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Mapping and Monitoring Land-Cover/Land-Use Change in the Gash Agricultural Scheme (Eastern Sudan) Using Remote Sensing

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Introduction

Agriculture is considered as the mainstay of the Sudanese economy and accounts for about 38.9 % of the GDP, provides about 80 % of the country's export, and employs 62 % of the labour force, with about 80 % of the population dependent on agriculture for livelihood and raw materials for the industries. The Gash Agricultural Scheme (GAS) is considered as one of the pilot projects that contribute to the rural development and population settlement in eastern Sudan, particularly towards local population around the Gash River area. Eastern Sudan, a vast blasted land of some 300,000 square kilometres, is home to an estimated three to four million of Sudan‘s poorest people. The region is made up of three states: Red Sea, Gadaref and Kassala. In each of these states the living conditions are so harsh that the local population has been facing acute poverty, persistent drought, in addition to land degradation and shrinking pasture areas, for a very long time (Abdel Ati, 2002). The process of desertification in eastern Sudan, especially in Kassala State, Gash agricultural Scheme (GAS) has increased rapidly and much effort has been investigated to define and study its causes and impacts. Kassala State is a region which is characterised by drought and desertification. The greater part of the area is semiarid with a small portion of rainfall ranges between 50-200 mm annually (Hielkema et. Al., 1986; IFAD, 2004).

The aim of the scheme is to settle poor nomadic people for growing cotton as a cash crop beside some other crops in order to achieve self-sufficiency of the local consumption food. In the last decade, the scheme has undergone serious deterioration, further drought spells have led to increased pressure on meagre resources, in addition to invasion of unfavorable Mesquite trees. These factors lead to acceleration of the degradation process in the study area. The area is characterized by semi-arid climatic conditions with rainfall ranges between 50-200 mm. semi-arid ecosystems with a single rainy season there is usually a short growth period followed by a long dry season with a great reduction in the amount of green plant material (Hinderson, 2004).

The area endures intensive land-use pressures which make it highly sensitive to climate fluctuations. Various practices in this region, such as changes in fire regimes, removal of vegetation and over-grazing have been linked to many recognized causes of land degradation (Hielkema et. Al., 1986; IFAD, 2004).

Change detection is the process of identifying differences in the state of an object or

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phenomenon by observing it at different times (Singh 1989). Accordingly, (Radke et al., 2005) Detecting changes in images of the same scene taken at different times is of widespread interest due to a large number of applications in diverse disciplines including remote sensing, surveillance, medical diagnosis and treatment, civil infrastructure, and underwater sensing.
Changes in land cover and land use in cultivated areas are dynamic processes, such that transitions and changes occur at varying rates and in different locations within the constraints of, or in response to, increase or decrease or social, economic and environmental factors.

Methodology of the study

This study is attempted to monitor and to assess the impacts of change in land use and land cover and detection process on the GAS area.
The research was conducted in the GAS scheme which located in the Kassala State between latitudes 15 30 31 and 16 04 06 N and longitude 36 05 26 and 36 05 20 E (Fig. 1). The crop production is depending entirely (since the beginning of the season) on the annual flood of the Gash River, in addition to a little amount of rainfall at the end of the season. The mean annual flooding of the Gash River (between jolly to august) is about 560 million cubic meters and only 17% of this amount is effectively used for the agricultural purposes, Great Basin (plods) and furrows irrigation are the main irrigation systems in the scheme. The major crops are cotton, sorghum, sun flower and cluster. However, recently sorghum is considered as the main cash crop.
Four cloud free multi-temporal Landsat images (path 171/row 49) acquired from the Global Land Cover Facility (GLCF) by University of Maryland, representing the period of the years 1979, 1987, 1999 and Aster data of the year 2010 covering the study area were selected for analysis, the characteristics of these image shown in (Table.1). The data were acquired during the same season to minimize the effect of seasonal variation on the images analysis. The Landsat images of MSS, TM and ETM+ were rectified and registered to the Aster 2010 using ground control points. Images were radiometrically and geometrically corrected to the (UTM) coordinate system (Zone 37 N). Maximum Likelihood Classification (MLC) was used for the image classification. Supervised

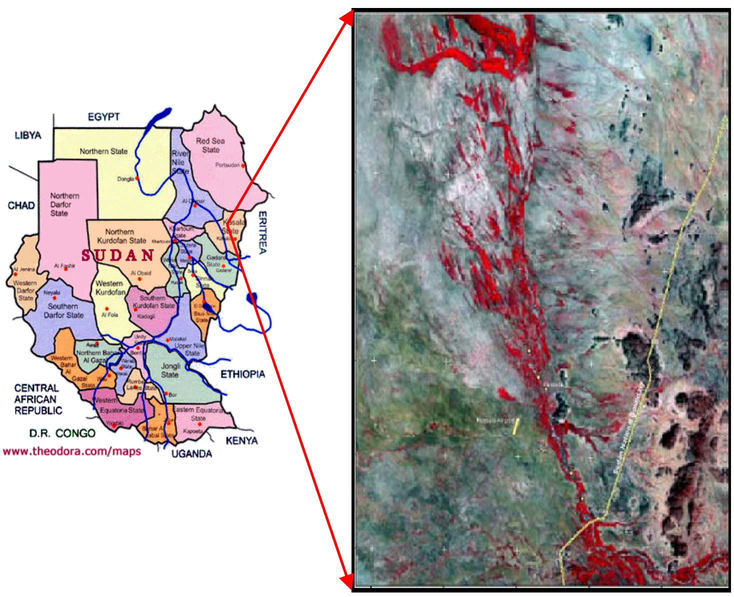

Fig.1: Location of the study area.

