Sudan University of Science and Technology

College of Graduate Studies

Detection of Land Cover Change Using Landsat Imagery in Elkhuwei Area, Western Kordofan State

الكشف عن تغير الغطاء النباتي لمنطقة الخوي باستخدام صور الاقمار الصناعية لاندسات

ولاية غرب كردفان -السودان

A Dissertation Submitted in Partial Fulfillment of

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Dedication

This work is dedicated to my father, mother, husband, brothers and sisters.

Acknowledgment

This work would not have been possible without the help and support of many people and institution.

I would like to thank my supervisor Dr. Mahgoub Suliman Mohamedain for his continuous help and scientific advices .

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Acknowledgment to forest National Corporation Elkhuwei locality

I am very glad and owed to share this moment of happiness with my father , mother , husband , brothers and my sisters .

Finally , I would like to thank all who direct and indirect support or helped me completing my thesis ,as well as expressing my apology for those

I could not mention personally.

Abstract

This study was conducted in Elkhuwei Area, West Kordofan State – Sudan. The objective of the study was to detect land cover change in Elkhuowei area for the period (2000-2016) by using Landsat satellites imagery. The study methods based firstly by clustering, the area into five strata using unsupervised classification ISODATA of ERDAS Imagine for the Landsat8, 2016 and ETM 2000. Then the area and number of sample plots were been identified. After that a field visit conducted to obtain the information about vegetation cover and verified classes by using GPS. The two imageries then processed and classified into five classes and produced the change detection map. Also questionnaire has been designed for collecting the socio economic data, total numbers of 86 respondents were selected to obtain information about vegetation cover in the past and current, SPSS were used to analyze socio-economic data. The results showed that the Forest cover area decrease from 86622.4 hectare in 2000 to 77573.2 hectare in 2016. Bare land area has increased from 40077 hectare in 2000 to the 62463. 2 hectare in 2016. Burned area with scatter trees was increased from 2791.6 hectare in 2000 to the 39838.5 hectare in 2016. Grasses with scattered shrubs were 90651.1 hectare in 2000 while it decreases to 71966.4 hectare in 2016. grasses with scattered trees and shrubs were 73327 hectare in 2000 while it showed 75177.6 ha in 2016 . Therefore, the study recommended that the use of Landsat imagery was effective in such cases.

الخلاصة

أجريت هذه الدراسة في منطقة الخوي، ولاية غرب كردفان - السودان. والهدف من هذه الدراسة هو الكشف عن تغير الغطاء الأرضي في منطقة الخوي للفترة (2000-2016) باستخدام صور القمر الصناعي لاندسات.تم تقسيم المنطقة إلى خمس اقسام باستخدام التصنيف غير المراقب لصور القمر الصناعى لاندسات 8 و7 للاعوام 2000 و2016. تم تحديد المنطقة وعدد العينات. دعمت الدراسة بمسح ميدانى تم من خلاله جمع معلومات عن الغطاء النباتى باستخدام جهاز تحديد المواقع العالمي GPS وايضا تم تصميم استبانة لجمع البيانات الاقتصادية والاجتماعية. وأظهرت الصورتان بعد المعالجة والتصنيف وتعديل الخريطة الكشف عن النتائج أن مساحة الغابات حدث فيها تغير من 86622.4 هكتار في عام 2000 إلى 77573.2 هكتار في عام 2016. وقد ازدادت مساحة الأراضي المكشوفة من 40077 هكتار في عام 2000 إلى 62463 هكتارا في عام 2016 وقد زادت المساحة المحترقة التي بها اشجار مبعثرة من 2791.6 هكتار في عام 2000 إلى 39838.5 هكتار في عام 2016 أما الأعشاب ذات الشجيرات المتناثرة 90651.1 هكتار في عام 2000 بينما انخفضت إلى 71966.4 هكتار في عام 2016. كانت االأعشاب ذات الأشجار والشجيرات المتناثرة 73327 هكتارفي عام 2000 بينما أظهرت 75177.6 هكتارا في عام 2016. عليه توصي الدراسة باستخدام صور الاقمار الصناعية لاندسات لفعاليتها فى مثل هذه الحالات.

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CHAPTER ONE

Introduction

1.1General

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Timely and accurate change detection of Earth surface features provides the foundation for greater understanding of the relationships and interactions between human and natural phenomena. In practice, different techniques are often compared to find the most useful change detection results for a specific application (Lu et al., 2004).Forest cover in Sudan according to the FAO estimate to 9.9% or about 169222130 ha, according to figures from the World Conservation Monitoring Center Sudan's forests contain 1,393, million metric tons of carbon in living forest biomass. Biodiversity and protected areas in Sudan has some 1431 known species of amphibian's birds, mammals and reptiles. The forestry sector in Sudan has contribution in the general economic cycle and also provides indirect benefits to environmental protection such as protection of agriculture land, soil fertile and human settlement from moving sands, desertification and protection of River Nile tributaries watershed. Over the last twenty years, Remote Sensing has become increasingly important in the study of vegetation changes due to increased spatial resolution of new sensors. After the independence of South Sudan the most forest went to the South Sudan government, this make necessity for studying land cover in Sudan using most effective techniques such as satellite imagery and remote sensing.

This study will use remote sensing and satellite imagery to detect change in land cover in ElKhuwei area.

1.2 Location of the study area

This study was conducted in Elkhuwei area, West Kordofan State, Sudan. Which lies about 100 km west of Elobied city with the center coordinates: 13°5'19"N 29°12'58"E

1.2.1 Area and population:

The total area of ElKhuwei estimated at 7956 square kilometers, the population is estimated 107000

1.2.2 The Climate and Vegetation cover

The climate is semi- desert, average rain fall of between 350-450 mm per year.

