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Impact of Urbanization on Land Use/Land Cover — Case Study: The Western Part of Khartoum State, Sudan

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Abstract: LANDSAT images of the Western parts of Khartoum State were taken from 1987 to 2014 to assess the impacts of urbanization on Land use/cover using ENVI Imaging 4.5. Unsupervised IsoData method was adopted for land cover classification. Change detection statistics of the years from 1987 to 2000 show that the sand and urban areas gained 5.62 Km^2 (38%) and 4.35 Km^2 (9%) respectively. Whereas the bare land and water loss 1.02 Km^2 (9%) and 9.03 (17%) respectively. From 2000 to 2014 there was a loss of sand by 11.23 Km^2 (56%) whereas the bare land, the vegetation and urban areas gained 7.03 Km^2 (16%), 1.62 Km^2 (11%) and 2.87 Km^2 (6%) respectively. The results also show a decrease of sand, bare land and water by 5.72 Km^2 (40%), 1.97 Km^2 (4%) and 1.15 Km^2 (13%) respectively, while the residential areas and the vegetation gained 6.8 Km^2 (16%) and 2.04 Km^2 (14%) respectively from 1987 to 2014. The study concludes that urban expansion could expose the area to wind and water erosion and without sustainable management of natural resources, the whole ecosystem will be in danger.

Key words: urbanization, change detection, GIS, RS

1. Introduction

Urbanization, population growth and globalization are considered one of the contributing factors to climate change [1, 2] resulting in the removal of vegetation cover and deterioration of ecosystems as well as natural resources. Urbanization is seriously threat the ecosystems as well as natural resources particularly, vegetation cover. This might lead to land cover change of the whole area. Urban expansion has increased rapidly since the second half of the twentieth century [3]. According to the United Nations, 2007a, about 30% of the world population lived in urban areas in 1957, increased to 50% in 2008, and predicted to reach 70% of the world population will urbanized by 2050. It was estimated that about 93% of urban growth will occur in developing nations, 80% of which occurring in Asia and Africa [4]. Globally, LULC changes caused by urbanization have created many environmental problems on biodiversity, air quality and water supplies [5]. The impact on air quality occurred by increasing the global atmospheric concentrations of the greenhouse gases during industrial revolution. Additionally, creating higher atmospheric temperature compared to the surrounding rural areas; this is due to the replacement of natural vegetation by the city surfaces (Urban Heat Island) [6, 7]. Other environmental problems include insufficient housing, traffic congestion, poor sanitation facilities, increase energy demands, increased air and water pollution and shortage of water supply [8, 9]. According to Auber (2013) [10], rapid urbanization together with changing environmental conditions, will

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affect the basic sanitation systems and create an unhealthy situation, which in turn leads to epidemics.

The current situation of the study areas shows large urban expansion particularly towards the northern and the western parts, which are affected by desert encroachment. Therefore, the study of the impact of rapid urbanization on the climate have become a top priority for better understanding of the relation between urbanization and the climate change issues. This study emphasizes on improving urban environment through intensification of urban afforestation programmes.

2. Materials and Methods

2.1 Site Description

This study area was located within Khartoum State focusing on the western parts particularly, Omdurman area. The state characterizes by a hot, arid climate with fluctuating mean annual rainfall of about 120 mm falling mainly in August [11]. It consists of seven localities namely: Bahri, Karrari, Omdurman, Ombada, Jebel Awlya, Khartoum and Shareq Alneel and covering an area of about 46,747 square kilometres. It was constructed during the initial periods of colonization by Ibrahim Pasha of Egypt since 1821, and became a military centre in 1824 [12]. This area is the most affected by intensive migration from rural areas as well as from other states resulting in its expansion at all directions even at marginal areas; such as watershed areas and around seasonal channels (Fig. 1).

