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Sensitivity to Desertification at Sidi Barrani Area, the North-Western Coast of Egypt

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ABSTRACT

The study area of Sidi Barrani is located in the North-Western Coast of Egypt to the west of Mersa Matroh City and lies between latitudes 31º 15' to 31º 44' N and longitudes 25º 18' to 26º 20' E, with an area about 2853 km^2. The landform of the investigated area was identified by using the Digital Elevation Model (DEM) satellite images and land surveying data. The obtained data illustrated that the main landscape units are plateau and coastal plain that includes several landform units as coastal plain, sabkha landform, dry valley, depression, and plateau. The areas sensitive to desertification are identified by the combination of 4 quality indexes about: soil, climate, vegetation and land management. The high sensitive areas for desertification, where the soil quality, climatic quality and vegetation quality are low; these areas represent by 26% (751km^2) of the total area. The sensitive areas are found where the vegetation cover is rather low; which represent by 37% (1056km^2) of the total area. The areas of moderate severe to desertification represent about 1.61% (43km^2). The low severe areas represent 35% (1001km^2). The low sensitivity areas are due to the good vegetation cover and soil quality.

Key words: Assessment, environment, sensitivity, desertification, soil, Sidi Barrani, North,Western Coast, Egypt

Introduction

Arid and semiarid environments cover more than 40% of the global land surface (Deichmann and Eklundh, 1991) and provide habitat to more than 1 billion humans (UNSO, 1997; Reynolds and Stafford Smith, 2002). Rural people in these regions ultimately depend on the effective use of natural resources (Reynolds, 2001). However, it is widely recognized that these lands are prone to desertification.

The geology of the Mediterranean coastal zone is intensively studied by Hume (1925), Ball (1939), Shukri *et al.* (1956), Shata (1957) and El-Shazly (1964). Generally, the sedimentary rocks found in this area are dated back to Late Tertiary and Quaternary ages; their stratigraphic sequence was given by Shata (1957), Abd El-Samie (1960), Conoco (1989) and Said (1991). The coastal landforms including coastal ridge, elevated plains, flood plains, drainage channels and lagoons. The shoreline is sculptured a series of destructive and/or constructive regional activities. These are mainly of marine, water streams, wind and even tectonic origins (Shata, 1957).

According to Shata (1957), Abdel Samie (1960), El-Kady (1961), Abdel Salam (1962), El-Shazly (1964), Hammad (1964) and Metwally (1969); the geomorphologic features encountered can be summarized as follows: the structural plateau, the coastal plain, foreshore plain (coastal belt) and sand sheets.

Abdel Rahman, *et al.* (1987) concluded that the soils of the study area are the most promising soil for agricultural expansion beyond the Nile Valley. Soils are distinguished into orders Entisols and Aridisols. The soils are mainly Torripsamments, Torriorthents and Calci/ Paleorthids (FAO, 1970). Hegazi and El Bagouri (2002) mentioned that soil types and properties are highly influenced by geomorphic and pedogenic factors. The depressions that are close to the shore is salt affected generally. Soil in the beaches – that is affected by salt – is unsuitable for cultivation; opposite to the soils in the wadies and highways, (Abdel Rady, 2011).

Desertification is recognized as a process of land degradation in arid, semiarid, and dry subhumid areas, which is the result of several factors, including human activities and climate variation (UNCCD, 1999). Desertification is a worldwide phenomenon estimated to affect 40 million km^2 or approximately one-third of the Earth's surface area and 1 billion people in over 110 countries (or about one-fifth of the human population of the world) (UNCCD, 2002). Afifi *et al.* (2010) illustrated that, the soil of the northern coast is mainly characterized by high sensitive areas for desertification. Abou Yuossef *et al.* (2005) estimated soil erosion risk by using CORINE model and erosion risk index in the Northern Coast of Egypt. Kotb (2013) mentioned that water erosion is recognized by different degrees of severity; some of them occur in the north coastal shore areas due to the relatively heavy short rain shower. The eroded materials are loaded away to low areas.

The MEDALUS method (Kosmas *et al.*, 1999) identifies regions that are environmentally sensitive areas (ESA's). In this model, different types of ESAs to desertification can be analyzed in terms of various parameters such as landforms, soil, geology, vegetation, climate and human actions.

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This study was carried out based on remote sensing data and GIS software facilitates. The obtained environmental conditions parameters, the stated analytical soil data and thematic produced maps were fed into MEDALUS Model to point out the sensitive areas to desertification.

