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Faculty of postgraduate Studies

Quantifying Change of Land Use and Land Cover Change Using GIS and Using Remote Sensing Technique: Case Study

(Sinnar state Siro Forest).

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بسم الله الرحمن الرحيم

In the name of Allah, Most Gracious, Most Merciful.

استهلال

(أَلَمْ تَرَ كَيْفَ ضَــرَبَ اللَّهُ مَثَلاً كَلِمَةً طَيِّبَةً كَشَــجَرَةٍ طَيِّبَةٍ } أَصْلُهَا ثَابِتٌ وَفَرْعُهَا فِي السَّمَاءِ) سورة إبراهيم: الآية رقم 24

Have you not considered how Allah presents an example, [making] a good word like a good tree, whose root is firmly fixed and its branches [high] in the sky?

Dedication

I Dedicate this Research to:

My father

My mother

My brothers and sisters

And all those who helped me in my study

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First and foremost, I would like to praise and thank God, the almighty, who has granted countless blessing, knowledge, and opportunity to accomplish the thesis. Apart from the efforts of me, the success of this thesis depends largely on the encouragement and guidelines of many others. I take this opportunity to express my gratitude to the people who have been instrumental in the successful completion of this thesis. Those are the vice-chancellor of Future University and his staff.

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Abstract:

Land use and land management practices have a major impact on natural resources, including water, soil, nutrients, plants and animals. Land-use technology can develop solutions to natural resource management issues such as studying the density of the forest and determining the quantifying change of land use and cover and also the impact of land cover degradation can be determined in an area where deforestation or have been eroded in forest area.

The Selection of the Siro riverine forest to be the study area came as a model for the riverine forests, and a study was conducted in it where the USGS program was applied to download satellites Imagers of Landsat and the application of the ERDS program was to determine the study period during 10 years from 2010 to 2020, and the attempt of this study was an attempt to determine change Quantification of changes in land use and change in land cover, through the study.

A field study was carried out to collect primary and secondary data, which aims to advance knowledge of the nature of the study area in terms of vegetation cover and conduct inventory of the forest using regular sampling and measurements on forest trees in order to determine the density and volume of trees in the current situation.

Where two satellite images of Landsat were used for the study area which are an image for the year 2010 from the moon of Landsat 5 and images for the year 2020 from the moon of Landsat 8, to study the use of land and land cover, and after that, the ERDS program was used to determine categories of land use and land cover, and then it was Using the supervised classification The special controlled classification of the ERDAS program was classified or produced three categories of land use and land cover, which is High dense tree, medium tree, and Burn land. It was presented and produced digital maps as from which a tabular matrix was created to change the vegetation cover and use it to discover and define Change with the help of reference to primary and secondary data and maps produced from pictures of Landsat imager.

The evaluation of the results showed that the use of land and the land cover in the Siro riverine forest had changed significantly within 10 years, the change was evident in most of the boundaries of the study area, and this is that high tree dense in 2020 decreased by 22.88% as it was. In the year 2010, that the medium vegetation cover in 2020 increased by 4.61%, as it was in the year 2020, also the study concluded that the soil absorbs carbon, which found carbon at 0.01% in the soil from a group of soil elements.

Finally, we find that the barren land increased in 2020 by 18.26% as it was in 2010.All these percentages indicate a negative change in the forest.

المستخلص

تؤثر ممارسات استخدام الأراضي وإدارتها تأثيراً كبيراً على الموارد الطبيعية، بما في ذلك المياه والتربة والمغذيات والنباتات والحيوانات. من شأن تكنولوجيا استخدام الأراضي توفير حلول لقضايا إدارة الموارد الطبيعية مثل دراسة كثافة الغابات وتحديد التغير الكمي في استخدام الأراضي والغطاء النباتي، كما يمكن تحديد أثر تدهور الغطاء الأرضي في المناطق التي تعرضت غاباتها للإزالة أو التدهور.

وقع الاختيار على غابة سيرو النيلية لتكون منطقة الدراسة وأنموذج للغابات النيلية والتي أجريت فيها الدراسة حيث تم تطبيق برنامج USGS لتحميل الصور الجوية للقمر لاندسات (Landsat) وتطبيق برنامج ERDAS 8.5 وتم تحديد فترة الدراسة بعشر سنوات من سنة 2010 إلى 2020 وكانت محاولة هذه الدراسة هي محاولة لتحديد التغير الكمي للتغيرات في استخدام الأراضي والتغير في الغطاء الأرضي، من خلال الدراسة.

تم تنفيذ الدراسة الحقلية لجمع البيانات الأولية والثانوية والتي تهدف إلى تعزيز المعرفة بطبيعة منطقة الدراسة من حيث الغطاء النباتي وإجراء الحصر للغابات باستخدام أخذ العينات والقياسات المنتظمة على أشجار الغابة وذلك لتحديد كثافة وحجم الأشجار في الوضع الراهن.

حيث تم استخدام صورتين من صور الأقمار الصناعية لاند سات8 و5 لمنطقة الدراسة وهما صورتان تعودان لسنة 2010 من قمر لاندسات 5 وصور لعام 2020 من قمر لاندسات 8 لدراسة استخدام الأراضي والغطاء الأرضي، وبعد ذلك، تم استخدام برنامج ERDS لتحديد فئات استخدام الأراضي والغطاء الأرضي، ومن ثم استخدام التصنيف الخاضع للإشراف تم تصنيف أو إنتاج التصنيف الخاص المتحكم به لبرنامج ERDAS لتحديد ثلاث فئات من فئات استخدام الأراضي والغطاء الأرضي وهي الأشجار عالية الكثافة والأشجار متوسطة الكثافة والأراضي المحروقة. وقد عُرضت وأُنتجت خرائط رقمية استُحدثت منها مصفوفة

مجدولة لتغيير الغطاء النباتي واستخدامها لاكتشاف التغيير وتعريفه بالاستعانة ببيانات وخرائط أولية وثانوية أُنتجت من صور لاندسات.

أظهر تقييم النتائج أن استخدام الأراضي والغطاء الأرضي في غابة نهر سيرو النيل قد تغير بشكل كبير خلال 10 سنوات، وكان التغيير واضحًا في معظم حدود منطقة الدراسة، وهذا هو أن كثافة الأشجار العالية في عام 2020 انخفضت بنسبة 22.88% مما كانت عليه في عام 2010، زاد متوسط الغطاء النباتي في عام 2020 بنسبة 4.61% مما كان عليه في عام 2020 وكل هذه النسب تشير إلى وجود تغيير سلبي في الغابة. كما خلصت الدراسة إلى أن التربة تمتص الكربون بنسبة 0.01% من جملة عناصر التربة.

وأخيراً خلصت الدراسة إلي وجود تغير سلبي أي الغابة في حالة تدهور مستمر وتراجع وأكثر تدهوراً مما كانت في سنة 2010 من حيث استخدام الأراضي وتغير الغطاء الأرضي.

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Abbreviations

LULCC	Land use land covers changer
FAO	Food and agriculture organization
UNEP	United nation environmental programs
UN	United nation
LULCF	Land use and land cover forests
IPPCC	Intergoremental panel climate changer
Gt	Gigatonnes
RCMs	Regional climate models
LUC	Land use cover
PPM	Parts per million
GIS	Geographic information system
RS	Remote sensing
NDVI	Normalized difference vegetation index
BMER	Bale Mountains Eco-Region
GHG	Green house gases
SDG	Sustainable development goals
MRA	Mechanized Rain-fed Agriculture
GPS	Global positioning system
RGB	Red, green and blue
AOI	Area of interest
USGS	United States geological survey
V	Volume
D^2	Diameter
H	High
FF	Form factor
AGB	Above ground Biomass
BGB	below Ground Biomass
BEF	Biomass Expansion Factor
WD	Wood Density

CHAPTER ONE

1.1 Introduction:

Land use and land cover change (LULCC) is a major issue of concern with regards to change in the global environment. The rapid growth and expansion of urban centers, rapid population growth, scarcity of land, the need for more production, changing technologies are among the many drivers of LULCC in the world today. LULCCs respond to socioeconomic, political, cultural, demographic and environmental conditions and forces, which are largely characterized by high human populations. LULCC has become one of the major concerns of researchers and decision makers around the world today.

Many researchers argue that LULCC emerged as a major aspect in the wider debate of global change; and that change originates from human-induced impacts on the environment and their implications for climate change .The indicators of these changes can be clearly seen in the current major global concerns such as increasing concentrations of carbon dioxide (CO_2) in the atmosphere, loss of biological diversity, conversion and fragmentation of natural vegetation areas and accelerated emission of greenhouses gases(Mercy .C, at all 2016)

The increasing impact of land use and cover changes on the environment has been an issue of concern in the developed and the developing countries with consequential effects on sustainable development and long term impact on the agricultural and other sectors of the economy. With the land use and land cover changes having a significant influence on the ecosystem with impact on biotic diversity, soil degradation, ability of biological systems to support human needs and the venerability of places and people to climatic, economic and sociopolitical perturbation, understanding these surface processes and predicting the impact on the environment and food production system is necessary for militating against the continuous negative impact of these changes. Deforestation, floods, drought, desertification and land degradation has been issues of environmental concern in Sudan with increasing incidence of aridity in the region and changes in the climatic conditions of the region.