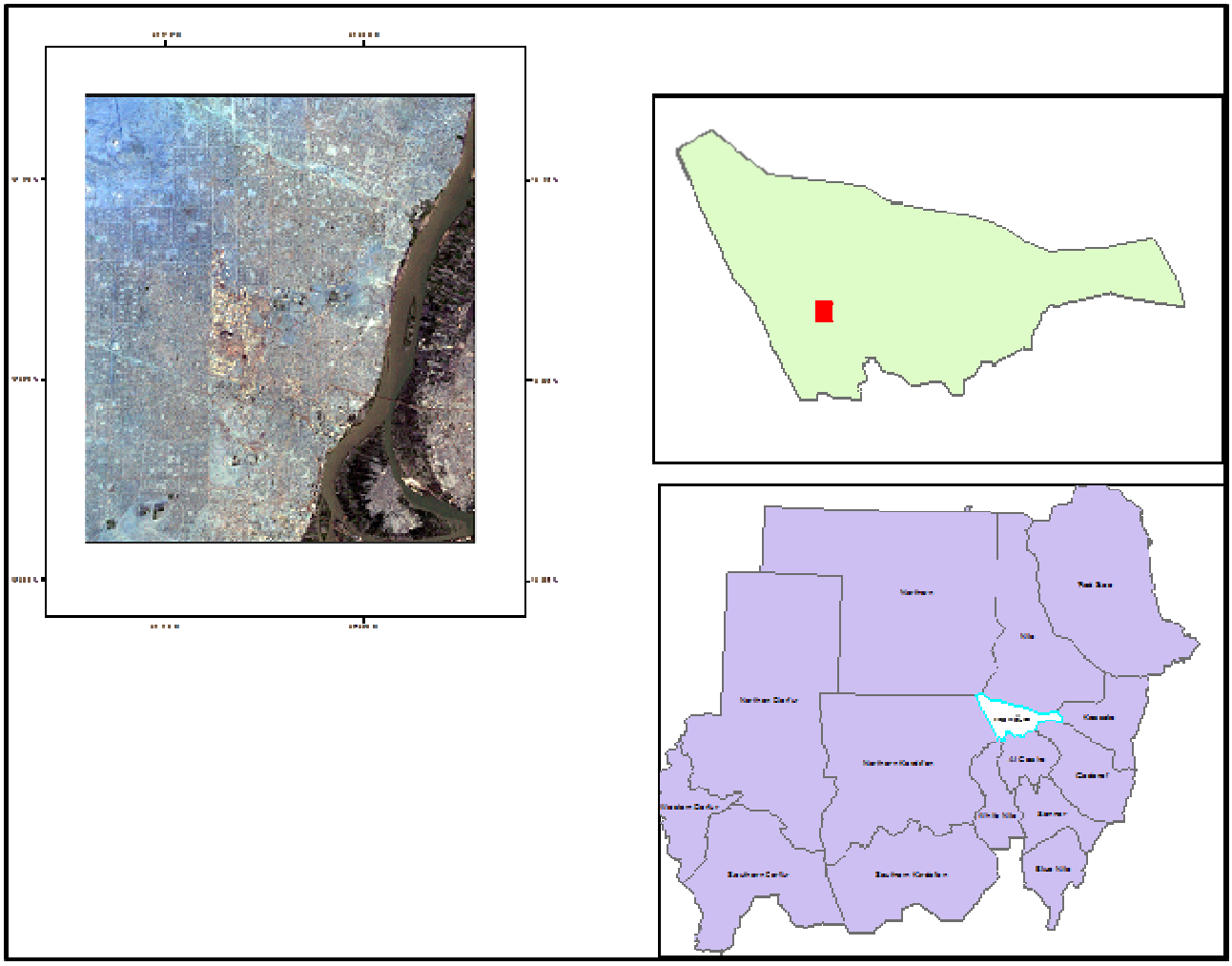

Fig. 1 Studyarea.