The main objective of this study is to assess the areas sensitive for desertification processes in the selected areas located in Sidi Barrani, north-western coast of Egypt areas by using the desertification method ESAs (Environment Sensitive Areas to Desertification) based on remote sensing and GIS tools.

Materials and Methods

The study area is located in the north western coast of Egypt from Sedi Barany to Salloum City which lies between latitudes 31º 15' and 31º 44' N and longitudes 25º 18' and 26º 20' E, with an area about 2853 km^2. This study is based on the multi concept of remote sensing, thematic maps, climatic and land surveying data. Thus, materials related to these data sources were used as the following details: Landsat ETM+ images acquired during the year 2012 were employed in this study (i.e. ETM+ path 180 & row 038 and ETM+ path 181 & row 038), Figure (1).

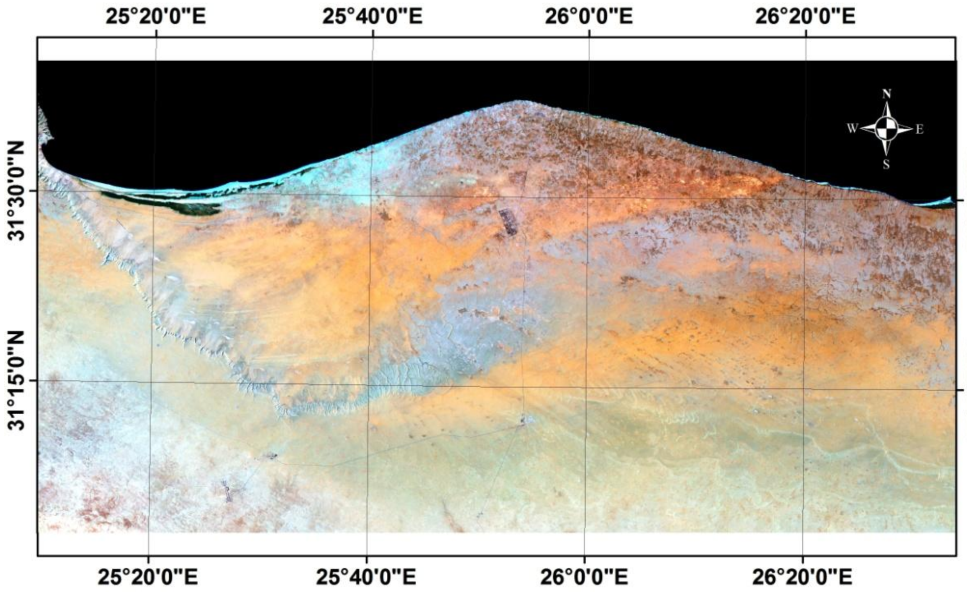

Fig. 1: Landsat ETM+ of Sidi Barrani, mosaic created from ETM+ path 180 & row 038 and ETM+ path 181 & row 038.

Digital elevation model (DEM) of the study area was extracted from the Shuttle Radar Topography Mission (SRTM), Figure (2). DEM could be used in conjunction with controlled imagery sources to provide better visualization of the terrain. The Landsat ETM+ image and SRTM data are processed using ENVI 4.7 software to identify the different landforms and establish the soil database of the studied areas using the methodology described by Zink and Valenzuala (1990) and Dobos *et al.* (2002).

The thematic maps used in this study include the soils and geology, these maps were collected from different sources and converted to digital form by using Arc-GIS 9.2 software.

Digital soil map of the study area was extracted and modified after the Soil Map of Egypt (ASRT, 1982).

The geological map of Egypt at scale 1:1000000 after CONOCO (1989) was used for extracting the geology of the Egyptian study area.

In this study, several contrast-stretching processes were applied to the images. The histogram equalization stretching process was used and resulted in the maximum contrast between features. False color composite enhanced images were produced using the combination of bands 7, 4 and 2, that were rendered in red, green and blue respectively. The created FCC's and their visual interpretations were used as guides for fieldwork survey. Rectification of studied scenes was performed using sufficient number of GCP's, which are distributed randomly all over the images. The root mean square (RMS) error was found to be 0.74 hence; image to image registration was accomplished.

Normalized Difference Vegetation Index (NDVI) shows patterns of vegetative growth by indicating the quantity of actively photosynthesizing biomass on a landscape (Burgan *et al.*, 1996). The NDVI can be estimated as follows:

NDVI = (NIR - RED) / (NIR + RED)
where: NIR is the near infrared band and RED is the red band.

