Journal of Soil Science and Environmental Management Vol. 3(5), pp. 97-103, May 2012
Available online at http://www.academicjournals.org/JSSEM
DOI: 10.5897/JSSEM11.017
ISSN 2141-2391 ©2012 Academic Journals

Full Length Research Paper

Assessment of sand encroachment in El-Qutaynah area, Sudan using remote sensing and geographic information system

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Accepted 26 March, 2012

This study focused on the assessment and evaluation of land degradation and desertification in El-Qutaynah area, White Nile State, Sudan. Through monitoring and mapping of the changes that occurred in the Land Use/land cover (LU/LC) due to drought and sand encroachment in the study area was the main goal of this research. The study covered the period between 1986 to 2006. The research was based on the data and information deduced and extracted from remote sensed landsat thematic mapper (TM) and landsat enhanced thematic mapper (ETM+) images, in addition to secondary data of geologic and soil maps. Image processing procedures were performed to determine land use/land cover classes for the recent and reference image. The study attempted to update land use/land cover information using different methods of data transformation such as: normalized difference vegetation index (NDVI) and supervised classification. The study revealed that the extent of cultivated areas and sand was largely increased. However, an increase in vegetation cover was indicated using NDVI images. The study also revealed that both natural environments and human activities witnessed remarkable changes. Sand encroachment has extremely affected the study area. The study proved that remote sensing and geographic information system (GIS) are efficient tools in land degradation studies.

Key words: El-Qutaynah, sand encroachment, geographic information system, remote sensing.

INTRODUCTION

The Sudan falls within the zone where the risks of desertification are great. Total area of 65 million hectares lying between latitude and longitude (32° 52' 16.48"E, 14° 24' 05.65"N) and latitude and longitude (32° 8' 1.48"E, 15° 9' 33.48"N).extending across the country from East to West has been decertified (DECARP, 1974). The reduced production of dura, sesame, millet and gum Arabic in Western Sudan combined with overgrazing and dominance of less palatable grasses as well as, the extinction of wildlife species are all strong indicators of the seriousness of the problem.

Desertification is the degradation of land in arid and dry sub-humid areas, resulting primarily from man-made activities influenced by climatic variations. It is principally caused by wind, overgrazing, over drafting of groundwater and diversion of water from rivers for human consumption and industrial use and all of these processes are fundamentally driven by overpopulation.

Land degradation is a process which lowers the current and/or the potential capability of land to produce (quantitatively and/or qualitatively) goods or services (FAO, 1983; UNEP, 1999). Land degradation will remain an important global issue at least for the rest of 21st century because of its adverse impact on agronomic productivity, the environment, and its effect on food security and the quality of life. Productivity impacts of land degradation are due to a decline in land quality on site where degradation occurs (for example, erosion) and off-site where sediments are normally deposited.

