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Remote Sensing for Detection and Assessment of Forests and Range Lands Degradation in Al-Halba Area White Nile State Sudan (1973-2014).

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Abstract: This paper attempts to detect the change in forests and range lands in the arid lands of the Sudan in general, and in Al-Halba Area in particular during the last 40 years (1973-2014). The main objective of the study is to measure the amount and rate of change in vegetation cover including both forests and grazing lands. Basically, the study is based on Remote Sensing of satellite imagery of Landsat data acquired in 1973 and 2014. The data were processed and analyzed using open sources of GIS and remote sensing software. In addition, the complementary data needed for the study were drawn from the field work conducted in October, 2015, and from secondary sources. The analysis revealed considerable deterioration of natural resources including the tree cover and range lands in the study area.

One of the main findings of the study revealed that, forests have been degraded from (33512.72 Ha.) in 1973 to (10508 Ha.) in 2014, with an annual removal rate of 1.67% or (561 Ha). During this period, the area loss was about 70% of the tree cover. The range lands also shrank from (60665.84 Ha) to (52455.2 Ha) with an annual rate of 0.33% or (200 Ha) during the same period.

The decrease in forest cover occurred as the result in the expansion of some land uses and bare lands (agriculture, settlements, and bare soil), they expanded from (12924.5 Ha) in 1973 to (44819.75 Ha) in 2014, with an annual growth rate of 1.7% or (779 Ha). The main reasons of degradation of natural resources and expansion of bare lands may be due to the rapid growth of population which stands for about 3% annually and to the increasing demand for more land for agriculture and the building of settlements. The removal of forests and range lands has disturbed the inherited ecosystems, and contributed to desertification and loss of fauna and flora in the area. Efforts from both authorities and people should be exerted to promote awareness and actions on conservation of forest and range land ecosystems.

Keywords: forests and range lands, degradation, White Nile State, Sudan, remote sensing,

المستخلص: تناولت الورقة تدهور الغابات والمراعي الطبيعية في منطقة الهلبة بولاية النيل الأبيض، بهدف قياس وتقييم مستوى ذلك التدهور في الفترة بين عامي 1973 و 2014، ومن ثم محاولة معرفة أسبابه وتداعياته. استندت الدراسة على بيانات الاستشعار عن بعد وخاصة صور القمر الصناعي للاندسات لعامي 1973 و 2014 وتم معالجة البيانات وتحليلها ببرنامجERDAS IMAGINE ونظم المعلومات الجغرافية (GIS). هذا بالإضافة إلى عمل ميداني تم إجراءه في اكتوبر 2015 ، كما استفادت الدراسة من بعض الأدبيات التي تناولت موضوع الدراسة. أشار تحليل البيانات إلى حدوث تدهور مقدر في الموارد الطبيعية وخاصة الغابات والمراعي في المنطقة. كشفت الدراسة أن مساحة الغابات في العام 1973 تدهورت من 33512 هكتار إلى 10508 هكتار في عام 2014 بنسبة تناقص 1,67% سنوياً فيها فقدت المنطقة 70% من الغطاء الشجري والغابات والتي كانت تمثل 20% من مساحتها. كما تناقصت مساحة المراعي الطبيعية من 60666 هكتار الى 52455 هكتار بنسبة تناقص بلغت 0,33% أو 200 هكتارسنوياً للفترة نفسها. أوضحت الدراسة أن النمو السكاني الهائل في المنطقة والذي قدر بـ 3% سنوياً وما صاحبه من حاجة ماسة للأرض للعمران والزراعة يمثل السبب الرئيس في تدهور الغابات والمراعي. حيث كشفت الدراسة أن تدهور الغابات والمراعي الطبيعية في المنطقة جاء متزامناً مع تمدد هائل في العمران مع توسع كبير في الرزاعة وزيادة في الأراضي الجرداء حيث زادت من 12925 هكتار إلى 44820 هكتار في العام 2014 بمعدل زيادة بلغت 1,7% أو 779 هكتار سنوياً، مما يفيد أن التوسع في استخدام الأرض في الزراعة والعمران تم على حساب الغابات والمراعي الطبيعية. إن ازالة الغابات والمراعي الطبيعية ساهم في إختلال النظم البيئية السائدة، كما أدى أيضاً إلى تناقص التنوع النباتي والحيواني في المنطقة. توصي الدراسة بتركيز الجهود نحو استحداث برامج ومشاريع للمحافظة على البيئة وللتقليل من الاستغلال غير المرشد للموارد الطبيعية.