Land degradation which can be measured in terms of soil erosion (loss of mineral, nutrients and organic matters), changes in soil structure, texture and fertility as well as changes in vegetation cover, reduction in palatable and nutritious plant species, increases in unpalatable and non-nutritious species and decrease in perennial grasses has been a phenomenon that has been associated with human pressure through improper land use practices and commonly characterized as a substantial decrease in the land biological productivity. Land use change in Riverine forests is one of the most important threats to degradation and deforestation. We find that this study focused on studying the current situation of the forest in that, using a field study, interviews of stakeholders and beneficiaries, observations during the study, analysis of satellite images of Landsat and a study of tree cover in the forest over the study period from 2010 to 2020 in order to know the types of land uses and determine the change in the forest. The study on the impact of changing uses and changing the land cover on emissions and greenhouse gases, especially carbon dioxide gas that causes the ozone hole.

In the present study, the researcher also deals with how to calculate carbon in forests by studying the density and volume of the forest and the amount that it absorbs and determines it in percentages.

This part tries to measure the impact of changing land use and land cover on forest degradation.

1.2 Research Objectives:

The main objective of this study is to quantify the change of land use and land over change in Siro forest using remote sensing and GIS

The specific Objectives are:

- To understand the relationship between land use, land cover change and emissions from deforestation
- To Study the impact of deforestation and forest degradation on the ground change in the land cover.
- To know the best ways to plan land use in emissions control.
- To understand how to calculate the sequestered carbon in the forests.

1.3 Research hypothesis:

According to the research problem, the hypotheses could be formulated as covering of all quantifying changes in land use/land cover class of Siro riverine forest was changed significantly during the period 2010 to 2020.

1.4 Problem statement:

The study area is located in Sinnar state, it is of a great importance for the economy of the statein the areas of agriculture and forests that provide livelihoods and employment opportunities for farmers who often practice traditional variable rain agriculture, which is harmful to the land cover and forests in the area. Land use and land cover change is one of the challenges in the light of changing traditional rain fed agriculture. In forest cover, excessive use of agriculture and overgrazing, it is possible to change land use and land cover and after conducting the quantification and study during the last ten years ago, the problems represented in the expansion of traditional agriculture and encroaching the forest resource, mostly by farmers and owners of gardens bananas and air purifiers which contributed to change of land cover due to the absence of awareness of the importance of the forests for the area, and this confirms the wrong approach in terms of land use and therefore the specific efficiency of land use and land cover for the period from 2010 to 2020 is need to be examined.

CHAPTER TOW

Literature Review

2.1 General introduction:

2.2 Land use

Land use is the modification of the natural or natural environment to an urban environment such as fields, pastures, and settlements. The most significant effect of land use on land cover since 1750 is the deforestation of temperate regions. Recent visible effects of land use include urbanization, soil degradation and degradation, salinization and desertification.

The change in land use, in addition to the use of fossil fuels, is the most important anthropogenic source of carbon dioxide, one of the main greenhouse gases .Land use has also been defined as "the sum of arrangements, activities and inputs made by man in a specific type of earth cover" (FAO / UNEP, 1999). Land degradation is defined by the UN as desertification in dry Areas and includes arid, semi-arid and dry sub-humid areas. The phenomenon of desertification is defined as "reduction or loss of productivity and biological diversity of land in arid, semi-arid and dry sub-humid areas as a result of natural factors or processes resulting from human activities." The extent of land degradation was estimated to be at least moderate, with about 30% Dry, 47% of rain-fed cropland and 73% of rangeland land. Africa is at the forefront of areas where land has been affected by desertification.

2.3 Land definition when planning land use:

The first question that arises when talking about land use planning, what is the land Earth is a natural resource, but the earth as a resource is more than just a natural gift to man. Survival is a place of space, but at the same time a complex natural ecosystem consisting of a set of sub-ecosystems that consists Each of which is composed of components and living and other non-living elements interact with each other in a balanced dynamic resulting in different images and forms of life, so we find that there are several concepts of the word land resulting from the different activities used by man.

2.4 Land use and impact on the environment

Land use and land management practices have a significant impact on natural resources, including water, soil, nutrients, plants and animals. Land-use technology can develop solutions to natural resource management issues such as salinity and water quality. For example, the water quality of water bodies varies in areas where forests have been deforested or have been eroded in forested areas (Mohamed 2017) According to the UN Food and Agriculture Organization (FAO) report, land degradation worsens when there is no necessary planning for its use, orderly implementation of such planning, or the existence of financial or legal incentives that lead to erroneous land use decisions or unilaterally centralized planning, To excessive use of land resources - for example, for rapid production. Consequently, the result is often detrimental to large segments of the local population, causing the destruction of valuable ecosystems. This narrow-minded approach has to be abandoned and replaced by a technology for planning and managing land resources that is complementary, taking into account the interest of land users. This will ensure long-term quality of human land use, prevention or resolution of related social conflicts, conservation of ecosystems 5 and important biodiversity.

2.5 International efforts to combat land degradation

At its fifth session on 17 June 1994, the United Nations adopted the International Convention to Combat Desertification. On 19 December 1994, the United Nations announced on 17 June the day of the United Nations Convention to Combat Desertification as World Day to Combat Desertification and Drought, to be observed from 17 June 1995. International organizations, including the United Nations

Environment Program UNEP and the Food and Agriculture Organization of the United Nations FAO, have paid particular attention to the fight against desertification through international conventions and desertification reduction programs in many developing countries, aimed at developing activities that should be considered as part of integrated development Land in arid, semi-arid, dry and semi-humid areas for sustainable development.

2.6 Forests and climate change

Forest resource management may play a key role in mitigation of climate change

Climate change and the forest environment are inseparably linked. On the one hand, climate change is battling forests and their environment through high average annual temperatures, changing rain patterns and frequent extreme weather events. At the same time, forests and wood are essential for ingesting and storing carbon dioxide, which plays a key role in mitigating climate change. The other side of the coin shows that the destruction or exploitation of forests beyond their natural capacity can make them a continuous source of greenhouse gas emissions, carbon dioxide. The Organization has repeatedly stressed that there are actions that must be taken today to manage these complex and interdependent relations in a holistic manner. As head of the FAO Climate Change Working Group, expert Wolf Hellmann says there is a clear need to "stop deforestation and expand forested areas". "But we also need to replace fossil fuels with bio-fuel resources - such as timber from managed forests and responsible management - to reduce carbon emissions, and to increase the use of wood in more durable products to keep the risk of releasing trapped carbon in the air for as long as possible.

2.7 Forests hold one trillion tons of carbon:

By burning fossil fuels, carbon dioxide is released into the atmosphere, contributing to increased concentration of this substance, known as greenhouse gas, which contributes, in turn, to rising temperatures or so-called "warming" ... and exacerbating climate change. Trees and forests help mitigate these changes by absorbing and converting carbon dioxide from the atmosphere, through photosynthesis to carbon, stored in the form of wood and plants. This process is called "carbon ingestion". Trees generally consist of about 20 percent carbonate in composition. In addition to the trees themselves, the living biomass of forests also plays the role of a "carbon sink". For example, organic matter in forest soils - such as naturally produced by the decomposition of organic matter - also creates a "storage" function for carbon.

As a result, forests store huge amounts of carbon. In total, according to FAO studies, the world's forests and forest soils currently store more than one trillion tones of carbon - double the amount of free space in the atmosphere.

But second-hand forest destruction adds nearly 6 billion tons of carbon dioxide to the atmosphere each year. The organization notes that preventing these stored carbon amounts is important to the overall carbon budget in the environment, as it plays a vital role in the overall conservation of the ecosystem.

2.8 Land use, land-use change and forestry

Land use, land-use change and forestry is defined by the United Nations Climate Change Secretariat as a "greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities. (LULUCF) has impacts on the global carbon cycle and as such, these activities can add or remove carbon dioxide (or, more generally, carbon) from the atmosphere, influencing climate. LULUCF has been the subject of two major reports by the Intergovernmental Panel on Climate Change (IPCC). Additionally, land use is of critical importance for biodiversity (ELTayeb August1972).

2.9 Climatic impacts of land-use, land-use change and forestry

Per capita greenhouse gas emissions by country including land-use change, in the year 2000Land-use change can be a factor in CO_2 (carbon dioxide) atmospheric concentration, and is thus a contributor to global climate change. IPCC estimates that land-use change (e.g. conversion of forest into agricultural land) contributes a net 1.6 ± 0.8 Gt carbon per year to the atmosphere. For comparison, the major source of CO_2, namely emissions from fossil fuel combustion and cement production amount to 6.3 ± 0.6 Gt carbon per year. This decision sets out the rules that govern how Kyoto Parties with emission reduction commitments account for changes in carbon stocks in land use, land-use change and forestry. It is mandatory for Annex 1 Parties to account for changes in carbons stocks resulting from deforestation, reforestation and a forestation and voluntary to account for emissions from forest management, cropland management, grazing land management and reforestation, the rules governing the treatment of land use, land-use change and forestry for the second commitment period are part of the Bali Action Plan under the Ad Hoc Working Group on Further Commitments for Annex 1 Parties under the Kyoto Protocol, the most recent options for rule changes under consideration are summarized in a "Non-Paper" the co-chairs of the contact group on LULUCF. The impact of land-use change on the climate is also more and more recognized by the climate modeling community. On regional or local scales, the impact of LUC can be assessing by Regional Climate Models (RCMs). This is however difficult, particularly for variables, which are inherently noisy, such as precipitation. For this reason, it is suggested to conduct RCM ensemble simulations (UNEP, et al 2000).