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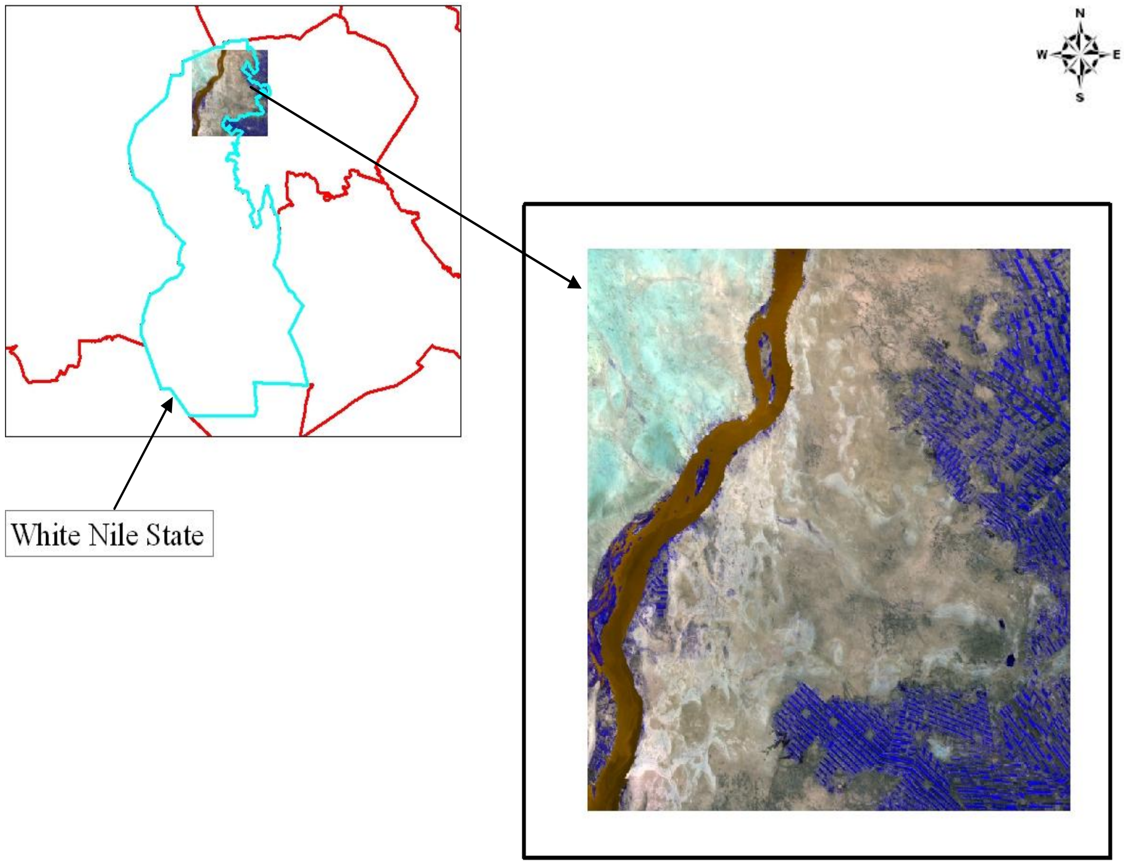

Figure 1. The location of the study area.

However, the on-site impacts of land degradation on productivity are easily masked due to use of additional inputs and adoption of improved technology which have led some to question the negative effects of desertification (Laurence et al., 2006).

GIS is the systematic introduction of numerous different disciplinary spatial and statistical data that can be used in the environment, observation of change and constituent processes and prediction based on current practices and management plans. Remote sensing helps in acquiring multi-spectral spatial and temporal data through space borne remote sensors. Image processing technique helps in analyzing the dynamic changes associated with the earth resources such as land and water using remote sensing data. Thus, spatial and temporal analysis technologies are very useful in generating scientifically based statistical spatial data for understanding the land ecosystem dynamics. Successful utilization of remotely sensed data for land cover and landuse change detection requires careful selection of appropriate data set (Ramachandra and Uttam, 2004). Remote sensing methods proved to be of high potential for the detection of vegetation cover. Classification change detection methods showed pattern of change in land use/and cover classes.

MATERIALS AND METHODS

Study area

Sudan is located in the North of the African continent between latitudes 22.4° North and longitude 38.22° East. White Nile State falls within (Latitude 13°, 30 to 12 North and Longitude 33°, 30 to 31 East). The total area is 39701 Km^2. El-Qutaynah area lies in central Sudan within the White Nile State and extends between latitude and longitude (32° 52' 16.48"E, 14° 24' 05.65"N) and (32° 8' 1.48"E, 15° 9' 33.48"N) (Figure 1).

Climate

Sudan is located within the region and the tropical climate that varies between the continental shelf in the North and savannah ecosystems in the tropical and Alooasit regions in the Southern part of Sudan. Rise in temperature in all parts of the Sudan in the period from March to July, is rated 42°C at day time and 23°C at night. Low temperatures in the period from November to February are up to 30°C at noon and 16°C at night, especially in the North.