كلمات مفتاحية: تدهور الغابات والمراعي الطبيعية ، ولاية النيل الأبيض الاستشعار عن بعد،

1-Introduction:

The Sudan is one of the most affected African countries by environmental degradation particularly in the arid and semi-arid zones, where the disappearance of vegetation cover , the recurrent drought conditions, desert encroachment, deterioration of land productivity are the prevailing environmental problems (Warren, 2001 and Mustafa,2007). These interrelated environmental challenges have led to many ecological, economic and social difficulties for the communities living in the most affected areas.

Al-Halba area lies in the White Nile State, about 200 Km south of Khartoum and 70 km of the White Nile, bounded by Lat. 14° 00″ and 14° 25″ N., and long. 31° 31″ and 31° 51″ E, covering an area of 1071 Km² (Figure 1 and 2).

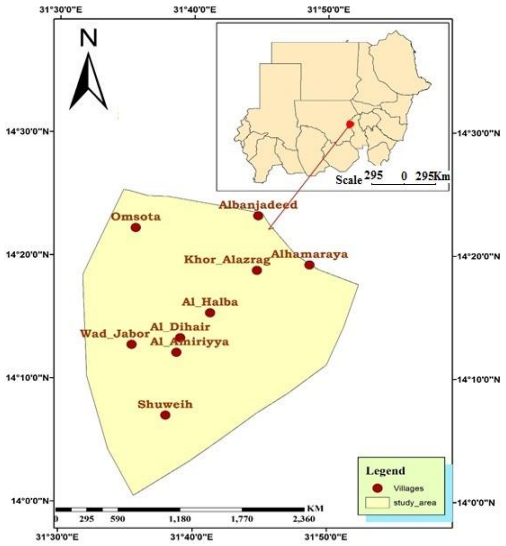
Ecologically, the area is part of the Arid Sahel Zone representing the most affected area in the Sudan (Warren, 2001). It constitutes an extension of the ecological sandy Sahel zone of Africa, with vegetation of semi-arid grass and shrubs, where ecological changes and rainfall variability are dominant phenomena (Alredaisy, 1993).

Since the 1960s, the area has been plagued by many interconnected problems in terms of deterioration of environmental ecosystems i.e. shrinking of vegetation cover and range lands, desertification, low productive capacity, and drying out of water sources (Wadi, 2007).

Change detection method is very important technique in remote sensing for assessing and measuring of land use/ land cover (LULC) changes, which can be applied for detecting social, economic and environmental changes between different periods of time (Bhatt, 2012). Change detection is one of the important methods used in Remote Sensing (RS). It can be defined as a process of identifying changes in the state of an object or phenomenon by observing images at different times (Violini, 2013).

In fact, the earth's surface is witnessing continuous changes due to physical or human factors. Therefore, assessing, tracing and measuring of these changes are very essential so as to understand the processes and causes of change.

This study is, thus attempts to assess and measure the changes of land uses particularly forest and range lands by using change detection method of Remote Sensing data based on satellite images acquired in 1973 and 2014. In other words, the paper is concerned with the changes of land use/land cover in the area as well as the interconnected environmental changes during the last 40 years.



Figure, (1): Location of the Study Area.

2. Methods and Material:

Change Detection is one of the most important methods of Remote Sensing based on comparison of multi-temporal data which have been selected dealing with specific area at different times (Campbell and Wynne, 2013). The evaluation of results indicates that various procedures of change detection produce different maps of change between the periods (Violini, 2013).

Presently, satellites have become a major source of detecting forests change because of their repetitive coverage (Sader, Bertrand, and Wilson, 2003).

The data required for the paper includes the following methods:

- Remote Sensing data (processing and analyzing of Satellite images).
- Field Survey conducted to collect some data.

Change detection requires remote sensing data about specific topic collected at different periods of time. The topic under study depends on Landsat Images. For 1973 the Landsat 1, Sensor ID (MSS) and Bands 1, 2, 3 were used. Landsat 8, Sensor ID (OLI_TIRS) and Bands 3, 4, 5 were used for 2014. By using open sources of remote sensing and GIS software, the images were classified to produce thematic maps to assess changes of forests cover and rangelands in the study area.

Despite the fact that the research depended on remote sensed data, a complementary field survey was conducted in in October, 2015. The main purpose of the field work can be summarized in the following:

- To geo-reference the administrative boundaries, forests, and main villages of the study area by using GPS (Global Positioning System).
- To select some points and features (bench marks) in the area to support the accuracy of the classification process.
- To conduct some observations and interviews for the documentation of vegetation cover.

3. Analysis and Results:

3.1 Data Processing

Change detection technique seeks to understand the pattern and process of change of phenomena which contributes to trend of changes and to predict its future prospect (Yoshino, 2012). The stages and the processes of detecting the topic under study can be illustrated in the following flow chart (Figure 2).