The dominant species are *Boscia senegalensis (Mukhaet*) and *Calotropis Procera (Ushar*) and the dominant grass are *Eragrostis aspera. (Bannu), Cenchrus biflorus (Haskaneet) and Aristida mutabilis* (*Gaw*) beside desirable species for livestock grazing such as *Merremia emarginata (Angret elwaral), Desmodium dichotomum (Abuarida), Clitaria stipoides (laflaf), Commelina subulata (Beiid), and Echinocloa colona (Diffra).*

1.3 Problem statement:

The natural resources facing many challenge due to climate change and human activities such as seasonal fire , over grazing, clear cutting , drought and mismanagement . This lead to the increase scarcity of vegetation covers and caused more local conflicts in the area. The land cover vegetation of West Kordofan State has been seriously affected by series of drought that hit Sahel during the last three decades. This leads to change in vegetation cover which needs to be evaluated. This could be detected by using Landsat imagery because the study area is wide.

1.4 The objective of the study

Main objective:

To detect land cover change in ElKhuwei area for the period (2000-2016) by using Landsat satellites imagery.

Specific objectives:

1. To determine the status of land cover in study area.

2. To highlight the causes of land cover degradation in the area.

3. To find out the suitability of using Landsat satellites imagery in detection land cover change in the area.

1.5 Research Hypothesis:

ElKhuwei Land cover has changed during the period 2000-2016

Literature Review

2.1 Characteristics and importance of land cover

Land-cover (LC) composition and change are important factors that affect ecosystem condition and function. These data are frequently used to generate land scape-based metrics and to assess land scape condition and monitor status and trends over a specified time interval (Jones et al., 1997).
Land cover is the physical material at the surface of the earth land covers includes grass, asphalt, trees, bare ground, and water. Earth cover is the expression used by ecologists that has its closest modern equivalent being vegetation. The expression continues to be used by the Bureau of Land Management .There are two primary methods for capturing information on land cover; field survey and analysis of remotely sensed imagery (lex Comber, et al., 2005). One of the major land cover issues with all natural resource inventories is that every survey defines similarly named categories in different ways for instance there are many definitions of (Forest) sometimes within the same organization, that may or may not incorporate a number of different forest features (e,g., stand height, canopy cover, strip width, inclusion of grasses, and rates of growth for timber production), Areas without trees may be classified as forest cover if the intention is to re-plant) while areas with many trees may not be labeled as forest if the trees are not growing fast enough .

2.2 Remote Sensing and GIS

Remote Sensing is the acquisition of information concerning an object or phenomenon without physical contact , and has been recommended for at least 30 years in assessing grassland resources development and management on worldwide basis (Tueller,1989).

Miller and Yool (2002) stated that, remotely sensed data has been applied successfully to assessment and monitoring vegetation cover, land degradation , forestation and deforestation floods ,fire and many other applications .

Zhou (2007) concluded that remote sensing can be reliable approach to update land cover information for implementing a rangeland insurance program by using a single –date multispectral imagery with medium resolution .

Satellite remote sensing and GIS technology are now widely used for environmental monitoring and mapping the distribution of land surface biophysical parameters that have an important effect on climate.

Remote Sensing is one of the best methods that provide a starting point for systematic monitoring and assessment of desertification in the Sudan

2.2.1 Advantage of Using Remote Sensing:

The main advantages of using satellite imagery for geographical research is the ability to capture in an instant synoptic view of large part of the earth's surface and to acquire repeated measurements of the same area on a regular basis .

it is precisely these properties that make satellite remote sensing such an important source of data for studies of dynamics of the earth surface and atmosphere .

There are several advantages and disadvantage associated with using satellite remote sensing for estimating surface environmental characteristics when compared to traditional ground based measurement In addition to that it provides a wide range of sensor system including aerial photographs, air borne multi –spectral scanners, satellite imagery low and high spatial and spectral resolution and ground based spectrometer measurement.

Al-Bakri and Abu Zanat (2007) reached that one big advantage of using remote sensing indices over ground surveys is the extent of spatial and temporal distribution of vegetation. The resulting information could be used for the management of range vegetation and the estimation of grazing capacity.

Remote sensing technology has received considerable interest in the field of biological invasion in the recent years. It is a tool offering well documented advantages including a synoptic view , multi spectral data ,multi –temporal coverage and cost effectiveness (Storms and Estes,(1993).Vander et al,2002).

2.2.2 Remote Sensing of Vegetation

Approximately 70 percent of the Earth s land surfaces is covered with vegetation. Furthermore , vegetation is one of the most important components of ecosystems .Knowledge about variation in vegetation species and community distribution patterns , alterations in vegetation phonological (growth) cycles , and modification in the plant physiology and morphology provide valuable insight in to the climatic ,edaphic, geologic, and physiographic characteristics of an area .Scientist have devoted significant effort to develop sensors and visual and digital image processing algorithms ,to extract important vegetation biophysical information from remotely sensed data (e.g. Townshend and Justice ,2002). Many of the remote sensing techniques are generic in nature and may be applied to a variety of vegetated landscapes , including;. Agriculture, forests, rangeland, wetland and urban vegetation.

2.3 Change detection

Several regions around the world are currently undergoing rapid, wide-ranging changes in land cover. Much of this activity is centered in the tropics in such countries (FAO1995). These changes in land cover, in particular tropical forest clearing, have attracted attention because of the potential effects on erosion, increased run-of and flooding ,increasing CO2, concentration-climatological, changes biodiversity loss (Myers ,1988, Fontan ,1994). Remote sensing provides available source of data from which update land-cover information can be extracted efficiently and cheaply in order to make inventory and monitor these changes effectively. Thus change detection has become major application of remotely sensed data because of repetitive coverage at short intervals and consistent image quality .

