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Sudan University of Science & Technology

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Application of Remote Sensing for Vegetation Cover Change Assessing Based on (NDVI) index (A Case Study of Koskary Area – North Darfur State - Sudan)

استخدام الاستشعار عن بعد لتقييم التغير في الغطاء النباتي بإستخدام مؤشر الإخضرار (دراسة حالة منطقة كوس كري – ولاية شمال دارفور – السودان)

A Dissertation Submitted in Partial Fulfilment of the Requirement for the Degree of M.Sc. in Environmental Forestry

By

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DEDICATION

To soul of my father

***

To my mother

***

To my brothers and sisters

***

To my wife Mariam Ahmed Yousef

And

To my son Jebril for his patience, a despite always says

BABA through all my absent days.

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The completion and final output of this dissertation haven't been possible without assistance and honest help of others, whose names may not all of them be enumerated.

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ABBREVIATION AND ACRONYMS

AVHRR	Advance Very High Resolution Radiometer
DEM	Digital Elevation Model
ETM+	Enhance Thematic Mapper Plus
FAO	The Food and Agriculture Organization of the United Nations
FNC	National Forest Corporation
GIS	Geographic Information System
GLCF	Global Land Caver Facility
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
MSS	Multi-Spectral Scanner
NASA	National Aeronautics and Space Administration
NDVI	Normalize Difference Vegetation Index
OLI	Operational Land Imager
PNT	Positioning, Navigation, And Timing
PVT	Positioning, Velocity, And Time
RS	Remote Sensing
TM	Thematic Mapper
UAV	Unmanned Aerial Vehicle
USGS	United States Geological Survey
UTM	Universal Transverse Mercator

ABSTRACT

The main task of this study is application of remote sensing to assess the vegetation cover change in Koskary area, North Darfur state - Sudan.

In this study, Normalized Difference Vegetation Index (NDVI) derived from Landsat data used, and linked with field investigations, to assess the change during the years 2000, 2010 and 2020.

In addition to that, the study observed other factors related to vegetation cove changes, like human activities and terrain which calculated from Digital Elevation Models (DEM).

The study results showed that, forest cover classes decreased from 14% in 2000 to 9% in 2010 then increased to 31% in 2020. Moreover, looks variant change in rangelands, from 60% in 2000 to 75% in 2010 then to 59% in 2020.

The bare lands also decreased from 24% in 2000, to 16% in 2010 then to 10% 2020.

The field observations revealed that, human factors had strong effect on vegetation, especially in charcoal production, illegal felling and wildfire

But from other side, land topography such as low slops had positive impact on vegetation by providing multi-watershed, streams and good habitats.

This study concluded that, NDVI index was effective remote sensing tool for detecting vegetation cover change. Moreover, forestlands degradations could reduce through proper forest management and early fire-lines.

المستخلص

تمثلت الهدف الرئيسي لهذه الدراسة في استخدام الاستشعار عن بعد لتقييم التغير في الغطاء النباتي بمنطقة كوس كري – ولاية شمال دارفور – السودان. في هذه الدراسة، استخدمت مؤشر الفارق الطبيعي للنباتات (NDVI) المستمدة من بيانات أقمارلاندسات الإصطناعية، كما دعمت بالدراسات الميدانية لتقييم التغيير خلال الأعوام 2000، 2010 و 2020.

إضافة لذلك، لاحظت الدراسة عوامل أخرى له صلة بتغير الغطاء النباتي مثل الأنشطة البشرية والتضاريس التي تم حسابها من نموذج الارتفاعات الرقمية (DEM).

أظهرت نتائج هذه الدراسة على نقصان مساحة أراضي الغابات من 14% في عام 2000 إلى 9% في عام 2010 ثم إزدادت إلى 31% في عام 2020. وكذلك تباينت التغير في مساحة أراضي المراعي من 60% في عام 2000 إلى 75% في عام 2010 ثم إلى 59% في 2020. كما انخفضت الأراضي الجرداء من 24% في عام 2000 إلى 16% في عام 2010 ثم إلى 10% في عام 2020.

أظهرت نتائج عمليات المسح الميداني أيضاً على وجود تأثيرات سلبية للعامل البشري على الغطاء النباتي، خاصة أنشطة إنتاج الفحم، القطع غير القانوني و الحرائق البرية المتكررة.

على السعيد الآخر، أظهر النتائج على أن تعدد التضاريس وخاصة الأماكن المنخفضة له تأثيرات إيجابية على الغطاء النباتي من خلال توفير العديد من مناطق تجمع المياه، المجاري المائية و الموئل الطبيعية الجيدة.

خلصت هذه الدراسة إلى أن مؤشر الفارق الطبيعي للنباتات (NDVI) من الأدوات الفاعلة في الاستشعار عن بعد والتي يمكن الاعتماد عليها في تقييم التغير في الغطاء النباتي، كما يمكن تقليل تدهور أراضي الغابات عبر تحسين إدارة الغابات، والعمل المبكر لخطوط النار.

CHAPTER ONE

Introduction

1.1: General

In the last century, the development of future technologies, satellite imagery and use of scientific tools designed to support Geographic Information Systems (GIS) have strongly influenced the track of applied research in land resource monitoring and assessment.

One of the most important applications and use of remote sensing data is the study of monitoring and assessing dynamic change of natural resource (Chuvieco, 1999).

The normalized difference vegetation index (NDVI) is one of the most useful techniques for detection of land cover change, due to increase of both spatial resolution (from km to meter) and spectral resolution (from wide band range to narrow band) of satellite imagery (coops et al, 2008).

The evaluation and detection of Vegetation cover change has a special meaning for integrated management of natural resources in regarding distribution and dynamics of ecosystems production potential, identify different levels of natural vegetation, richest ecosystems, regional hydrology and the global climate dynamics (Forkel et al., 2013; Du et al., 2015; Igbawua, Zhang, Chang, & Yao, 2016).

The natural vegetation cover in Sudan occupies a little geographical area compared to its economic and environmental importance. However, it has been exposed over the past decades and still under great pressure, and its area has decreased for many reasons.

The vegetation cover in Koskary area where located in North-Darfur state, was deteriorated by a great pressure of population growth, increase on livestock and continuous expending shifting cultivation.

The main aims of this study work is to identify the changing pattern of vegetation cover including increasing or decreasing trend of green plants coverage and his view on catchment area using NDVI indices in the years 2000 to 2020.

1.2: Problem statement

Africa has been observed to be experiencing the fastest rate of vegetation change and most of its segments are already evidently been impacted and plagued with diverse ecological problems (Erika et al., 2015; Ofori et al, 2014).

In Sudan, especially In Darfur, conflicts, firewood for brick-making, timber for construction, unmanaged and unregulated felling of trees; traders, carpenters and sawmill operators are a major causes of deforestation, (UNEP, 2008) and due to FNC, forest reserves have been badly damaged during the Darfur conflict.

By the year 2000, the legal position of the study area natural resource was so affected by the issuance of Darfur tribal conflict. During this period, the study area has seen a large movement of Constrain civil emigration from far villages to center of area for population body defense, accompany that an increase in population with increase on livestock and expending shifting cultivation. This, give the community ownership over any illegal activity while the law never provide for regulations of existing, which constituted a great pressure on the region's natural resource. This pressure over available natural resources in study area, which led to deterioration in natural resource and natural variety in area. There for there is a need to use cost effective techniques and indices such as RS and GIS to assess and mapping this change by square kilometers in study area.

1.3: Justifications

There are several motives that contributed to evaluating the vegetation cover in the study area, including:

- Significant deterioration of vegetation cover in the study area.
- Lack the details and assessment of environmental degradation in the study area.
- To conserve the forest and wildlife habitat in study area, knowing that, the Wilderness expanse of study area, gives opportunity to attractive multi-activities as seasonal migration birds, shepherds, huntsmen and woodmen.
- Implementing spatial information systems reduces effort, time, and money.

- Rural areas, especially the North-Darfur, host huge of deterioration, over grazing, felling, in return, it has a minimal area of forests**.**

1.4: Objectives

1.4.1: Main objective

Application of remote sensing for vegetation cover change assessing based on Normalized Difference Vegetation Index (NDVI) in Koskary area during the years 2000, 2010 and 2020.

1.4.2: Specific objectives

- To assessing of vegetation changes during the years 2000, 2010 and 2020 in study the area.
- To detection of vegetation covers change in study area for the years 2000, 2010 and 2020.
- Production of NDVI Maps show the levels of vegetation cove areas during the period (2000 to 2020) in study area.

1.5: Research hypotheses

- The vegetation cover of Koskary area has been significantly changed during the years 2000, 2010 and 2020.
- The natural disaster and human activities are core factors of affecting vegetation cover change.
- The flow direction and topography are affecting vegetation covers pattern.

CHAPTER TWO

LITERATURE REVIEW

2.1: Vegetation of the Sudan:

Sudan is divided into about five ecological zones divided by latitudes and the amount of rainfall. Average annual rainfall varies considerably across the Sudan, from nil (zero) in the desert and semi-desert in north Sudan to more than 800 mm in the south (Mohamed et al. 2014). Within these ecological zones there are five different soil types: desert soils (gravel and sands), alkaline catena soils, Goz soils (sands), alluvial soils and lacustrine soils.

Table 2.1: Vegetation zone of the Sudan in relation to ecological zone and soils

Aridity Zone	Ecological zone	Area (sq.km.)	% (Area of the Sudan)	Annual Rainfall (mm)
Hyper-arid	Desert	776,000	41.2	< 20
Arid	Semi-desert	630,000	33.5	20–100
Semi-arid	Grassland Savanna	340,000	18.1	100–300
Dry sub-arid	Low Rainfall Woodland Savanna	65,000	3.4	300–500
Sub-tropic	High Rainfall Woodland Savanna	70,000	3.8	500–800
TOTAL		**1,881,000**	**100**	

Source: Mohamed et al. 2014

Most of Sudan's ecological assets such as rangelands and forests are very threatened by environmental degradation. More than 50.7% of the landscape is bare soil or seriously degraded (FAO 2012). Also according to (Mohamed Awad and Mohamed Abdelmanan.2017) they are mentioned that the annual increase of desertification over about 1.2 Km towards south every year.

The Sudan is seriously affected by biodiversity loss, reduced range land carrying capacity, deforestation, pollution and increased incidence of environment related diseases, fire and over grazing.

2.2: Vegetation Cover Changes Detecting and Remote Sensing

2.2.1: Historical Perspective

A vegetation cover change is one of desertification appearances, it became known in the 1930s, when parts of the Great Plains in the United States was hit by dust storms "Dust Bowl" as a result of drought and poor practices in farming, although the term itself wasn't used until almost 1950 (Wordiq, 2004). The French geographer Andre Aubreville first used the word desertification in 1949 to describe the change in North and Equatorial Africa from productive savanna forest, grasslands, and shrub lands into unproductive desert (Aubreville, 1949).

In countries as vast as the Sudan, the use of remote sensing technology is perhaps the only economically feasible way of surveying the natural resources in several fields. Many studies of land degradation have been carried out in different ecological zones in Sudan, with more emphasis on desert and semi desert areas which are influenced by different interaction factors.

RS in the Sudan dated back to 1970s whereas in early 1971 the Food and Agricultural Organization (FAO), has chosen the Sudan and two other countries in Asia and South America as test areas for the possible utilization of remote sensing for recourses surveying, mapping, planning and development.

In year 1972 the Sudan government in cooperation with FAO, carried out the Savannah Development project for reconnaissance of land and water resources in the southern part of the Blue Nile. For this, FAO requested images for that part of the area and obtained by Landsat-1 during August 1972 to March 1973.

It appears that the impact of vegetation cover loss on the environment and the resource in Sudan highlights the importance of remote sensing as an efficient tool for surveying and mapping.

2.2.2: Delineation of Vegetation cover

In satellite images processing techniques, bands ratio usually represents special surface characteristics. The difference of two bands are called "index ". If this index comes from near Infrared to Red regions of spectral, it represents "Vegetation index

(VI)". The green plants have chlorophyll and reflect Infrared bands in high level; consequently, it appears in red color in the satellite images (GeoMart, 2021).

For the normalization of the vegetation index data, the vegetation index has been divided by the total of the two bands. The result of them called "Normalized Difference Vegetation Index (NDVI)" (Anwar et al 2016).

2.3: Introduction to Remote Sensing results

Bossler (2010) described change detection as "comparing images of the same region as observed at differing times to summarize the changes that have occurred".

That means it is a useful technique in detection of the change dynamics of land features or phenomenon including natural resources.

In general, vegetation cover is a dynamic process and Geospecial information science (RS, GIS, GPS) are great techniques in change monitoring.