Rainfall rate ranges between 75 to 300 mm in the central regions, 400 to 800 mm in the Southern and Alooasit regions, and 800 to 1500 mm in the tropics. The most important soil types for farming in Sudan are dominated by expanding clay. Such soils cover most of central Sudan and the Eastern plains. They are calcareous and moderately well drained, but generally contain little nitrogen. The Eastern plains lying North, Southeast and East of the Gadaref town

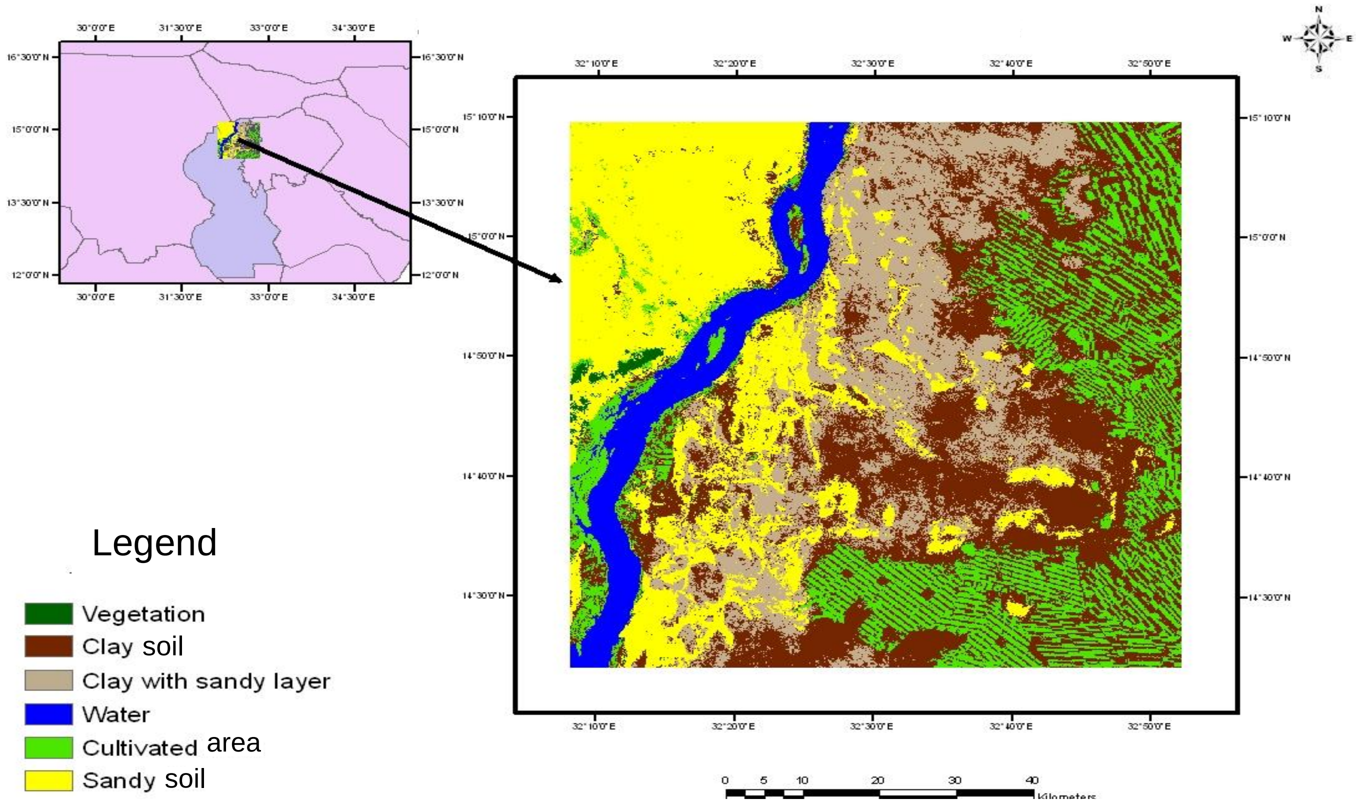

Figure 2. Classifications of landsat thematic mapper (1986).

