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Land use/cover Change Detection Using Remotely Sensed Data and GIS (1984 - 2014) Case Study: Al-Ubayyid Area- Sudan

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Abstract: This study was conducted in the Al-Ubayyid Area in North Kordofan State (1985 to 2014), its aim was to assess the Land use/cover change using Remote Sensing and GIS technologies. A supervised (Maximum likelihood) method was implemented for land cover classifications. The overall results from the change detection report show a noticeable change in the land use classes during the study period of (1984 – 2014. During the period 1984 – 1994, there was a decrease of bare land 1 and vegetation, and a significant expansion of urban areas; this might go back to heavy migration of rural people to the city due to conflicts and drought. During (1994 – 2014), there was an observable loss of sand and water, and a gradual increase of vegetation; this might be attributable to intensive afforestation programs followed by the construction of the green belt of Al-Ubayyid area. During the period 1984 – 2014, there was a dramatic increase of bare land 2 and urban areas, and a decrease of bare land 1 and sand. The research concludes that urban growth has led the city to expand outward at the expense of vegetation cover and bare land. However, in the absence of wise; land management, serious land use problems will occur in the near future. This might negatively impact the ecosystems of the whole area of North Kordofan State.

Keywords: Al-Ubayyid Area, Land use, Change Detection, Remote Sensing, GIS

المستخلص: أجريت هذه الدراسة في منطقة الأبيض بولاية شمال كردفان خلال الفترة (1985 – 2014) بهدف تقييم استخدام الأرض وتأثيره على الغطاء النباتي بتقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية. أشارت النتائج الكلية بان هناك تغيرا ملحوظا في أصناف استخدام الأرض خلال فترة الدراسة. ففي الفترة 1984 – 1994 كان هناك انحساراً في الأراضي الجرداء (1) والغطاء النباتي، وتمدد الرقعة الحضرية، ويعزى هذا إلى النزوح الكثيف لسكان الريف والقري المجاورة إلى المدينة بسبب النزاعات والجفاف. خلال الفترة من 1994 إلى 2014 كان هناك إنحسار ملحوظ للرمل والماء، وزيادة تدريجية في الغطاء النباتي؛ ويعزى ذلك إلى برامج التشجير المكثفة وإنشاء الحزام الأخضر لمنطقة الأبيض. خلال الفترة من 1984 إلى 2014 كان هناك توسع شاسع في الأراضي الجرداء (2) والمناطق الحضرية وإنحساراً في الأراضي الجرداء (1) والرمال. يخلص البحث إلى أن هناك تمدد عمراني واسع النطاق على حساب الغطاء النباتي والأراضي الجرداء، وهذا قد يؤدي إلى ظهور مشكلات كبيرة في استخدام الأرض في المستقبل القريب، وإذا لم تتوافر الإدارة السليمة لإستخدام الأرض قد تؤثر هذه المشكلات سلباً على النظم الإيكولوجية لولاية شمال كردفان بأكملها.

كلمات مفتاحية: منطقة الأبيض، دراسة التغير في استخدام الأرض والغطاء النباتي، الاستشعار عن بعد، نظم المعلومات الجغرافية

1- Introduction

Land use refers to human economic activities that are carried on a particular land cover such as agriculture, settlement, grazing, etc. While land cover refers to the physical materials on the surface of land, such as vegetation, bare land, wetlands and water as well as artificial construction (Longley *et al.*, 2001). Land use/cover change (LULC) is mainly due to human pressures on vegetation cover for urban expansion (infrastructure, transportation) due to economic, technological, institutional, cultural and demographic factors< Therefore, people are the main cause of the global environmental change (Vitousek, 1994; Moran, 2001; Turner, 2001). Other factors include natural factors such as floods, hurricane, earthquake, pests, etc. These changes have affected the function of global ecosystems in many areas and have contributed to the overall climate change. The impact of these changes affects the ability of the biological systems to support human needs. Deforestation and deterioration of ecosystems and natural resources due to different practices including urbanization, population growth and globalization is another contributing factor to the climate change. It is found that the world's natural forests decreased by 16.1 million hectares per year on average during the 1990s, which is about 4.2% of the natural forest that existed in 1990 (Lambin, 2003).