2.2 Methodology

The Data obtained using USGS GLOVIS, LANDSATS 4-5 Multispectral scanner and Thematic Mapper (TM) of the study area in December 1987, 2000 and 2014 with zero cloud. The study area was determined by creating a subset data via ROI for the three images using Erdas Imagine 2014, the data were geometrically corrected to each other, bands 4, 3, and 2 RGB were used to develop a False Color Composite (FCC) images, which represent Red, Green and infrared respectively. Unsupervised classification of 5 classes and 24 Iteration were identified on clipped images using ENVI Imaging 4.5 and change detection table were derived. ArcMap10.3 was used for further processing. Landsat TM 1987 image was used as a reference image to assess the change in the study area compared with the results that obtained from 2000 and 2014 images (Figs. 2 and 3).

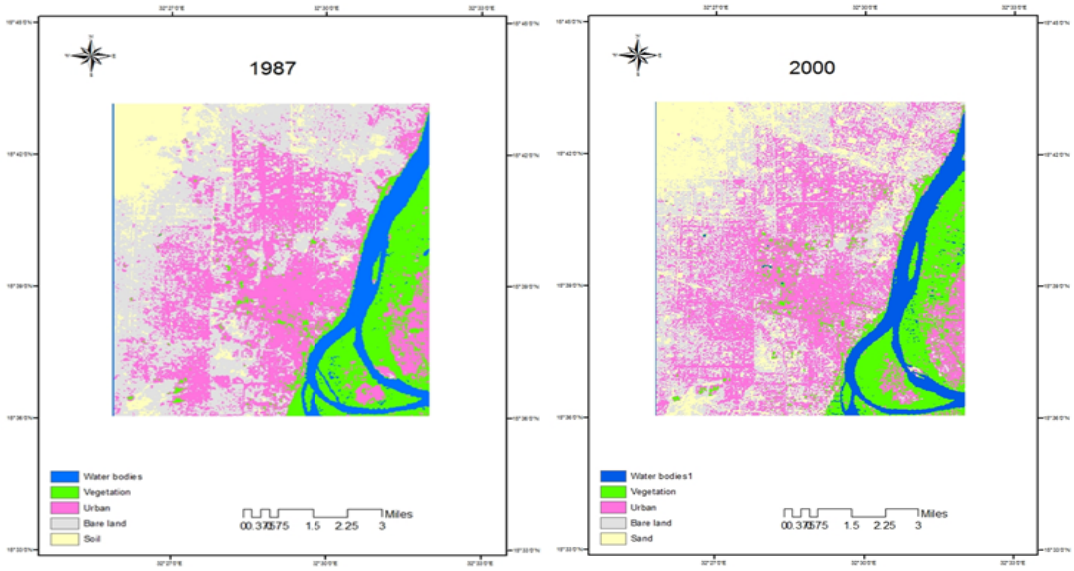

Fig. 2 Classified images 1987 & 2000.

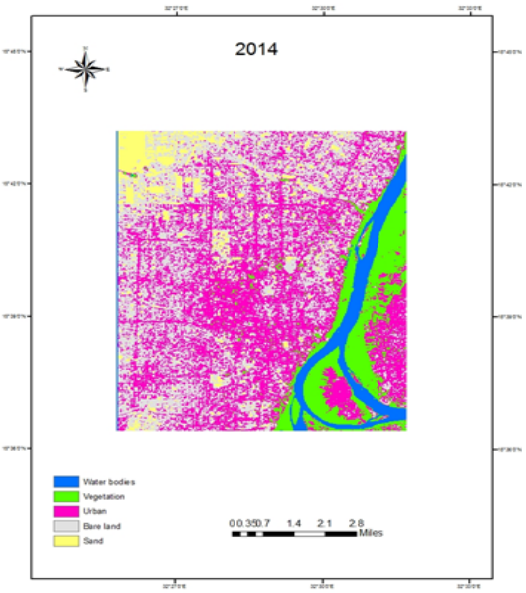

Fig. 3 Classified image 2014.