2.10 Land use and biodiversity

Per capita greenhouse gas emissions by country not including land-use change, in the year 2000the extent and type of land use directly affects wildlife habitat and thereby impacts local and global biodiversity. Human alteration of landscapes from natural vegetation to any other use typically results in habitat loss, degradation, and fragmentation, all of which can have devastating effects on biodiversity. Land conversion is the single greatest cause of extinction of terrestrial species. An example of land conversion being a chief cause of the critically endangered status of a carnivore is the reduction in habitat for the African wild dog, Lycaonpictus.

Deforestation is also the reason for loss of a natural habitat, with large numbers of trees being cut down for residential and commercial use. Urban growth has become a problem for forests and agriculture, the expansion of structures prevents natural resources from producing in their environment. The loss of forestland is estimated to have been sixteen to thirty four million. In order to prevent the loss of wildlife, the forests must maintain a stable climate and the land must remain unaffected by development. The Forest service predicts that urban and developing terrain in the U. S will expand by forty one percent in the year 2060. These conditions cause displacement for the wildlife and limited resources for the environment to maintain a sustainable balance.

2.11The difference between land cover and land use

Land cover data documents how much of a region is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types. Water types include wetlands or open water. Land use shows how people use the landscape, whether for development, conservation, or mixed uses. The different types of land cover can be managed or used quite differently. Land cover can be determined by analyzing satellite and aerial imagery. Land use cannot be determined from satellite imagery. Land cover maps provide information to help managers best understand the current landscape. To see change over time, land cover maps for several years are needed. With this information, managers can evaluate past management decisions as well as gain insight into the possible effects of their current decisions before they are implemented.

2.12 Characteristics of land planning

Land has many characteristics that distinguish them from other development resources or elements of production and each of the characteristics of great economic importance in how to use the land and are:

- Land as a fixed-area resource whether at the level of the globe or at the state level, while resources and other elements of production increase and decrease

- Land as a fixed resource cannot be transferred from one place to another.
- Land is a heterogeneous resource where its characteristics vary from region to region.
- Land is a resource that no man has made any effort in producing and forming. It is a gift from God Almighty and this means that is no production cost for the land. Therefore, it is difficult to determine the value of the land accurately and correctly.

Land use is a complex process compared to other planning processes where the natural, social and economic data of a particular use is linked to an assessment and anticipation of future needs. Land use planning can be defined as follows, a series of logical activities that aim at organizing human societies by studying and understanding the relationships between the patterns of patterns and their functions in a particular place and time. Therefore, the plan must know the lines between urban and rural areas, Natural and cultural data in order to develop.

2.13 Nature of land use planning

Land use planning is not a sectoral planning. Even if the plan focuses on the use of land for one sector, rural land use planning is part of a comprehensive planning plan based on a clear future vision for future development in its urban, administrative, social, cultural, and economic and service aspects. This scenario is usually documented in a comprehensive plan known as the Master Plan. It usually includes planning objectives, policies, levels, management, and growth rates to be achieved. The establishment and development of development planning**:**

- In recent years, we notice that there is a continuous increase in the number of people in the world, especially in Sudan, which resulted in a continuous conflict over the use of different natural resources in an irregular manner, "agriculture, pastures, forests, wildlife, urbanization, and tourism."

- The need to use land and forests has increased in developing countries for the purpose of obtaining foodstuffs to meet population needs in addition to energy, which is expected to double in the coming period (Abdorhman, 2017)

2.14 Global Carbon Cycle overview

The dynamics of terrestrial ecosystem depend on interactions between a number of biogeochemical cycles and nutrient cycle and the hydrological cycle, all of which may be modified by human actions. Terrestrial ecological system, in which carbon is retained in live biomass, decomposing organic matter and soil, play an important role in the global carbon cycle. Carbon is exchange naturally between these systems and atmosphere through photosynthesis, respiration, decomposition, and combustion. Human activities change carbon stocks in these pools and exchange between them and the atmosphere through land use, land use change, and forestry, among other activities .substantial amounts of carbon have been released from forest clearing at high and middle latitudes over last several centuries and in the tropics during the latter part of the 20th century, there is carbon uptake into both vegetation and soils in terrestrial ecosystems, current carbon stoke are much larger in soils than vegetation, particularly in non-forested ecosystems in middle and high latitudes, From 1850 to 1998, approximately 270 (± 30) Gt C has been emitted as carbon dioxide (CO_2) into the atmosphere from fossil fuel burning and cement production. About 136 (± 55) Gt C has been emitted as a result of land use change, predominantly from forest ecosystems. This has led to an increase in the atmosphere content of carbon dioxide of 176 (± 10) Gt, atmospheric concentrations increased from about 285to366 ppm and about 43% of total emissions over the time have been retained in the atmosphere.

Ecosystem model indicate that the additional uptake of atmosphere carbon dioxide arising from the indirect effects of the human activities (e.g,CO_2 fertilization and nutrient deposition) on a global scale is likely to be maintained for a number of decades in forest ecosystems, but may gradually diminish and forest could even become a source. One reason, for this is that the capacity of ecosystems for additional carbon uptake may be limited by nutrients and others biophysical factors .a Second reason is that the rate of photosynthesis in some types of plants may no longer increase as carbon dioxide concentration continues to rise, whereas heterotrophic respiration is expected to rise with increasing temperatures. a third reason is the ecosystem degradation may result from climate change .These conclusions consider the effect of future CO_2 and climate change on the present sink only and do not take into account future deforestation or actions to enhance the terrestrial sinks, for which no comparable analyses have been made. Because of current uncertainties in our understanding which respect to acclimation of the physiological processes and climatic constrains and feedbacks among the processes, projection beyond a few decades are highly uncertain.

For the technical reason, only emissions and removals of CO_2 can be determined directly as change in carbon stocks. Methane emissions and removals cannot in practice be directly measured as carbon stocks change, although CH_2 and N2O can be determined by other means. Methane and nitrous oxide emissions from many land use activities are included in Anne of the Kyoto protocol and in the revised 1996 IPCC reporting guidelines for national greenhouse gas inventories, and therefore they will be captured in national inventories. This is not the case, however, for emissions of these gases related to forestry activities and projects, which are not included in annex A, although some of these forestry activities are discussed in the 1996 Revised IPCC guidelines for national greenhouses Gas inventories. If the net emissions of $CH_2$and N_2O are not considered, the full climate impact of forestry activities may not be reflected in the accounting system under the Kyoto protocol (Radnor, 1992).

2.15 Remote sensing and GIS

2.15.1 Remote sensing

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from a satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth. Some examples are:

- Cameras on satellites and airplanes take images of large areas on the Earth's surface, allowing us to see much more than we can see when standing on the ground.
- Sonar systems on ships can be used to create images of the ocean floor without needing to travel to the bottom of the ocean.
- Cameras on satellites can be used to make images of temperature changes in the oceans.
- Some specific uses of remotely sensed images of the Earth include, Large forest fires can be mapped from space, allowing rangers to see a much larger area than from the ground and Tracking clouds to help predict the weather or watching erupting volcanoes, and help watching for dust storms(Mohmadain, 2003).

2.15.2 GIS

Geographic Information Systems (GIS) combine layers of data about specific locations that provide powerful and critical decision-making tools for State and local agencies. Examples of decisions that are made using GIS include highway planning, forecasting environmental impacts, plotting spreads of infectious diseases, mapping the best routes for inspectors and first responders, and zoning and distracting mapping. The power and value of GIS are not simply in “map making”. GIS analysis can sift through or combine multiple data layers and identify the interdependencies and cumulative value of those layers.

GIS functions exist in multiple agencies across the state, but it is important to note that all GIS groups are not alike. In most agencies, the GIS team embedded in an agency is a collection of professionals who understand what mapping data and tools are available within the state, and use these assets to help solve business problems. These efforts include routing for agriculture inspectors, plotting of infectious disease spread, tracking bird migrations, etc. There is a much smaller subset of GIS professionals who collect and maintain GIS data on behalf of the state. There is not as much overlap of these efforts as one might predict in looking at the diversity of GIS groups within the state agencies. This report will address some of those overlap areas, Today GIS gives people the ability to create their own digital map layers to help solve real-world problems. GIS has also evolved into a means for data sharing and collaboration, inspiring a vision that is now rapidly becoming a reality continuous, overlapping, and interoperable GIS database of the world, about virtually all subjects. Today, hundreds of thousands of organizations are sharing their work and creating billions of maps every day to tell stories and reveal patterns, trends, and relationships about everything(December 2014).

2.15.2.1 Data of GIS

GIS integrates many different kinds of data layers using spatial location. Most data has a geographic component. GIS data includes imagery, features, and base maps linked to spreadsheets and tables.

2.15.2.2 Analysis of GIS

Spatial analysis lets you evaluate suitability and capability, estimate and predict, interpret and understand and much more, lending new perspectives to your insight and decision-making

2.15.2.3 Maps of GIS

Maps are the geographic container for the data layers and analytics you want to work with. GIS maps are easily shared and embedded in applications, and accessible by virtually everyone, everywhere.

2.16 Previous Studies

There are many studies conducted in this field related to this reached different results, as shown by the following studies

- Arfat. Y, 2010 Land Use / Land Cover Change Detection and Quantification Lund University Master degree

This study was conducted in eastern Sudan and the following results were reached

- It is hard to explain the changes that have occurred in this area.
- The period 1972 to 2006 shows the intensive clearance of natural vegetation due to dramatic expansion of rain fed mechanized farming.
- The period 1972 to 2006 shows the high increase in settlement area, this is due to high increase in population; this leads to increase in demand of food and shelter. This increase in population could be one of the reasons of deforestation and expansion of agricultural land to meet their daily livelihood.
- The maximum likelihood classification along with masking technique has ability to produce good classification results.