Population growth and urbanization have increased rapidly since the second half of the twentieth century. According to the United Nations (2007a), about 30% of the world population lived in urban areas in 1957, this increased to 50% in 2008, and is predicted to reach 70% by the year 2050. Nowadays, the most urbanized countries are North America (82%), Latin America and the Caribbean (80%), and Europe (73%+). However, 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 urbanize, faster due to population growth, conflicts, drought, land degradation, economic instability, unemployment, etc., and are projected to grow by 56% and 66% urban respectively by 2050 (Tawhida, *et al.*, 2015).

Land cover change detection may help to understand the mechanism of land response to many users, and provide valuable references for future management decisions, as well as planning and implementation of land use schemes to meet the increasing demands of basic needs (Biswas, 2016). Many researches used different satellites for change detection; for instance, Selçuk (2014) used Landsat MSS and Landsat ETM+ for Analysing Land Use/Land Cover Changes in Rize, North-East Turkey. Alqurashi and Kumar (2014) used TM 4, 5 and IKONOS images for Makkah City and a SPOT image for Al-Taif Province. Rawat (2015) used Lansat TM for monitoring change at Hawalbagh block, India. Joao (2014) used Landsat MSS, Landsat TM and Landsat ETM+ for change dynamics across the Brazilian Amazon, etc.

2-Environmental implications of changes:

Globally, LULC is the most important driver of global biodiversity change and extinction of terrestrial species, because any change of landscapes from natural vegetation to any other use, typically results in habitat loss, land degradation and fragmentation. Deforestation can result in biodiversity loss, particularly in the tropics. This loss results in declines in ecosystem integrity and genetic losses that might hinder future scientific advances in agriculture and pharmaceuticals. Population growth increases the demand for agricultural land, causing the loss of natural habitat and species extinctions. According to Elmhagen (2014), biodiversity loss changes the structure and function of ecosystems, which might affect human societies through changes in ecosystem services, Therefore, he emphasises the fact that land use is the main driver of climate change.

Vegetation and soils are the main natural carbon sink because they sequester carbon from carbon dioxide through photosynthesis. Clearing of land reduces its ability to act as carbon sink. This leads to the retaining of more CO_2 in the atmosphere, which in turn increases the total amount of greenhouse gases. Clearing of land also creates higher atmospheric temperature compared to the surrounding rural areas in a phenomenon known as urban heat islands. LULC also leads to slight reductions in surface runoff, groundwater discharge and stream flow (Zhuotong, 2016). More than 60% of the global population living in downstream areas are negatively affected by the impacts of land use/land cover, change of water resources and water shortages. Due to urbanization, between one quarter and one-half of the population in developing countries lacks in clean water and has poor sanitation facilities resulting in the spread of diseases. Other environmental problems include traffic congestion, slum formation, increased energy demands, increased air and water pollution (Jianguo and Diamond, 2005).

Different types of satellites were widely used for studying LULC; these are Landsat Multispectral Scanner (MSS), Landsat 4, 5 Thematic Mapper (TM), Landsat 7 ETM+. They have been widely utilized for monitoring and mapping land cover changes since 1972 in forest and agricultural areas (Campbell, 2007). They have relatively high resolution and provided data for oceanography, aerosols, bathymetry, vegetation types, peak vegetation, biomass content analysis, moisture analysis, cloud cover analysis, thermal mapping, soil moisture estimation (NASA, 2013 and USGS, 2013). SPOT1, Ikonos, Quick bird and SPOT6 launched in 1986, 1999, 2001, and 2012 respectively, all need purchases from Digital Globe or a commercial reseller. They have quite high resolution providing data for mapping, change detection, planning (engineering, natural resources, urban, infrastructure), land-use, environmental impact assessment, tourism, military, crop management, environmental monitoring (EADS, 2013 and SIC, 2013).

Change detection techniques are used to monitor LULC change, deforestation, urban expansion, shifting cultivation, impact of natural disasters (Priyanka *et al*., 2013). Usually, change is detected by comparing two satellites or aerial imagery taken at different times of the same area. There are two methods of classification; pre-classification methods refer to operations carried out to bring satellite images to the desirable geometric and spectral standard, whereas, post-classification methods refer to activities done after classification such as the computation of statistics, accuracy assessment and map preparation.

