Land Use/Land Cover Change Detection due to Urbanization Case Study: Southern part of Khartoum

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Land Use/Land Cover Change Detection due to Urbanization
Case Study: Southern part of Khartoum

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Abstract:
Overpopulation has become obsessed haunt the whole world, especially in developing countries due to continuous migration from rural areas to large cities and towns, as a result, these cities have greatly expanded and extended in all directions to accommodate those newcomers, this expansion has been at the expense of vegetation cover. In this study, Khartoum city also underwent a considerable population growth during the last decades, as a result, a part of the green belt South of Khartoum has been chopped down and converted into residential areas, e.g. Jabra district, Abuadam district, Al Azhari district, etc. This study aimed to point out the effect of urbanization on vegetation cover of Khartoum city using Remote Sensed and GIS data as integrated tools for land use change and land transformation over 39 years (1972 – 2011). Satellite images were obtained from the USGS Global web site as the main data for interpretations to create land cover maps of the study area and to locate the location. Three false colour composite (FCC) subsets images from Landsat TM and ETM+ were used in this study. An image of 1972 was enhanced by a Thematic Mapper (TM), while the 2006 and 2011 images were Enhanced using Thematic Mapper Plus (ETM+). Landsat TM 1972 was used as a reference image, while the images ETM+ 2006 and 2011 were used to assess the change detection. ERDAS IMAGINE 9.2 and Arc 9.3 software were used as the processing and analyzing tools; whereas ERDAS software is used in obtaining multi-spectral classifications. The results show that there is a significant decrease of vegetation from 29% in the 1972 to 8% in 2006, bare land decreased from 20% to 2%; while urban areas increased from 47% in 1972 to 85% in 2006, in addition to an insignificant increase in water bodies. The study concluded that RS and GIS are effective tools to assess land use land cover change, which revealed that: the Southern part of Khartoum shows a remarkable land cover change due to urbanization that will seriously endanger the whole state if no serious attempts or preventive measure were taken to mitigate its effect on vegetation cover, which in turn will affect the climate, because one of the main causes of the climate change is deforestation.

***Index wards*:** Change detection, land use, land cover, Urbanization, GIS, RS.

I. Introduction:

More than ever before urbanization is an important issue all over the world therefore is considered a global phenomenon. The world has experienced its fastest rate of urbanization since the second half of the twentieth century, particularly in developing countries [1]. Globally, in 1950, 30% of the world's population lived in urban areas, in 2008 it was 50%, in 2014 was 54% and is projected to be 70% in 2050 [2]. Nowadays, the most urbanized countries are: North America (82%), Latin America and the Caribbean (80%), and Europe (73%), nevertheless, in Africa and Asia the reverse is true where only 40% and 48% of their respective population are urbanized. Africa and Asia are expected to be urbanized faster due to conflicts, drought, land degradation, economic instability, unemployment, etc., and are projected to be 56% and 66% urban respectively by 2050 [3].

There are many causes of migration to urban areas, including lack of employment, insecurity, reduction of agricultural productivity, lack of human life facilities, poverty, drought, natural disasters. Cities and towns have positive and negative trends; positive trends as commercial and employment opportunities, economic and social development, in addition to the basic facilities [4], whereas negative trends include competition for limited resources, overcrowding, pressures on infrastructure congestion, high cost. These might lead to poverty, unemployment, high crime rates,

insufficient housing, the growth of slums and shanty towns, traffic congestion, etc. [5].

Urbanization has global, regional, and local environmental problems because the natural vegetation cover is largely replaced by the city surfaces (concrete, high buildings, asphalt, and industries), this results in greater production and retention of heat, which in turn creates an urban heat island phenomenon. These changes in vegetation imply changes in the physical properties of the land surface, including surface albedo, surface roughness, leaf area index, rooting depth, and availability of soil moisture [6]. Other environmental problems include poor sanitation facilities, local climate change, increase energy demands, increased air and water pollution and shortage of water supply [7, 8]. The most significant impact of urbanization is on the surface air temperature, wind speed and direction; this can affect air quality, as well as human health [9]. According to UN expert, rapid urbanization together with changing environmental conditions, will affect the basic sanitation systems and create an unhealthy situation which in turn leads to epidemics. These epidemics potentially cause humanitarian and environmental nightmares [10].