- Eman O. S, January 25, 2019 Multi-temporal Landsat Images for Land Use Land Cover Changes in Sinnar State, Sudan

  This paper showed the forest cover was decline; meanwhile the RfA areas were increased. It found about 15029 Ha that resulted in a high decline of forest area. A successful application of multi-temporal Landsat data and maximum likelihood algorithmic mapping of LULC classes, Comparisons between two images were made both visually and digitally to identify the LULCC and transformation that has occurred from one class to other. Analyzing and mapping trend of LULC dynamics within the study area provide basis for strategic planning, management and conservation decision-making, because changes in the LULC will have strong local, social and environmental implications, such as alterations in social stability, conflicts on natural resources, impacts on rates and types of land deforestation and thus can reduce biodiversity. This study showed that remote sensing imagery from the different sensor could be used to monitor the LULCC over long periods.

This research recommended continues research depending on the remote sensing (RS) to monitor the LULC. Particularly, these studies not only to improve our understanding about LULC changes and its implications in management and conservation efforts, but also will provide perspectives for the planner in the sustainable development of LULC.

- Olagunju E. G, 2008 Remote sensing for agricultural land use changes and sustainability monitoring in Sudan

The remote sensing technology is increasingly being used to study land use and vegetation cover changes and identify changes that has occurred through different land use activities which may have negative impact on the sustainability of the environment and biodiversity protection and conservation. The research study work has focused on agricultural land use and cover changes in the Country with the aim of investigating the land use changes that have occurred in the country from 1987 to 2000 using the remote sensing technique. Two remote sensing methods were used for the classification analysis to identify the land use changes, namely the NDVI and the parallelepiped classification techniques. The changes occurred because of the increase in use of irrigation and mechanization for agricultural crop production. The findings from the empirical material analysis however revealed that the increases in agricultural production were brought about due to land expansion and not as a result of increased productivity. The result analysis also indicated that there has been a significant change with loss and conversion of agricultural land use type to other types of land use categories. The findings through visual observation of the classified images shows that there has been an evidence of agricultural land use abandonment with plots formerly used for agricultural crop production being abandoned with no vegetation cover as indicated with the NDVI analysis. This gives evidence of the deteriorating conditions of the agricultural lands from long use with eventual loss of their vegetation covers. Some reasons identified for this include soil nutrient 53 leaching, flooding and erosion, waterlogging and salinity problem, overgrazing among others. This gives indication of the negative impact of agricultural land use in the area, with effect on the biodiversity protection and conservation and long-term sustainability of the environment and resource use.

The parallelepiped and Maximal Likelihood (MAXLIKE) classification analysis also indicated that there have been changes from one land use class to another from 1987 to 2000. The parallelepiped classification analysis showed that there has been a significant change in the land use class Agriculture, rangeland and bare land in the study period there was no change in the land use class urban and water. The maxlike classification analysis on the other hand indicated that there were only slight changes in the land use class agriculture, rangeland, urban and bare land while there was no change in the land use class water from 1987 to 2000.

- Sisay Nune. et, al ,2016 Land Use and Land Cover Change in the Bale Mountain Eco-Region of Ethiopia during 1985 to 2015

  Landsat imageries are medium-scale remote sensing tools that are ideal for LULCC analyses of such scales as BMER. Eight major lands uses And land cover types were identified, and their extent in terms of coverage (ha) was assessed between1985 and 2015. Finally, although the assessment of classification accuracy was not a simple task, the overall accuracies of these classifications were 85.2%, 87.2%, 76.9%, and 87.9% for 1985, 1995, 2005, and 2015, respectively. BMER encompasses a very large area, and diverse soil types, topography, latitudinal variation, and vegetation density exist. In total, 123,751 ha of forest, 93,078 ha of shrub land, 83,158 ha of grassland, 2,473 ha of Erica-dominated land, 3,601 ha of woodland, and 3,455 ha of Afro alpine vegetation were lost during 1985–2015. The forest LULC type lost the most, while farmland gained at the same magnitude. The capacity of forests to provide ecosystem services may be significantly constrained, which, directly and indirectly, may have impacts on the 12 million people living within and around the eco-region as well as Northern Somalia and Kenya due to the negative impact on rivers originating from the BMER.

The major driving force behind all these changes is farming. A strong correlation between the areas of farmland and cropland expansion was observed.

A strong correlation between population growth and cropland expansion was also observed, More than 24 million tons of carbon has been removed from the forest ecosystem during1985–2015 in BMER. The majority of this carbon has probably, been released into the atmosphere in the form of GHG. The potential of the forest ecosystem to absorb CO_2 from the atmosphere has also been reduced. At this rate, achieving the goal set by the Government of Ethiopia of reaching middle-income country status by 2025 while maintaining GHG emission at the 2010 level may be difficult; in the future, allocation of land to different uses needs to be based on land use policies. Tagging values for each land cover as per the SDG 15.9, which recommends integrating ecosystem and biodiversity values into national and local planning, etc, may be one mechanism for limiting the unplanned expansion of one LULC type at the expense of another.

- Yousif .E. Y, et al 2015 Land Use and Land Cover Change in Northeast Gadarif State in Sudan:

  This study was conducted in El Rawashda Forest, Sudan and the following results were reached:

  Vegetation covers in El Rawashda forest under different sowing treatments during the two seasons. Similar to the trend of productivity, the vegetation cover under disc plowing was the best compared to the other treatments, including the control in two seasons.

The density was variable among the different treatments, with the highest under disc plowing relative to others in the two seasons. This variation could be justified by variations in the planting conditions. Under disc plowing, the seeds were likely more protected and were enjoying better soil moisture compared to the seeds in other treatments. This will create a suitable environment for the young.

Growing seedlings, consequently increasing plant density, Satellite Images Classification Accuracy Assessment and LULC Mapping In this study, the image processing approach was found to be effective in producing compatible LULC data over time, irrespective of the differences in spatial, spectral and radiometric resolution of the satellite data. According to the produced LULC map, it was found that trees, MRA, Grasses and Bare land were the dominated types of LULC classes for the years 1984, 1994 and 2013. According to, percentages of LULC classes showed that in the year 1984, trees, MRA, Grasses and Bare land had occupied 94.2, 1.0, 2.3 and 2.5 percent of the study area, respectively. In the year 1994, trees, MRA, Grasses and Bare land had occupied 87.2, 1.6, 4.2 and 7, percent of the study area, respectively. In 2013 Trees, MRA, Grasses and Bare land had occupied 60.9, 9.6, 10.9 and 18.6 per cent of the study area, respectively, however, large decrease in Trees 94.2 to 87.2, 60.9 per cent was observed in the year 1984, 1994 and 2013 of the study area, respectively. Consequently, large increased in MRA 1.0, 1.6 and 9.6 per cent was observed in the year 1984, 1994 and 2013 of the study area, respectively. Agriculture is the main economic activity, followed by livestock rising in the traditional seasonal transhumant pattern, village livestock rising and, as a recent element, livestock rising by large-scale mechanized Merchant-farmers investing surplus wealth in cattle, a significant increase of the MRA indicate of deforestation, mainly due to illegal over cutting of trees, which has been a continuing trend in the study area. The natural resources in developing countries like Sudan are continuously decreasing. Most of the population in Sudan is dependent on rain-fed agriculture, and removal of forests for mechanized rain-fed has increased at high rate during the last few years. A large increase of Grasses 2.3, 4.2 and 10.9 per cent was observed in the year 1984, 1994 and 2013, respectively in the study area. A large increase in the Barren land 2.5, 7 and 18.6 per cent was observed in the year 1984, 1994 and 2013, respectively. A high significant increase of the Barren land indicated deforestation; in Trees class 114465.2, 105913.5 and 74031.6 feddan in the year 1984, 1994 and 2013, respectively.

CHAPTER THREE

Material and methods

3.1 Study area:

The study area is located within Sinnar state, north of Abu Hajjar the locality, opposite the city of Karakuj on the west bank of the Blue Nile, south of the village of Siro Al-Jalin, and the forest was named after this village. It is estimated at 558.956 acres, and it lies between longitudes 33.45° and 34.10 ° east, and latitude 10-12°, and 13-13 ° north.