The current situation of the study area shows large urban expansion at the expense of vegetation cover, leading to the removal of almost all the green belt. Therefore, the ultimate objective of this research is to assess, evaluate and monitor the nature of land cover changes in the Al-Ubayyid Area during the period 1985 – 2014 using remote sensing and GIS technologies. Studying the effect of such changes on the climate has become a top priority for improved Knowledge of the land change trend and its relation to climate change. This study calls for improving the environment of the area.

3-Materiaks and methods:

Al-Ubayyid Area is a part of the Sheikan locality of North Kordufan state. The state is located in the middle part of Sudan and characterized by arid and semi-arid conditions with an average rainfall of more than 350 mm (Manal *et al*, 2014). It is estimated that about 40% of the total state area is affected by desertification (WFP. 2010). The state lies between latitudes 12° 20′ N and 13° 40′ N and longitudes 29° 20′ E and 30° 40′ E (Figure 1) and covers an area of about 244, 700 km^2 with a population of 2.9 million (Sudan census 2008). Approximately 80% of the population lives in rural areas and only 20% live in urban centres. Most rural people are nomads mainly Kababish, Guamaa, Bideriya, Dar Hamar and Dar Hamid. The rational for site selection stemmed from the fact that this area is the most important producing Gum Arabic. It has been affected by drought, lack of water and pest infestation during recent decades. This area is also located in the immediate hinterland of Al-Ubayyid where, the vegetation cover has been removed due to settlement expansion.

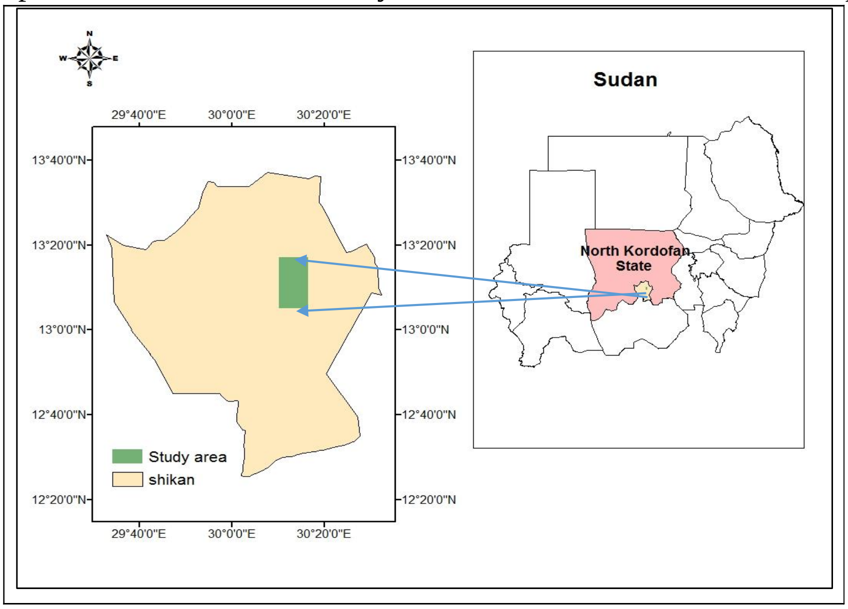

Figure 1: Location of the Study Area

Data for the study area was selected from USGS GLOVIS, LANDSATS 4 - 5 (TM) of Al-Ubayyid area in September 1984, 1994 and Landsat 8 for the image in October 2014 with zero cloud. The study area was determined by creating a subset data via ROI for the three images using ENVI IMAGINE 4.5. Bands 7, 4, 2 were used to develop a False Colour Composite (FCC) for images of 1984 and 1994, whereas, bands 7, 5, 3 were used for 2014 image. These bands represent RGB colors respectively (Figure 2). A Supervised Classification method with a Maximum Likelihood algorithm was applied on clipped images using ENVI Imaging 4.5. Five classes were identified in the study area water bodies, vegetation, urban areas, bare land and sand. Landsat TM 1984 image was used as a reference compared with 1994 and 2014 images to assess the change in the study area (Figure 3).

4- Results and discussion:

Figure 3 shows the classified images of the study area, while figure 4 represents the spatial distribution patterns of land cover in 1984, 1994 and 2014. The overall accuracy of the classes were 88%, 86% and 100% of the years 1984, 1994 and 2014 respectively, whereas, the overall kappa coefficients for the images of 1984, 1994 were 0.8224 and 1.00 for the image 2014. Tables (1, 2, 3, 4, 5 and 6) illustrate land cover change (area and percentages) that took place in the land use pattern of the study area during the periods 1984 - 1994, 1994 – 2014 and 1984 – 2014, respectively.