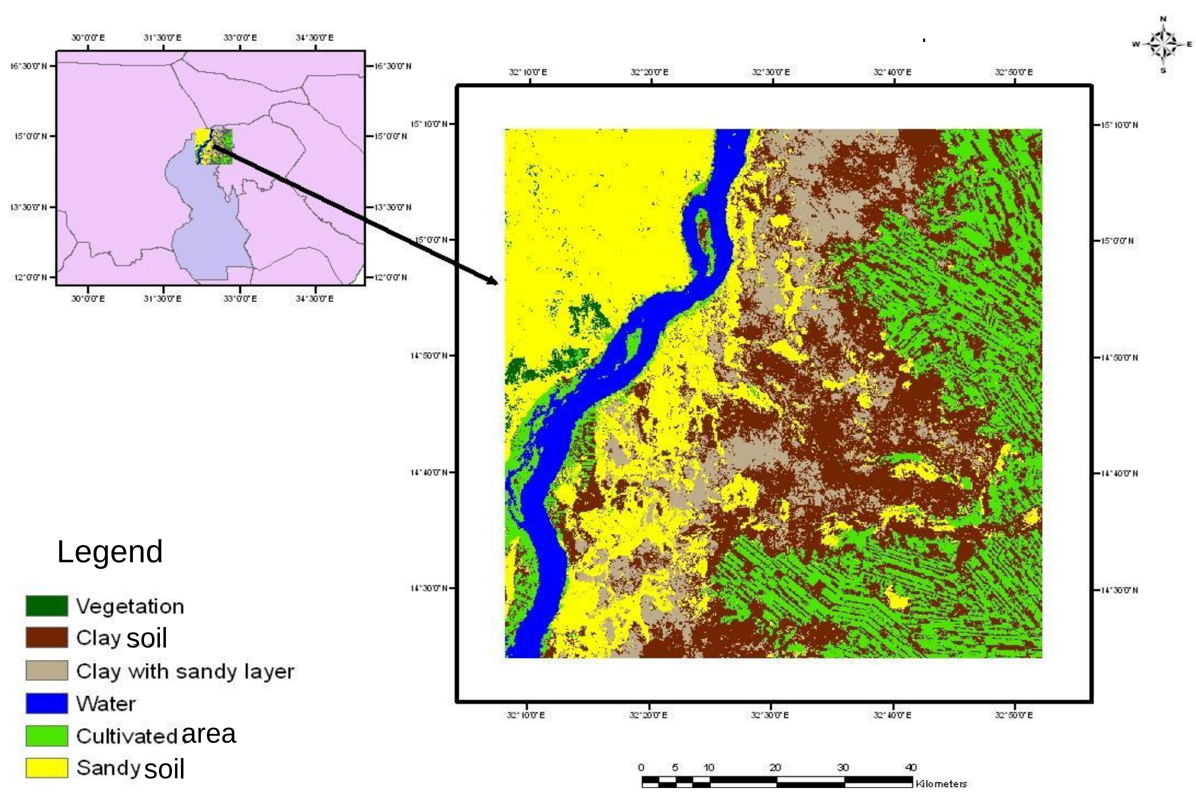

Figure 3. Classifications of Landsat Thematic Mapper (2006); source: (Landsat ETM, 2006).

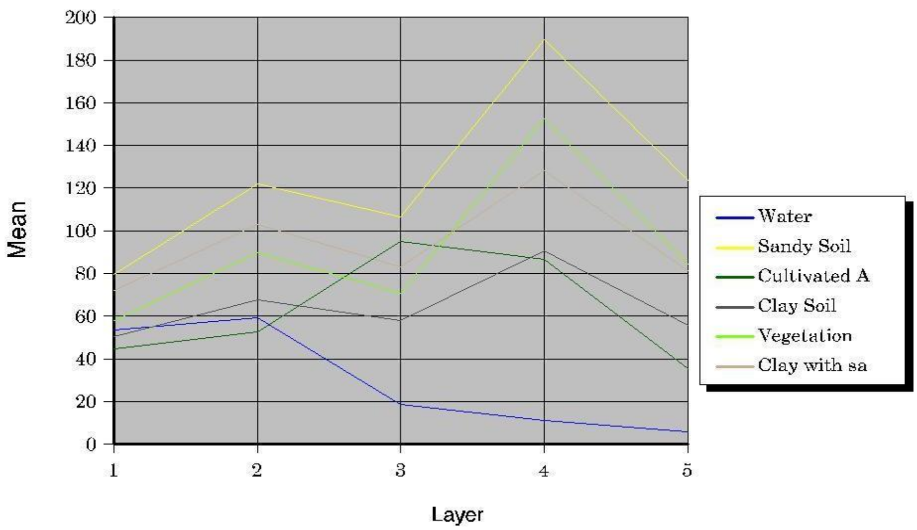

Figure 4. Signature of the main classes in image 1986.