3. Results & Discussion

In a broad sense, change detection statistics of the years from 1987 to 2000 show that, the sand and urban areas gained 5.62 Km^2 (38%) and 4.35 Km^2 (9%) respectively. whereas the bare land and water loss 1.02 Km^2 (9%) and 9.03 (17%) respectively (Table 1 and Fig. 4). As this area is characterized by desert nature where the extreme climatic conditions have an influential adverse effect on the assemblage and distribution of vegetation cover. Therefore, vegetation land cover in Omdurman is generally poor and only the narrow vegetation strip parallel to the western bank of the White and Blue Niles. Some scattered trees along the streets and houses exist. Vegetation cover and small

shrubs in the fringe areas of the town absorbed by urban and suburban development.

The period 2000 to 2014 witnessed insignificant change of water bodies, a sharp loss of sand by 11.23 Km^2 (56%) whereas the bare land, the vegetation and urban areas gained 7.03 Km^2 (16%), 1.62 Km^2 (11%) and 2.87 Km^2 (6%) respectively (Table 2 and Fig. 5). The characteristics of such land use changed dramatically from 2000 to 2014 might be due to the fact that many areas have converted to high-density areas and became part of the main city while other was completely absorbed in the city boundaries. The alteration of natural environment by human activities in different ways such as agriculture, constructions and paving of new roads along with natural calamities led to decrease in land cover in the study area.

Change detection statistics of the period 1987 to 2014 show a decrease of sand, bare land and water by 5.72 Km^2 (40%), 1.97 Km^2 (4%) and 1.15 Km^2 (13%) respectively, while the residential areas and the vegetation gained 6.8 Km^2 (16%) and 2.04 Km^2 (14%) respectively (Table 3 and Fig. 6).

Table 1 Change detection statistics (Km^2) 1987-2000.

Land classes	Water bodies	Vegetation	Urban	Bare land	Sand
Water bodies	8.82	1.01	0.09	0.03	0
Vegetation	1.53	13.59	2.89	0.56	0.03
Urban	0.24	3.28	28.56	17.32	0.95
Bare land	0.23	0.58	12.93	27.22	3.77
Sand	0.14	0.07	1.53	8.64	9.87
Class Total	10.97	18.52	46	53.77	14.62
Class Changes	2.15	4.93	17.44	26.55	4.75
Image Difference	-1.02	0.08	4.35	-9.03	5.62

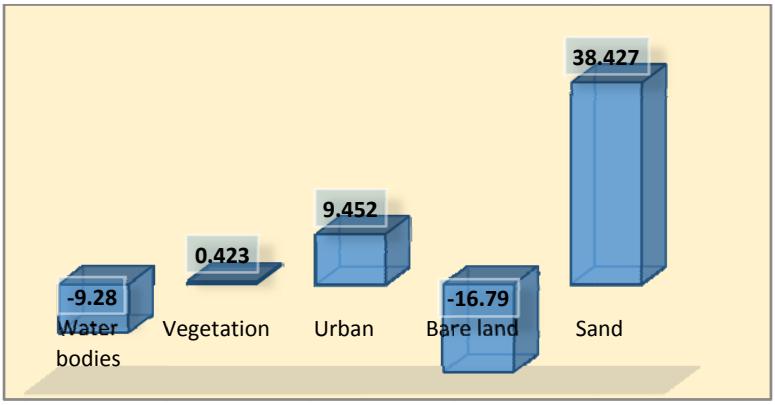

Fig. 4 Change detection in percentage (1987-2000).

Table 2 Change detection statistics (Km^2) 2000-2014.

Land classes	Water bodies	Vegetation	Urban	Bare land	Sand
Water bodies	2.84	2.03	1.82	0.95	0.21
Vegetation	4.65	6.01	2.8	1.98	0.51
Urban	0.58	5.12	22.58	16.97	4.43
Bare land	0.07	1.1	18.16	20.87	9.96
Sand	0	0.07	1.44	2.36	4.91
Class Total	8.15	14.32	46.8	43.13	20.02
Class Changes	5.31	8.31	24.22	22.26	15.1
Image Difference	-0.29	1.62	2.87	7.03	-11.23