Table 1: Change Detection Statistics (Km^2) 1984 - 1994

Land classes	Vegetation	Water	Urban	Bare land1	Bare land2	Sand
Vegetation	6.99	0.42	4.51	18.59	1.32	3.99
Urban	30.83	0.22	14.93	63.11	1.09	11.82
Water	0.05	0.81	0.61	0	0	0
Bare land 1	2.29	0	0.11	19.46	0	1.26
Bare land 2	0.07	0	0.79	13.36	1.99	0.01
Sand	24.7	0.05	0.13	11.02	0	33.04
Class Total	64.93	1.49	21.09	125.55	4.4	50.11
Class Changes	57.94	0.69	6.15	106.09	2.41	17.08
Image Difference	-29.1	-0.02	100.92	-102.43	11.81	18.82

Table 2: Change Detection Statistics (Percentage) 1984 - 1994

	vegetation	Water	Urban	Bare land1	Bare land2	Sand
Vegetation	10.769	28.116	21.4	14.81	30.063	7.958
Urban	47.479	14.57	70.819	50.268	24.77	23.594
Water	0.079	54.004	2.898	0.004	0	0
Bare land 1	3.526	0	0.512	15.5	0	2.514
Bare land 2	0.104	0.181	3.756	10.64	45.167	0.013
Sand	38.042	3.131	0.615	8.778	0	65.921
Class Total	100	100	100	100	100	100
Class Changes	89.231	45.996	29.181	84.5	54.833	34.079
Image Difference	-44.817	-1.385	478.574	-81.587	268.24	37.552

Table 3: Change Detection Statistics (Km^2) 1994 – 2014

Land classes	Vegetation	Water	Urban	Bare land1	Bare land2	Sand
Vegetation	19.22	29.21	1.15	3	2.48	18.96
Urban	7.13	54.22	0.02	11.26	3.14	9.08
Water	0.03	0.1	0.3	0	0	0
Bare land 1	0.44	1.72	0	0.1	0	2.07
Bare land 2	3.26	10.14	0	1.64	10.51	0.38
Sand	5.75	26.6	0	7.11	0.08	38.44
Class Total	35.83	122	1.47	23.12	16.22	68.93
Class Changes	16.61	67.78	1.17	21.48	16.14	66.86
Image Difference	38.18	-37.13	-1.03	2.82	61.75	-64.6

Table 4: Change Detection Statistics (Percentage) 1994 – 2014

Land classes	Vegetation	Water	Urban	Bare land1	Bare land2	Sand
Vegetation	53.633	77.717	23.943	12.98	15.285	27.503
Urban	19.904	1.648	44.445	48.727	19.386	13.177
Water	0.095	20.635	0.084	0.004	0.006	0.001
Bare land 1	1.231	0	1.413	0.428	0.011	3.004
Bare land 2	9.101	0	8.315	7.101	64.841	0.551
Sand	16.036	0	21.8	30.76	0.472	55.764
Class Total	100	100	100	100	100	100
Class Changes	46.367	79.365	55.555	92.899	99.528	96.996
Image Difference	106.564	-69.902	-30.434	12.217	380.814	-93.71

Table 5: Change Detection Statistics (Km^2) 1984 – 2014

Land classes	Vegetation	Water	Urban	Bare land1	Bare land2	Sand
Vegetation	19.31	0.93	4.77	35.08	1.01	12.91
Urban	18.93	0.16	14.77	41.67	0.88	8.45
Water	0	0.37	0.05	0.02	0	0
Bare land 1	1.3	0	0.06	0.72	0	2.27
Bare land 2	0.47	0	1.25	21.59	2.51	0.12
Sand	24.93	0.03	0.19	26.47	0	26.36
Class Total	64.93	1.49	21.09	125.55	4.4	50.11
Class Changes	45.62	1.12	6.32	103.96	4.4	47.85
Image Difference	9.08	-1.05	63.79	-99.6	73.57	-45.78