2.3:1 NDVI, Remote sensing and vegetation cover

To determine the density of vegetation cover on a patch of land, the distinct colors (wavelengths) of different ranged of visible band and near-infrared sunlight reflected by the phenomena must be observed. (Goward et al. 1991).

By detectors and measure the intensity of light coming off the Earth in visible-red and near-infrared wavelengths and quantify the photosynthetic capacity of the vegetation in a given pixel of land surface (Holben et. al., 1990; Kelly and Hood, 1991).

The most successful and commonly used of these techniques is Normalized Difference Vegetation Index (NDVI), which calculated using near-infrared radiation minus visible radiation divided by near-infrared radiation plus visible radiation, this formula it written mathematically as follow:

NDVI= (Infrared – Red) / (Infrared + Red) (Howard. 2002).

The value is between +1 (vigor) ~ -1 (stress)

NOAA AVHRR : NDVI = (B2 – B1) / (B2 + B1)

Landsat TM/ETM : NDVI = (B4 – B3) / (B4 + B3)

Landsat8 : NDVI = (B5 – B4) / (B5 + B4)

Sentinel-2 : NDVI = (B8 – B4) / (B8 + B4)

MODIS : NDVI = (B2 – B1) / (B2 + B1)

IKONOS/Quick Bird : NDVI = (B4 – B3) / (B4 + B3)

The NDVI takes 32 bit data varying between (-1) and (+1). The positive values represents the vegetation; however, the negative values represents the non-vegetated areas. These data can be scaled into 8 varying bit values (0 to 255). Where (-1) value goes to (0); on the other hand, (+1) value goes to (255). As a result of NDVI value, the light areas represent regions of high vegetation, while, the dark areas represent regions of low vegetation. This results can be extracted and masked in the pre-classification input data (Anwar el at. 2016).

2.3:2 Imagine DeltaCue and Change Detection:

DeltaCue is a software package add-on Erdas Imagine designed specifically to identify changes of interest in remotely sensed imagery acquired on two dates.

The software provides a series of algorithms, procedures and automated processing steps central to change detection in a user-friendly form that helps efficiently manage the image processing activities associated with this task (Mohamadain, 2019).

2.4: The Fundamental of Remote Sensing

2.4.1: Simply definition:

When you are reading a sentence of this line, now you are doing RS.

2.4.2: Scientific definition:

- Any information acquired from the object without touching (Koko Lwin 2008).
- The science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation (Lillesand and Kiefer, 2015).

Remote sensing is the examination or the gathering of information about a place from a distance. Such examination can occur with devices (like cameras) based on the ground, and/or sensors or cameras based on ships, aircraft, satellites, or other spacecraft (Gupta el at 2012).

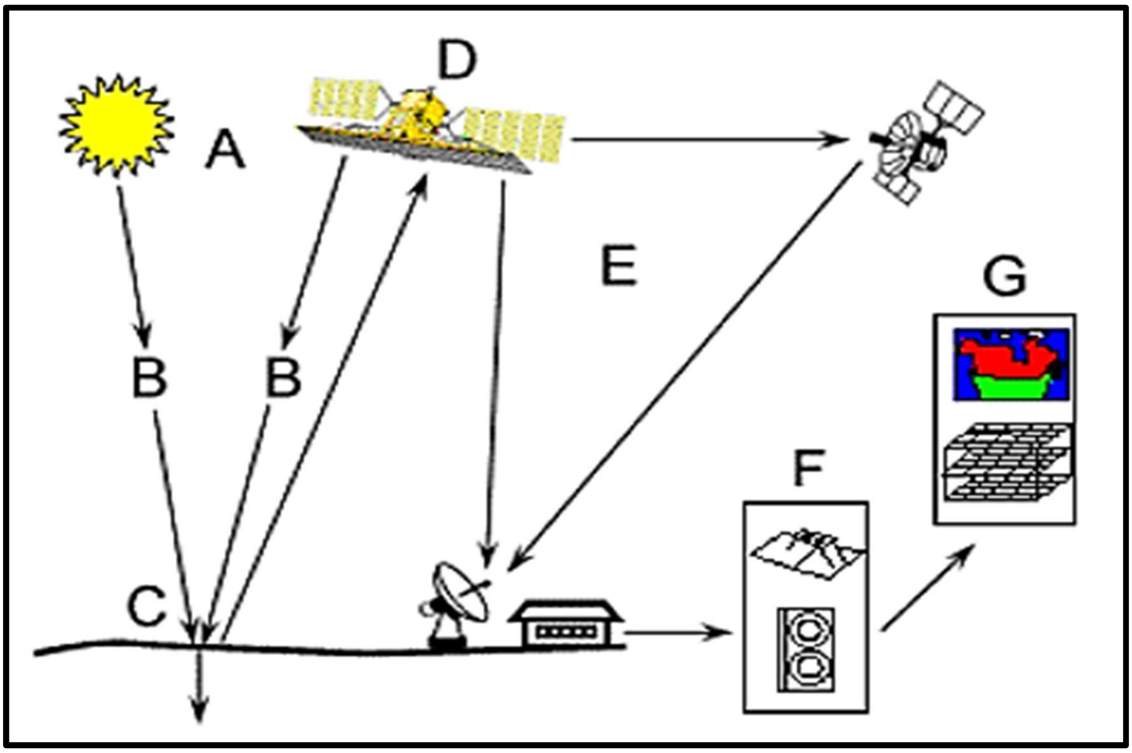


Fig 2.1: the process of remote sensing

Source: CCRS

1. Energy Source or Illumination (A)
2. Radiation and the Atmosphere (B)
3. Interaction with the Target (C)
4. Recording of Energy by the Sensor (D)
5. Transmission, Reception, and Processing (E)
6. Interpretation and Analysis (F)
7. Application (G)

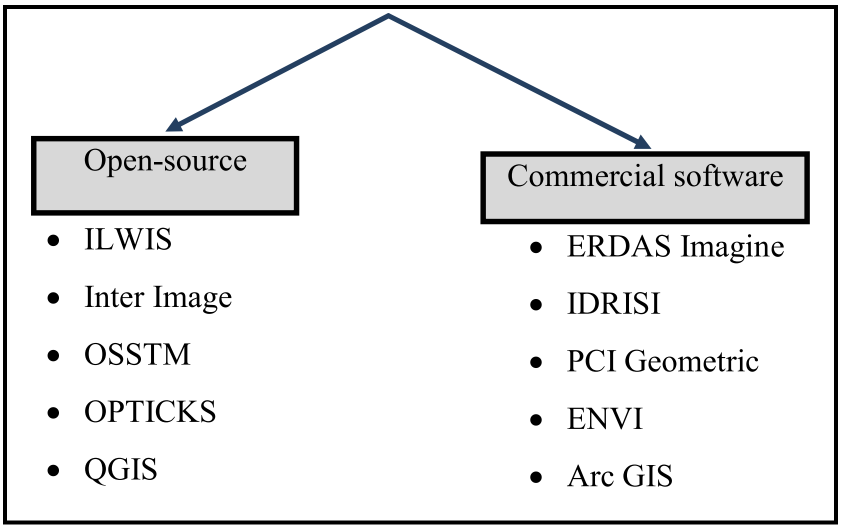


Fig 2.2: Some Open-source and commercial software used in remote sensing

Source Dawod. 2015

2.5: Geographical information system (The Science of Where?)

Geographic Information System which consists of three words, viz. Geographic, Information and System. Where the word:

1) '**Geographic**' deals with spatial objects or features which can be related or referenced to a specific location on the earth surface. The object may be physical/natural or cultural / man made. Likewise the word.

2) '**Information**' deals with the large quantity of data about a particular object on the earth surface. The data includes a set of quantitative and qualitative aspects which the real world objects acquire.

The term 3) '**System**' is used to represent systems approach where the environment consists of a large number of features /objects on the earth surface and their complex characteristics are broken down into their component parts for easy understanding and handling.

Over the past eight years, GIS technology has been widely accepted by public as well as private forestry agencies. In large part this has been a result of the benefit of using GIS technology over current forest and vegetation maps.

It is used to access the existing forest resource and develop harvest schedules and treatment programs to project future timber supplies and for other operational planning activities. Forest inventory data is collected using remote sensing techniques. With GIS technology, the average age of the information in the forest data base could be reduced from 20 years to only a few weeks. The time factor alone has led to a wide acceptance and large demand for GIS applications in forestry (Gupta el at 2012**).**

2.6: Remote Sensing and GIS Work Flow

- RS is used as a tool for obtaining or gathering the data for use in GIS.
- GIS data are used as ancillary information to enhancement and improve the data products derived from RS (QjhaoWeng, 2010).

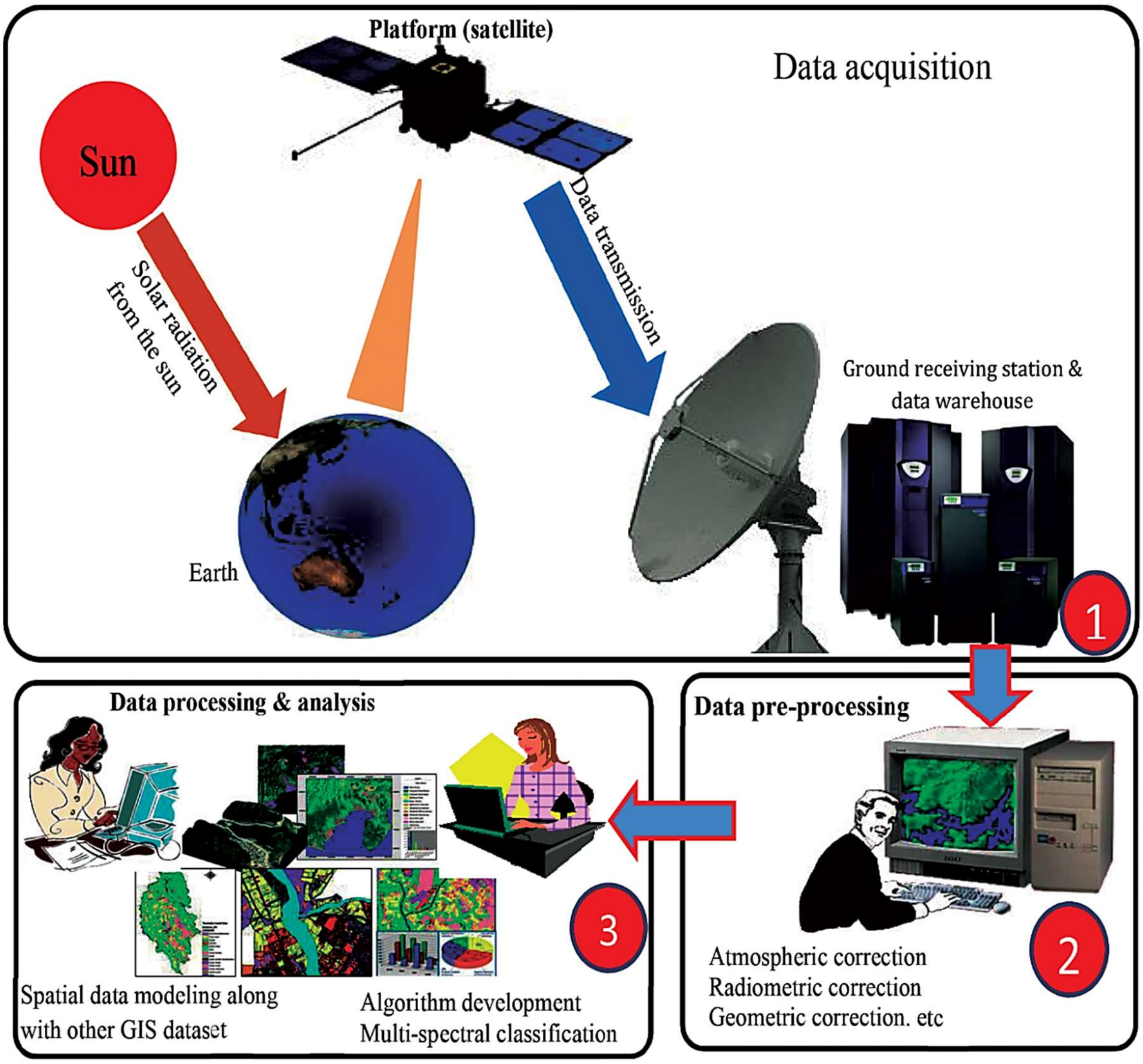


Fig 2.3: the contribution of Remote Sensing to GIS and vies versa
Source, Koko Lwin 2008

2.7: Landsat Imagery

2.7.1: Overview

Landsat is a name indicating (Land + satellite) is become available since 1972 from eight satellites in the Landsat series. These Landsat satellites have been a major component of NASA's earth observation program, with four primary sensors evolving over forty two years: MSS (Multi-Spectral scanner), TM (Thematic Mapper), ETM+ (Enhance Thematic Mapper Plus) and OLI, TIRS (Operational Land Imager, Thermal Infrared Sensor)(Global Land cover Facility web site. 2021).