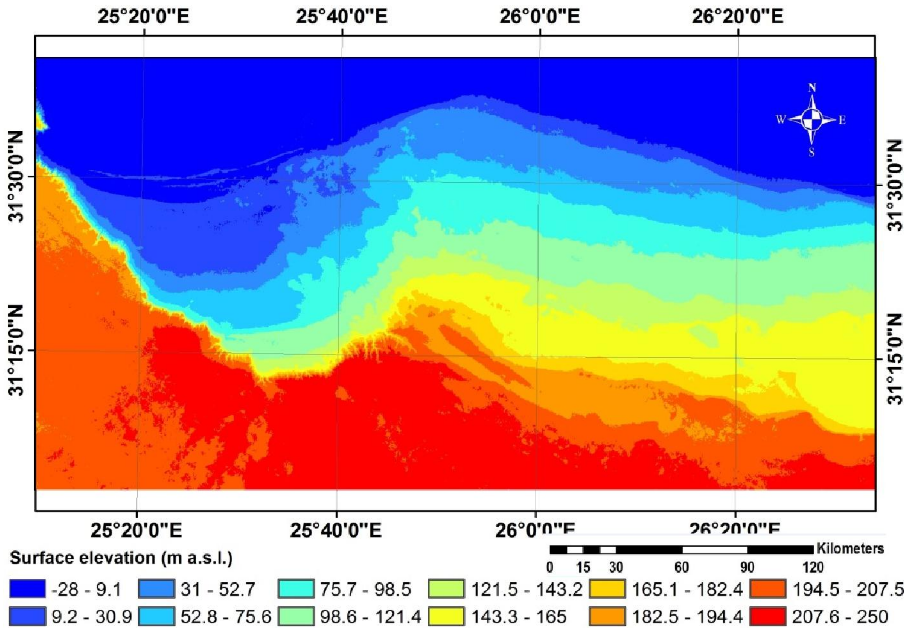

Fig. 2: Surface elevation of Sidi Barrani area as extracted from the Shuttle Radar Topography Mission (SRTM) images.

Arc GIS 9.2 software was used in data analysis, the first step in the analysis began with locating the field observation sites on the thematic layers with their attributes. Using the 3D module of Arc-GIS 9.2, the interpolation of the spatial distribution of the land use classes was performed. Spatial analyst of Arc GIS was used to classify the soil parameter ranges on the map and deduct the relation between the soil conditions and the land features. Also, the 3D analyst was used for generating digital Elevation Model (DEM) from the contour lines and spot heights the DEM creation depending on the nearest neighboring function. Statistical parameters and presentations were used to find out the relation between ground truth and image classification. Landsat satellite images dated 2012 were used in this study to obtain an up-to-date land use and land cover maps. The satellite images were geometrically corrected to the UTM grid system (Zone: 36N, datum: WGS84). The study used spatial analyses in a Geographic Information System (GIS) to assess and map the environmental sensitivity to desertification in northwestern coast of Egypt depending upon the soils, climate, vegetation and management quality indexes. Concerning the data required for estimating the environmental sensitivity to desertification, the indices of soils (SQI), vegetation (VQI) and climate (CQI) were computed. The main input data for calculating these indices include land survey and laboratory analyses, Landsat ETM+ images, Digital Elevation Model (DEM), climatic data and geological map of the studied areas (CONOCO, 1989). An image processing system (i.e. ENVI 4.2) and a GIS system (i.e. Arc GIS 9.0) were the main tools in indices computations and ESA's mapping.

Different quality indexes were calculated and displayed as GIS ready maps from which class areas were deduced. The Desertification Sensitivity Index (DSI) was calculated in the polygonal attribute tables linked with the geographic coverage according to the following equation:

DSI = (SQI * VQI * CQI) 1/3

The Ranges and classes of DSI are illustrated in Table (1).

Table 1: 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

Results and Discussion

The obtained data of using DEM satellite images and land surveying data illustrated that the study area is divided into plateau and coastal plain that includes several landform units as coastal plain, sabkhas, dry valley, depression and plateau. According to the obtained chemical data and field description and keys to soil taxonomy (USDA, 2010) soils of the study area are classified to *Typic Torriorthents*, *Typic Torripsamments*, *Typic Haplocalcids* and *Typic Haplosalids*. Rock outcrops represent only 11.62% in the southern part from the total investigated area. Figure (3) represents the spatial distribution of the soils.