Table 6: Change Detection Statistics (Percentage) 1984 – 2014

Land classes	Vegetation	Water	Urban	Bare land1	Bare land2	Sand
Vegetation	29.734	62.372	22.616	27.945	22.849	25.769
Urban	29.159	10.716	70.043	33.192	20.069	16.87
Water	0.001	24.865	0.235	0.016	0.041	0
Sand	1.999	0.06	0.265	0.57	0	4.522
Bare land 1	0.717	0.241	5.941	17.195	57.041	0.241
Bare land 2	38.39	1.746	0.901	21.082	0	52.598
Class Total	100	100	100	100	100	100
Class Changes	70.266	75.135	29.957	82.805	100	95.478
Image Difference	13.989	-70.319	302.488	-79.337	1670.55	-91.347

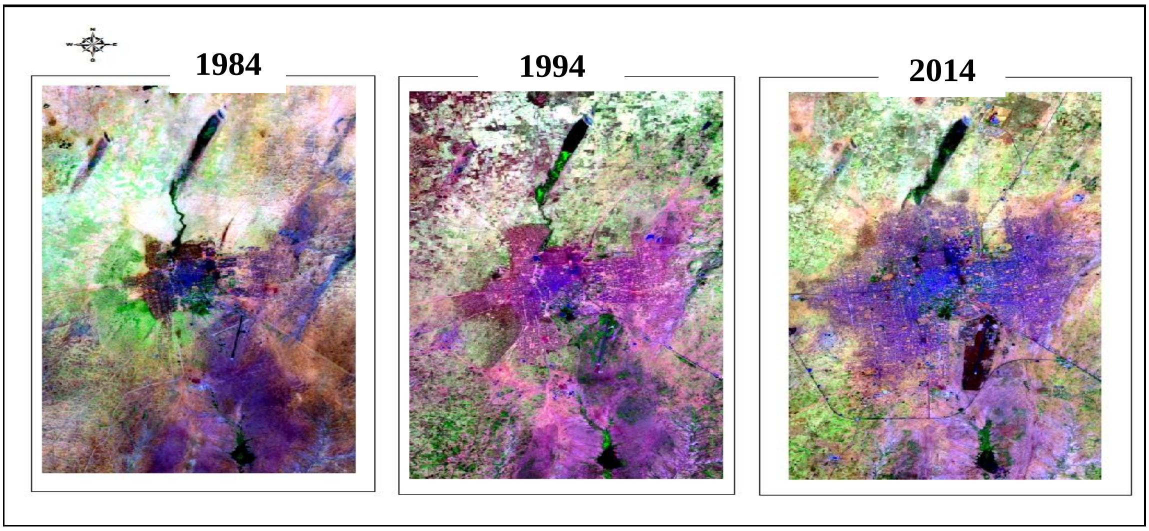

Figure 2: False Colour Composie Imagies (FCC)

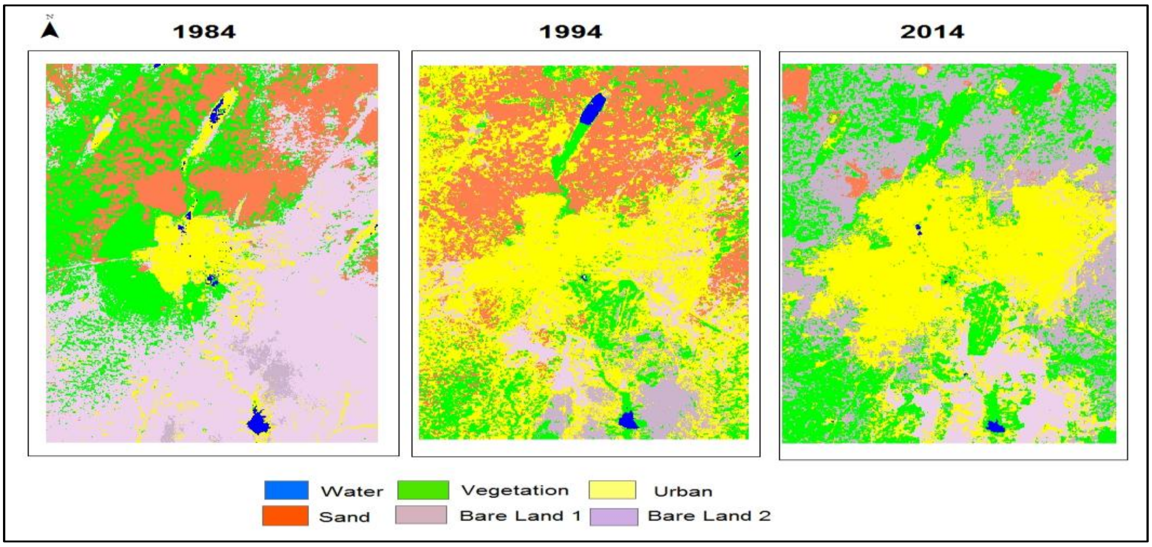

Figure 3: Classified Images (1984, 1994 and 2014)