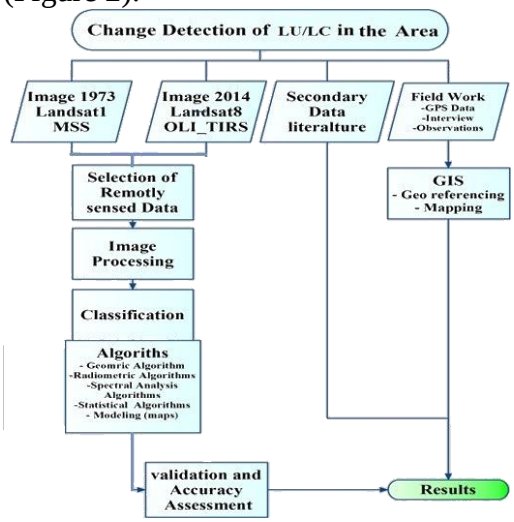


Figure 2: Flow Chart of the Research. Source: the authors

The accuracy assessment is a fundamental step of the process of change detection as it gives an idea of the validity of the results. The overall classification accuracy obtained for 1973 and 2014 images were 76.0%, 80.0% respectively (Table, 1).

Table, 1: Accuracy Report of the imagery classification results.

Accuracy Assessment of Image 1973			
Class	Total Reference	Classified Total	Number correct
Forests	29	33	22
Bare lands (Cultivated Area, settlement ,bare soil)	17	15	11
Range lands	54	52	43
Total	100	100	76
Overall classification Accuracy 76%			
Accuracy Assessment of Image 2014			
Class	Total Reference	Classified Total	Number correct
Forests	14	17	11
Bare lands (Cultivated Area, settlement ,bare soil)	40	37	30
Range lands	46	46	39
Total	100	100	80
Overall classification Accuracy 80%			

Source: the authors

3.2 Forest and Range Lands Changes:

The analysis of satellite images indicated radical changes of land use/ land cover of the area. For instance, the tree cover underwent immense change from (33512.72 Ha) which accounted for 20% of the study area in 1973, they declined to (10508 Hectare) or only 6% of the area in 2014. During this period, the area lost about 70% of it is tree cover. During the same period, the range lands degraded from (60665.84 Ha) representing 37% of the area to (52455.2 Ha) accounting for 31% (Table, 2) and (Figure, 3). In other words, the annual rate of degradation of forests and range lands are (561 Ha) and (200 Ha) respectively (Table, 3) and (Table, 5).

Equally, the bare lands which include settlements, bare soil and agricultural land uses increased from (12924.5 Ha) representing 8% of the area in 1973 to (44819.75 Ha) representing 26.5% in 2014. This is a clear indication that, the land use/land covers have drastically changed during the period (1973-2014). Deterioration of natural resources particularly the removal of the vegetation cover has been instigated by the expansion of settlement and agricultural land uses (Table 2) and (Table 3).

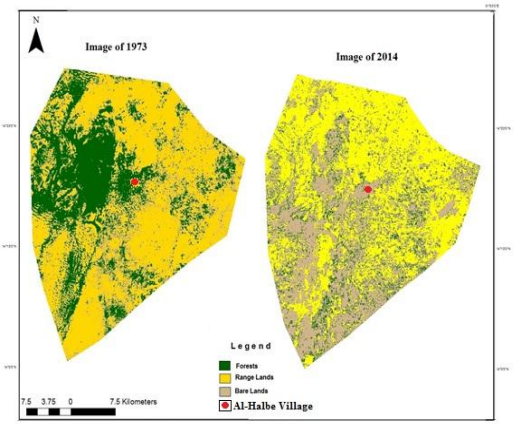


Figure (3): Comparison of forests and range lands in 1973 and 2014.

Table, 2: Classes of Images

Image 2014	Land Use/ Land cover	Area in (Hectare)	Percentage
	Forests	10508	6.1%
	Bare lands (Cultivated Area, settlement ,bare soil)	44819.75	26.5
	Range lands	52455.2	31.0%
	Unclassified	61779.1	36.4
	Total	169562.05	100%
Image 1973	Land Use/ Land cover	Area in (Hectare)	Percentage
	Forests	33512.72	20 %
	Bare Lands (Cultivated Area, settlement ,bare soil)	12924.5	8%
	Range lands	60665.84	37%
	Unclassified	56701.9	35%
	Total	163804.96	100%

Source: the authors

Table, 3: Change Detection

Land use/ Land Cover	Image 2014 Area in Hectare	Image 1973 Area in Hectare	Change Detection
Forests	10508	33512.72	(-23004.72)
Bare lands -Cultivated Area -Settlement -Bare soil	44819.75	12924.5	(+31895.25)
Range lands	52455.2	60665.84	(-8210.64)

Source: the authors

Degradation of natural resources can be clearly shown in the deterioration of the indigenous vegetation species during the last 40 years (Table, 4).