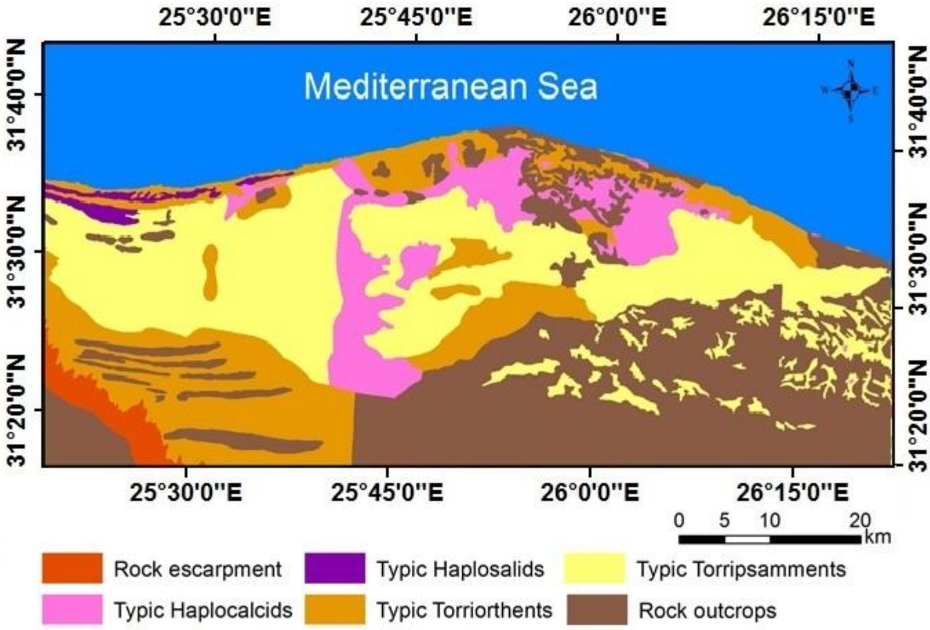

Fig. 3: Soil classification of Sidi Barrani area, Egypt.

The Soil Quality Index (SQI) was evaluated based upon the parent material, soil depth, soil texture class and slope. Table (2) represents the spatial distribution of class and scores of soil quality index. The layer of soil quality index of the studied area indicates that the areas of high soil quality index which is slightly sensitive to desertification (value <1.13) was found in large areas especially in western and southern parts of Sidi Barrani area, representing about 35.01% (999 km^2) of the total area. The moderate soil quality index (value 1.13 - 1.45) represents only 1.61% (46 km^2) of the total area, it was mainly found in the middle north part of the area. The low soil quality index area represents about 37.03% (1057 km^2); and very low soil quality index was estimated as 26.35% (752 km^2), which dominates the rest of the area characterized by sandy texture, shallow depth and undulating soils.

The vegetation type, drought resistance, and erosion protection parameters were used for assessing the vegetation quality index (VQI). (Table 3) shows the classes, and scores of vegetation quality index of the Sidi Barrani area. It is also indicated that the areas of slight sensitivity (value <1.20) dominate creation parts near the coast. It represents 1.61% of the total area. The moderate sensitive areas (value 1.2 – 1.4) cover most of the study region (63.38%). The high sensitive (value 1.4 – 1.6) and very high sensitive areas (value >1.60) dominates 3.66% and 31.35% the total area, respectively. These categories exhibit the south and south west parts of the investigated area. The low vegetation index is due to the low density of vegetation cover.

Table 2: Soil quality index (SQI) in Sidi Barrani, Egypt.

SQI	Rate	Area (km^2)	Area (Feddan)	Area %
slight	< 1.13	998.91	237834.60	35.01
moderate	1.14 -1.45	45.94	10937.27	1.61
Severe	1.46-1.66	1056.54	251557.13	37.03
Very sever	> 1.67	751.82	179004.33	26.35
Total		2853.20	679333.33	100.00

Table 3: Areas of vegetation quality index classes and scores in Sidi Barrani, Egypt.

Vegetation Index class	Vegetation Index score	Area (km^2)	Area (Feddan)	Area (%)
Slight	(VQI>1.2)	45.93652	11024.7648	1.61
Moderate	(1.2<VQI<1.4)	1808.358	434005.9584	63.38
High	(1.4<VQI>1.6)	104.4271	25062.5088	3.66
Very high	(VQI>1.6)	894.4782	214674.768	31.35
Total		2853.20	684768.08	100.00

Climate quality index (CQI) was assessed depending upon the amount of rainfall, aridity and slope aspect parameters. The climatic quality index layers of the area indicate that the Sidi Barrani is characterized by low (>1.80) climatic quality index due to the low amount of rainfall compared with the evapotranspiration. The value (score) of climatic quality index (CQI) enhances the desertification process in such area.