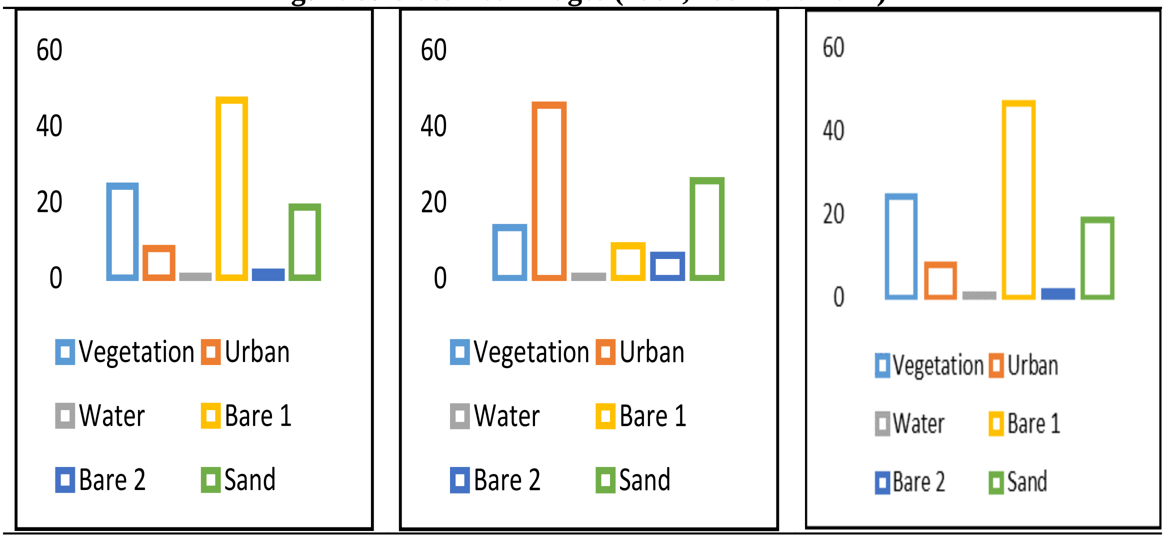

Figure 4: Distribution Pattern of Land Cover (1984, 1994 and 2014)

The change detection reports show a noticeable change in the land use classes during the study period of 1984 – 2014. Within the years of 1984 – 1994 there was a decrease of bare land 1 and vegetation, and a significant expansion of urban areas; this might be attributed to heavy migration of rural people to the city due to conflicts and drought (Tables 1 and 2). During 1994 – 2014 there was an observable loss of sand and water, and a gradual increase of vegetation; this is attributed to intensive afforestation programs followed by the construction of the green belt of the Al-Ubayyid area (Tables 3 and 4). During 1984 – 2014 bare land 2 and urban areas, show a dramatic increase and a decrease of bare land 1 and sand (Tables 5 and 6). This means that this area is under a high pressure of land use changes particularly urbanization; and in spite of the efforts for afforestation programs and the green belt, there is settlement expansion towards this belt. This might affect the whole ecosystem in the absence of well-planned sustainable development and soil conservation programs.

5-Conclusion and recommendations:

This research underlines the effectiveness of remote sensing and GIS in quantifying land cover changes with high accuracy and low cost. In conclusion, it is assessed that built up areas were significantly increased at the expense of vegetation, bare land or even sand area. If such practices are left without control of land use management, the whole vegetation cover at the outskirts of the Al-Ubayyid Area will disappear. The following points are highly recommended:

1. Raise community awareness about ecosystem conservation
2. Reservation of marginal areas particularly at the northern parts of the study area
3. Rehabilitation of the green belt
4. Settlement expansion should be directed towards the east
5. Land use is crucial for ecosystem stability
6. Intensification of urban afforestation programmes through community participation.