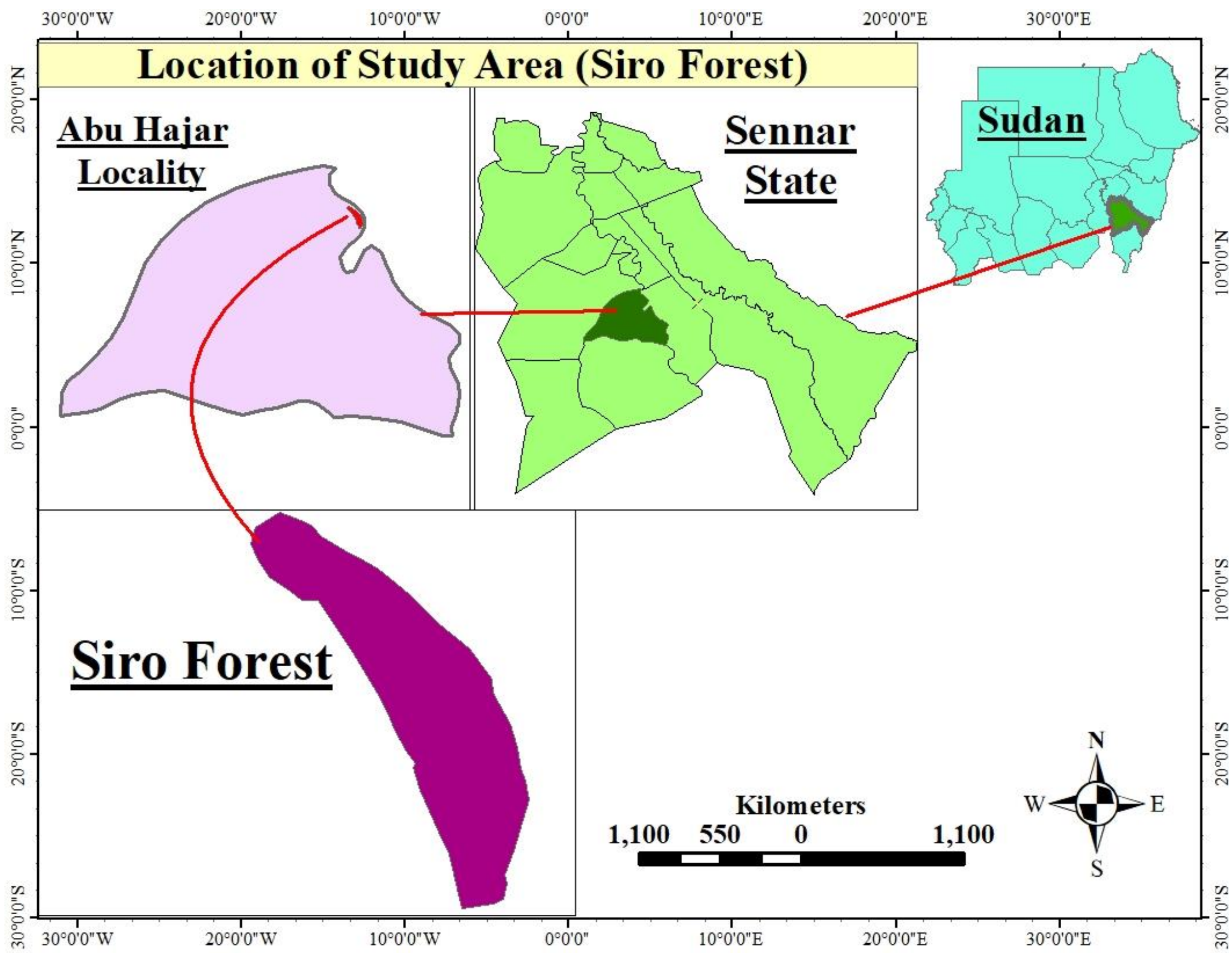


Figure (3.1) shows the study area

Siro Riverine forest is one of the beautiful forests that prevail in it the nature of the clay soil in the area; the forest is divided into 12 compartments from north to south, which is double and single. In the forest there is irrigation of 65 meters interval 4, 5 and 6 its liquid area is 94 acres, too which tangia are grown, the water is restricted in August to March. A number of population live in the study area, which is the village of Siro al-Ja'alin, Al-Dayer, Sidrat and Al-Tawfiqeya.

Table (3.1) showing compartments, their area and the last date of cutting and cultivation:

compartment	Area of compartment/acres	Date of cutting	Date of cultivation
1	33	1990	1991
2	49	1990	1991
3	69	1990	1991
4	52	1993/92	1994
5	59	1993/92	1994
6	60	1993/92	1994
7	51	1993/92	1994
8	29	1990	1991
9	46	1990	1991
10	26	1991	1992
11	45	1991	1992
12	40	1990	1993/91

Current vegetation covers in the study area:

The current vegetation cover around the study area indicates the presence of some types of plants and trees that were identified through fieldwork in the study area conducted 2019.

Table (3.2) showing the current vegetation cover around the study area (Siro Forest)

No	The scientific name	The family	Nature of plant	Local name
1	*Solonnmin carum*	*Solanaceae*	Herb	Al juoben
2	*Sendlms oletacea*	*Asteraceae*	Herb	AL moleta
3	*Cissns ahadragncaria*	*Vitaceaa*	Climber	AL Salala
5	*Acacia nilotica*	*Memosaoida*	Tree	AL Sunot
6	*Sesbnmia sesbandias*	*Papilancea*	Herb	AL Soreab
7	*Blanites aegyptiaca*	*Balanitacea*	Tree	AL Higlieg
8	*Ziziphns spina chris*	*Rhamnecea*	Tree	AL Sider
9	*Leptating leterphyla*	*Aselpidacea*	Climber	AL Shalob
10	*Capparis deadns*	*Capparacea*	Tree	ALTwndob
11	*Lpoweam carnea*	*Conrolnlecea*	Shrub	AL Aweer

3.2 Material

The purpose of the first visits to the study area was to collect basic information up data information on the area and establish boundaries for the area using the Global Positioning System (GPS), Field works, image preprocessing, image classification and accuracy.

3.2.1 Secondary data:

Secondary data were collected from Sinnar state archives annual reports previous studies and works plans, including topographic and thematic maps.

3.2.2 Primary data:

Primary data collection was elaborated to sufficient control points to verify the classification and also to observe and record the vegetation composition and land Use types it was collected using field survey, questionnaire and observation.

3.2.3 Group discussion:

Through the survey and fieldwork in the study area, they conducted a number of interviews for the locals who live around the forest, and they are three villages (Siro al-Ja'alin, Sidrat and al-Daraa). The total of the interviews were 8 groups from those villages adjacent to the forest in order to know the current and previous state of the forest.

3.2.4 Inventory:

At the beginning, the riverine Siro forest was chosen as a model for the riverine forests, and an inventory and inventory study was conducted for the study area by taking inventory samples by the fieldwork team.

At the beginning of the inventory, the base point was determined from the forest, after which the baseline was determined from the base point, and then the sampling line was selected at a distance of 60 meters in the baseline from the base point. The first sample was taken 20 meters from the beginning of the sample line with an area of 1000 square meters, and then selection The rest of the samples with a distance of 100 meters between the sample and the other, and with the same steps of selecting a sampling line and sampling, were used in the rest of the lines and samples to the last line and sample in the forest from samples of forest inventory.

Inventory of vegetation cover by systematic sampling system 2020

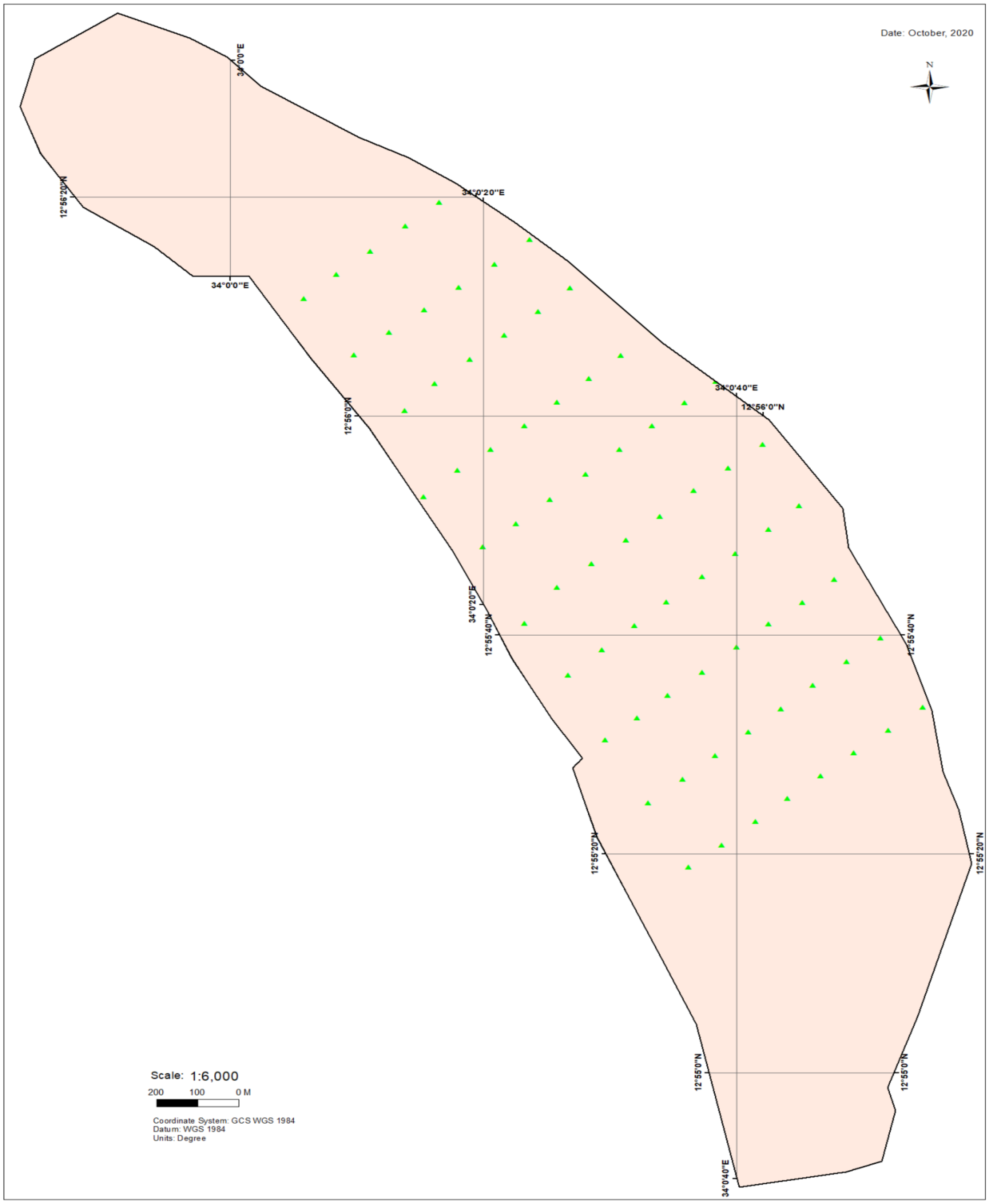


Figure (3.2) shows the inventory samples in the study area

3.2.5 Devices and tools:

To conduct the inventory, the inventory devices and tools must be available, and they are as shown in the below.

