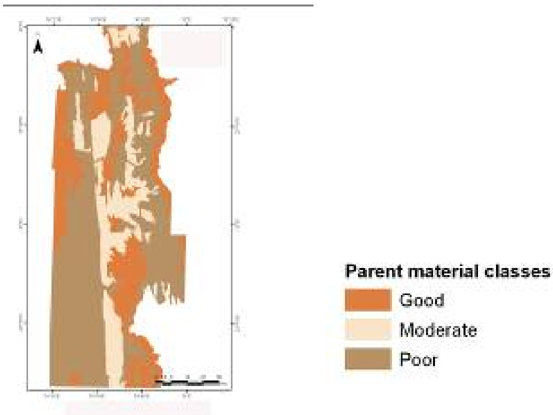

Fig. (15) Parent Material classes of Kharga oases

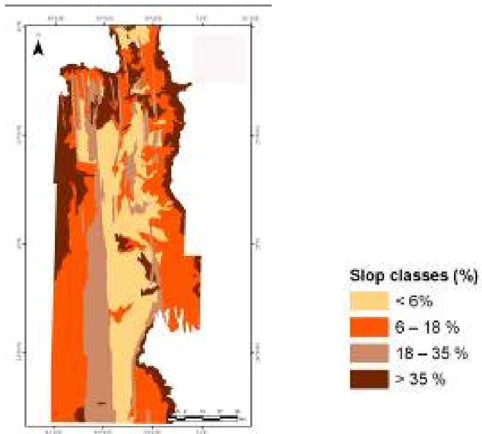

Fig. (16) Slope classes of Kharga oases

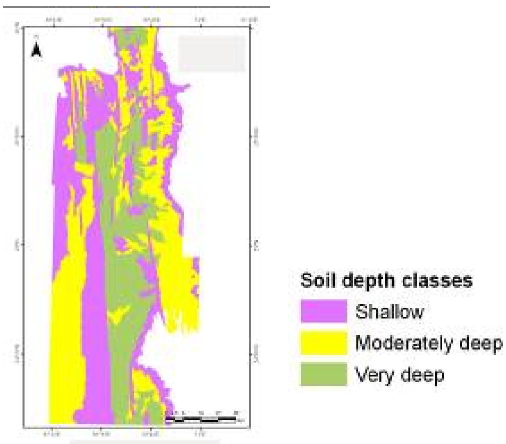

Fig. (17) Soil depth classes of Kharga oases

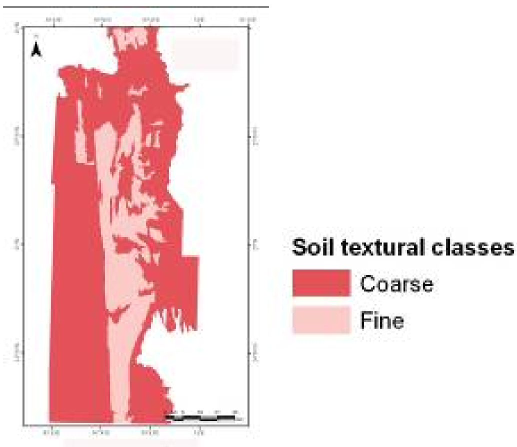

Fig. (18) Soil texture classes of Kharga oases

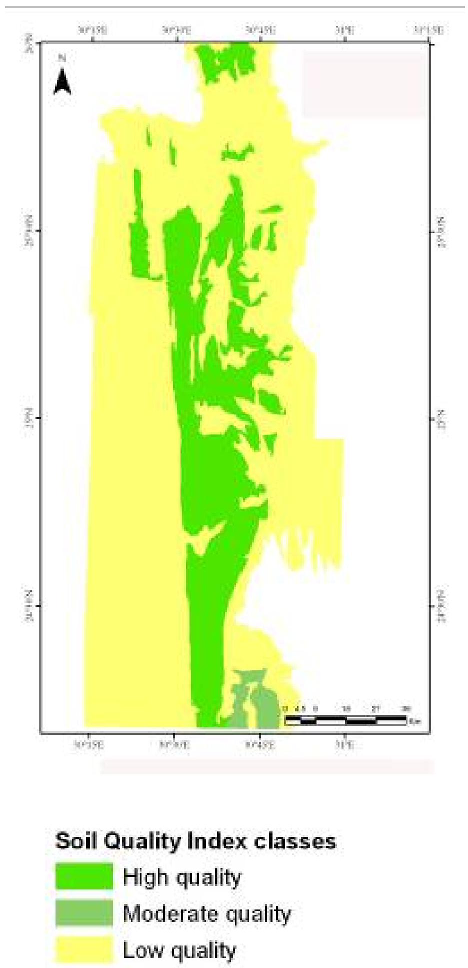

Fig. (19) Soil Quality Index classes of Kharga oases

3.2 Vegetation Quality Index (VQI)

The ETM satellite image was processed for unsupervised classification, thus training sites were chosen representing different classes. Field validation was performed to convert the unsupervised classes to vegetation type once (Table 11and Figs. 20, 21 and 22). Different vegetation types were given a score evaluating vegetation cover type, erosion protection and drought resistance.

Table (11) Areas of Vegetation cover classes and assigned scores for different elements

Class	Oases	Area (km^2)	%	Scores		
				Vegetation cover	Drought resistance	Erosion protection
Halophytes	Bahereya	1.6	0.08	1.33	1.33	1.66
	Dakhla	61.8	0.64			
	Kharga	138.7	1.15			
Crop lands mixed with orchards	Bahereya	1761.7	91.63	1.00	1.00	1.33
	Dakhla	329.1	3.41			
	Kharga	202.0	1.68			
Saharan vegetation < 40%	Bahereya	159.2	8.29	1.80	1.66	2.00
	Dakhla	9251.6	95.95			
	Kharga	11674.6	97.17			

Calculating the vegetation quality index, on basis of the previous parameters (table 12 and Figs. 22, 26 & 30) reveal that the Bahereya and Dakhla oases attain the largest areas (91 and 96.6% respectively within the average VQI class, while rest of the area (8.3 and 3.4 % respectively) within the good class. The reverse situation is noticed in the Kharga oases where 97.1% of its area is characterized by very week vegetation quality and 1.2% by average one. The results demonstrate that the