Table, 4:.

Trees		
Latin name	Local Name	Present Situation
Grewia tenax	*Gideim*	Disappeared
Dalbergia melonoxylon	*Babanoos*	
Acacia albida	*Haraz*	
Acacia mellifera	*Kitir*	
Boscia abyssinica	*Meikah*	
Boswellia papyrifera	*Gafal*	Few Scattered trees
Acacia tortilis	*Samor*	
Accia nubica	*Laoot*	
Acacia sayal	*Talih*	
Copparis decidua	*Tondob*	
Boscia sensgalensis	*Mikheit*	
Balanites aegyptiaca	*Hijleej*	Abundant
Acacia nilotica	*Sunut*	
Acacia radiana	*Sayyal*	
Ziziphus spina-	*Sidir*	

christi		
Bushes and Shrubs		
Latin name	Local name	Present Situation
Indigofero ablongifolia	*Dahaseer*	Few Scattered Trees
Cymbopon proximus	*Mahareib*	
colatropis procera	*Ushar*	Abundant
Leptadenia pyrotechnica	*Marakh*	

Source: Field work: 2015

Table (4) indicates the extent of loss of vegetation cover. Due to the recurrent drought conditions, the study area was classified as one of the most affected during the period (1948-1985) recording a loss of more than (70%) of it is population (Table: 5).

Table, 5: Land Uses Changes (1973-2014).

Years	Land uses/ land cover			Population (1000)
	Forests (in Hectare)	Bare lands (in Hectare)	Range lands (in Hectare)	
1973	33512.72	12924.5	60665.84	57
1983	27512.9	20714.5	58665.82	84
1993	22292.7	28504.5	56665.82	16
2003	16682.7	36294.5	54665.82	27
2014	10508	44819.75	52455.2	40

Source: Wadi, 1992 and 2007.

4- Discussion:

Deterioration of the vegetation cover in the study area has had negative impacts on ecosystems of the area as exemplified by increasing sand movement (Figure 4).

Figure (4), Source: Wadi, 2009.

The sand movement, removal of tree cover, and the recurrent drought conditions depleted both surface and underground water (Figure, 5).

Figure (5): Drying out of Underground water. Source: Wadi, 2009

Before 1970s, the area was covered by a variety of tree species, characterized by thickness, tallness and higher economic value, in addition to a mixture of bushes and short-lived grasses that grow during the rainy season, which provided the main animal feed. The destruction of the vegetation cover resulting from increasing numbers of human and animal populations has contributed to the present level of desertification (Figures; 6, 7).

The analysis of results of data in this research raises many challenging questions: what are the factors behind the change of land use/land cover in the area? And what is the role of each factor?

Many researchers believe that physical factors are to blame for causing the destruction of natural resources in the arid lands, while others highlighted the anthropogenic factors or the irrational exploitation of natural resources by local inhabitants.

Figure (6): Field work, 2015

Figure (7): Source: Field work, 2015

Although the problem of drought condition is a common and recurrent phenomenon in the study area since the beginning of 19th century, the authors believe that it is the anthropogenic activities which are having the upper hand behind the deterioration taking place in the study area. The anthropogenic activities include the cutting trees for fuel, building materials, animal feeding as well as claiming land for growing crops. In the absence of measures of conservation and reforestation, the negative impact on ecosystem has been tremendous.

5. Conclusion and Recommendations:

The result of the research showed extreme changes in the ecosystem of the study area. Vast areas of vegetation cover have deteriorated by 70%, while the rangelands by 14% during the period (1973-2014). The factors contributing to environmental decline are attributed to both climate change and human activities.

In fact, the removal of the natural vegetation does not only disturb the ecosystems, but also affects the ecological setting of the area. The removal of forests and range lands, the repeated occurrence of drought and sand movement contributes to the deterioration of soil fertility which affects the productivity of some crops. Furthermore, the drying out of some seasonal water courses *(khors)* which constitute the main source of underground water in summer is also becoming widespread.

Finally, one can say that, using the scientific approach such as remote sensing data for further study of land uses/ land cover to assess the natural resource potentialities is very essential step to solve the problem of deterioration of natural vegetation. Moreover, efforts should focus on promoting conservation of natural resource measures and, upgrading awareness of the local population towards the environment.

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