In Sudan, Khartoum city underwent a considerable population growth during the last decades, e.g. the population was six times in the year 1988 than in 1956, and if it is growing by this rate, it will be more than nine times by the year 2010 [11]. The population increase in this area is mainly due to the migration from rural areas, thus the state has greatly expanded and extended in all directions to accommodate those newcomers, therefore this expansion has been at the expense of vegetation cover, as a result, the green belt South of Khartoum has been chopped down and converted into residential areas e.g. Jabra, Abuadam, Al Azhari areas etc. This green belt was declared according to the central forest reserved in 1962. It occupies an area of about 28028ha (280.28Km2), the overwhelming parts of it was irrigated by Al Gezeira canal while the western block of it was irrigated from the sewage effluents of the city. A coppice system with a 10 year rotation was adopted for Eucalyptus and other coppicing species. The project was estimated to produce 300,000 building poles and 12,600 m3 of firewood and 2,000 tons of forage annually [12]. The main objectives of the establishment of the belt were: fire wood and round building pole production; recreation; experimental site for the students of the Technical Forestry College and the proposed Forestry School at the University of Khartoum at that time; fodder production and employment; soil conservation and protection of the city from sand storm that became frequent during summer and prior to rain [13].

II. MATERIALS AND METHODS

STUDY AREA

This study area was located in the southern part of Khartoum City which is characterized by a hot, arid climate with fluctuating mean annual rainfall of about 120 mm falling mainly in August [14]. Khartoum City has been constructed during the initial periods of colonization by Ibrahim Pasha of Egypt since 1821, and became a military center in 1824 [15] and the capital of the Sudanese possession of Egypt in 1830. The study was conducted on the green belt South of Khartoum and the surrounding areas of about 12553ha. This area is the most affected by intensive migration from rural areas as well as other states.

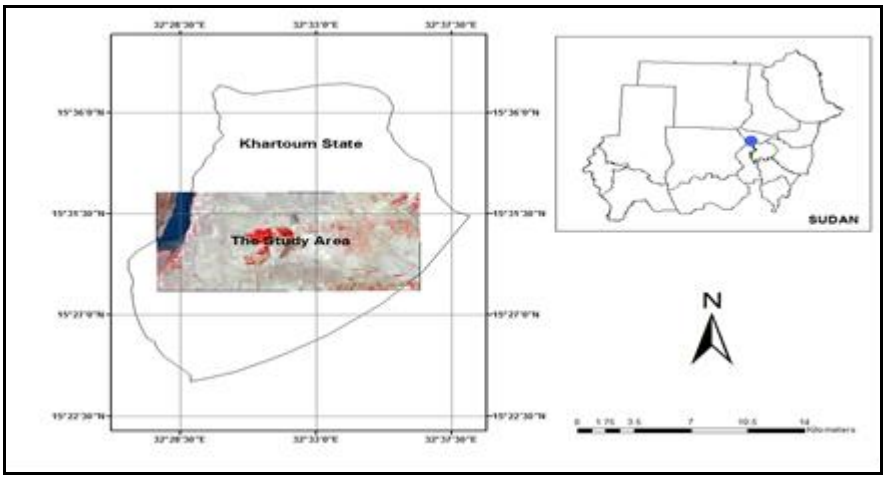

Fig. 1: Location map of the study area

METHODOLOGY

Descriptive data were obtained using Remote Sensing and GIS as integrated tools for land use, change and land transformation. The land use/ land cover condition of the study area was estimated for different time periods by using satellite imageries of years 1972, 2006, and 2011. These Satellite images have been interpreted and classified to show the change in the land cover and land use in the study area. Three false colour composite (FCC) subsets images from Landsat TM and ETM+ covering the study area were used to assess and measure the changes. The boundary of the study area was adjusted to the Landsat images. The Satellite imageries were obtained from the USGS Global web site. Image 1972 was a Thematic Mapper (TM), while the others images were Enhanced Thematic Mapper Plus (ETM+ 2006, and 2011). Landsat TM 1972 was used as a reference image to assess the change in the study area compared with the results that obtained from the other images (2006 and 2011). ERDAS IMAGINE 9.2 and ArcMap 9.3 software were used as the processing tools; ERDAS 9.2 was used as a main software for image classification. The Landsat data were geometrically corrected to each other in order to cut out the areas of interest and get the same size and exactly the same area using ERDAS. Bands 4, 3 and 2 (RGB) were used in TM1972, and ETM+ 2006, while bands 5, 4 and 3 RGB which represent the green, red, and infrared respectively in 2011 (Landsat 8), were used to develop a False Colour Composite (FCC) images. This combination of colours gives various shades and tones of red for healthy chlorophyll-rich vegetation in FCC image.