geographic location of different oases influence the vegetation quality which contribute to the desertification sensitivity. Where the Baharia oases is situated at the north low lying altitudes, near from ground water and existence of sulphur springs, the vegetation quality is adapting. Also, the existence of several wells at the Dakhla oases and fertile alluvial soil sustain vegetation quality characterized by average. The Kharga oases is mostly situated at 350 m elevated plateau, thus ground water is rather deep resulting in weak vegetation type quality.

3.3 Environmental Sensitivity Areas (ESA's)

The desertification sensitivity index was computed in for each pixel in the geographic coverage of the three oases, on basis of Medalus project methodology, using both SQI and VQI values. Table (13) and show the output of the calculation, whereas Figs. (31, 32 and 33) demonstrate the geographical extension of each Environmental Sensitive Areas (ESA's). The desert oases, in general, lie within the sensitive and very sensitive areas to desertification. However, some location as most of the Bahereya oases and some spots in Kharga Oases may be classified as moderately sensitive due to existence of sufficient vegetation cover or shallow water sources. It may be pointed out that comprehensive environmental conditions should be considered to determine the desertification sensitivity in desert oases precisely

Table (12) Areas of different vegetation quality index classes

Class	VQI range	Oases	Area (km^2)	%	Score
Good	<1.2	Bahereya	159.2	8.3	1.19
		Dakhla	329.1	3.4	1.00
		Kharga	000.0	0.0	
Average	1.2-1.4	Bahereya	1763.3	91.7	1.22
		Dakhla	9313.3	96.6	1.26
		Kharga	138.7	1.2	1.21
Week	1.4-1.6	Bahereya	000.0	0.0	
		Dakhla	000.0	0.0	
		Kharga	202.0	1.7	1.54
Very week	>1.6	Bahereya	000.0	0.0	
		Dakhla	000.0	0.0	
		Kharga	11674.6	97.1	1.81