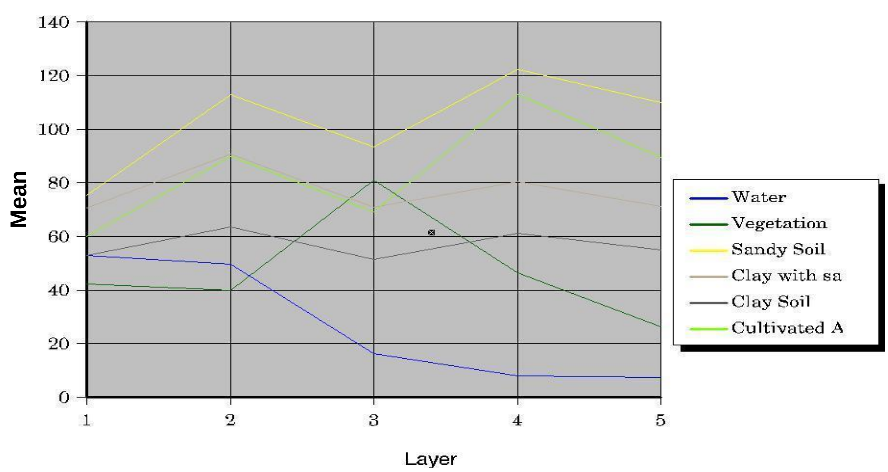

Figure 5. Signature of the main classes in image 2006.

and the central plains from Gezira to Rosaries on the Blue Nile, are the best example of soils: loam, deep and generally well drained. The soils of the Northern agricultural zones along the flood plain of the Nile are Loam, stratified and calcareous (Osman, 2005).

The main classes of soil in El-Quanah area

The main classes of soil in El-Quanah area are:

1. Alluvial, subtropical and tropical (fluvial)-Dark vertic (vertisols)-Brown of semi desert savannah and shrub land (calcic).
2. Brown of semi desert savanna and shrub land (calcic).
3. Soda solonchaks.

METHODOLOGY

Two false colour composite (FCC) subsets images from Landsat TM (1986) and ETM+ (2006) covering the study area (6652 km^2) were used to determine the main land use/land cover classes. For change detection ETM+ scene in 2006 was used as recent dataset, while that of TM scene 1986 was used as reference dataset.

Supervised classifications based on visual interpretation and NDVI analysis were used in this study. Extent and percentage of the areas affected by sand in each year were determined and post classification change detection approach based on map calculation was applied to determine the dynamic of change in sand encroachment.

RESULTS AND DISCUSSION

Figures 2 and 3 showed the spectral signature of the different land use/land cover classes in year 1986 and 2006. Sand movement was interpreted based on Landsat false colour composite (FCC) (173/50 TM dated 1986 and

Table 1. Extent of land use/land cover in the study area (1986 to 2006).

Number	Class name	Area/km^2 in 1986	Area/km^2 in 2006	Difference in km^2
1	Vegetation	3240.4	5434.6	+ 2194.2
2	Clay soil	221942	216427	-5515
3	Sandy soil	157112	179012	+21900
4	Cultivated area	112420	136999	+24579
5	Clay with sandy layer	127522	84351.2	-43170.8
6	Water	42973.5	42820.3	-153.2