A supervised classification techniques (Maximum Likelihood Classification) were used to classify the two satellite image in order to extract information about the land use land cover of the study area within different periods. While the Object-Based oriented classification method was used to classify the satellite image ETM+ 2011 which obtained from (Landsat 8). Spectral classes were defined as a cluster of pixels which are characterized by a common similarity in their pixels. DNs in the multi-spectral space, where about 10 spectral signature file (Training areas) for each class used to classify the satellite images. The Change detection matrix was used to extract the change between the three classified images, which give more valuable information about the previous and recent periods.

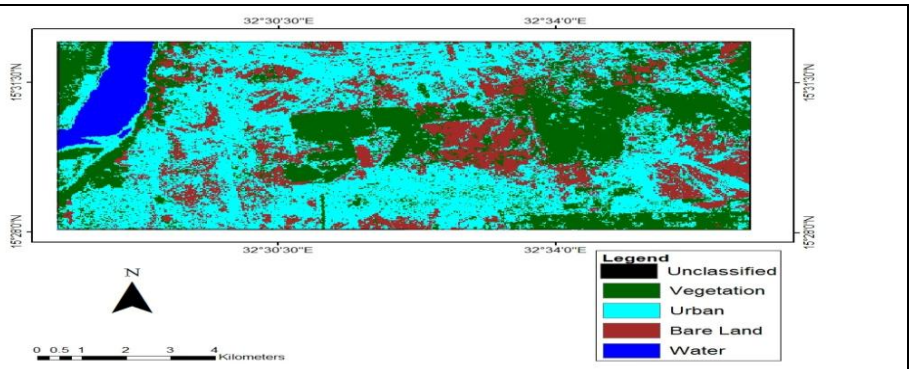

Fig. 2: A Classified Image of Year 1972

Fig.3: A Classified Image of Year 2006

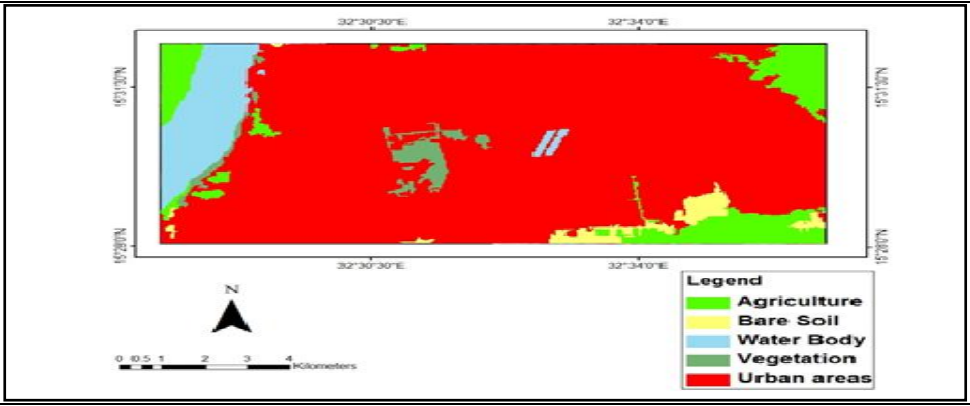

Fig. 4: A Classified Image of Year 2006

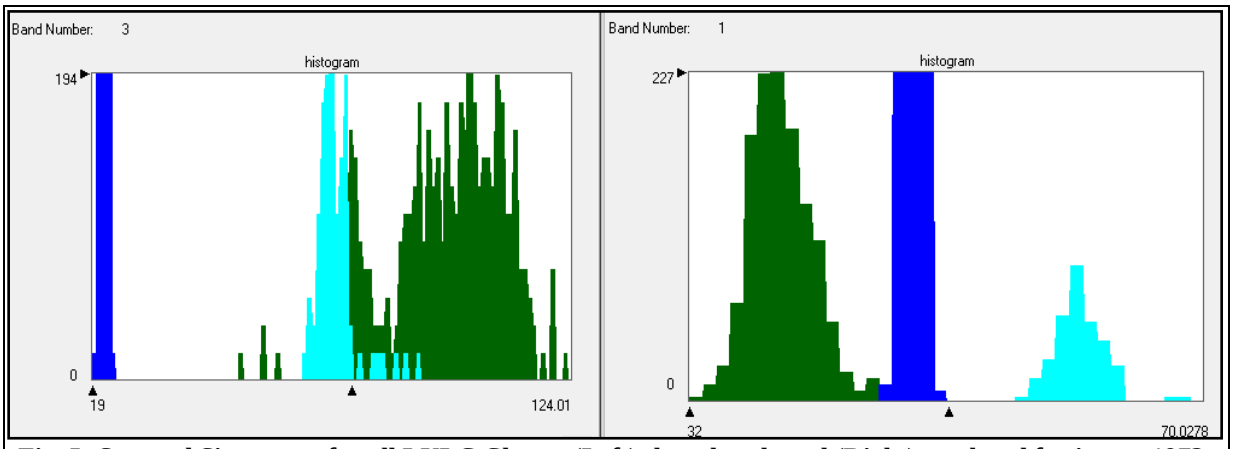

Fig. 5: Spectral Signatures for all LULC Classes (Left) three bands and (Right) one band for image 1972

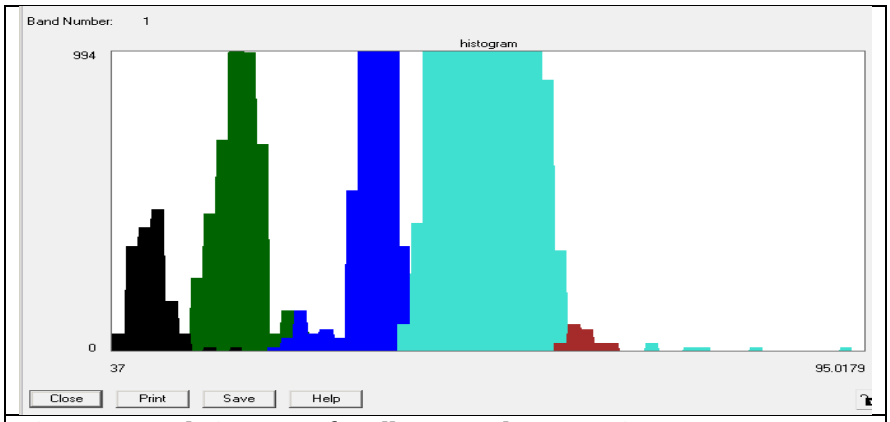

Fig. 6: Spectral Signatures for all LULC Classes For image 2006

III. RESULTS and DISCUSSIONS