Table (13) Occurrence of Environmentally sensitive areas (ESA's

Classes	DSI	Description	Oases	Area (Km^2)	%
1	> 1.2	Non affected areas or very low sensitive areas to desertification	Bahereya	140.29	7.3
			Dakhla	0.0	0.0
			Kharga	0.0	0.0
2	1.2 < DSI < 1.3	Low sensitive areas to desertification	Bahereya	0.0	0.0
			Dakhla	0.0	0.0
			Kharga	0.0	0.0
3	1.3 < DSI <1.4	Medium sensitive areas to desertification	Bahereya	1790.69	92.7
			Dakhla	0.0	0.0
			Kharga	92.32	0.8
4	1.3 > DSI <1.6	Sensitive areas to desertification	Bahereya	0.0	0.0
			Dakhla	2149.85	22.7
			Kharga	2894.26	24.1
5	DSI > 1.6	Very sensitive areas to desertification	Bahereya	0.0	0.0
			Dakhla	7306.80	77.3
			Kharga	8986.46	75.1

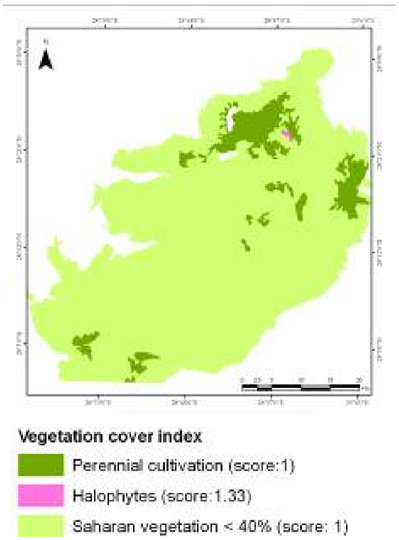

Fig. (19) Vegetation Cover index classes of Bahereya Oases

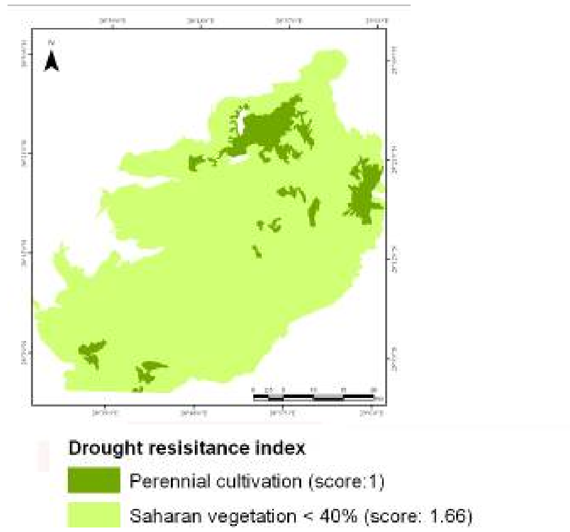

Fig. (20) Drought Resistance index classes of Bahereya Oases

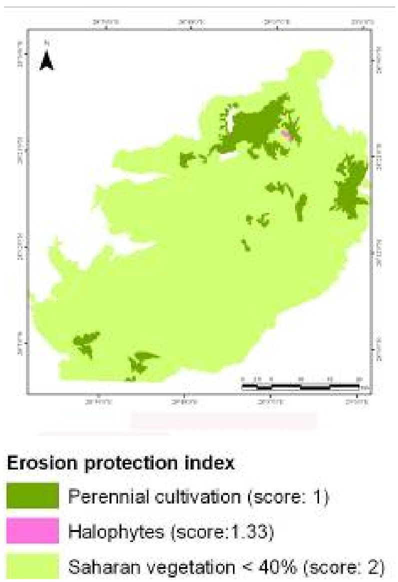

Fig. (21) Erosion Protection index classes of Bahereya Oases

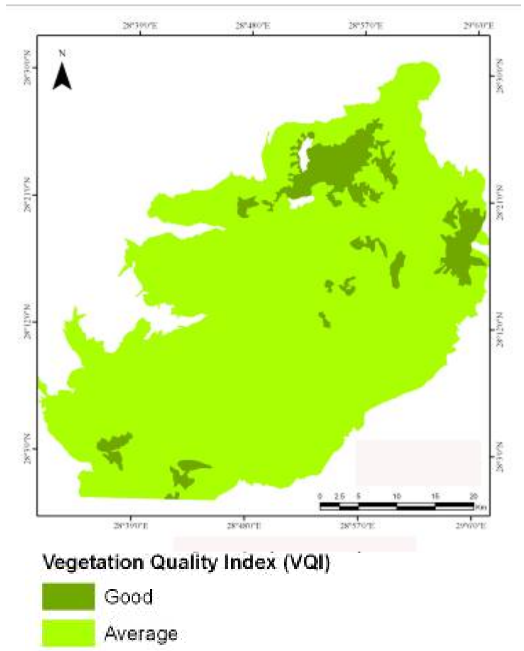

Fig. (22) Vegetation Quality Index classes of Bahereya Oases

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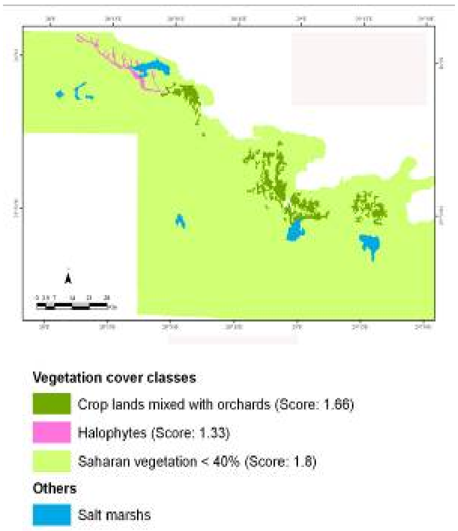