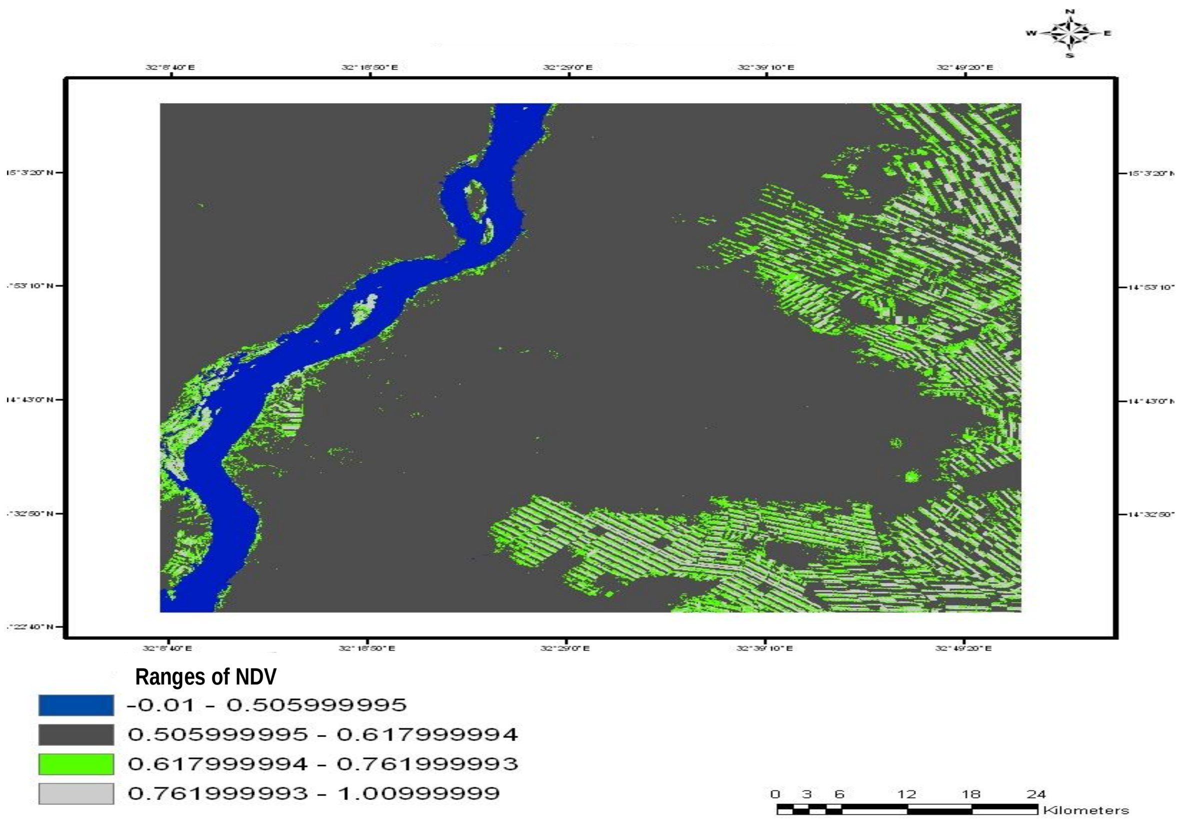

Figure 6. NDVI of landsat TM 1986.

ETM 2006). From this interpretation, it was possible to state that sand moved from Western Kordofan and North western parts from Goz Abu Dolua towards the El-Qutaynah area (Figures 4 and 5). The area covered with sand was 1571 and 1790 km^2 in the year 1986 and 2006, respectively. This result agreed with Nawal and Al-Amin (1998) and El_Hag (2007).

Figures 4 and 5 showed sand cover in the North western and South-western part of the study area, which is a problem threatening the land, especially, after the dry season. Analysis of images of years between 1986 and 2006 showed that a higher sand soil and sandy clay layer around the study area in year 2006 compared to the years 1986, this could be attributed to mobile sand dunes moved from Western Kordofan and North western parts from Goz Abu Dolua toward the El-Qutaynah area. The movement of the sand and sand dunes was induced mainly by climate change (drought) and human activities come second. It seems that wind erosion was the main driving forces of sand encroachment around the study area.

El_Hag (2005) and Salih (1996) found that sand moved from the Sahara desert towards the river Nile in the Northern Sudan. This study showed that the sand moved from the North Kordofan, through a corridor across the White Nile to El Qutaynah areas due to the drought and human activities through deforestation. Table 1 and Figure 8 showed that positive changes in areas are