Landsat supplies high resolution infrared and visible imagery with panchromatic image from ETM+ OLI sensors and thermal imagery, this imagery available through global land caver facility (GLCF) is designated to complement overall project goals of distributing a global, multi-spectral, multi-temporal and multi-resolution range of imagery appropriate for land cover analysis.

Table 2.2: The Landsat satellite Specifications

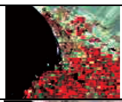
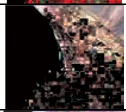
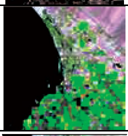
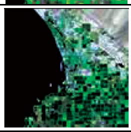
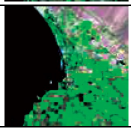
generation	Shooting	Height km	Equator Transit/ AM	Spectral resolution		Temporal resolution	sensor	Scan size
				Panchro-matic	Multi-spectral			
Landsat-1	1972 (over)	912	8:50 9:08 9:31			18 day	MSS‹RBV	185 × 185
Landsat-2	1975 (over)		9:08					
Landsat-3	1975 (over)		9:31					
Landsat-4,5	1982, 1984	705	9:45			16 day	TM, MSS	
Landsat-7	1999		10:00	15 m	30 m		EHM+, MSS	
Landsat-8	2013		9:30				OLI, TIRS	

Table 2.3: Landsat Images Properties

Landsat 4-5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper plus (ETM+)		Landsat8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)	
Band	**Wavelength**	**Band**	**Wavelength**
Band1 – blue	0.45 – o.52	Band1 - costal aerosol	0.43 – 0.45
Band2 – green	0.52 – 0.60	Band2 - blue	0.45 – 51
Band3 – red	0.63 – 0.69	Band3 - green	0.53 – 0.59
Band4 – Near infrared	0.77 – 0.90	Band4 - red	0.64 – 0.67
Band5 – short-wave Infrared	1.55 – 1.75	Band5 -Near Infrared (NIR)	0.88 – 0.85
Band6 – Thermal Infrared	10.40 – 12.50	Band6 -short-wave Infrared(SWIR)1	1.57 – 1.65
Band7 short-wave Infrared	2.09 – 2. 35	Band7 short-wave Infrared(SWIR)2	2.11 – 2.29
Band8 – panchromatic (Landsat7 only)	0.52 – 0.90	Band 8 - panchromatic	0.50 – 0.68
		Band9 - Cirrus	1.36 – 1.38
		Band10 - TIRS 1	10.60 – 11.19
		Band11 - TIRS 2	11.50 – 12.51

Note: *There was become some problem on Landsat7 sensor since year 2003 up to now where give Images have black strips in many part of Image any strip space is about 1km width. So it need high processing when using.*

Table 2.4: Landsat images and Visual Interpretation (Band combination)

The view	Color	Landsat8 (Bands)	Landsat 4.5.7 (Bands)
	Infrared	5-4-3	3- 2 -5
	True color	4 - 3 – 2	3 - 2 - 1
	False color	6 - 5 – 4	5 - 4 - 3
	False color	7 - 6 – 4	7- 5 - 3
	False color	7 - 5 -3	7 - 4 - 2

Nofal, 2018

It’s the First step interpretation and to distinguish various land covers into different colors.

- In Landsat ETM, the colors RGB in bands 321 gives natural color. Where assign band 3 to red channel, band 2 to green channel and band 1 to blue channel in computer program display. To see landscape in realistic view.
- RGB 432 gives false color. Where assign band 4 in red channel, band 3 to green channel and band 2 to blue channel to determine vigor and vegetation stress.(Koko Lwin 2008).

2.8: Fundamental of Global Positioning System (GPS)

2.8.1: Concept of GPS

The NAVSTAR Global Positioning System (GPS) is a satellite-based positioning, navigation, and timing (PNT) system designed, deployed, financed, and operated by the U.S. Department of Defense (PNT 2009).

2.8.2: The Attractions of GPS as a PNT Technology

- High accuracy, ranging from meters down to the millimeter level.

- The capability of determining velocity and time, to an accuracy commensurate with position.
- Signals are available to users anywhere on or above the earth.
- Obtained Results with reference to a single, global datum.
- Low-cost user hardware.
- Provided Position information in three dimensions.
- There are no user charges.
- An all-weather system, available 24 houses a day.

2.8.3: Revolutionized of GPS And Fields Of Geodesy, Surveying, And Mapping:

GPS has revolutionized the fields of surveying, mapping, and geodesy, commencing with its introduction to the civilian community in the early 1980s. Among the first users were geodetic surveyors who applied GPS to the task of surveying primary control networks that form the basis of digital databases and all map data (PNT 2009).

CHAPTER THREE

MATERIAL AND METHODS

3.1: Preface

A chapter focuses on how materials and data has been obtained and processed, and how vegetation cover change information was extracted, processed and analyzed.

3.2: Study Area

The area of Koskary is located in North-Darfur state, about 65 km North-east Mellit town and 30 km east Al-sayyah locality (Fig3.1). Geographically located at semi-arid zone, at longitudes 26.01218 E and latitudes 14.39987N. Altitude above sea level ranges from 830 m in clay soil (Wadis) to 1008 m in sandy soil, the mean annual precipitation range between (60 - 200) mm/annual. Spanning through a big water-way (Wadis).

Most houses construction system in area are depending on woods and sorghum canes.

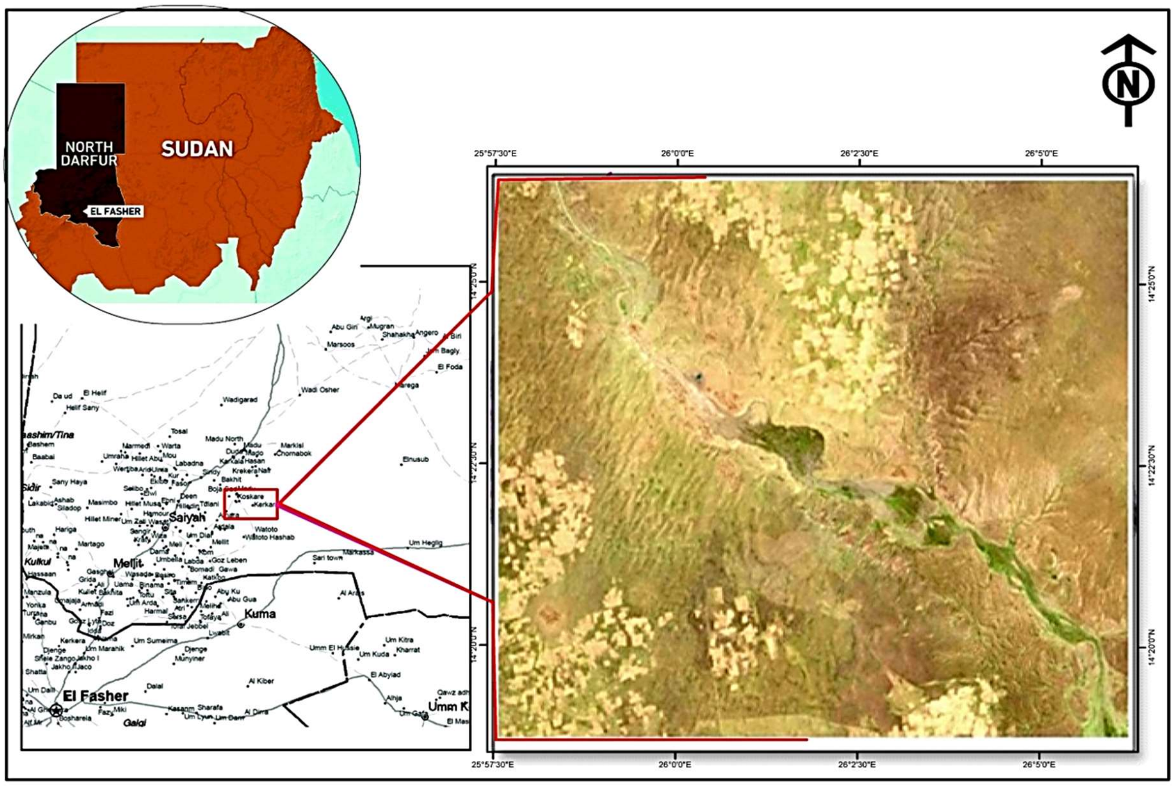


Fig 3.1: The location of study area in Sudan region
Source: researcher preparation 2021

3.3: Population

The population of Koskary area is about 5 thousand, due to last informal report of area managing-committee. They distributed variably in Koskary districts. The mean of family size in area is about 5-7 person, more than 50% of them youth (field survey 2021).

3.4: Topography

The topography is characterized by gently undulating to vehemently level uplands (map 4.6 and map 4.7), however, it is interspersed with various hills. The hilly parts cover areas around the main water sources (Wadis) and sub seasonal streams (field observation 2021).

3.5: Soils

There are two main soils in Koskary area: the dark clay soils and the sandy soils. The sandy soils are mainly stabilized sand dunes or (Goz lands) as locally known, in generally, flat in some place and very slops in others. Moreover, very permeable, excessively drained and have low water holding capacity, Have potential for different type of agriculture crops.

The clay soil is covering a part of water catchment and seasonal waterways. With high PH values and much more pervious to water and better drained (field observation 2021).

3.6: Water Supply and Quality Standards

Generally, the enviable water in study area is scarcity impede the production potential of the available. The water is conserved by ponds in clay soil (Wadis) which available in rainy months July to March from each season, or in artificially excavated ponds (Hafirs) as locally known, used for both animal and human consumption, usually pollution an earlier time.

In dry season, the population drinking vary salt water from pumps or a wells that digging manually about 30 meter or more (field investigation 2021).

3.7: Climatic Profile

3.7.1: Climatic Zones

The Koskary area inside in semi- Arid zone, where the rainy season is almost short, and the dry season is very long.

3.7.2: Temperature

The average of maximum annual temperatures varies between 33°C and 35°C, and minimum average is varies between 17°C and 19°C. The highest temperature on record is 40.1°C in May of 2004, and the lowest was 7.6°C in January of 2007 and 2016 (field investigation, 2021).

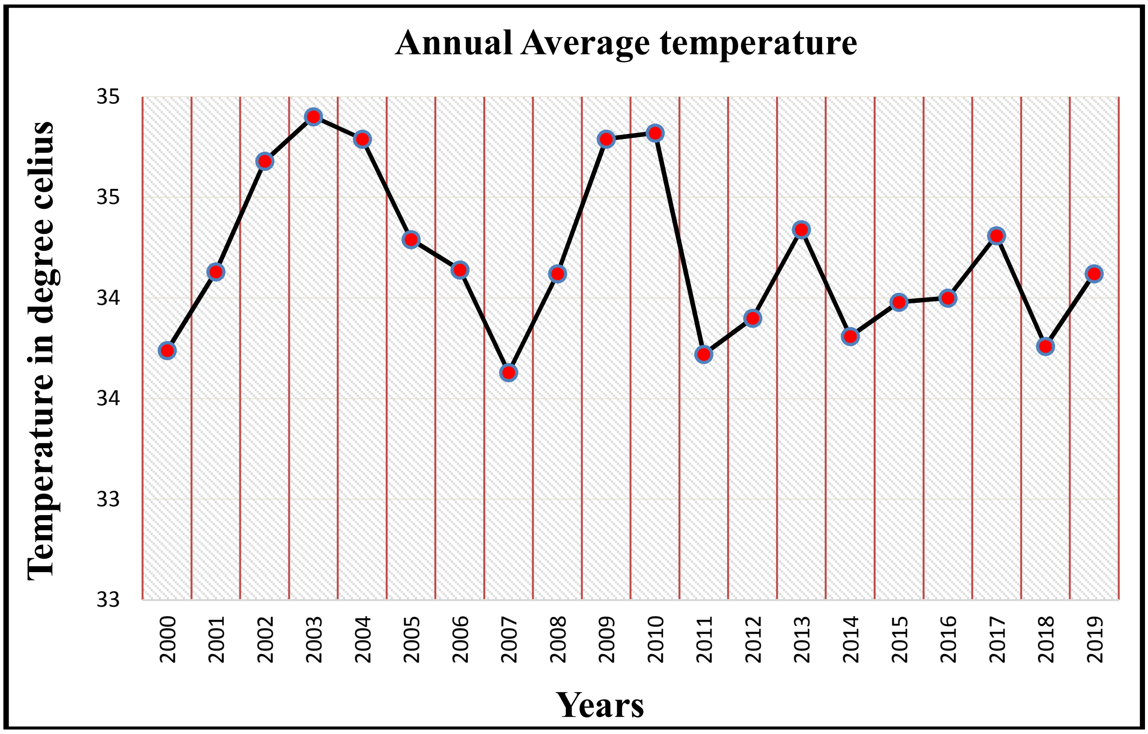


Fig 3.2 the average of annual temperatures at study area
Source :(NASA, 2021)

3.7.3: Rainfall

The annual rainfall in Koskary area varies from almost 60 mm to 200 mm annually. The rainy season is limited to two or three months with the rest of the year remaining virtually dry.