Fig. (23) Vegetation Cover index classes of Dakhla Oases

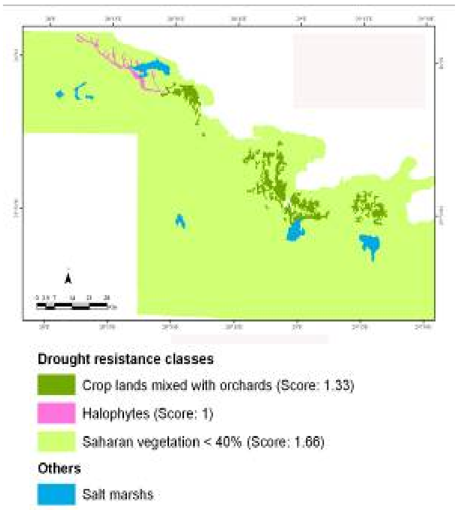

Fig. (24) Drought Resistance index classes of Dakhla Oases

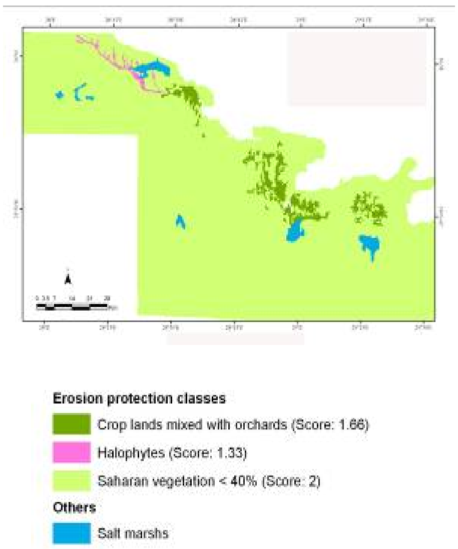

Fig. (25) Erosion Protection index classes of Dakhla Oases

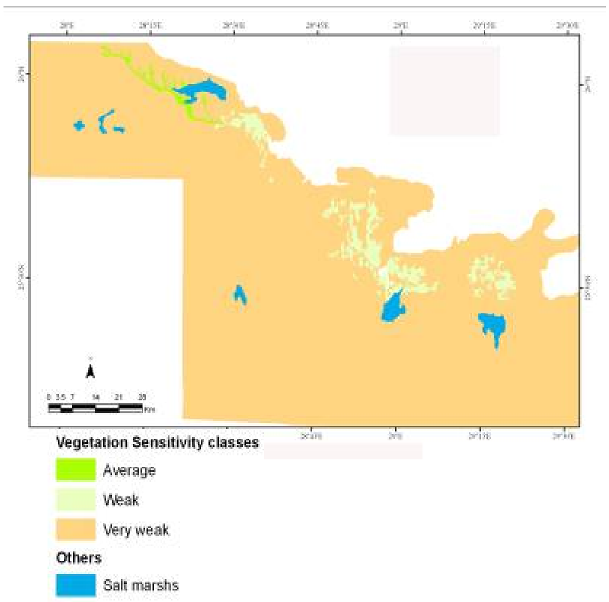

Fig. (26) Vegetation Quality Index classes of Dakhla Oases

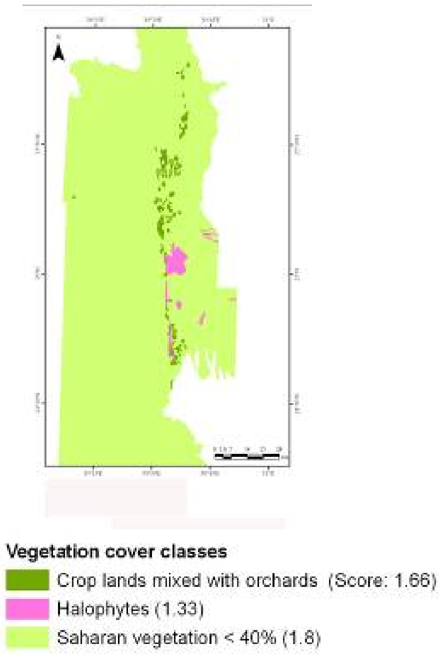

Fig. (27) Vegetation Cover index classes of Kharga Oases

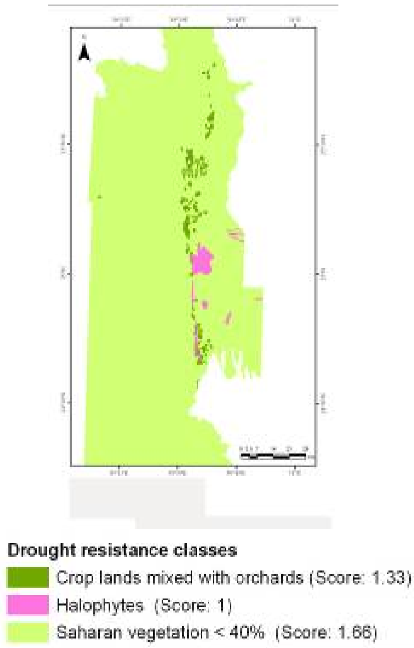

Fig. (28) Drought Resistance index classes of Kharga Oases

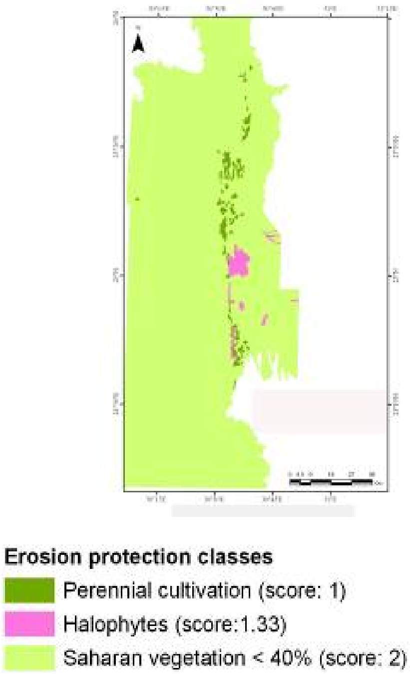

Fig. (29) Erosion Protection index classes of Kharga Oases

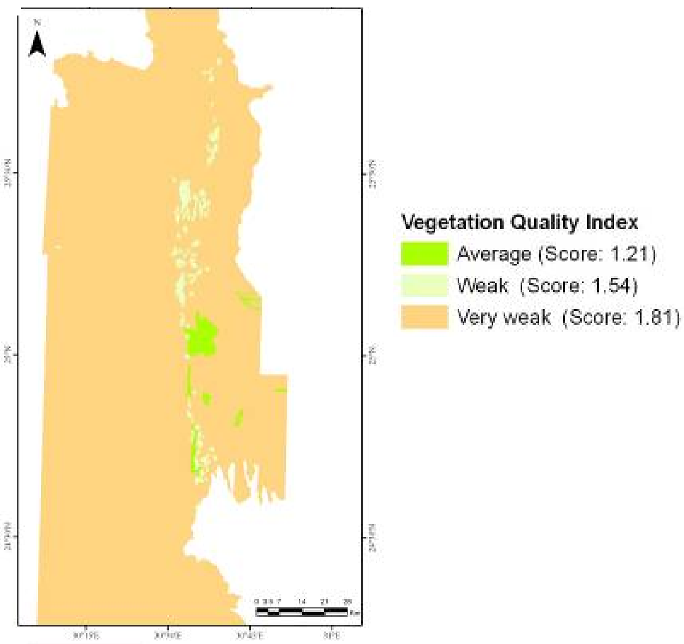

Fig. (30) Vegetation Quality Index classes of Kharga Oases

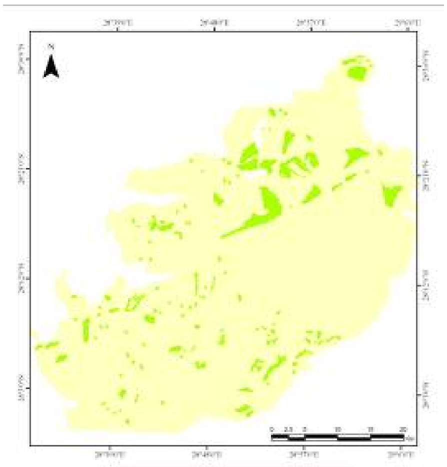

Fig. (31) Environmentally sensitive areas (ESA’s) for desertification in the Bahereya oases.

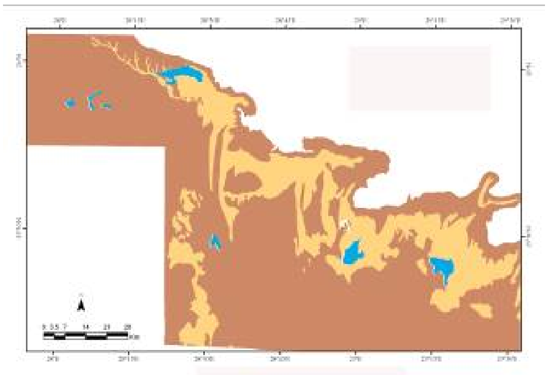

Fig. (32) Environmentally sensitive areas (ESA’s) for desertification in the Dakhla oases.

Fig. (33) Environmentally sensitive areas (ESA’s) for desertification in the Kharga oases**.**

Conclusions