1/ GPS 2/ Compass 3/ Note book 4/ Forma inventory 5/ Diameter tape

6/ Measurement line (tape) 7/ Santo/hypsometer 8/Ranging rod 9/ Chalk

3.2.6 Data analysis

When analyzing the inventory data collected during the study, after collecting the data from the field, the samples were divided according to the forest fields and after that they were analyzed using an Excel program by tabulating all the data in excel and after tabulation, the followed mathematical laws were used to calculated the volume, the laws used ($V=\pi/4\times D^2\times H\times F$), after calculating the volume, the biomass was calculated from the volume using the mathematical laws on soil surface(AGB=V×WD×BEF(Mohamed.S,2016)) and biomass below the soil surface(BGB=AGB×0.28) after the calculation of the biomass, carbon was calculated from the biomass using the mathematical laws to calculate the carbon (Co_2=biomass×0.5). A program did all these operations. Excel. And at the end of these mathematical operations that were used in Excel, the goal is to obtain the volume of the forest, the biomass and the percentage of carbon as shown in the table for the chapter results and discussion.

3.2.7 Image processing

In the study, ERDAS imaging 8.5software was images preprocessing, processing and analyzing. The operations of processing were involving layer stack, enhancement, subset area of interest, visual interpretation (bands combination).

3.2.7.1 Layer stack:

The image which were downloaded using Landsat satellites sensor in (2010 and 2020) consist of all spectral bans mentioned above to classify the High tree density, Low tree density and bare land. The condition of layer stack of band 1,2,3,4,5 and 4_5 in landsad_5 and Lansad_7 such bands represents colors red, green and blue(RGB). Landsat, and near infrared respectively every single bands reflects different colors, and it means that there are different features in landsat 8 was layer stack in band 2,3,4,5, 6,7and 9.

3.2.7.2 Subset area of interest

The subset allows the amount of data this working with to be minimized by specifying a particular geographic area. The area of interest (AOI) is Siro Forest which has an area about 558.956 acres the forest boundaries were clipped which were matched with ship file of study area from Original image that was downloaded with much larger than the forest. It is helpful to reduce the size of the image file to include only the AOI, this not only eliminates the extraneous the data in the file, but it speeds up the processing due to the smaller amount of data to process.

3.2.7.3 Enhancement

The image enhancement is the process of making an image more interpretable for the particular application; enhancement can make important feature of row remotely sensed data and aerial photographs more interpretable to human eye. The advantage of digital imagery is that it allows us manipulating the digital pixel values in an image.

Sometimes the analysis extracting information's from imager by using enhancement techniques in stet classified a process of enhancement techniques was used to all under analysis in years 2010 and 2020 using contrast, filtering and band combination.

3.2.8 Image classification

Image classification is one of the most powerful tools in digital processing, it allows for the utilization of multispectral bands of data and converts them into a value's product which highlight the vegetation cover and land use /cover in the study area there are more different approaches to classify remotely sensed data.

They all under two main topics: unsupervised and supervised classification.

3.2.8.1 Unsupervised classification

In unsupervised classification an algorithm is Chosen that will analysis sensed data set in order to find a per specifying number of statistical clutter in a multispectral space, Although these clutters are not always equivalent to actual classes of land cover vegetation, this method can be used without having prior knowledge of the ground cover in the study area.

3.2.8.2 Supervised classification

In the supervised classification, it does require prior knowledge of the ground cover in the study area. The process of gaining this prior is known as verification of ground truth, with supervised classification the researcher locates areas on the study area (Siro Forest) image with known types of vegetation cover and land use/cover than polygons is plotted around the known study area and the pixel within the polygon are signature to the specific land use /cover class. This process is continuous until a statistically significant number of pixels exist for each class in the classification scheme. Then the multispectral data from the pixel in the sample polygons are used to train a classification, once train the algorithm can then be applied to the entire image and a final classified image is obtaining.

3.2.9 Soil:

Soil samples were taken at four forest levels, which include Dahra, Karba, Maiea and Jurf. Eight samples were taken, with two samples in each level, with a depth of 50 cm. The first sample and a depth of 100 cm, the second sample from each level were analyzed by the Soil Laboratory of the College of Agricultural Studies, Sudan University of Science and Technology.

3.2.10 Create carbon maps:

- When the date collected in field of study area, create excel sheet after that create shape file using the field data (excel sheet from excel 97, 2003).
- Failed to conceit to databases, right click in tool pox from ArcGIS display(x,y) date.
- Right click on events to date export add shape filed.

- After that to go selected goeostatiscal analyses in tool pox to cake in goeostatiscal wayward to selected shape file volume or biomass or carbon after that RC layer (e.q 3biomass) to go Extent properties
- Set the extent to the rectangular of the boundary of forest (study area).

3.2.11 Carbon Calculate:

When calculating carbon in forests, it is preceded by calculating the volume and the biomass, for this study the carbon was calculated from the forest inventory, some of it was calculated and the measurements samples taken during the field study the volume was calculated from the following equation.

$V = \pi/4 \times d^2 \times h \times f$

After calculating the volume, the biomass was calculated, which is the important part for calculating carbon, the simplest way to calculate the Biomass is calculated from the following equation.

- The biomass on the soil surface = volume × the calculation factor of the biomass × the density of wood It is expressed in the equation

  $AGB = V \times BEF \times WD$
- The living mass under the soil surface = biomass on the soil surface × the ratio of the mass of the island total / the mass of the shoot It is expressed in the equation $BGB = AGB \times 0.28$
- After calculating volume and biomass, carbon is calculated from the biomass and the percentage of carbon is calculated from the following equation

  $Co_2 = AGB + BGB \times 0.5$

We find that the percentage of carbon is equal to nearly 50% of the total biomass of the vegetative and root group.

CHAPTER FOUR

Result and discussion

4.1 Introduction

Forests represent the lungs of the earth, including the riverine forests, which must be taken care of because of the natural resources of economic and social value. Therefore, it was necessary to conduct studies in this field to know the current status of the forest cover and to address the challenges facing the forest resource in order to ensure its sustainability, through this study. After field work from inventory and interviews to residents around the forest and analysis of that data, we obtained the following results.

4.2 Inventory

By inventory the forest, data was collected by using regular samples and making measurements on forest trees on each sample, and after collecting the data, tree density and volume were calculated using mathematical form as described in Chapter three methodology. The density and Volume of trees were obtained as shown in Table (4.1) through these results; we find a difference in the density of trees from one compartment to another and the difference in volume as well, the reason is the difference in density and area from one compartment to another.

Table (4.1) shows the area of compartment and the volume and density of the tree

No	Compartment area	density of tree/Compartment	volume/Compartment
3	69	0.82	3709.09
4	52	0.51	1843.932
5	59	0.55	2304.987
6	60	0.41	2035.774
7	51	0.51	1407.767
8	29	0.33	741.9889
9	46	0.47	1162.938
10	26	0.65	1113.854
Total			14320.33

Table (4.2) shows volume, biomass and amount of carbon in the compartment:

Compartment area	volume/meter	Biomass/	Carbon/tons
69	3709.09	9685.1758	4842.588
52	1843.932	4713.0384	2356.519
59	2304.987	6018.7821	3009.391
60	2035.774	5315.8131	2657.907
51	1407.767	3675.9612	1837.981
29	741.9889	1937.4814	968.7407
46	1162.938	3036.6637	1518.332
26	1113.854	2908.4956	1454.248

From Table (4.2) we find that the relationship between volume, biomass and carbon and the extent of their relationship with each other, and through an analysis we find that carbon is calculated from the biomass and biomass is calculated from the volume and volume are calculated from the inventory measurements, and we find that the relationship between carbon and biomass and volume is a direct relationship.