The rainfall is characterized by large variations from year to year, and the area has a systematic increase and so decrease in rainfall, and wide spread droughts affecting the area as in happened in Sub-Saharan Africa (field investigation, 2021).

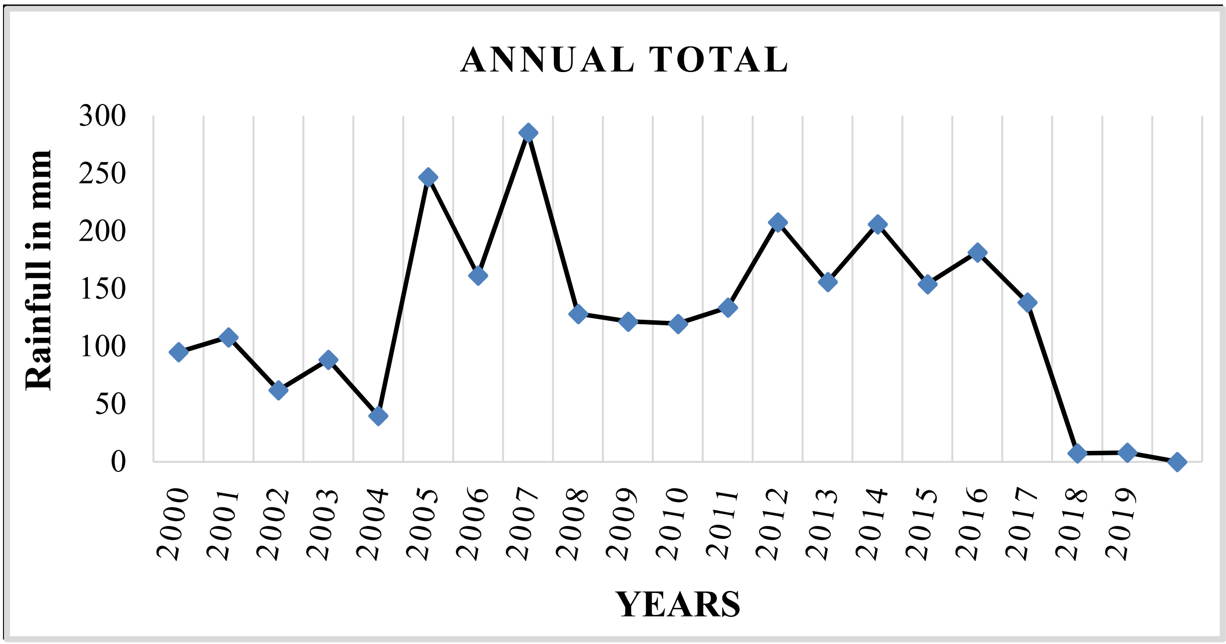


Fig 3.3: A total of annual Precipitation at study area
(NASA, 2021).

3.7.4: The Wind

Most of wind in study area are dry and windy, prevailing from north-east, and south-west wed winds with mean speed usually in rainy months.

3.8: Socio-Economic Aspects

Population of Koskary area has grown from 10- 15% of the area land in far past year, but nowadays, the agriculture land in rainy season is become more than 20% and continuously increase with the increase of population, mechanical agriculture and shifting cultivation due to variations of rainfall from site to site. Most of population deboning on Dura, Sorghum as a main crops (field survey, 2021).

3.9: Data Sources and Materials

3.9.1: Satellite Image

To carry out this study a Landsat7 ETM+ imagery for the years 2000, 2010 and Landsat 8 image for the year 2020 were used. A digital elevation model (DEM) also has been used for topography and hydrology characteristic extraction.

The other materials also used that obtained from scientific web site as (USGS) and power.jarc.nasa.gov (NASA web site) to download historical daily and monthly climate data.

Table 3.1: the characteristic of study Instrument images

<table>
<tr><th>Instrument</th><th>Truncation</th><th>Spectral Bands</th><th>radiometric Resolution</th><th>Date</th><th>Path / Row</th><th>Datum and projection</th></tr>
<tr><td>Lansat 7</td><td>ETM+</td><td>8</td><td>8 bit</td><td>04.02.2000
19.03.2010</td><td rowspan="2">177 / 50</td><td rowspan="2">WGS84 UTM_ZONE - 35</td></tr>
<tr><td>Lansat 8</td><td>OLI / TIRS</td><td>11</td><td></td><td>03.02.2020</td></tr>
</table>

3.9.2: Field Survey Approaches and Samples Selected System

Effective field data are best obtained through knowledge of valid sampling techniques, thoughtful planning, accurate location-finding procedures, and reliable field measurements (Roger, 2005).

3.10: Sampling Selecting System

3.10.1: Simple Random Pattern

The simple random sampling pattern is applied in this study (map 3.1).

Basically, the simple random pattern is used to ensure that all parts of the project area have an equal chance of being sampled with no operator bias (Roger, 2005). This condition is important to the assumptions of the underlying statistics used in classification. Random sites are selected by dividing the study area into a grid with numbered coordinates. Then coordinate pairs are selected from a random number table and plotted on the study area map. Each random point becomes a sample point or the center of a sample area.

3.10.2: Number of Samples and Training Sites

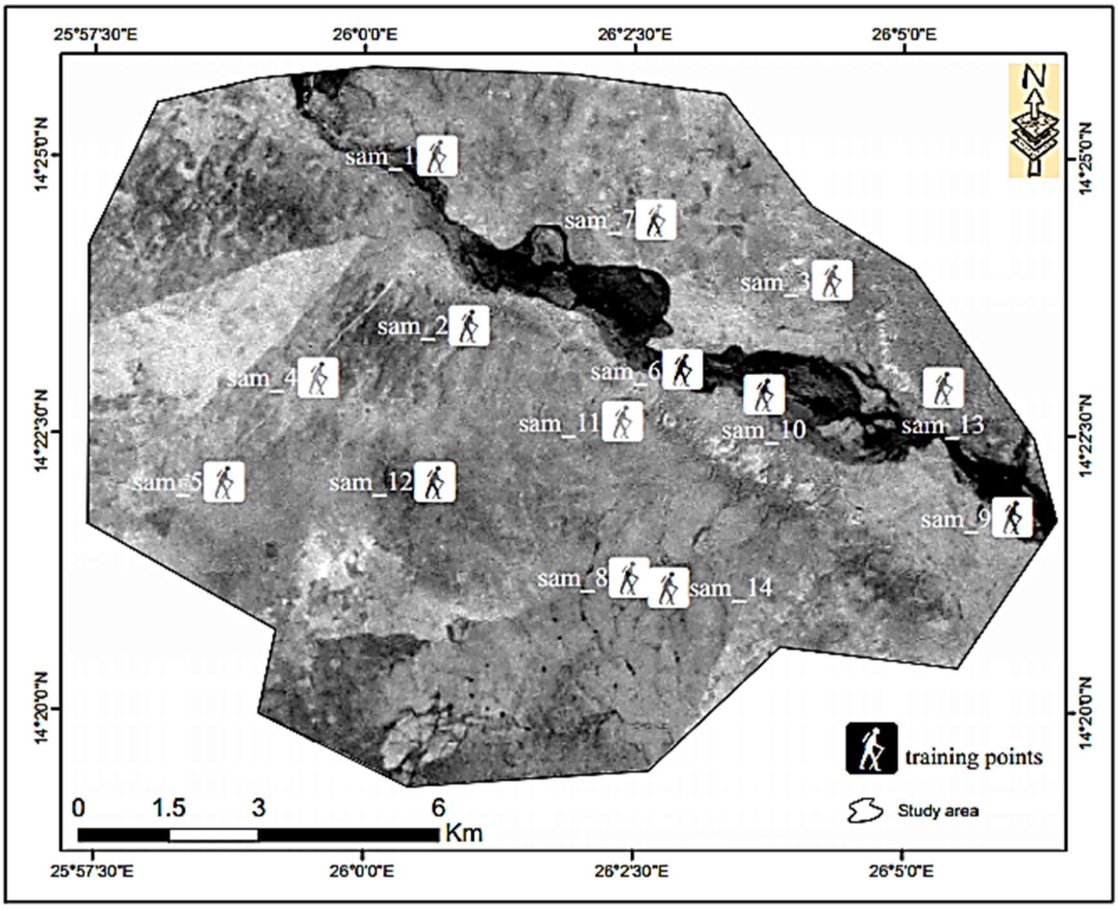
To selecting sample sites for training data, chosen area equaled 143.6km square from study area to be a size of research study area, and 10% as an accuracy level to chosen the size of sample, while:

The size of sample = (an accuracy level % × Total area in unit squire) = $\frac{10 \times 143.6}{100}$ = 14.36 km^2. And 1000 m^2 (17.81 meters plastic rope) is used as a sample unit.

The numbers of samples are calculated from size of sample while:

The numbers of samples = $\frac{\text{Size of sample km}^2}{\text{Sample unit m}^2} = \frac{14.36 \times 1000}{1000} = 14.36 \approx 14.$

Finally, 14 samples (training points) are selected and identified for measurement purposes.



Map 3.1: Sample units locations in study area due to ArcGIS program selected

Note: * Sam + number like (sam11) = sample + its number

* The boundary of this area is taken as a boundary of scientific research, not implying any full formal of managing-committee or government boundaries.

3.11: Finding Locations in the Field and measurements

Handy GPS (German GPS map 62) is used as a tool to find out training point locations, field measurements and site-specific observations.

Plate 3.1: training points locate, and measurement

3.12: Choice of Maps and Coordinate System

As a maps are the first item to consider in planning for field work, in this study, the maps and Coordinate System chosen is Universal Transverse Mercator

(UTM), for the reason that high level of planimetric accuracy. Also, UTM system, it has helpful to provide the UTM zone, geodetic datum, and measures magnetic declination.

3.13: The Climate Data and Topography

The annual climate data calculation and land surface ware implemented by following equation model:

3.13.1: climate data

As it is, the climatic conditions are very important for vegetation zone divide and vegetation pattern, the annual calculation of precipitation was taken in total, while the temperature was taken in mean.

3.13.2: The slops and stream order

A Digital Elevation Models (DEM) is one of the better method for land Terrain representation in GIS because the value of pixel in it equal the value of land service elevation or the level, this study dependence on eight neighbors system method to account the slops as follow:

$$b = (z3 + 2z6 + z9 - z1 - 2z4 - z7) \big/ 8D$$

$$c = (z1 + 2z2 + z3 - z1 - 2z8 - z9) \big/ 8D$$

$$\text{Tan (slps)} = \sqrt{\mathbf{b^2 + c^2}}$$

$$\tan(\text{aspacts}) = b/c$$

Wile: D = cell distance or pixel size

Z = elevation value at each cell of eight cells which around by basic cell

3.14: Programs and Software

One of a main programs used in this study is (ENVI 5.3 and Erdas2014 programs) to display image, perform geometric and Radiometric correction, import Generic Binary data, and image analysis and conversion. Arc map 10.8 is used also to view raster and vector data, calculation NDVI, Overlay polygon, Prepare, edit and geocoding descriptive information, topology building, overlay, and calculate change detection. Also helping programs as Microsoft office 2013 packages are used.

3.15: Image Acquisition and Data Processing:

Most data of remote sensing can be acquired or purchased radio metric, computation of NDVI values, atmospheric, and geometric corrected (Koko Lwin 2008).

3.15.1: Radiometric and Atmospheric Corrections (Small Haze Removed)

Radiometric corrections are necessary due to variations in viewing geometry and scene illumination, atmospheric conditions, and sensor noise and response.

3.15.2: Geometric Correction (Earth Rotation)

Involves identifying the image coordinates of several clearly discernible points, called ground control points (or GCPs).

Methods of Geometric correction: 1-Using satellite header file (satellite onboard GPS) 2-Image to image registration, 3-Image to map registration 4-Manually entered GCPs.

3.16: The Flora and Fauna

Koskary area has been a refuge for plants, animals, reptiles and birds since long time due to his over lands.