It can be concluded that the desert oases are mostly very sensitive areas to desertification. However, as various environmental conditions may control the desertification sensitivity, some areas within the oases may be exposed to relatively less sensitivity. Assessment of desertification sensitivity is rather important to plane combating actions and to improve the employment of natural resources. The merely quantitative aspect of desertification sensitivity demonstrates a clearer image of the risk state, thus, reliable priority actions can be planned.

Remote sensing, in addition to thematic maps, may supply valuable information concerning the soil and vegetation quality. However, field validation is rather important for reliable information. The Geographic Information System (GIS) is a valuable tool to store, retrieve and manipulate the huge amount of data needed to compute and map different quality indices to desertification.

The Dakhla and Karga oases are susceptible to a high-to- very high desertification sensitivity. The majority of Bahererya oases is moderately sensitive due to satisfactory vegetation cover, in addition to near sub-surface water resources. Action measures are essential for the sustainable agricultural projects located in the desert oases due high desertification sensitivity. Multi scale mapping of ESA's are needed to point out the risk magnitude and causes of degradation in problematic areas.

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تتبع وتخريط الحساسية البيئية للتصحرلبعض واحات الصحراء الغربية بمصر باستخدام الاستشعار من البعد ونظم المعلومات الجغرافية

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تعرف مبادرة الأمم المتحدة لمواجهة التصحر الصادرة فى سبتمبر 1994 عملية التصحر بأنها "تدهور الأراضى بالمناطق الجافة والشبه جافة والشبة رطبة والناتجة بفعل عوامل مختلفة تشمل التغير المناخى وانشاط البشرى". أجريت دراسات للتصحر بمصر من خلال مشروع "الاعداد لمواجهة الكوارث" وال1ى جرى نشاطه بأكاديمية البحث العلمى والتكنولوجيا فى الفترة من 1989 الى 1992 بالاضافة الى انتاج العديد من الخرائط على المستوى الاقليمبواسطة عدد من الباحثين. حديثا تم تطوير نماذج رياضية تتناول المفهوم الكمي لتحليل التصحر. تعد واحات الصحرتء الغربية مناطق واعدة للتنمية المستدامة بما فيها التنمية الزراعية ، لذا فان تحديد الحساسية البيئية للتصحر بمناطق الواحات يمكن أن يدعم اتخاذ القرار لصيانتها وتنميتها.