The major assumption of change detection is as follows: “a difference exists in the spectral response of a pixel on two dates if the biophysical materials within the instantaneous field of view have changed between dates” Jensen p.259. Specifically, change detection is the act of comparing two or more satellite images acquired at different times (multi-temporal) for the purpose of detecting spectral reflectance differences between the images (Masry et al 1975) .

CHAPTER THREE

Materials and Methods

3.1 General

This study was conducted in Elkhuwei Area, West Kordofan State, Sudan. The data was collected after the rainy season of September 2017. It was included the assessment of vegetation cover in addition to socio- economic investigation that covered settled and nomads.

3.2 Sampling procedure

Stratified random sampling design has be used to collect the training set data and Ground Control Points (GCPs) .Accordingly; the study site was divided in to several strata, were recorded to their spectral reflectivity with the help of unsupervised classification and then sample points assigned randomly to each stratum.

-Sampling intensity:

The sample size (A) is defined to be 903m calculated from justice and Townshend, (1981) and Mccoy, formula (Mccoy, 2005).

Formula:

$A = P (1+2L)$

A =is minimum sample site dimension

P = pixels size =30m

L = Accuracy to calculate the pixel =15

A= 0.5*1/30=15

A =30(1+2*15)

A =30(1+30) =903m

3.4 Measurements (Ground survey)

The coordinates of study area were recorded such as 29 11 51.9 E 13 05 45.3N

Five strata that represented five classes according to unsupervised classification in the study area were selected. In each stratum nine plots each 100m×100m were located. Within each plot two transects 100 m each were randomly located to measure tree density and vegetation cover. One m^2 quadrate, compass, 100 m tape, digital camera and GPS were used. Measurements were conducted by the researcher and three assisting experienced technician.

3.4.1 Vegetation Measurements

The following measurement were taken within sample plot and along the transect, the measurements through counting and observations. The data have been organized, analyzed and tabulated using Excel.

3.4.2Trees Density

Density describes the number of individual plants in a given area. This was obtained for all tree species in the selected sites. Direct count method was used. The total number of trees and shrub was determined by counting them inside the sample plots.

3.5 The implementing of change detection:

The implementing change detection using image-processing software requires a number of steps (Figure 1).

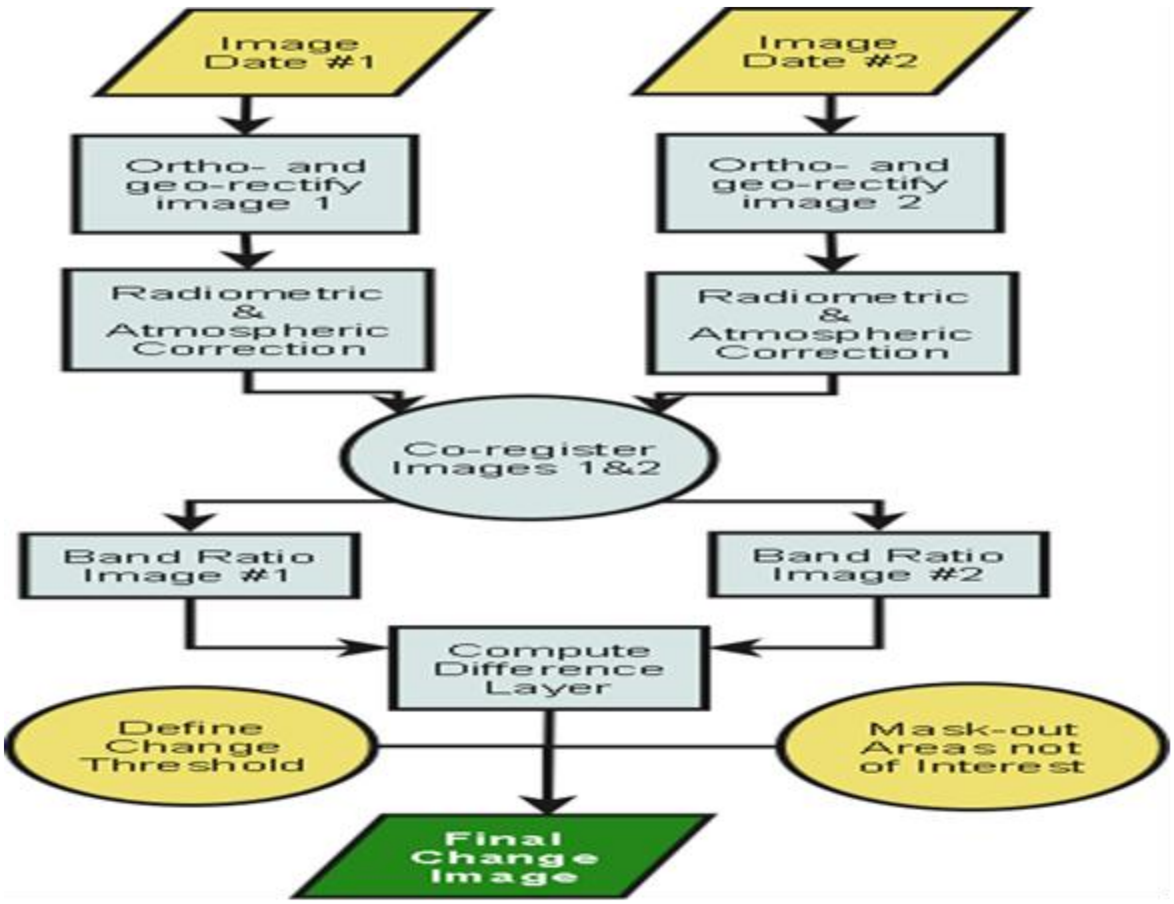


Figure (1) Steps of implementing change detection

3.6 Data acquisition and processing:

The image processing and analysis have been carried out using ERDAS Imagine and ARC/GIS software. These include radiometric, spatial and spectral enhancements, unsupervised classification, change detection methods. The SPSS and Microsoft Excel statistical programs were been used to analyze the data.