The remotely sensed data revealed that, there was a clear change in the land use classes during the study period 1972 - 2011 (Fig. 1, 2 and 3). The results showed that, there was a steady decrease of vegetation cover in the area from 3645 ha (29%) in the year 1972 to 948 ha (8%) in the year 2006, with a negative change of about 2697 ha. This decrease directly related to urban expansion and income generation bases, and indirectly with higher migration rates of rural people in Khartoum as a capital of Sudan, searching for a better mode of living including education, income generation, health services etc. The bare area has dropped also from 2523 ha (20%) in the year 1972 to 207 ha (2%) in the year 2006 with a negative change of about 2316 ha, this decrease is due to a dramatic increase of urban settlements from 5884 ha (47%) during 1972 to 10644 ha (85%) during 2006, with a positive change of about 4760 ha. In addition to this, the area of water bodies shows a tiny increase from 502 ha (4%) in the year 1972 to 729 ha (6%) in 2006 with a positive change of about 228ha (Table 1 and Fig. 6). As a matter of comparison, there was slight land cover change from 2006 - 2011 because most of the study area has already been converted to residential areas, the appearance of agricultural lands of about 1114 ha that haven't seen before 2011 or might be found as scattered patches of negligible areas (Table 2 and Fig.7). This means that the overwhelming parts of the study area have been converted to residential areas significantly. The appearance of agricultural lands in 2011 might generally referred to a recent development in agricultural production and farming systems particularly after introducing the pump irrigated farming