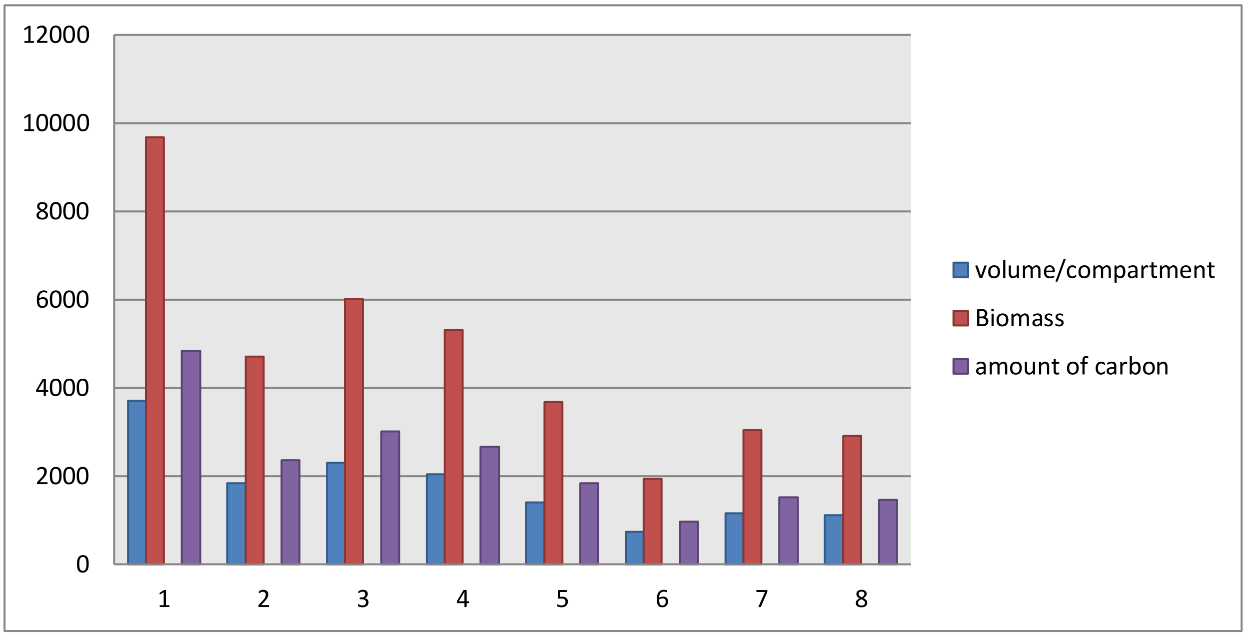


Figure **(4.1)** Shows relationship between volume, biomass and amount of carbon in the compartment

4.3 Group discussions

The results of these meetings were It was evident that there was a difference in viewpoints and opinions about the state of the forest, and we reached to the conclusion that the condition of the forest in the past was better than the current situation by the majority of opinions and in contrast to others, and they are a small number. The majority confirmed that the forest is in decline, especially the last 10 years. He also confirmed that there were previously agricultural activities inside The forest (Agroforestry) with the sowing of acacia seeds during the agroforestry operations, especially in percent and confirmed that the cause of forest degradation is the result of unfair cutting and thefts from the local population in order to meet the daily needs as well as cutting by the shepherd, especially in the summer due to the lack of vacancy for grazing animals such as goats The lavender refers to the expansion of the agricultural fields, banana gardens and mangoes, towards the banks of the Nile.

By the end of the interviews and analyzing the opinions, we reached the following percentages.

4.4 Imager Classification

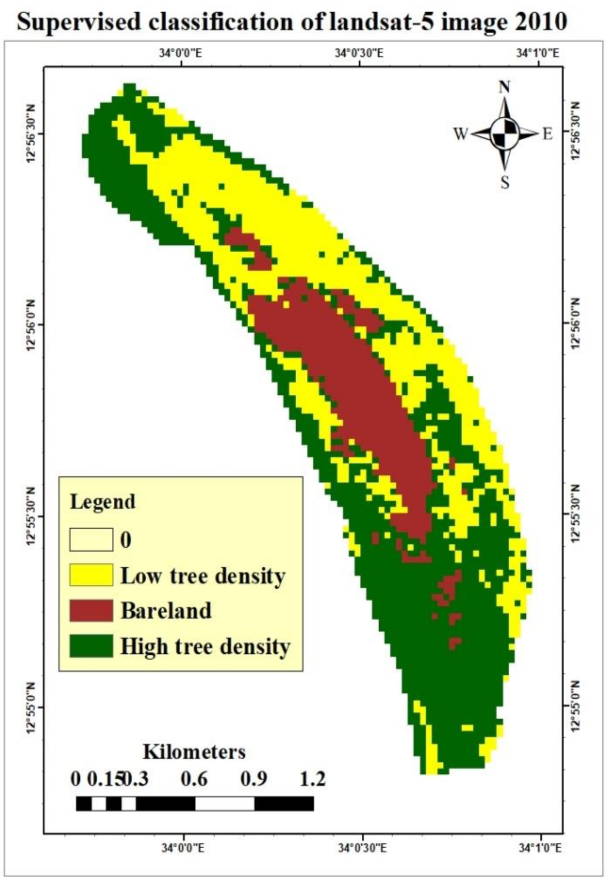


Figure (4.2) supervised classification landsat imager 2010

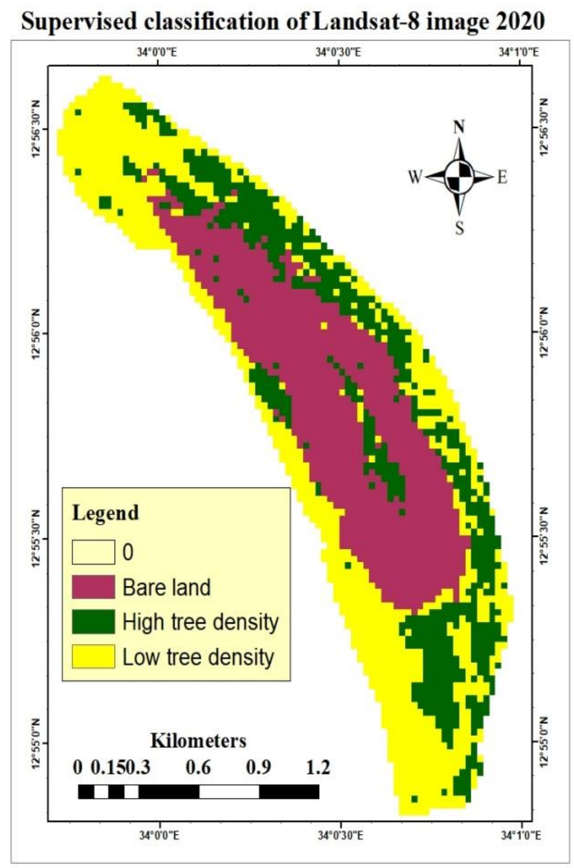


Figure (4.3) supervised classification landsat imager 2020

Figure 4.3 shows high and medium vegetation cover and per land from the satellite images of Landsat 5 for the year 2010, as we find in Figure 4.4 showing the high and medium vegetation cover and per land from the satellite images of Landsat 8 for the year 2020 according to the classification, the two figures show clear differences during the study period. This is in conformity with what we find where Table 4.3 reflects the differences in percentages.

Table (4.3) shows the results of the classification and analysis of Landsat satellite:

Classes	**Area/ha 2010**	**Percentage**	**Area/ha 2020**	**Percentage**
High Tree Density	125.46	47.67	65.25	24.79
Low Tree Density	90.36	34.34	102.51	38.95
Bare land	47.34	17.99	95.4	36.25
Total	263.16	100%	263.16	100%

Images for the study area and the results of this study to find out the land uses in the forest to obtain knowledge of the very current situation and what was previously conducted, study was conducted for the year 2010 and 2020. The image was analyzed after it was downloaded from the USGS program and all the images were classified into three classes (High tree density, Low tree density and per land).

The results of the 2010 image analysis showed that the High tree density covers an area (125.16 ha), Percentage of 47.67% of the total forest area, which equals 263.16 hectares, while this cover in the 2020 image results covers an area of 65.25 hectares Percentage 24. 79% of the total area of the forest, and this that there is a decrease in the area that high tree density cover in 2020 Percentage 22.88% compared to the area that covered 2010, and the result indicates the degradation of the forest.

The results of the second classes appeared, which were classified on medium tree cover, and the results of the 2010 image analysis showed that the average tree cover covers an area of 90.36 hectares, and this covers Percentage 34.34% of the total forest area, which equals 263.16 hectares, while this cover is covered in the results of a picture. 2020 An area of 102.51 hectares, Percentage 38.95% of the total forest area, and in the season we find that there is an increase and expansion in the year 2020 by 4.91% compared to what was in 2010, also find that the results of the last classes, which were classified on per land as a result of the results of the 2010 image classification, covered an area of 47.34 hectares, Percentage to 17.99% of the total area of the forest, while this cover in the results of the 2020 image covered an area of 95.4 hectares, equivalent to Percentage 36.25% of the total area of the forest, which equals 263.16 hectares, as well as in the season there is an increase and expansion in the year 2020 by Percentage 18.28% of the area that was in 2010.

Through the results we reached through analyzing the satellite image, the field study of the study area, and the interviews of stakeholders and beneficiaries, we find that the forest is in a state of continuous degradation and decline, as the results of the analysis show in numbers and percentages compared to what it was in the past and as it is now, the reasons for this degradation of the forest resource represented in thefts, illegal cutting, overgrazing, the increase in the areas of traditional agricultural lands around the forest and the expansion of the mango and banana gardens on the bank of the Nile and adjacent to the forest, and this is what we proved through the results of this research.