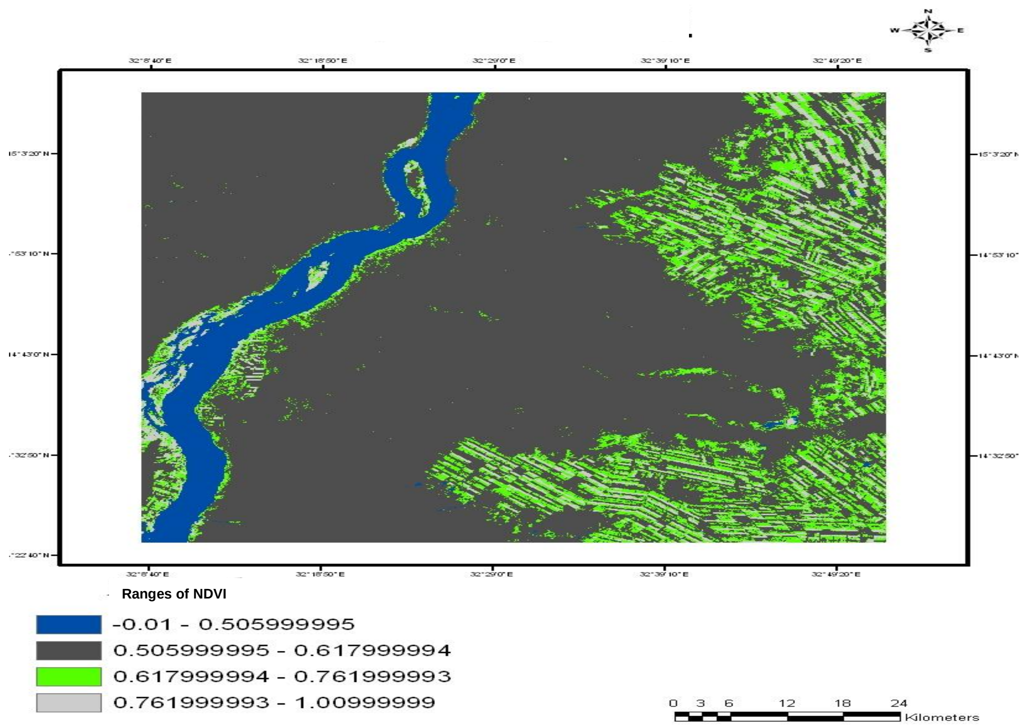

Figure 7. NDVI of landsat ETM 2006.

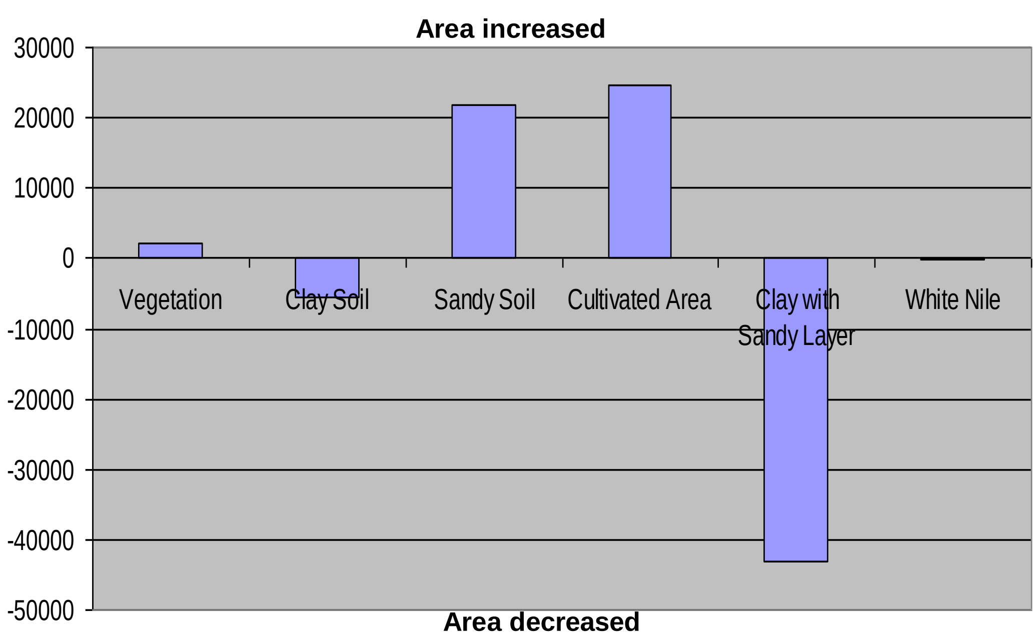

Figure 8. Difference in land use/land cover classes between years 1986 and 2006.

covered by sandy soil, vegetation and cultivated areas during the period of 1986 to 2006 and negative change in areas covered by clay soil, water and sand clay during the same period. NDVI image for years 1986 and 2006 (Figures 6 and 7) showed that vegetation covered an area of 536.2 km^2 in year 1986 and area of 758.4 km^2 in the year 2006. In year 1986, soils covered an area of 5328 km^2 and this area decreased to 5111 km^2 in year 2006. Water bodies in the study area covered 431 km^2 in year 1986 and 445 km^2 in year 2006.