3.16.1: The Flora

- **Sandy soil (Goz land) vegetation**: a dominant species of this part are *Acacia Senegal* (Hashab) which miss's economic value by Camels overgrazing and community neglect, and *Leptadenia pyrotechnica* (Marakh) which classified as a desert trees, extend very quick.
- **Clay soil vegetation (Wadis)**: *Acacia mellifera* (Kater), *Boscia senegalensis* (Makhit), *Capparis decidua* (Tondob), and *Balanites aegyptiaca* (Hglig) are a dominant species in this part, which so degraded by falling. And at that time, the majority of species in Wadis constitute a source of many benefits to local communities, and under two parts left, inside grass varieties (field observation 2021).
- ***Agroecosystem:*** a trees in this habitat as *zizipgus Spaina-Chiristi* (Sidir), have top chance to rich due to his economic levels, the community breeding it in all

parts of cultivations, fields, houses and homesteads that give it permeation to covering a better space in study area.

3.16.2: The Fauna

Shepherd-Invasion and rarely extended wildfire degrade most of wildlife habitats. And the over-hunting reduces and threatened most of values memos and birds spicily (the deer, Rabbits and Houbara) for food and income, (Foxes, wolfs, and monkeys) as a crops and animal-husbandry enemy.

While a number of memos, bird and reptiles adapted with this hard Circumstance, but it faces great threats (field observation 2021).

CHAPTER FOUR

RESULT AND DISCUSSION

4.1: Overview:

In this section, three types of data were collected constituting the necessary information, main of them the results of NDVI data series change detection analysis, which will be illustrated in forms of maps, figures, statistics and tables. And the specific data illustrated occasionally, that included field observation results and Digital Elevation Models (DEM) results.

The discussion of results will be performed to highlighting the categories.

4.2: NDVI images

Through the NDVI images, the vegetation cover is represented. And the images were divided into five classes that ranged from land has (high vegetation cover (forest), perfect cover (Shrubs and scattered Trees), medium, low and less land as bare lands). And two duration decades were investigated, values of NDVI within each were compared.

In a term of values, it ranged between (-1 for the less land or bare soils) up to (+1 for the high vegetation cover (forest lands). And the levels of vegetation classes also represented by a colors ranged from dark green area to present a high vegetation cover, light green, light yellow, light brown and dark brown as very less or nil vegetation cove.

4.2.1: Change detection Assessment

From the statistical findings of the NDVI classification of bi-temporal imagery (ETM 2000, 2010 and OLI 2020). The total area of coverage data is 143.62 km^2 (Table 4.1).

The comparing of NDVI images taken on different dates, at an interval of 20 years or two decades, 2000-2010 and 2010 - 2020, first to determine the areas where land cover has changed and to interpret these changes in terms of negative change (desertification / deterioration) or positive change (recovery).

By comparing the NDVI classification output of the three images, (table 4.2) show the high vegetation cover (forest) and other land use categories change over the period 2000 to 2020.

Table 4.1 vegetation Cover dynamic change area 2000-2020

classes	Area in 2000 (sq km)	Area in 2020 (sq km)	Total net change (sq km)	Total net Change %	General trend	Annual net change %
High cover	2.36	12.09	+ 9.73	+ 6.77	↑	+ 0.81
Perfect	18.17	33.16	+ 14.99	+ 10.43	↑	+ 1.25
medium	35.81	45.55	+ 9.74	+ 6.79	↑	+ 0.81
Low	52.36	38.72	- 13.64	- 4.09	↓	- 0.5
Less	34.91	14.10	- 20.81	- 9.5	↓	- 1.14

Through the overlaying of NDVI images for decade (2000 – 2010), showed that most of high vegetation cover (forest) and perfect vegetation cover (shrubs and scattered trees) area (Map 4.2) concentrated around the Koskary Wadi and decrease or absent in Goz land. However, are totally diffract in next decade (2010 -2020).

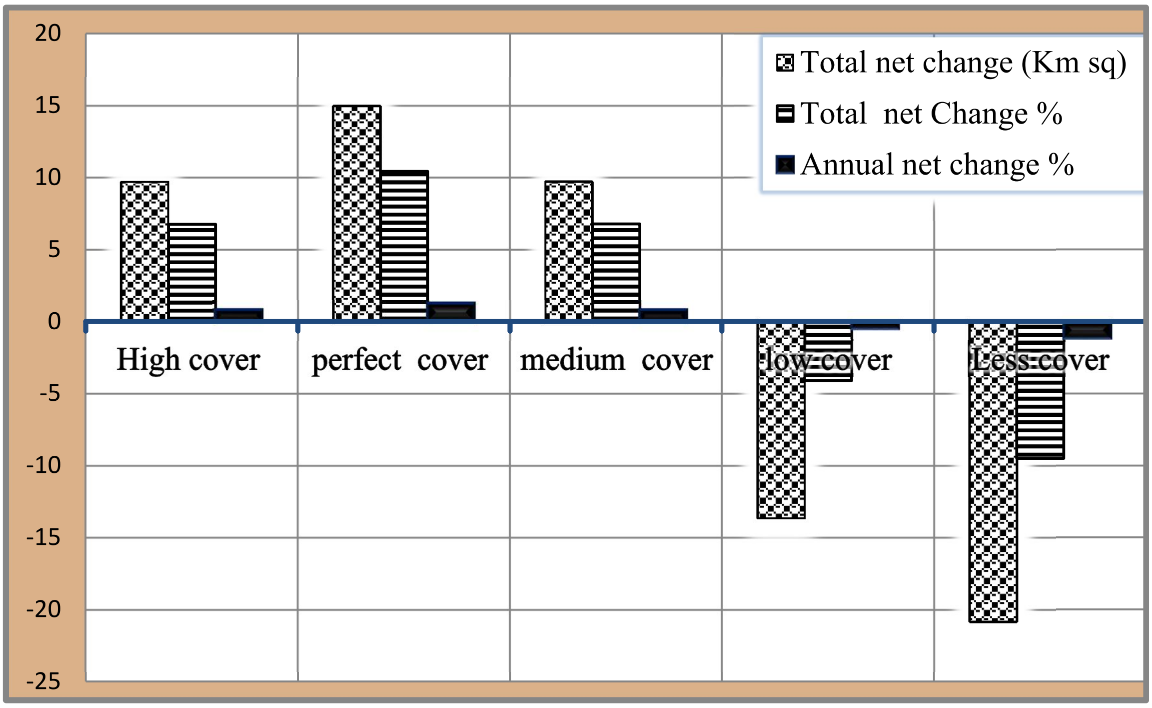
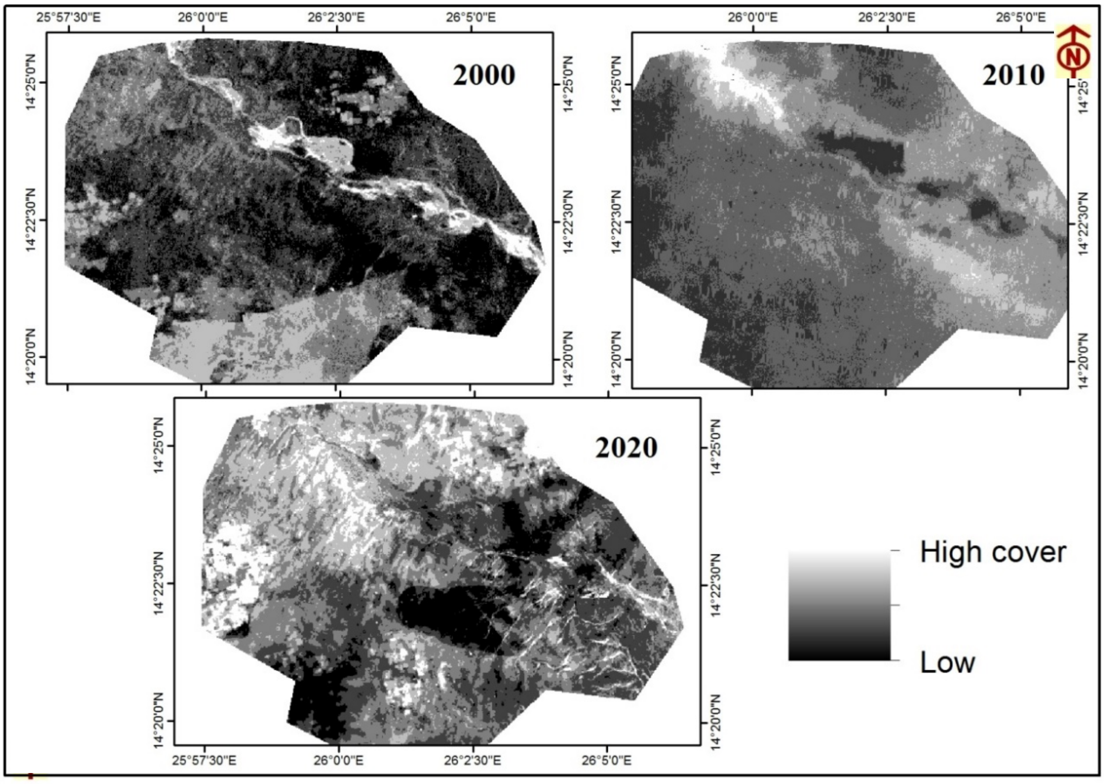


Fig 4.1 Trends of vegetation cover changes in study area



Map 4.1: NDVI classes for vegetation cover change through Two decades

4.2.2: Forest and forest land assessment

In general assessment, the forests is decreased from 2.36 sq.km in 2000 to 2.19 sq.km in 2010 resulting in a decrease of 0.17 sq.km equivalent to 0.12% of the total area of the land under study. However, increased to 12.09 sq.km between years (2010 to 2020) resulting in success of 14.28 sq.km, equivalent to 9.94% of the total area under study.

Through the decade (2010 – 2020) showed that, the level of forest cover on hot area (Wadi) (Map 4.4) are so decreased, by operation of cutting trees, unregulation of precipitation (dry), flood and silt movement (fig 3.3), so rarely of fire (more than ten time in season), due to peoples meeting statements.

However, the forest cover on goz lands is increased, but unfortunately Most of Goz trees compound are *Leptadenia pyrotechnica* (Marakh), while presented as a trees of degradation or desert lands.

The shrubs and scattered trees area decreased from 18.17 sq.km equivalent to 12.65% in 2000 to 10.18 sq.km equivalent to 7.09% in 2010 resulting in a decrease of 7.99 sq.km. However, the area of shrubs and scattered trees increased to 33.16 sq.km equivalent to 23.09% in 2020 resulting in an increase of 22.98 sq.km between the years 2010 to 2020.

By taking the two categories (forest) and (scattered trees and shrubs) (Table 4.2) to combined as forestlands, their total area in 2000 was 20.53 sq.km equivalent to 14.29% of the total area under study. Between 2010 and 2020 the area of forest cover are increased to 45.25 sq.km, equivalent to 31.51% indicating a win of 17.22% of the two categories. However, the forests are witnessed greater loss than the area of scattered trees and shrubs.

4.2.3: Agricultural lands and bare lands assessment

4.2.3.1: Agricultural lands

The agricultural lands in study area are not clear due to:

- All the agricultural system in study area are depending on the rain (July – October) and all of them a count as a bare lands after harvesting in January from each year.
- Some cultivation lands are so far from residential areas, so most of them out site the research boundary.

4.2.3.2: Bare soils

The bare land, which classified as a lees vegetation cover in term of this research is decreasing in area from 34.91 sq.km in 2000 up to 23.01 in 2010 and 14.10 sq.km in 2020 or from 24.31%, 16.02% up to 9.82% of total study area.

In general assessment, the bare lands in study area aren't have limited criterion, while depending on the situating of pastures from season to season, human activities and disaster.

4.2.4: The range and rangeland assessment

Most of land cover in study area inside under rangeland, and this category classified as medium and low vegetation cover in term of NDVI classification.

By comparing the both Medium and Low vegetation cover category, a general assessment of rangelands are increased from 88.17 sq.km 61.39% in 2000 up to 108.33 sq.km 75.36% in 2010 and decreased to 84.26 sq.km or 58.68% in 2020. May one of the reason of rarely wild fire.

Table 4.2: The NDVI Classification at study area by (sq.km).