Data acquisition: satellite imagery covering the study area was downloaded from land sat. These were Landsat ETM 2000, and landsat8 2016 . Unsupervised classification has been used and classification map to five classes with false colors were produced.

Image radiometric and geometric enhancement, Transforming and interpreting data from field and inventories, use of unsupervised classification to extract appropriate pixels for classification from training and field sites.

The classification of land covers change dynamics, production of land cover map, production of land covers and change detection maps and production of change detection of land cover change dynamics, refine analysis and presentation of the result.

3.7 Socio-economic aspect

A questionnaire was designed to collect quantities and qualitative information. The interview covered 86 respondents from different sectors in the study area including pastoralists, local leaders and settled group. Information covered vegetation cover in the past and current and other issue related to study.

3.8 Methods of data analysis

Data obtained were proceed and analyzed according to standard range assessment indices. The Socio-economic data were analyzed on a personal computer using Statistical Package for Social Science (SPSS) software.

CHAPTER FOUR

Results and Discussion

4.1 Introduction

This study has investigated the land cover change detection in the study area in addition to socioeconomic aspects related to the land cover change.

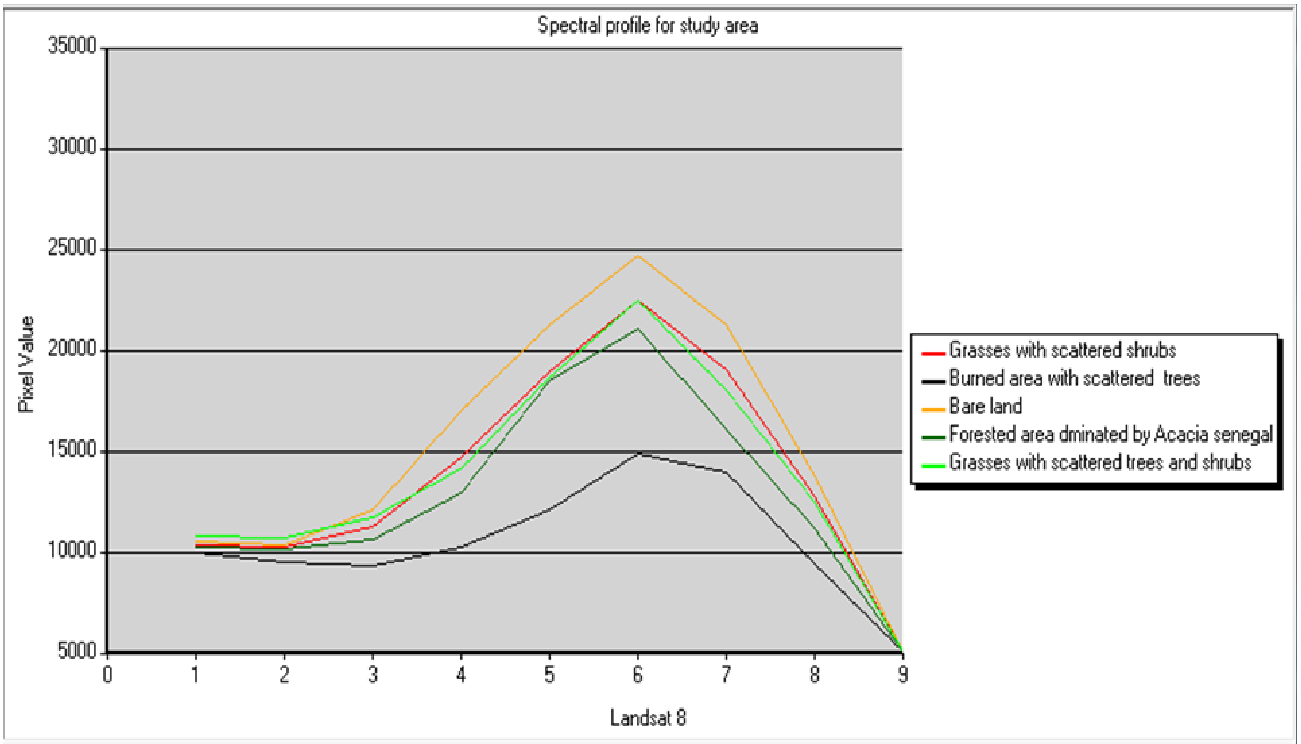
4.2 Signature evaluation

A set of tests procedures have been applied to study the spectral values of collected signatures. Among those was the spectral profile tool which shows the spectral reflectivity curve of the signatures in the relation to the wavelength. For Elkhuwei Area, the Landsat8 2016 results showed the forest land has low reflectivity in the visible range while it has high in the bare land (Fig.2.).

After accuracy assessments and analysis of the spectral signatures have been tested , the unsupervised classification process has been applied to categorize the multi – temporal imagery in to different classes. The images were firstly classified into five classes (Figure 2)

- Forest area dominated by *Acacia senegal*
- Bare land
- Grasses with scattered shrubs
- Grasses with scattered trees and shrubs
- Burned area with scatter trees

Figure (2)


Spectral profile for study area
35000
30000
25000
20000
15000
10000
5000
Pixel Value
0
1
2
3
4
5
6
7
8
9
Landsat 8
Grasses with scattered shrubs
Burned area with scattered trees
Bare land
Forested area dminated by Acacia senegal
Grasses with scattered trees and shrubs

4.2 Elkhuwei land covers classification

The image classification has been used to cluster the study imagery into LC categories. The classification was intended to produce a set of land cover map, forest cover map, change detection maps, vegetation change matrices and dynamics.

By having a look to the LULC Changes of Elkhuwei area (Fig, 3). It could be seen clearly that there was considerable change in the cover attributes during the period 2000- 2016. The change in the bare land cover category was the greatest among the classes, however the other classes also have been changed .In other way we could see that the forest land area has decreased while the bare land area increased .