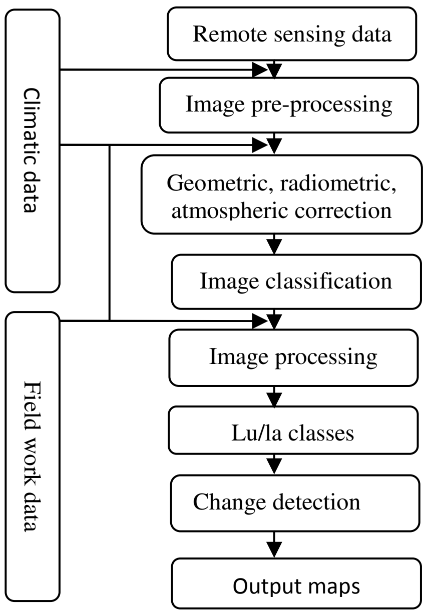

Fig.2: Flow chart of research methodology.

Instruments	MSS	TM	ETM+	ASTER
Time to acquisition	15.11.1979	21.11.1987	22.11.1999	24.10.2010

Table.1: The characterized of image covering the study area.

classification was carried out by training samples for each information class by visual interpretation of imagery supported by training samples measurement according to Cohen *et al.* (1999) and Hayes and Sader (2001). The spectral signature of training samples were assessed by signature editor tools of Erdas 9.2 as implemented in imagine such as image alarm, statistics, mean plots and contingency. The classification supervised training was followed instead of classification unsupervised signature to avoid the misclassification errors. According to similarities of training spectral signature there are many land cover classes could not be obvious classified such as mesquite trees and some scattered trees and some spp. of grasses.

Five land cover/land use classes were identified explicitly; Mesquite trees, grass land, clay soil, stabilized sand and mobile sand (Fig.3). Visual and statistical change detection was carried out for the periods 1979 – 1987, 1987 – 1999 and 1999 – 2010 to detect the respective land use and land cover changes for the area.