<table>
<tr><th colspan="2" rowspan="2">classes</th><th colspan="2">2000</th><th colspan="2">2010</th><th colspan="2">2020</th></tr>
<tr><th>Area km²</th><th>%</th><th>Area km²</th><th>%</th><th>Area km²</th><th>%</th></tr>
<tr><td colspan="2">High cover (forest)</td><td>2.36</td><td>1.65</td><td>2.19</td><td>1.52</td><td>12.09</td><td>8.42</td></tr>
<tr><td colspan="2">Perfect (trees and shrubs)</td><td>18.17</td><td>12.65</td><td>10.18</td><td>7.09</td><td>33.16</td><td>23.08</td></tr>
<tr><td>Medium</td><td rowspan="2">(range land)</td><td>35.81</td><td>24.93</td><td>39.29</td><td>27.29</td><td>45.55</td><td>31.72</td></tr>
<tr><td>Low</td><td>52.36</td><td>35.46</td><td>69.04</td><td>48.07</td><td>38.72</td><td>26.96</td></tr>
<tr><td colspan="2">Less (bare land)</td><td>34.91</td><td>24.31</td><td>23.01</td><td>16.02</td><td>14.10</td><td>9.82</td></tr>
</table>

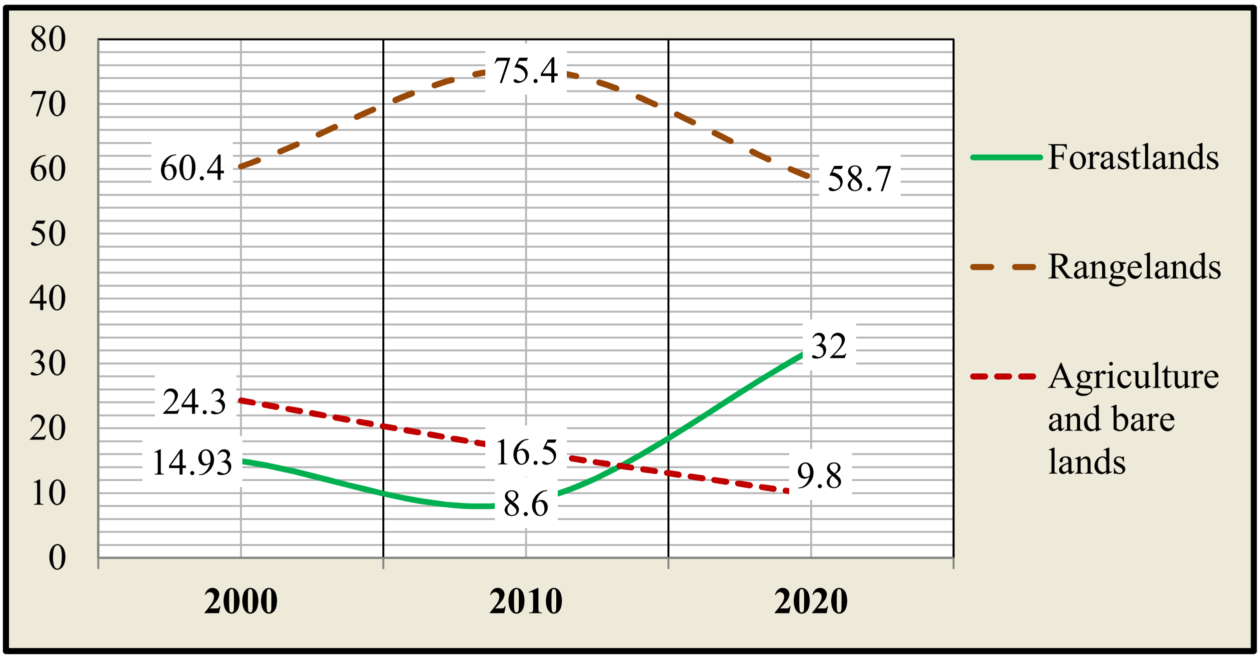
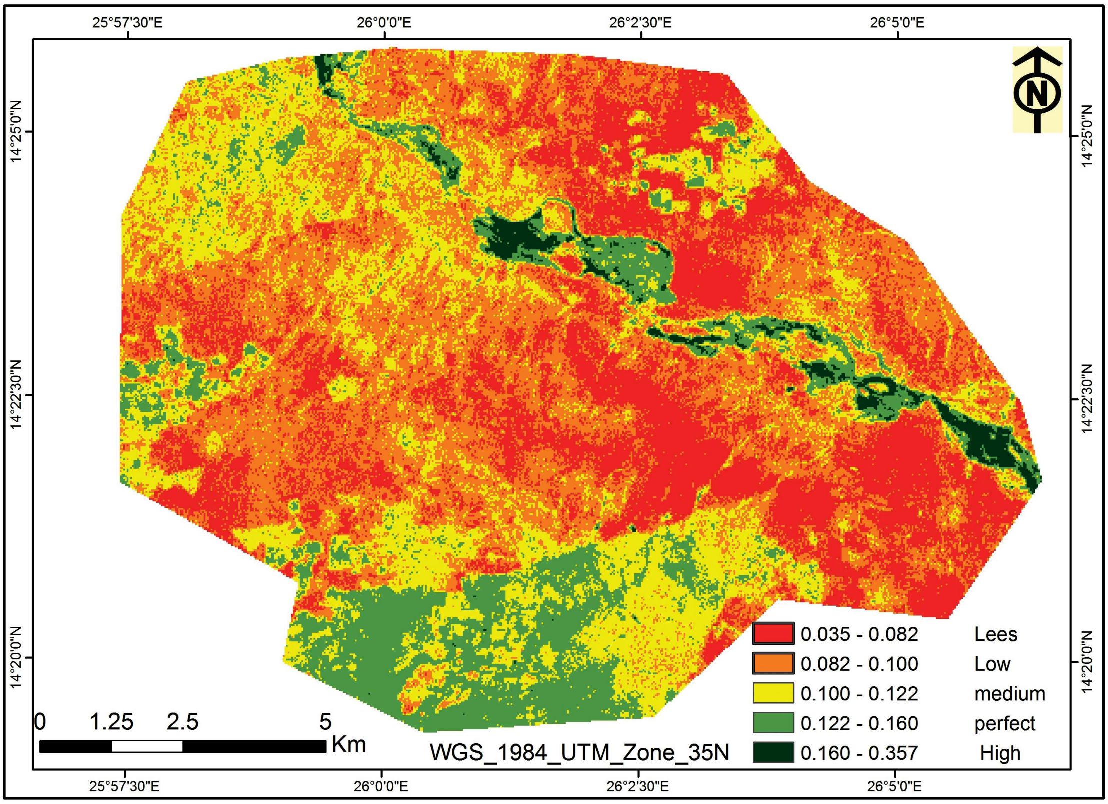


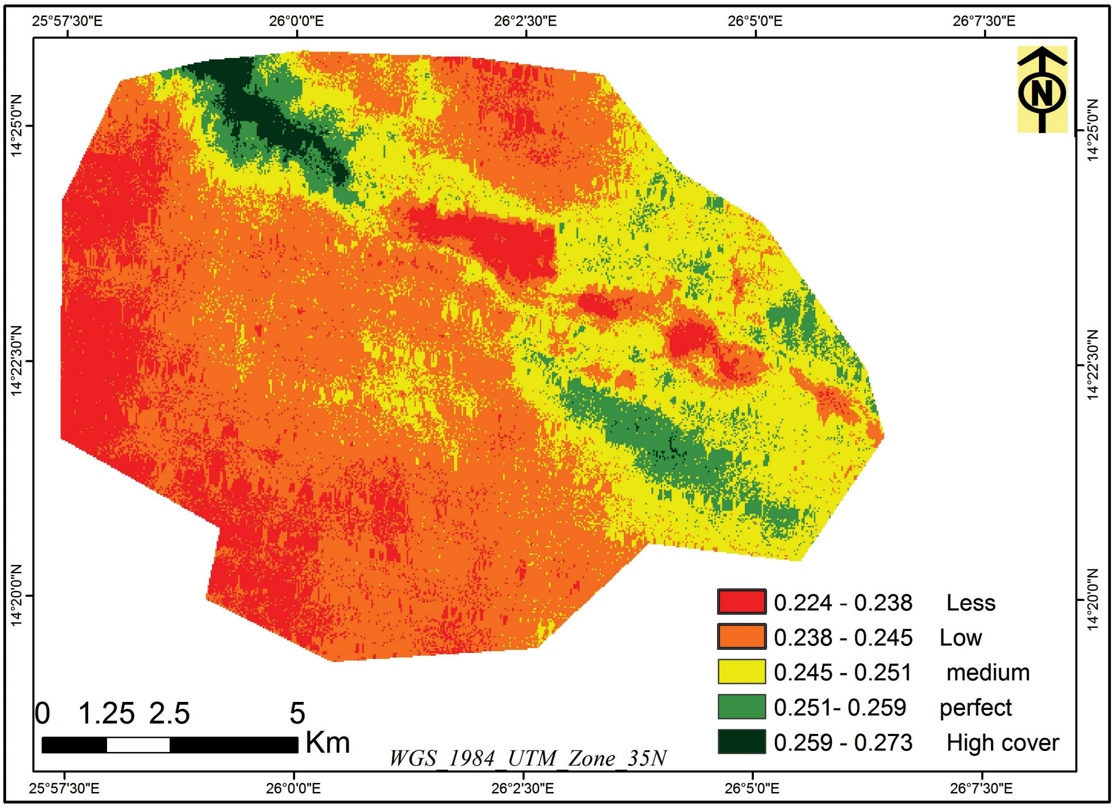
Fig 4.2: Land covers change by percentage

4.2.5: Extent of vegetation cover

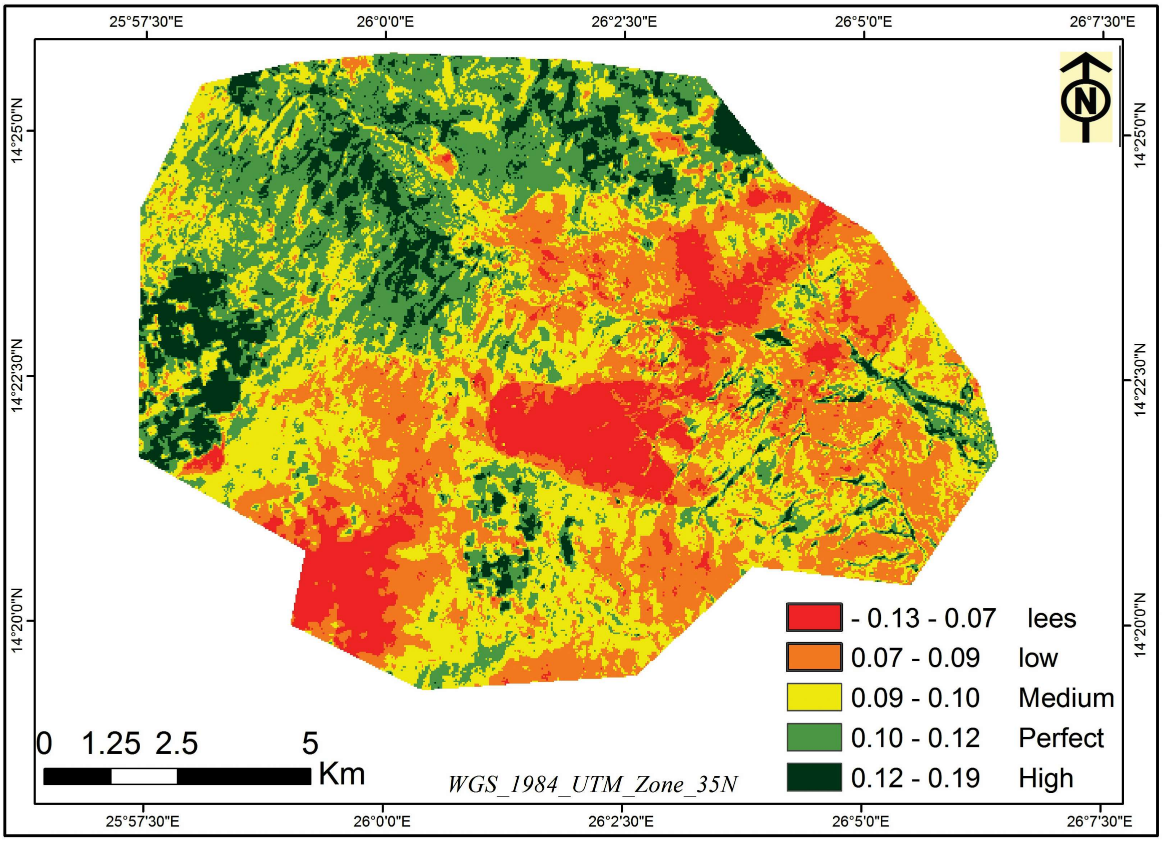
After comparison between vegetation cover categories obtained from NDVI classification of Landsat imageries, indicates that, the land cover of the study area showed obvious changes during the period from 2000 to 2020. However, it seems necessary to use some indicators to evaluate the extent changes of forestland and other land categories when displayed in maps at the specific times.