References:

- Alqurashi, A.F. and Kumar, L., (2014). Land Use and Land Cover Change Detection in the Saudi Arabian Desert Cities of Makkah and Al-Taif Using Satellite Data. In Advances in Remote Sensing 3 (3):106-119.
- Biswas, B., (2016). Change Detection of Land use and Land cover for sustainable Development. A case Study of Sanka River basin, India. Journal of Global Resources. Volume 3, pp-122-128.
- Campbell, J. B., (2007). Introduction to Remote Sensing, Fourth edition, The Guilford Press, New York, USA.
- EADS Astrium, (2013). Astrium GEO-Information Services SPOT International Price List. EADS Astrium.http://www2.astriumgeo.com/files/pmedia/.
- Elmhagen, B., (2014). Implications of climate and land-use change for landscape processes, biodiversity, ecosystem services, and governance. Department of Zoology, Stockholm University, 106 91, Stockholm, Sweden, https://www.ncbi.nlm.nih.gov/pmc.
- Jianguo, J., L., and Diamond, J., (2005). China's Environment in a Globalizing World-How China and the Rest of the World Affect Each Other. In Nature, Volume 435. http://csis.msu.edu/research/publications/
- Joao M. B., (2014). Land use and Land Cover Change Dynamics across the Brazilian Amazon: Insights from Extensive Time-Series Analysis of Remote Sensing Data. In Journal of PLOS ONE, http://journals.plos.org/plosone/
- Lambin, E. F., Geist H. J. and Lepers E., (2003). Dynamics of Land use and cover Changes in Tropical Regions, pp. 7
- Longley, P., Donnay, J., and Barnsley, M., (2001). Remote sensing and urban analysis, London, Taylor and Francis.
- Manal A. K, Tarig E. M, Elmar C, Hassan I., Abdelrahman A. K., (2014). Description and Assessment of Land Cover Changes in Relation to Climatic Conditions and

Socioeconomic Activities in Semi-arid Areas of North Kordofan State, Sudan. In University of Kordofan Journal of Natural Resources and Environmental Studies, UKJNRES, 1(2): 20-38, 2014ISSN: 1858-6686; ISSN: 1858-6694 www.kordofan.edu.sd

- Mor an, E, F., (2001). Progress in the Last 10 Years in the Study of Land-use / Cover and out Look for The Next Decade.
- NASA, (2013). Technical Details. Landsat Science. [Online] September 18, [Cited: September 19, 2013.] http://landsat.gsfc.nasa.gov/.
- Priyanka K., Krishna K., S., Singh, B., K., and Akansha M, (2013). Unsupervised Change Detection of Multispectral Images using Wavelet Fusion and Kohonen Clustering Network. International Journal of Engineering and Technology.
- Rawat, J., S., (2015). Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. In The Egyptian Journal of Remote Sensing and Space Science http://www.sciencedirect.com/science.
- Selçuk R., (2014). Land Use/Land Cover Changes in Rize, North-East Turkey. In Journal of Advances in Remote Sensing, Issue September (2014). http://dx.doi.org/
- SIC, 2013. Quick Bird satellite Imagery and Satellite system Specifications. Satellite Imaging Corporation. http://www. satimagingcorp.com/satellite-sensors/ quickbird.html.
- Quick Bird satellite Imagery and Satellite system Specifications. Satellite Imaging Corporation.http://www.satimagingcorp.com/satellite-sensors/quickbird.html.
- Tawhida A. Y., Abdelrahim A. M., and Elmugheira M. I., (2015(. Land Use/Land Cover Change Detection due to Urbanization Case Study: Southern part of Khartoum. In JOUR. NAT. RESOUR. & ENVIRON. STU., 3. 2, 1-8, (6) 2015 ISSN 1683-6456 (Print): ISSN 2332-0109 (Online).
- Turner, B. L, (2001). Towards Integrated Land Change Science. Advances in 15 Decades of Sustained International Research on Land-use and Land cover change. Berlin, New York, Springer Verlage.
- USGS, (2013). Frequently Asked Questions about the Landsat Missions. USGS Landsat Missions. [Online] August 29, 2013. [Cited: September 19, 2013.] http://landsat.usgs.gov/tools_faq.php.
- Vitousek, P., M., (1994). Beyond Global Warming: Ecology and Global Change. Ecology 75, 1861 – 1876.
- WFP. (2010). World Food Program. Emergency Food Security Assessment (EFSA). North Kordofan - Sudan