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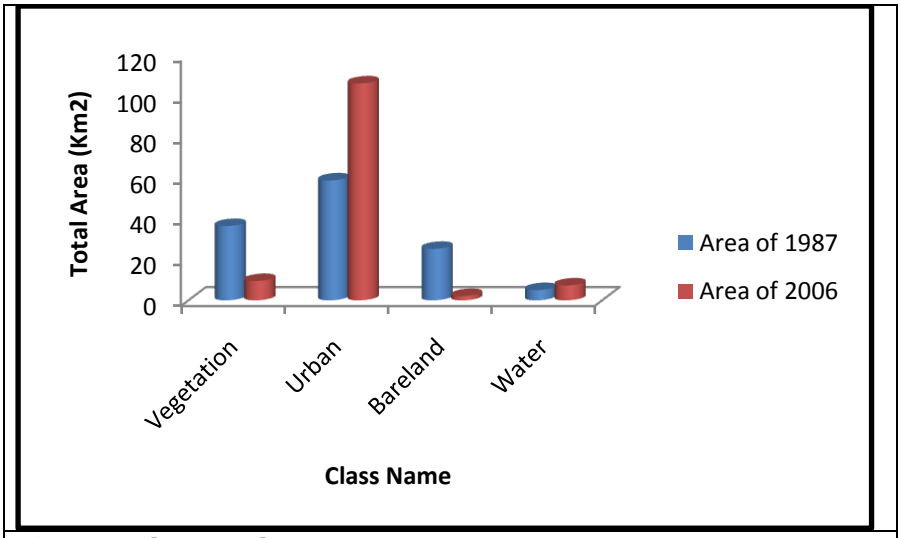

Fig. 7: Land Cover Classes 1972-2006

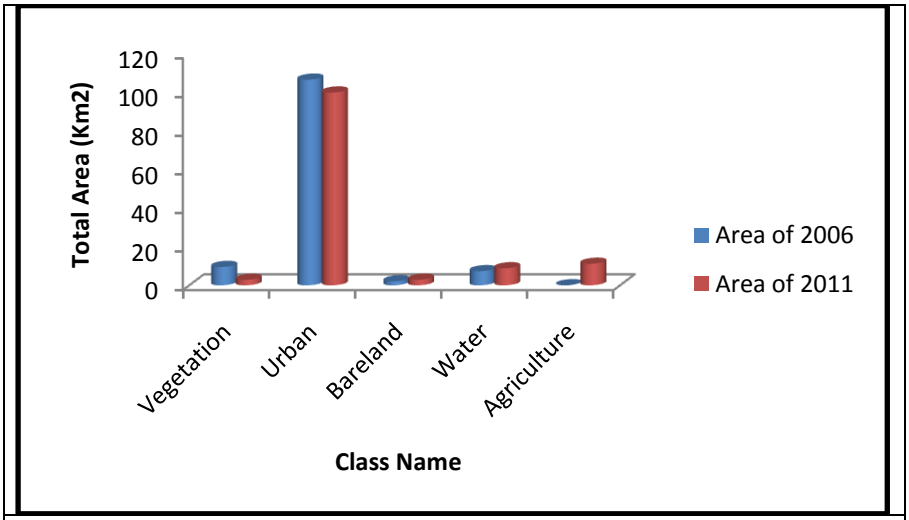

Fig. 8: Land Cover Classes 2006-2011

Table 1: Land Use Land Cover Classes during 1972 - 2006

Land use Type	Areas of 1972 (ha)	Area (%)	Areas of 2006 (ha)	Area (%)	LULC Change (ha)
Vegetation	3645	29	948	8	-2697
Urban	4884	42.2	9644	83.6	4760
Bare land	2523	20	207	2	-2316
Water	501	4	729	6	228
Total	**11553**	**100**	**11528**	**100**	-

Table 2: Land Use Land Cover Classes during 2006 - 2011

Land use Type	Areas of 2006 (ha)	Area (%)	Areas of 2011 (ha)	Area (%)	LULC Change (ha)
Vegetation	948	7	283	2	665
Urban	9644	83.6	9980	79.5	336
Bare Land	207	2	288	2	-81
Water	729	6	880	7	-151
Agriculture	0	0	1114	9	-1114
Total	**11528**	**-**	**12545**	**100**	**-**

IV. CONCLUSIONS AND RECOMMENDATIONS

Our study of this area has concluded by stressing the fact that RS and GIS are effective tools to assess land use land cover change, which revealed that: the Southern parts of Khartoum shows a remarkable land cover change due to urbanization that will seriously endanger the whole state if no serious attempts or preventive measure were taken to mitigate its effect on vegetation cover, which in turn will affect the climate, because one of the main causes of the climate change is deforestation.

The following points are highly recommended:

1) Adoption of strategies of urbanization and urban sprawl based on the green cover areas.
2) Raising awareness among inhabitants about the importance of trees, particularly on shanty towns
3) Additional research is needed on how to mitigate the effect of urbanization on vegetation cover
4) Introduction of urban forestry concept on urban planning

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