Figure (3) ElKhuwei Unsupervised Classification in 2000 and 2016

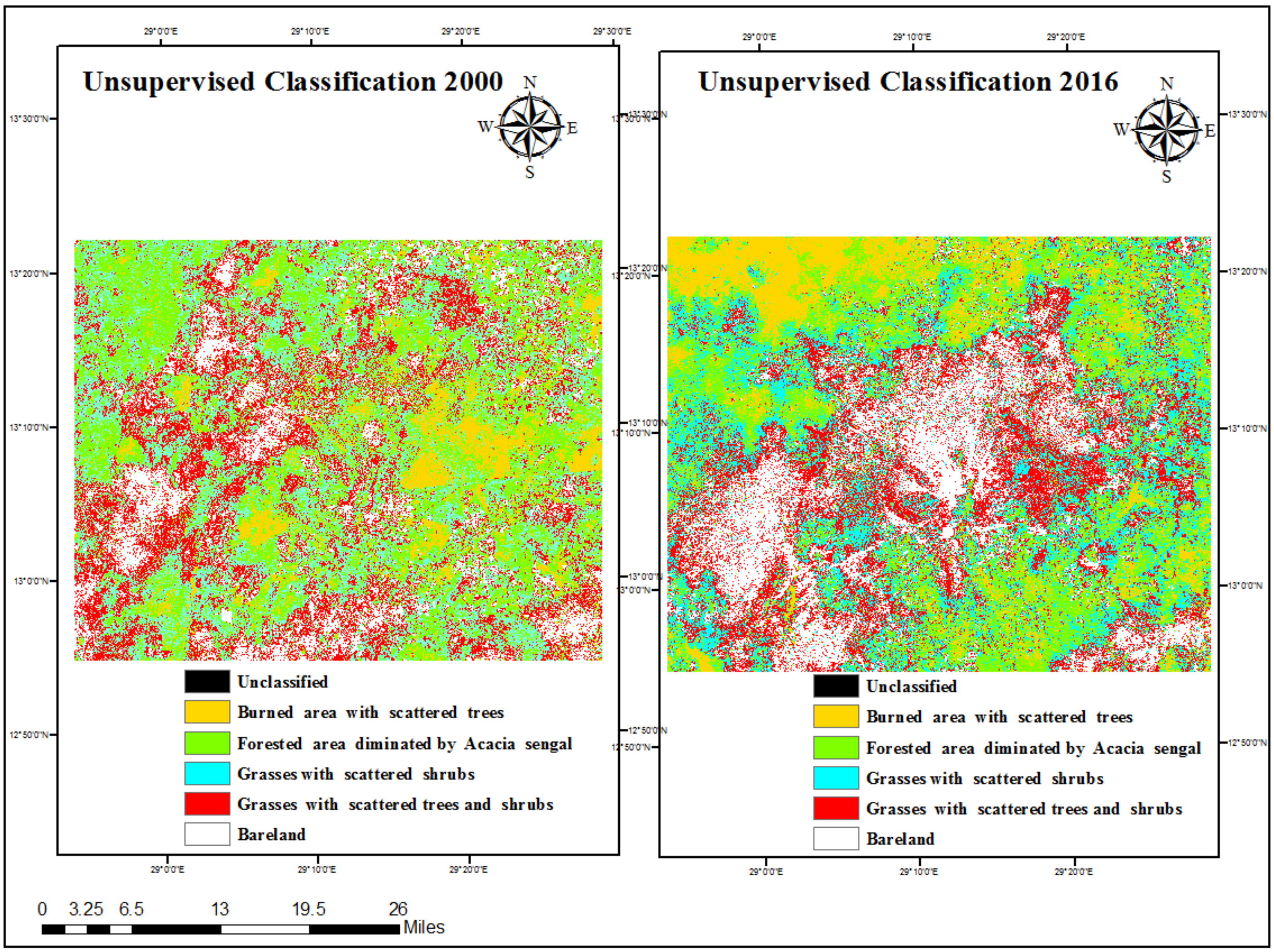
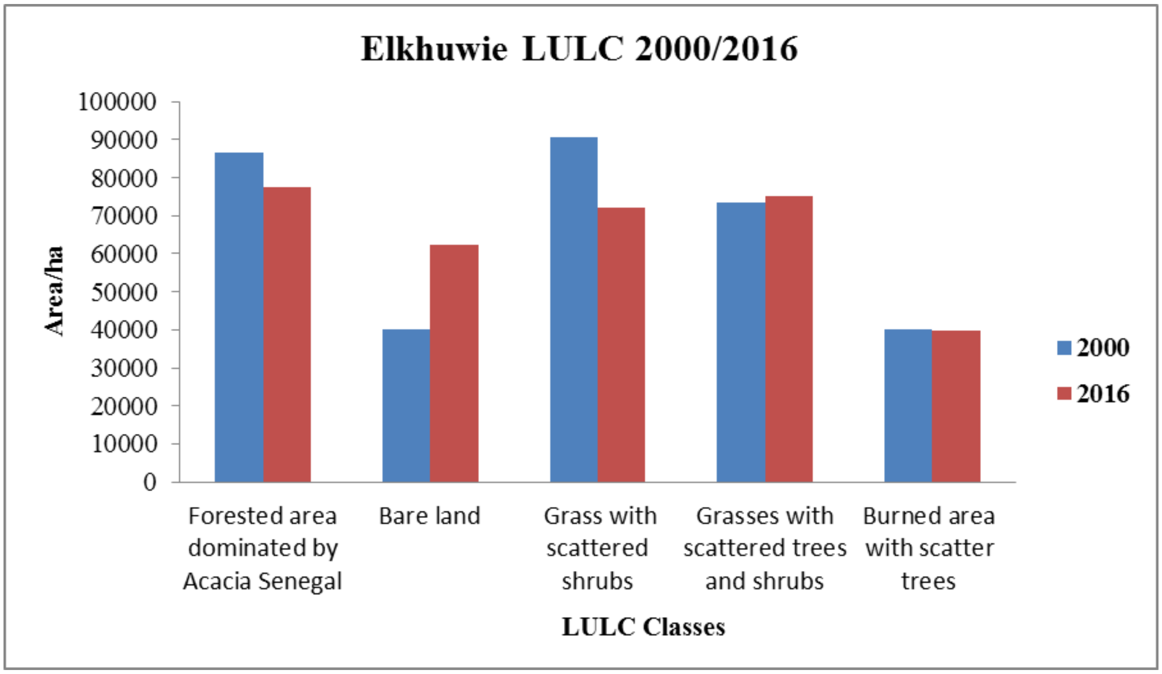