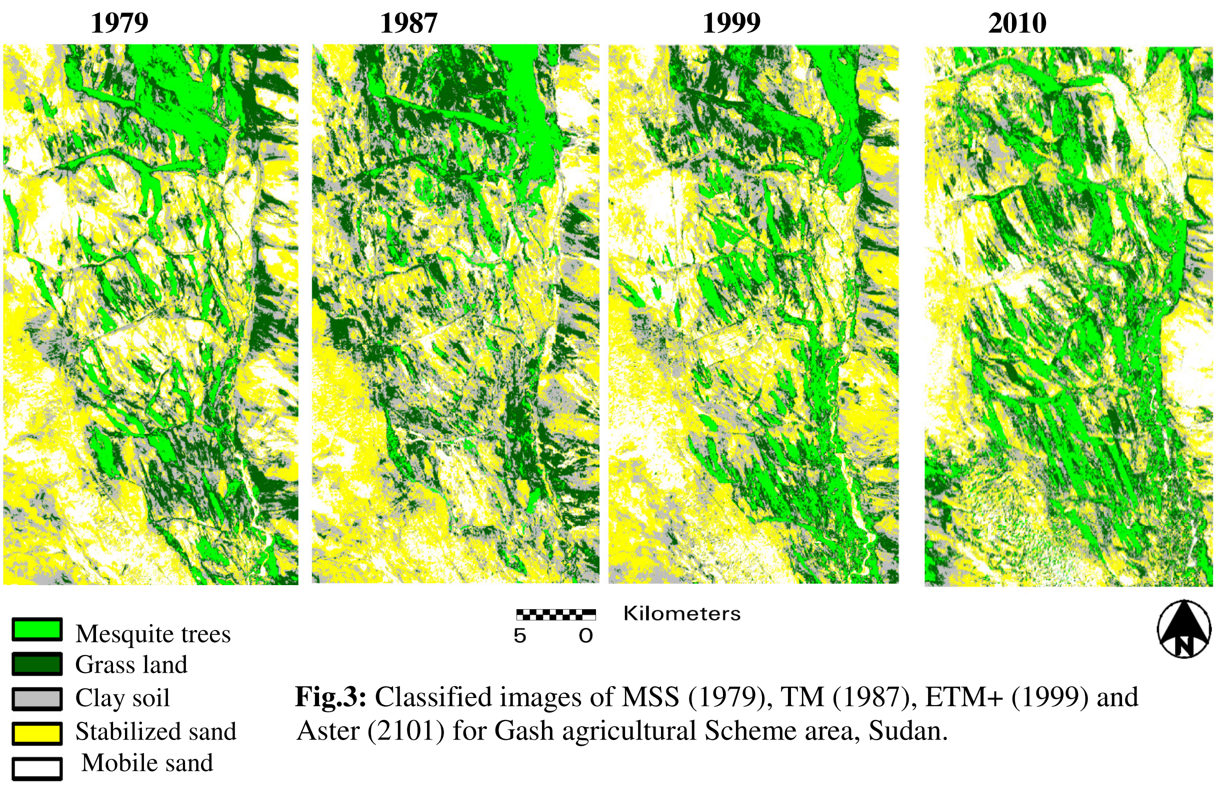

Fig.3: Classified images of MSS (1979), TM (1987), ETM+ (1999) and Aster (2101) for Gash agricultural Scheme area, Sudan.

Final results of the study

The results show that stabilized sand (31.75%) and mobile sand (19.88%) are the most dominant classes in the study area (Table.2). They extremely affect the agricultural and residential areas as well as threaten the Gash River course during the dry season. The mesquite trees, grass land and clay soil cover 19.15%, 10.05% and 19.25% respectively. Furthermore, the stabilized sand and mobile sand increased at the expense of the cultivated

Classes	1979(%)	1979(ha)	1987(%)	1987(ha)	1999(%)	1999(ha)	2010(%)	2010(ha)
Mesquite trees	8.68	6611.94	12.04	36655.65	13.32	162172.89	19.15	60022.30
Grass land	21.73	16552.53	17.36	52856.64	16.23	197529.84	10.05	142321.12
Clay soil	28.97	22064.94	22.44	68326.11	23.47	285732.18	19.25	50215.15
Stabilized sand	27.80	21104.55	28.40	86453.82	29.94	364413.42	31.75	52312.54
Mobile sand	12.91	9829.89	19.75	60134.13	17.04	207365.94	19.88	723541.25

Table.2: Land cover/use classes distributions during 1979 – 2010.

area (clay soil).This mainly due to practicing of the traditional agriculture which usually lack for regular crop rotation, over irrigation, and increasing the amount of fine sand (i.e. carried by gash river water). Also, the appearance of mesquite trees help in accumulation of sand within the area. The results also revealed that a rapid decrease of agricultural areas (clay soil) was observed over time as a result of Mesquite trees expansion and mobile sand encroachment, the final results is decreasing in overall production of the area. The increase of the mesquite trees areas can be attributed to the use of these trees as shelterbelts during the inception of drought years in 1970's and 1980's, to protect the cropped area against the encroachment of mobile sand. Moreover, improper use of irrigation water could be another reason also. This explains why the cultivated area suffered from sand encroachment during the seasons. The change detection pattern from 1979 to 2010 shows a positive change (39.04%), negative change (32.66%) and no change (28.29%) Fig.4. the results of study showed that the increase of sand encroachment and mesquite trees invasion during the period from 1979 - 2010 at the expense of cultivated and range land is the most important factor of causing land degradation in the Gash Agricultural Scheme, as well as in the arid and semi arid region.

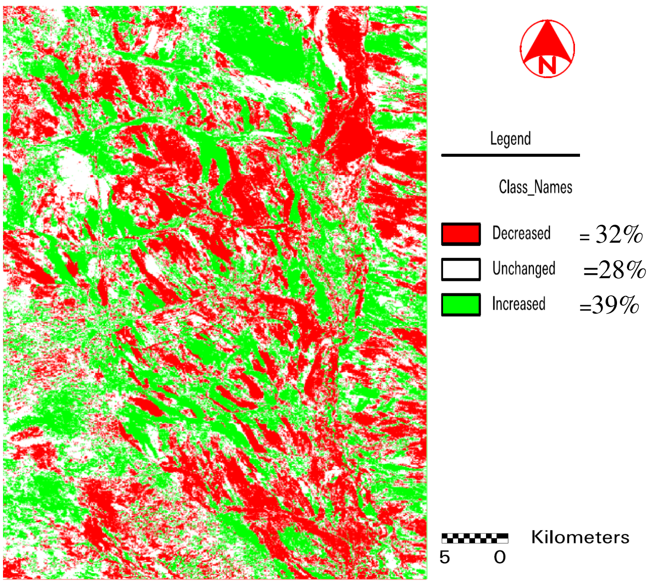

Fig.4: Vegetation change cover pattern from 1979 to 2010.

Conclusions and Recommendations

The study concludes that remote sensing provides important tools for generating and analyzing information on land degradation status and its geographical extent in the Eastern Sudan. Therefore, it is recommended as a most suitable approach to periodically monitor land degradation processes in the semi-arid area of the (GAS) of Eastern Sudan.

Also, Remote sensing technology offers an innovative potential avenue to acquire, analyze and visualize land use and land cover dynamics to address the related issues.

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