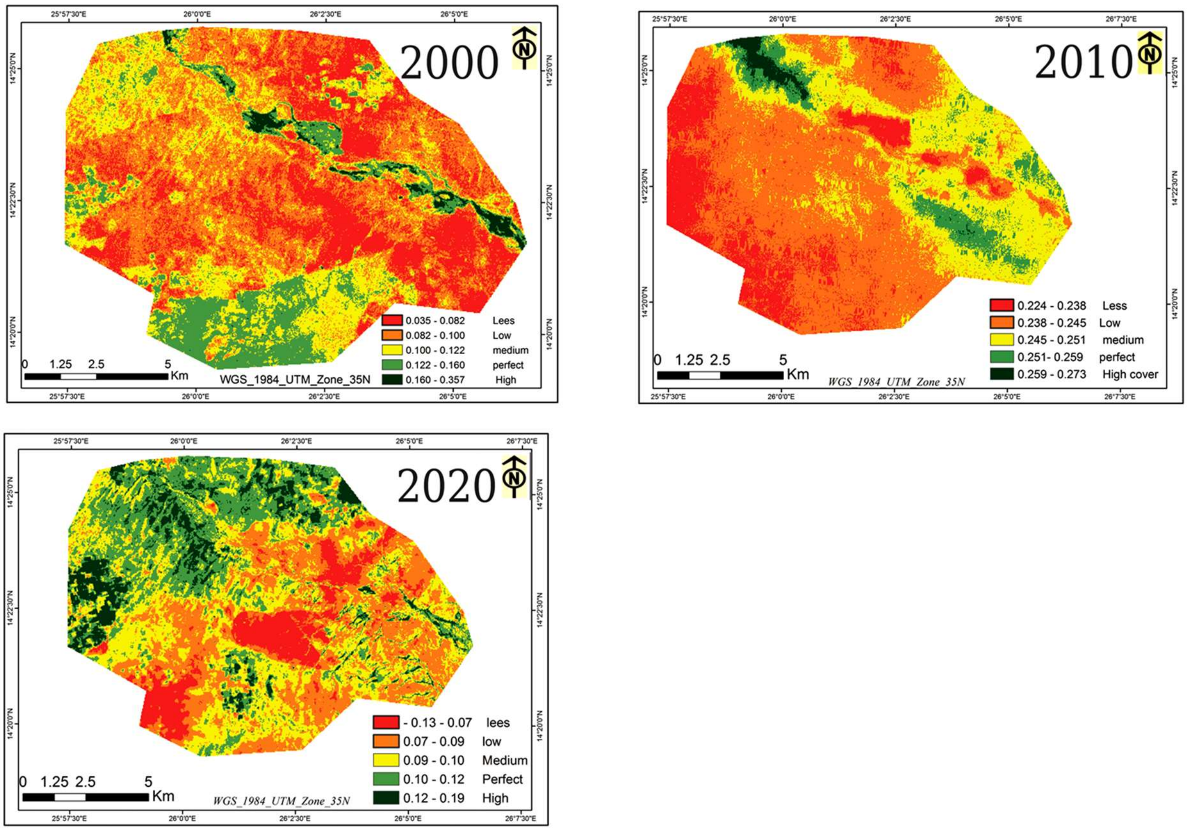
Map 4.2: NDVI images in the study area in the year 2000



Map 4.3: NDVI images in the study area in the year 2010



Map 4.4: NDVI images in the study area in the years 2020



Maps 4.5: vegetation covers change Detection in the study area during two decades

4.3: Human Activities

There are many aspects show the connection between community and natural resources around them. People depend on forests and forestland for wood and non-wood products for domestic purposes or income generation. Local people also need the forestland for grazing and cultivation of crops. On the other hand, the rural community constantly defends for forest lands by participation in putting out fires and reporting about forest crimes.

Some human activities have direct effect that observed in study area include:

- Cutting trees for cultivation, construction and fencing the fields and houses.
- This is mine (metaphorical term), illegal and vary effects system which some peoples observe continuously to mark(s) any trees that slanted by wind or the rain through a day or became older, to prevent the other to gate from it any benefit, this system let community in competition to marks and falls any trees for personal monopoly.
- The voluntary participation in put out forest fire and reporting forest crimes, are so decreased.
- The acceleration to get and store the wood for strategic future stock.
- Acceleration to production the block and charcoal for incomes.
- A fire for agriculture activities (insects control, fighting birds) or Reprisal
- Over grazing and timber trade by shepherds

Plate 4.1: Field fencing and houses

Plate 4.2: Block production

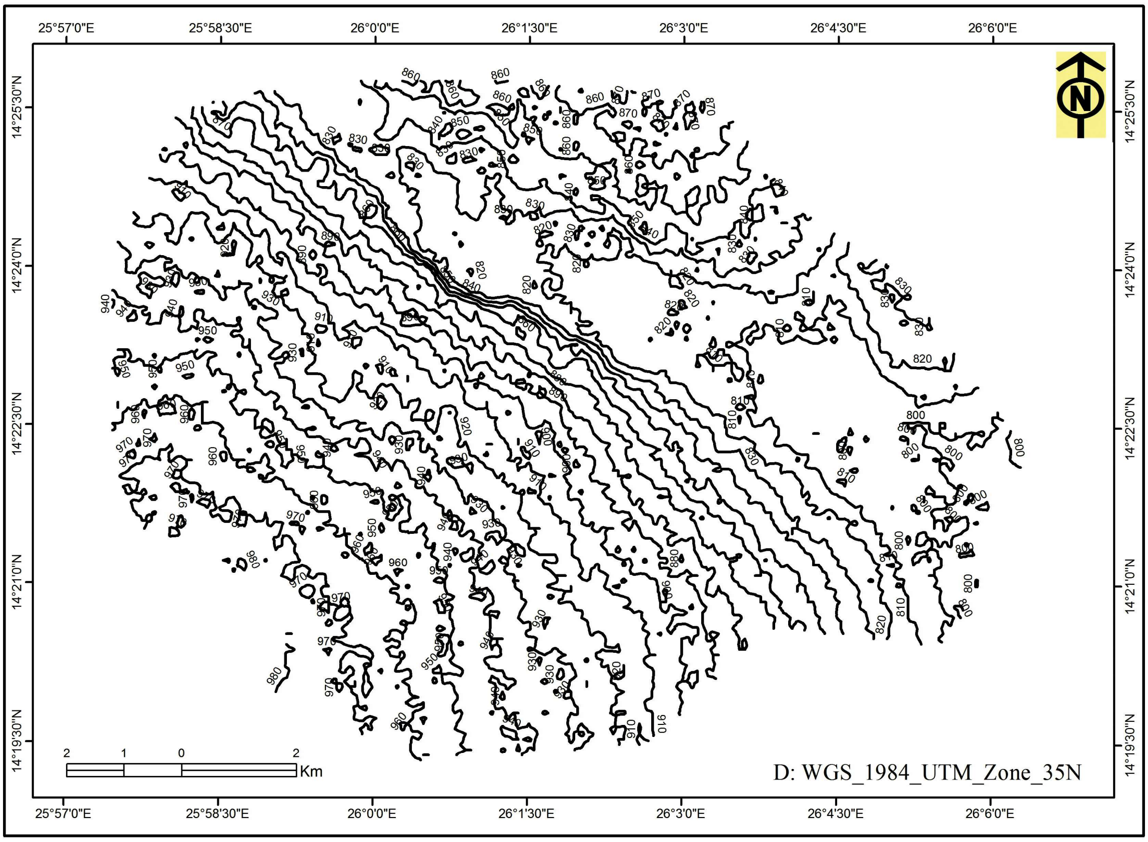
Plate 4.3: The wood for stock

Note abut plat 4.3:
Most of people stored the wood indoors, so it's difficult to access it for photography.

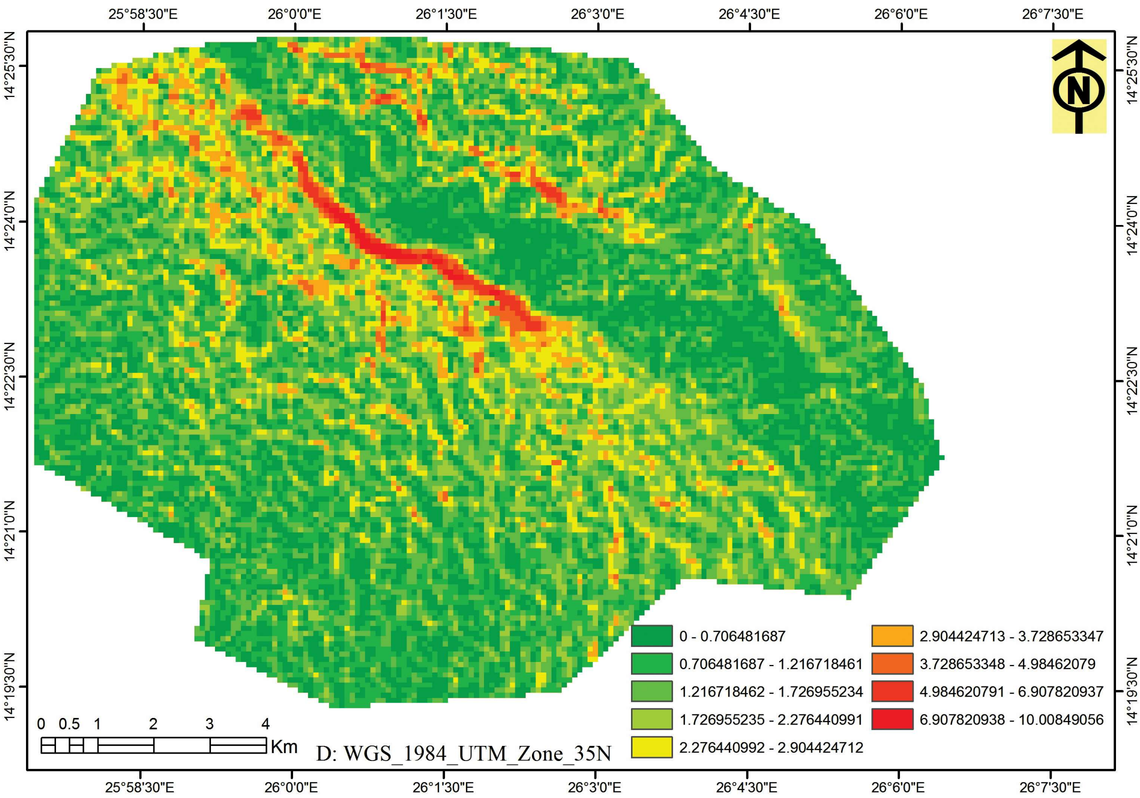
4.4: The Terrain and Vegetation Cover

Vary Irregular terrain of study area land that ranged between 0-10 maters in slop term (map 4.6 and map 4.7), give the plants adjust to their location in a landscape. Through the common field observation and compared with Digital Elevation Modals data (DEM) show that, the topography had strong effects on distribution and vegetation state as follow:

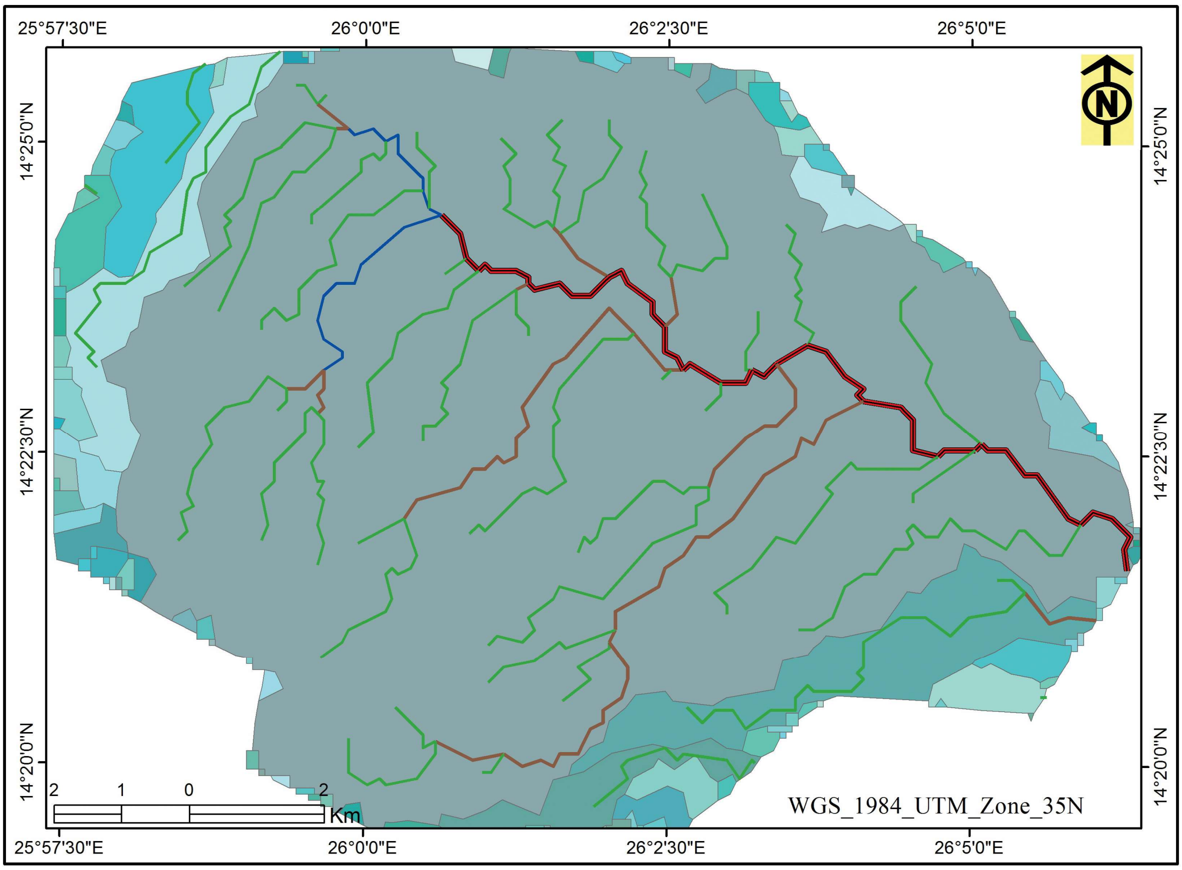
- The plants locate in high slops are vary scatter that effected negatively by lateral redistribution of elements, water and high winds speed.
- Multi-flow direction of study area in sandy soil (Goz land), gave better opportunity to providing multi-water catchment bodies, that give chance to grow density and different species.
- In general, the study area has two slops direction, from east to west and from west to east. That gives opportunity to create a big waterway (Wadis) with multi stream order (map 4.8) that gives a good property to create a ponds and to be a batter habitat for different type of plant and wildlife species.



Map 4.6: the study area contour lines for each 10 interval



Map 4.7: the Slops in study area



Map 4.8: the stream and stream order of study area

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1Conclusions

- The forest lands area increased from 20.53 sq.km in 2000 to 45.25 sq.km in 2020. During the period from 2000 to 2020 the forest cover increased to 24.72 sq.km. The general trend of forest land volatilize is from 14.29% to 31.51% of the total land of the study area.
- Agricultural land and bare land decreased in area from 24.31% to 9.82% respectively between the years 2000 to 2020.
- a general assessment of range lands are increased from 88.17 sq.km 61.39% in 2000 up to 108.33 sq.km 55.36% in 2010 and decreased to 84.26 sq.km or 58.68% in 2020.
- The land cover categories are continuous dynamic changes where there is deforestation due to size of rangeland and associated of forest expansion resulting from natural regeneration.
- The neglected of fire-sentry system by governments, contributed greatly to destruction and removal the forest, as he was responsible for mobilizing people to extinguish the fire and condemnation them when they default.

5.2: Recommendations

- Continuous forestlands and other land cover inventory by satellite images are recommended as effective method in natural resource assessment.
- Employment of forest guardsmen and fire-sentries in study area by FNC reduces more than 70 % of forest commotion.
- The wild fire by shepherds and farmers can solve by earlier fire-line and national control lesions.
- Most of encroachments are separates by managing-committee (shikh) that they never have great knowledge of forest legislation so managing-committee training by FNC is enhance many forest issues.
- Recommend further studies about a better strategic management of rural forest in future, within aggravate of ownership conflicts at the level of individual and group.

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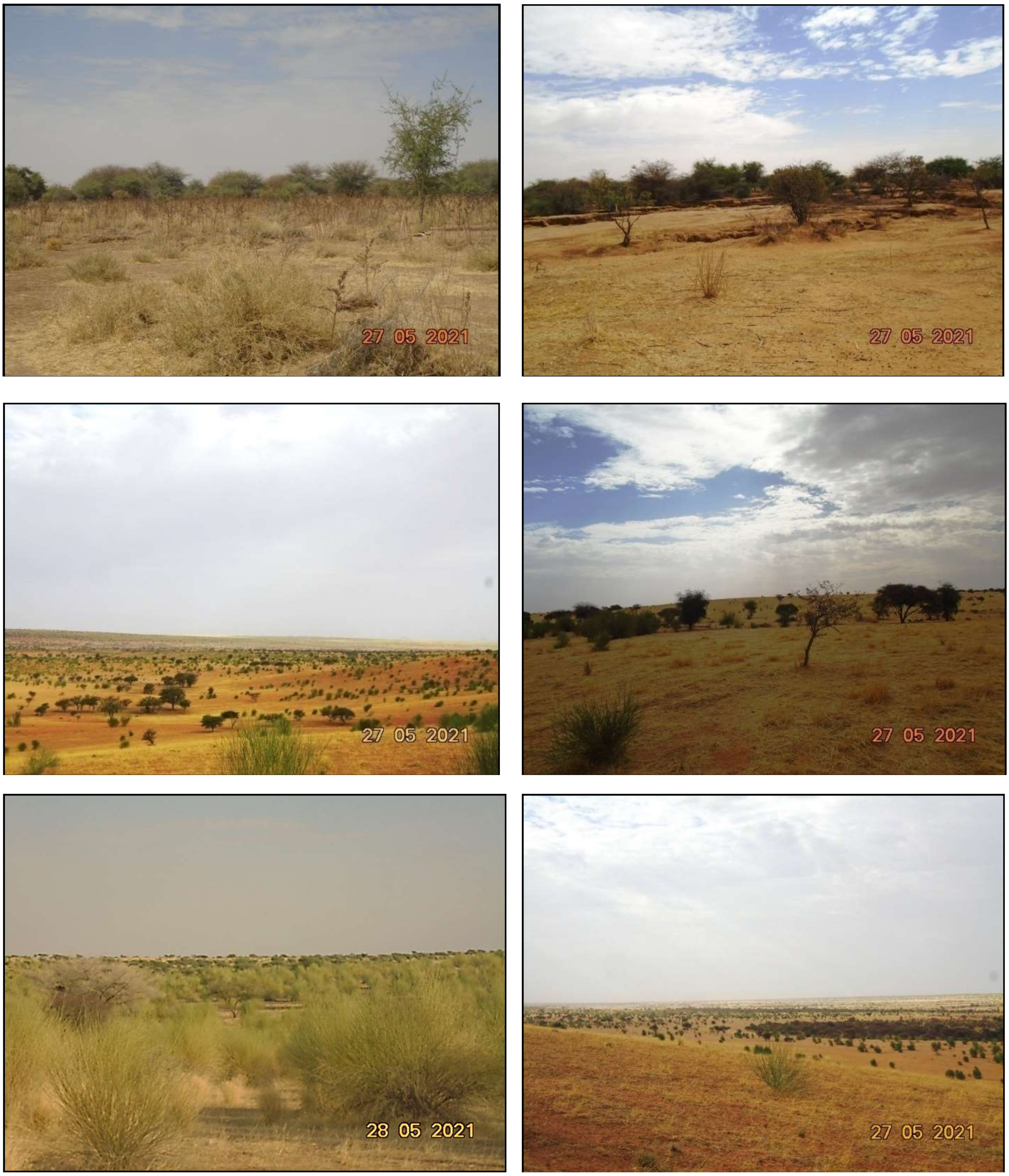
APPENDICES

Appendix 1: The slops, area landscape, water catchment and vegetation



Appendix 2: Land degradation

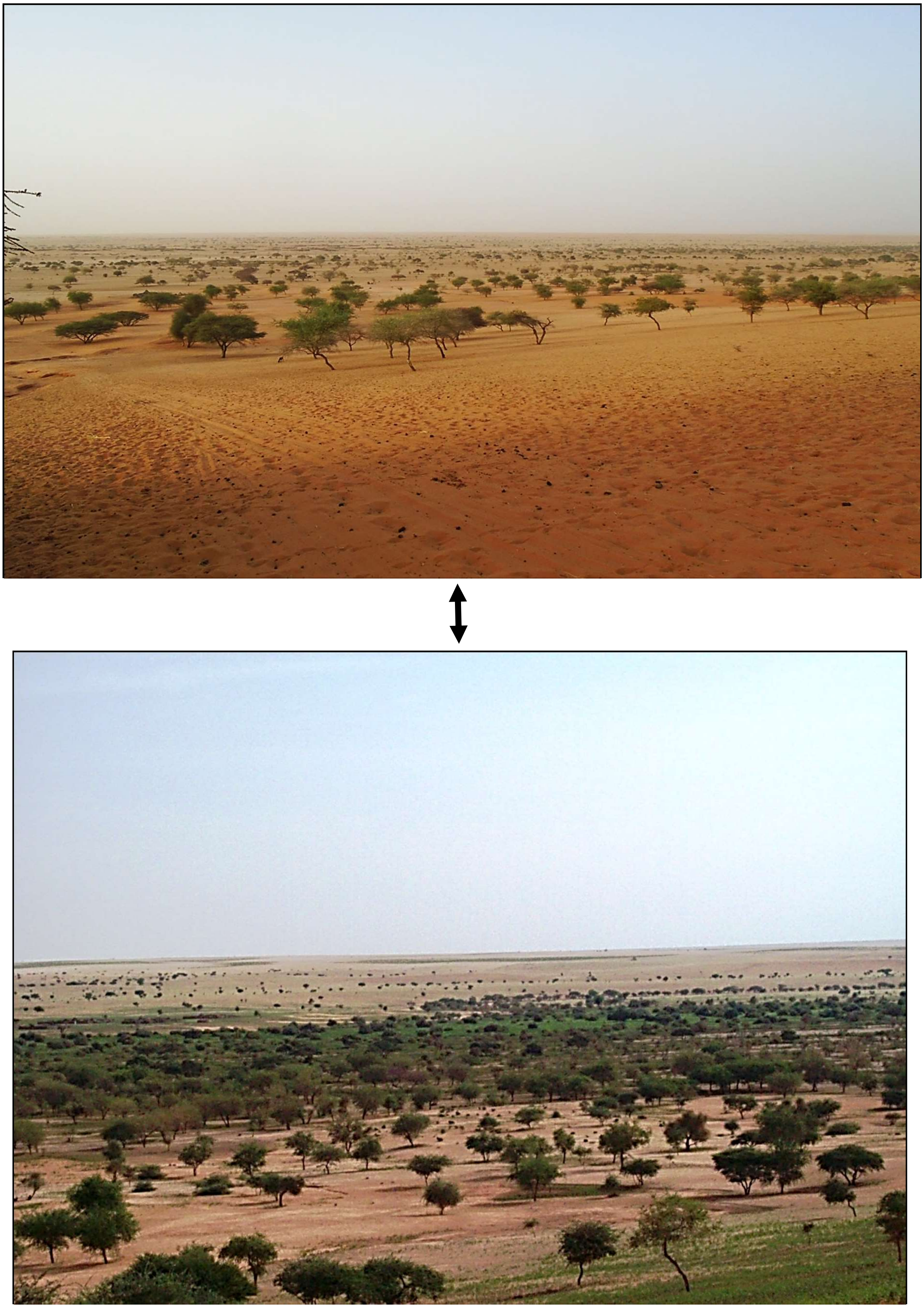


Plate top taken in 2021, bottom the same place in 2009 (Abdurra-hman's archive)

Plate top taken in 2021, bottom the same place in 2010 (Abdurra-hman's archive)


24 05 2021


24 05 2021


27 05 2021


27 05 2021

Appendix 3: filed measurement and Data collection Sheet

FIELD SURVEY
Data collection Sheet

Project Name ________________________ Date/Time __________/__________
Site ID/Photo Reference _________/____________ Observer_______________
GPS Grid _________ Coordinates Lon: ______________ Lot: ______________
LAND USE ______________________________Sample unites ______________

TOPOGRAPHIC INFORMATION
Slope angle: __________________Slope Aspect: _________________________

SOILS INFORMATION
Texture: sandy:_________ silt:_________ clay:__________ loam:___________
stony: ________ soil absent:___________ parent material: _________
Moisture: dry:____________ moist:_____________ saturated:______________
signs of seasonally waterlogged soil:________________________
Color:_______________________ _________________________

VEGETATION INFORMATION
Physiognomic Type: ____

	Dominant Species	*% Cover*
Top Layer 1	_________________________	_________________________
2	_________________________	_________________________
Intermediate 1	_______________________	__________________________
2	_______________________	__________________________
Ground Layer 1	______________________	__________________________
2	______________________	_________________________

COMMENT : --