Table (1) showed the study area change during period 2000 and 2016. Forest covers area decrease from 86622.4 ha in 2000 to 77573.2 ha in 2016. Bare land area has increased from 40077 ha in 2000 to the 62463. 2 ha in 2016. . Grasses with scattered shrubs were 90651.1 ha in 2000 while it decreases to 71966.4 ha in 2016. Burned area with scatter trees increased from 27921.6 ha in 2000 to the 39838.5 ha in 2016. Grasses with scattered trees and shrubs were 73327 ha in 2000 while it showed 75177.6 ha in 2016 .

Table (1) ElKhuwei LULC Classes 2000 and 2016

Class	Area (ha)	
	2000	2016
Forested area dominated by Acacia Senegal	86622.4	77573.2
Bare land	40077	62463.2
Grasses with scattered shrubs	90651.1	71966.4
Grasses with scattered trees and shrubs	73324	75177.6
Burned area	27921.6	39838.5

Figure (4): ElKhuwei LULC Classes 2000 and 2016



4.3 Elkhuwei Land Cover Change Detection

Figure (5) Shows that there have changed in study area between the period 2000 and 2016 It decreased 108779 ha, increased 129807 ha and the area unchanged is 80010 ha.

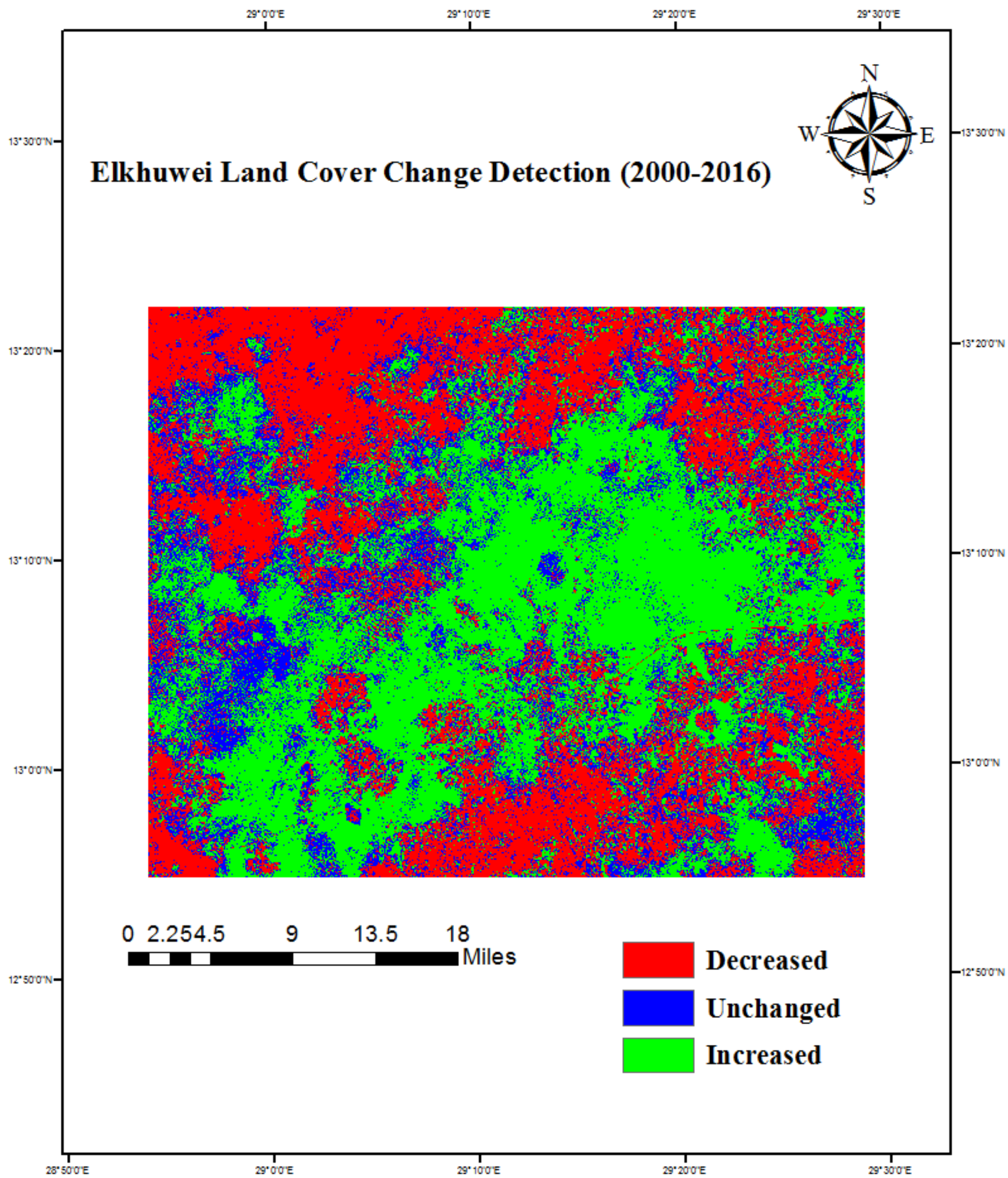


Figure (5) ElKhuwei Land Cover Change Detection (2000- 2016)

4.4 Socioeconomic results:

4.4.1 Type of respondents

Table (2): shows that 80.2 % of respondents are males, while the females are 19.8% of the total respondents.