The layers (soil, vegetation and climate indices) were driven together to assess the environmentally sensitive areas to desertification, on basis of the calculated desertification sensitivity index (DSI). The obtained results show the distribution of environmentally sensitive areas (ESA's) in the studied area at the northwestern coast of Egypt. It is clearly seen that the high sensitive areas (very severe) for desertification in the area are found in southwest and south east parts, where the soil quality, climatic quality and vegetation quality are low; these areas represent 26.35% (752 km^2) of the total area. The sensitive (severe) areas are found where the vegetation cover is rather low; which represents 37.03% (1057 km^2) of the total area of Sidi Barrani. It occurs in the middle parts of the investigated areas. The areas of moderate severe to desertification represent about 1.61% (43 km^2) of the total area: They are found in limited parts located at the coast of the studied area. The low severe areas exhibit the western parts of the area: representing 35.11% (1002 km^2) of the total area. The low sensitivity areas are due to the good vegetation cover and soil quality. Table (4) and Figure (4) represent the classes, scores, description and areas of the environmentally sensitive areas to desertification in Sidi Barrani area, Egypt.

Table 4: Environmentally sensitive areas to desertification in Sidi Barrani, Egypt.

Status	DSI score	Area (km^2)	Area (Feddan)	Area (%)
Slight severe	> 1.2	1001.63	240390.76	35.11
Moderate severe	1.2 < DSI <1.3	43.16	10359.00	1.61
Severe	1.3< DSI < 1.4	1056.70	253609.20	37.03
Very severe	1.4> DSI <1.6	751.71	180409.48	26.25
Total		2853.20	684768.08	100.00

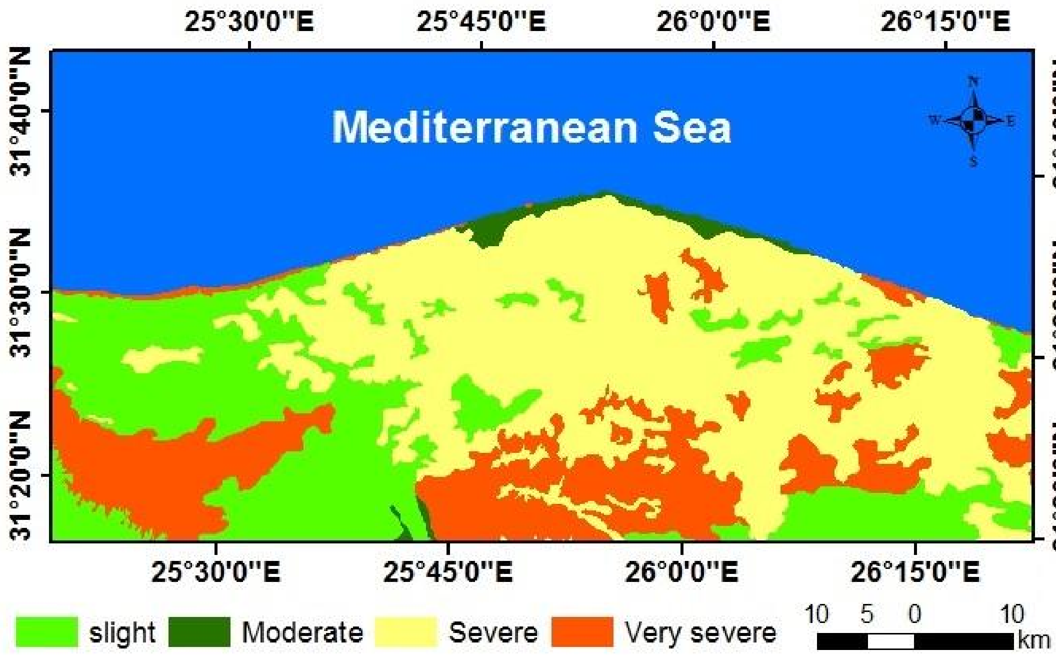

Fig. 4: Environmentally sensitive areas to desertification in Sidi Barrani, Egypt.

Summary and conclusions:

The obtained results show the distribution of environmentally sensitive areas (ESA's) in the studied area at the northwestern coast of Egypt. It is clearly that the high sensitive areas for desertification, where the soil, climatic and vegetation qualities are low. The sensitive areas are found where the vegetation cover is rather low. The low sensitivity areas are due to the good vegetation cover and soil quality. It is recommended that to use applied safety environmentally techniques to reduce the sensitivity for desertification in our regions.

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