أختير لاجراء البحث الحالى ثلاثة من واحات الصحراء الغربية المصرية (البحرية والداخلة والخارجة). استخدمت صور القمر الصناعى من نوعية ETM ونوعية SRTM والخرائط الجيولوجية وخرائط التربة والبيانات المناخية كمصدر أساسى للبيانات المستخدمة فى تخريط استخدامات الأراضى والنموذج ثلاثى الأبعاد وحساب دلائل الحساسية البيئية للتصحر. تم تطوير المعادلة المستخدمة على أساس الطرق المستخدمة بمشروع MEDALLUS لداسة دليل الحساسية البيئية للتصحر (ESI) بحوض المتوسط كالتالى:

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

حيث تشير SQI دليل حساسية نوعية التربة ، CQI دليل حساسية المناخ ، VQI دليل حساسية الغطاء النباتى

تم حساب دليل حساسية التربة SQI بتقييم كل من المادة الأمية وانحدار السطح وقوام وعمق التربة. تقدير دليل حساسية الغطاء النباتى VQI بنى على تقييم دلائل الحماية من التدهور ومقاومة الجفاف ونوعية الغطاء النباتى. كما تم حساب دليل الحساسية البيئية للمناخ CQI من خلال معمل الجفاف بمعلومية معدلات الأمطار والبخر. أعتبرت قيمة دليل الحساسية البيئية للمناخ متجانسة نظرا لسيادة المناخ شديد الجفاف بمناطق الدراسة. استخدم نظام المعلومات الجغرافى Arc-GIS 9 لحساب الحساسية وانتاج الخرائط.

تشير النتائج الى أن التربة بمناطق الواحات تتميز بمعاملات منخفضة الى متوسطة لنوعية التربة باستثناء الواحات الخارجة التى تتصف 24.4% من أراضيها بمعاملات عالية. تتضمن الواحات الشمالية (البحرية) مناطق أوسع تتصف أراضيها بمعاملات نوعية تربة متوسطة مقارنة بالمناطق ذات المعاملات المنخفضة لنوعية التربة. التربة بالمناطق الجنوبية (الواحات الخارجة والداخلة) تتميز بتواجد أكثر للتربة ذات النوعية المنخفضة. أظهرت حسابات دليل حساسية الغطاء

النباتى مدى واسع ينحصر بين المتوسط بمناطق النباتات المحبة للأملاح والضعيفة الى الضعيفة جدا بالمناطق المغطاه بالعشب الصحراوى. بالاشارة الى معامل حساسية المناخ فقد وجد أن مناطق الدراسة بواحات الصحراء الغربية تقع بالمناطق شديدة الجفاف التى تتميز بمعدلات فئقة للبخر نتح مقارنة بمعدلات الأمطار السائدة.

تمثل المناطق ذات الحساسية البيئة المنخفضة للتصحر 7.3% من الواحات البحرية بينما تمثل المناطق المتوسطة الحساسية 92.7 و 0.80% من أراضـي الواحات البحرية والخاجة على الترتيب. تتصف كل أراضى الواحات الداخلة بحساسية بيئية عالية الى عالية جدا للتصحر.

يمكن الخلاصة أن انتاج خرائط الحساسية البيئة للتصحر لها أهمية فائقة بواحات الصحراء حيث تؤدى الى التصور الكمى لتأثير عمليات التصحر. يمكن تطويع استخدامات الأراضى على ضوء دلائل الحساسية البيئية للتصحر يمكن أن يؤدى التكامل بين العوامل المساهمة فى الحساسية البيئية للتصحر الى التحطيط الناجح لمجابهة عمليات التصحر. ان استخدام البيانات الفضائية ونظم المعلومات الجغرافية أثبت كفاءته كأداة لحسابات دلائل الحساسية البيئية التى تتطلب امكانيات رياضية عالية ، كما أنها تقدم المفهوم المرئى لوضع الحساسية البيئية للتصحر