Generally, the NDVI during the period of the study showed a clear change from 1986 to 2006. It is remarkable that vegetation cover is lowest during the year 1986 and is continuously increased afterward during the addressed periods. Sand soils are highest in year 2006, thus, this change can be attributed to droughts, human activities and bad management. Similar results were found by Nawal and Al-Amin (1998) and El_Hag (2007, 2005).

CONCLUSION AND RECOMMENDATION

The study revealed different signs of desertification and land degradation in the study area as judged by change in patterns of land use and land cover types, this changes indicated increase of farming land, vegetation cover, sandy soil and sandy clay inside the study area,. These signs could be revised with the use of agricultural indicators. Based on the research result we conclude that:

1. Sand encroachment threatens the highly productive agricultural land, drainage system and villages in Elg area and Gezira-Manaqil schemes area.
2. Sand dunes threatens the White Nile as a source of water, this has endangered the crop production and livelihood of inhabitants in this area.

Based on these findings, the following recommendations can be stated:

1. Adoption of strategies of sand dunes stabilization and plantation of shelter belts to retard sand movement.
2. Adoption of optimal land uses that are suitable for these vulnerable areas.
3. Improving the level of awareness of the inhabitants about this problem.
4. Conduction of research aiming at understanding and creation of new methods to prevent sand encroachments.
5. Conduction of periodical assessment and monitoring of natural resources with use of remote sensing technology
6. Extra research is needed to trace and pin point the land degradation effects.
7. Some measures should be taken to avoid the effects of irrigation system such as sand dunes and sand movement.

REFERENCES

DECARP (1974). Desert Encroachment Control. Project proposed by Sudan Government 1975-80. The National Council for Research, Khartoum, Sudan, p. 68.

El_Hag HA (2005), Assessment of sand encroachment in Dongla, (Northern State), Sudan, M.Sc. Thesis U of K., p. 94.

El_Hag HA (2007), Assessment of threat of sand encroachment in Gezira and Managil agricultural scheme, Sudan, Postgraduate Diploma (PGD), African Regional Center for Space Science and Technology Education in English (ARCSSTE-E), Obafemi Awolowo University Campus (OAU), ILE – IFE, p. 66.

FAO (1983). Guidelines: Land evaluation for rainfed agriculture, FAO Soils Bull., p. 52.

Laurence A, Lewis D, Johnson L (2006). Land Degradation: Creation and Destruction. (NRCS, Nat. Resour. Conserv. Serv., US Dept. Agr.).

Nawal Kh, Al-Amin N (1998) Steps in protecting Gezira scheme against drifting sand in Sudan. Department of Botany and Environmental Science-College of Forestry and Range Sciences, Sudan University of Science and Technology- Khartoum –Sudan (World Meteorological Organization Commission for Agricultural Meteorology CAgM Report, p. 93).

Osman MG (2005). Evaluation of Soil Erosion in Sudan. Space Technology Centre, Computer Man College, Khartoum, Sudan. (LinkCpings university, Olagunju Emmanuel Gbenga LIU-IDA/FFK-UP-A--08/021—SE, 1: 5-6.

Ramachandra TV, Uttam K, (2004), Geographic Resources Decision Support System for land use, land cover dynamics analysis, Centre for Ecological Sciences, Centre for Sustainable Technologies Energy and Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore – 560 012, pp. 52-59.

Salih EM (1996). The geographical extent of desertification in Sudan. Paper (NDDU). [ALBUHUTH Sci. J., 5(1):18-40].

UNEP (1999). World Atlas of Desertification. London: Edward Arnold. Printers. UNCCD (1994) United Nation Environment Programme (UNEP) information unites for the convention on behalf of the interim secretariat of the convention to compact desertification, pp. 136-139.