Table (2) Type of respondents

Description	Frequency	Percentage
Male	69	80.2
Female	17	19.8
Total	86	100

4.4.2 Education level

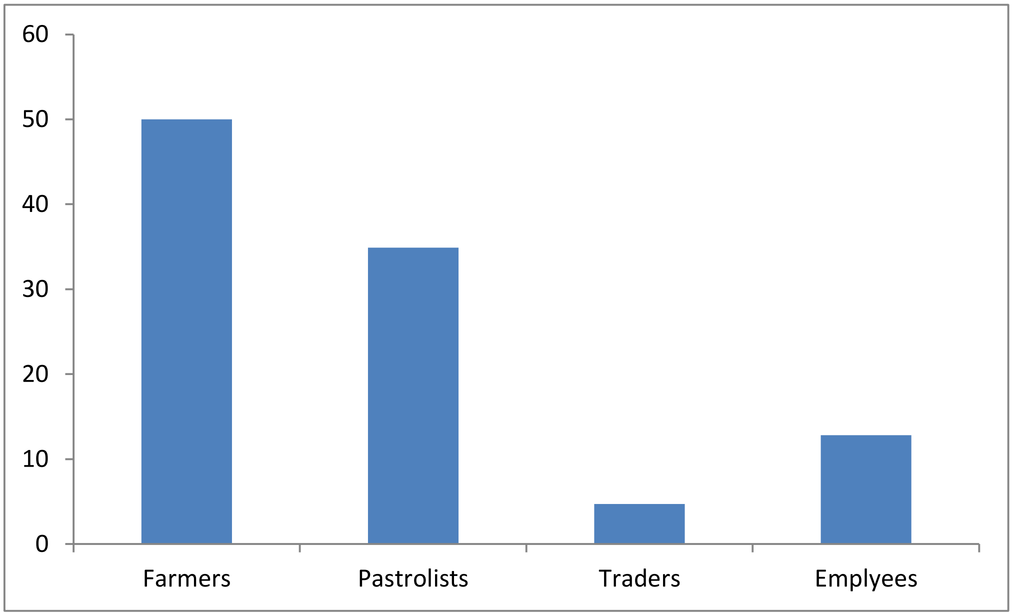
Table (3): shows that there were differences among respondents in education level. 31.4% of the respondents their education levels are a basic school , 29.1 an illiterate 26.7% education quran , 8.1% secondary school and 4.7 % of them are university .

Table (3) Educational level

Education Level	**Frequency**	**Percentage**
Basic school	27	31.4
Illiterate	25	29.1
Quran education	23	26.7
Secondary school	7	08.1
University	4	4.7
Total	86	100

4.4.3 Source of Jobs

Figure (6) explain the source of Jobs in study area



According to of the respondents the main jobs are famers and the second pastoralists

4.4.4 Causes of degradation in study area

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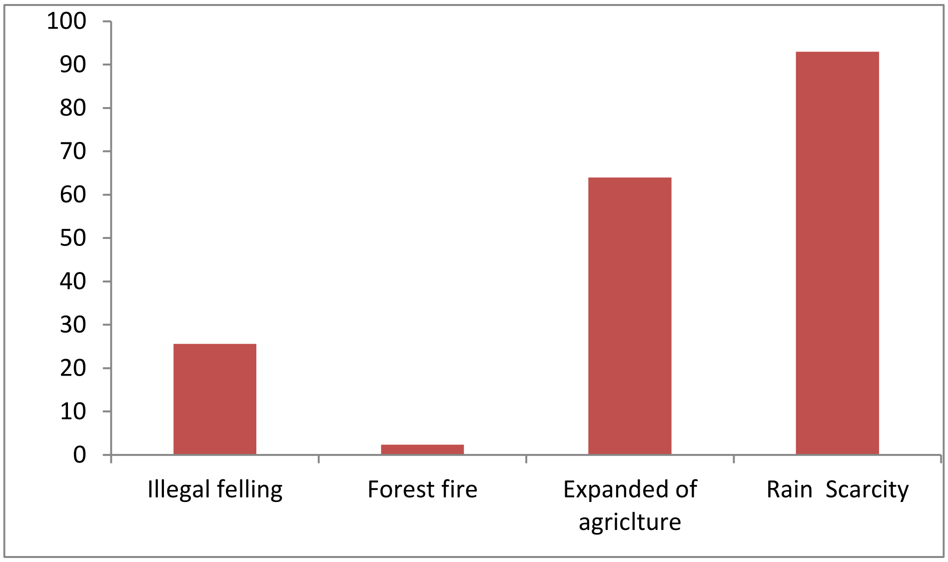

Figure (7)

Figure. (7) According to the respondents answers the main causes s of the degradation of tree cover and shrubs in study area of rain scarcity , expand agriculture and illegal felling .

4.4.5 Change in vegetation cover

The respondents answered that there was change in trees composition some of them are disappeared such as *Dichrostachys cinerea(Alkadad*) *Dalbergia melanoxylon(Babanos)* *and perr*, *Albizia amara subsp. Sericocephala (Arad)* while there was appearance new plant in study area such as *sida cordofolia (Niada*) plant .