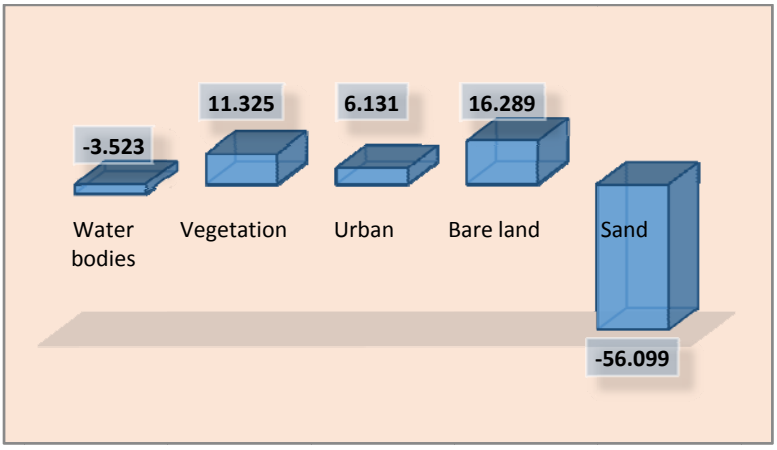

Fig. 5 Change detection in percentages (2000-2014).

Table 3 Change detection statistics (Km^2) 1987-2014.

Land classes	water bodies	Vegetation	Urban	Bare land	Sand
Water bodies	2.96	1.85	1.95	0.71	0.02
Vegetation	4.81	6.16	3.21	1.66	0.1
Urban	0.53	4.99	20.96	20.34	2.58
Bare land	0.26	0.85	15.26	25.8	7.2
Sand	0.08	0.05	1.22	2.82	4.29
Class Total	8.63	13.9	42.6	51.34	14.19
Class Changes	5.67	7.74	21.64	25.53	9.9
Image Difference	-1.15	2.04	6.8	-1.97	-5.72

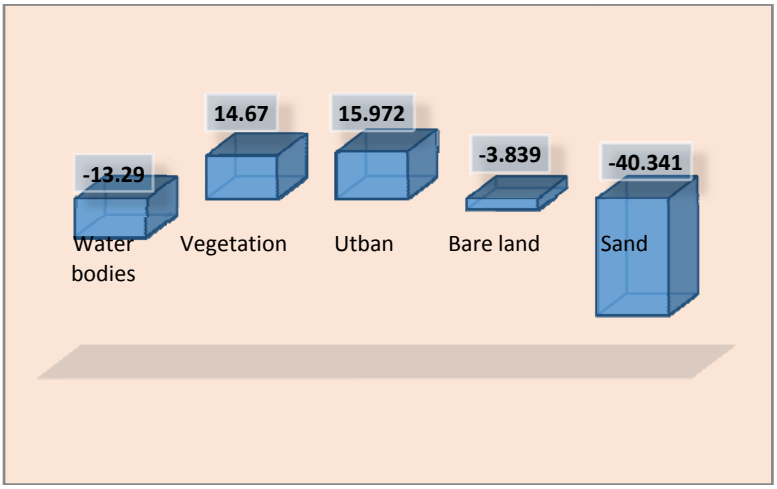

Fig. 6 Change detection in percentages (1987-2014).

The findings by Alsalman et al. (2012) [13], and Adam et al. (2012) [14] support the results where both concluded that human interferences are sorely affect the nature and its ideal land use, as well as the advantages of using remote sensing and GIS in natural resources assessment and land use change monitoring.

The researchers emphasize the effectiveness of remote sensing and geographical information systems techniques as sole tools for change detection. The study concluded that urban expansion at the expense of vegetation could expose the area to wind and water erosion particularly the northern parts beyond latitude

14° N. It is paramount that this point necessitates the importance of introducing landscape management, urban forestry and environmental conservation for SDGs, which are in line with Copenhagen conference on climate change vision.

Finally, it is highly recommended that:

- Intensification of urban afforestation
- Construction of wind breaks at the northern parts of the state against sand encroachment
- Reservation of marginal areas
- Raise people awareness about the importance of urban greening

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