CHAPTER FIVE

CONCLUSION AND RECOMMENDATINS

5.1 Conclusion

- Refer to the results discussed it can be concluded that the land cover of ElKhuwei has changed during the period 2000-2016

- The results showed that forest covers area decrease from 86622.4 ha in 2000 to 77573.2 ha in 2016. Bare land area has increased from 40077 ha in 2000 to the 62463. 2 ha in 2016. Burned area with scatter trees increased from 27921.6 ha in 2000 to the 39838.5 ha in 2016. Grasses with scattered shrubs were 90651.1 ha in 2000 while it decreased to 71966.4 ha in 2016. Grasses with scattered trees and shrubs were 73327 ha in 2000 while it showed 75177.6 ha in 2016.

- The more detailed change was found in the increased, unchanged and decrease indicators, which showed that the change in the bare land cover category was the greatest among the classes, however the other classes also have been changed. In other way we could see that the forest land area has decreased while the bare land area were increased .

- For ElKhuwei area the study showed that the use of Landsat imagery was effective in study of change in land cover.

5.2 Recommendations

- Continuation of studying the land cover of ElKhuwei change as the study showed significant change during the period 2000-2016
- Application of multi temporal satellite imagery (preferred with high resolution) for studying the land cover in the area.
- It has been observed that during the field survey there was considerable change in species composition . Some of them are disappeared such as *Dichrostachys cinerea* , *Dalbergia melanoxylon Guill and perry* , *Albizia amara* while there was appearance new plant in study area such as *sida cordofolia* plant . The study recommended that to conduct species composition survey in order to assure the sustainable management of plants.

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Annex

Table (4): Previous trees in the study area:

Species	Local name	Frequency	percent
Combretum glutinosm	*Habeel*	14	16.3
Lannea fritcosa	*Luon*	9	19.5
Albizia amara subsp.sericocephala	*Arad*	15	17.4
Salvadora persica	*Arack*	5	5.8
Dichrostachys cinerea	*kadad*	28	32.6
Terminalia brownii	*sobag*	8	9.3
Commiphora pedunculata	*Luban*	5	9.3
Commiphora africana	*Alkfal*	10	11.6
Dalbergia melanoxylon	*Alabnose*	16	18.6
Grewia mollis	*Albshm*	10	11.6
Guiera senegalensis	*Algobashe*	14	16.3

Table (5) Previous grasses in the study area:

Scientific name	Local Name	Frequency	percent
Euphorbia forssalii	*Um lebeina*	34	39.5
Rogeria adenophylla	*Afreet samsam*	8	9.3
Cymbopogon schoenanthus	*Mahreeb*	3	3.5
Dactyloctenium aegyptium	*Abo Asaba*	4	4.7
Crotalaria senegalnsis	*Altgtaga*	8	9.3
Blepharis linariifolia	*Albgeel*	4	4.7

: Table (6) some grasses currently exist

Scientific name	Local Name	Frequency	percent
Alysicarpus	*Shuluny*	51	59.3
Aristida Sp.	*Gsha alhmra*	16	18.8
Andropogon gayanus	*Abo rkhase*	2	2.3
Aristida seibeiana	*Algo*	37	43
Sida Cordifolia	*Nuada*	56	65.1
Ipomea cordofana	*Altbar*	7	8.1
Schoenefeldia gracilis	*Um frudo*	4	4.7
Indigofera prieureana	*Algbasha*	14	16.3
Aristida	*Um sumuma*	1	1.2
Echinochloa colona	*Aldfra*	2	2.3
Ipomoea sp.	*Alfluf*	5	5.8
Dactyloctenium aegyptium	*Abo Asabaa*	2	2.3
Chrozophora brocchianna	*Alargsaee*	10	11.6
Eragrostis tremula gada	*Albno*	2	2.3
Ipomoea	*Hantot*	1	1.2

Table (7) Some Trees currently exist

Scientific name	*Local name*	Frequency	percent
Acacia senegal	*Hshab*	30	34.9
Adansonia digitata	*Tbeldie*	26	30.2
Balanites aegyptiaca	*Hglage*	35	40.7
Acacia nilotica	*Sunt*	32	26.7
Ziziphus spina – christi	*Sider*	5	5.8
Terminalia brownii	*Sobag*	18	20.9
Sclerocarya birrea	*Hmade*	33	38.4
Guiera senegalensis	*Gbashe*	18	20
Acacia Polyacantha	*Allaot*	5	5.8
Azadirachta indica	*Alnaem*	16	18.6
Boscia senegalansis	*Almkhate*	23	27.1
Combretum glutinosum	*Habeel*	5	5.8
Acacia .mellifera	*Alcter*	2	2.3
Maerua crassifolia	*Alsrah*	12	14
Acacia tortilis	*Alsyal*	9	10.5
Faidaherbia albida	*Alhraz*	8	9.3

Table (8) Density of trees in different sites:

Categories	Species	Density/ha
Grasses with scattered trees and shrubs	*Acacia senegal*	42
	Boscia Sengalensis	212
	Balanites aegyptiaca	2
	Guiera senegalensis	16
	Calotropis Procera	5
	Leptadenia Pyrotechnica	98
Grasses with scattered shrubs	*Boscia Sengalensis*	167
	Maerua crassifolia	2
	Calotropis Procera	4
	Balanites aegyptiaca	6
	Acacia senegal	15
Burned area with scattered trees	*Boscia senegalansis*	170
	Calotropis Procera	53
	Leptadeia pyrotechnica	2
Forested area dominated by Acaia senegal	*Acacia senegal*	217
	Boscia senegalansis	37
	Guiera senegalensis	121
	A.Polycantha	73
	Acacia seyal	1
	Combretum glutinosm	6
	Sclerocarya birrea	1
	Calotropis procera	2

Plate (1) ElKhuwei forest area dominated by *Acacia senegal* (photo, 2017)

Plate (2) ElKhuwei Burned area with scatter trees (photo, 2017)

Plate (3) ElKhuwei Bare land (photo 2017)

Plate (4) ElKhuwei Grasses with scattered trees and shrubs (photo. 2017)