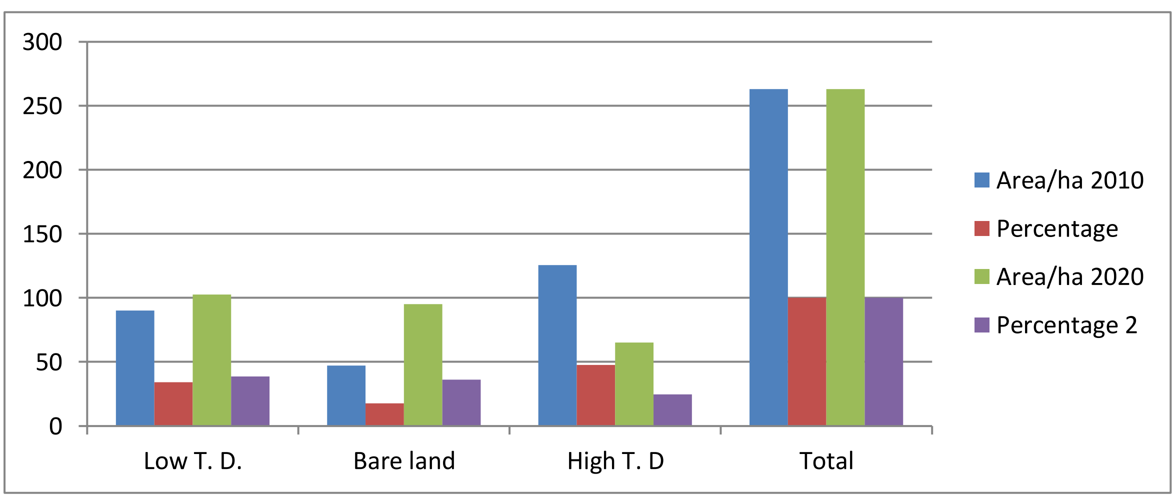


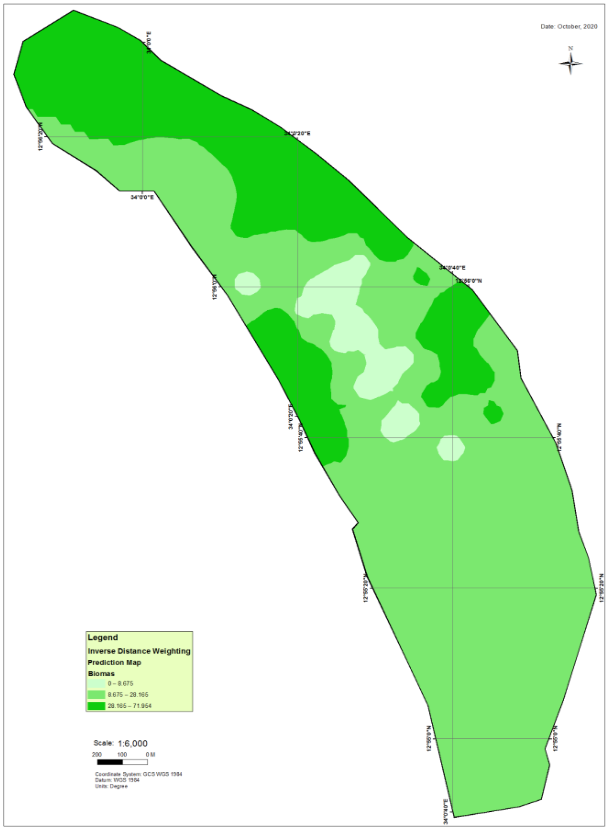
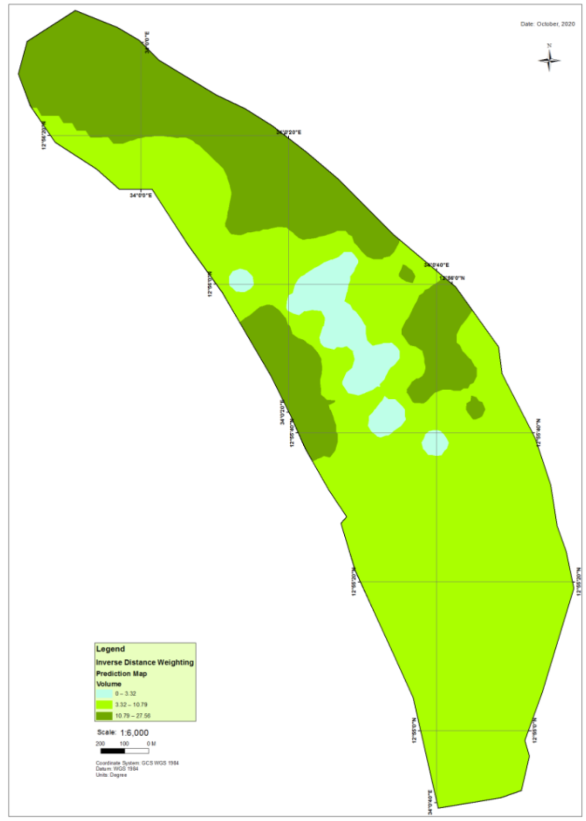
Figure (4.4) shows the area, volume, biomass and carbon in the boundary

This figure shows the area in hectares, the percentage of cover, high and medium tree and per land, through the results of the classification of satellite imagers for the year 2010and 2020 as shown in the table (4.3).

Table (4.4) shows the area volume, biomass and carbon in the boundary:

No	Name of map	High /ha	Medium/ha	Low/ha
1	Volume in boundaries	74.863	165.25	14.022
2	Biomass in boundaries	73.116	168.12	13.209
3	carbon in boundaries	73.729	167.38	13.333

This table shows the areas that cover the high and medium volume and the bare land to the study area as shown in the figure (4.6) and also this table shows the areas that cover the biomass as in the form figure (4.7) as well as shows the areas that cover the amount of high and medium carbon and per land as in the form figure (4.8). In the table that these areas are close to each other, the reason is that the volume, biomass and carbon are all computed with each other in the same area.

	
• High volume • Medium volume • Low volume	• High biomass • Medium biomass • Low biomass
Figure (4.5): The map of volume	**Figure (4.6): The map of biomass**

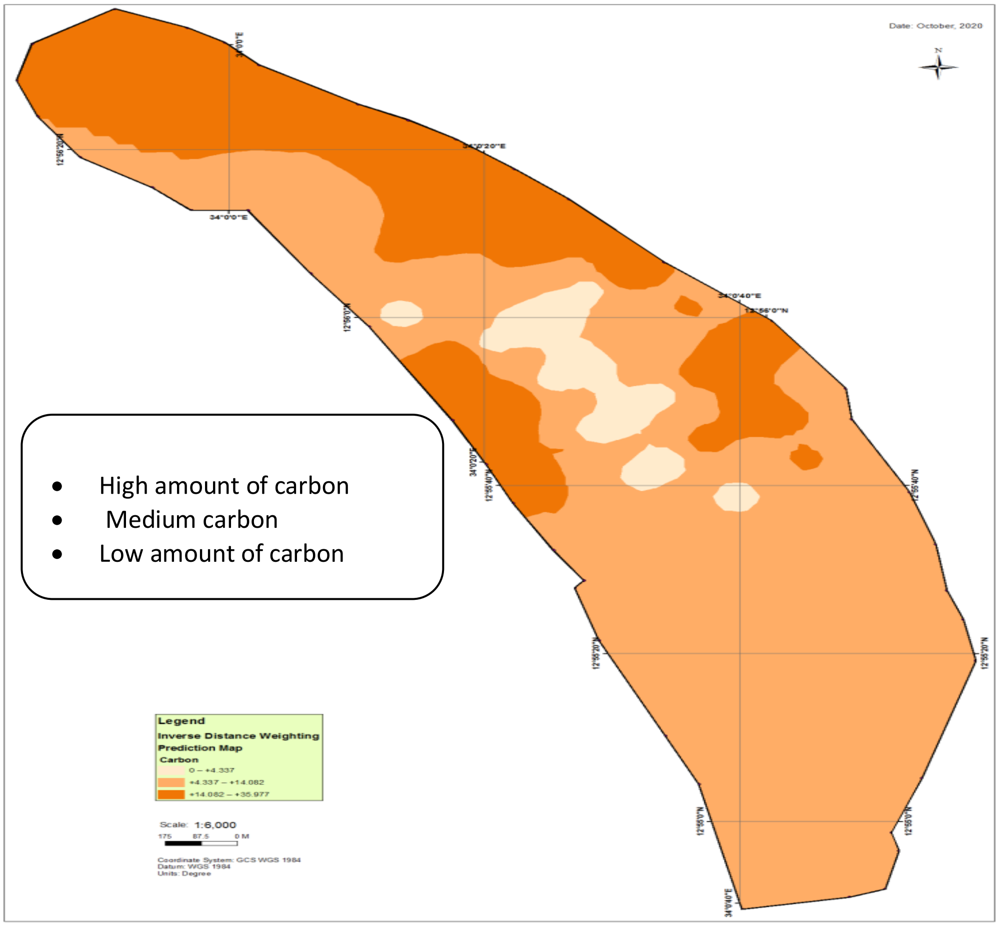


Figure (4.7): The map of carbon at Siro forest

Figure 4.5 shows the map of carbon ratios , and from this map we find variation and difference in carbon ratios in the study area, and we find there are high carbon ratios in some parts of the forest as well as the figure and medium carbon in other parts of the forest and the low carbon in other parts, and we find the difference in carbon ratios in the forest resulting from the difference in the trees density we find that, the higher the density of trees, the higher carbon percentage, and vice versa. All these results indicate the relationship between carbon and the tree, and these studies proved that the relationship between carbon and tree density is a direct relationship, the higher the density of trees increased carbon.

Table (5.5) shows the result of presenting carbon in soil

Field No	Lab No	Depth Cm	N %	P PPM	O.C %	Ex. Ch. Cations Meq/L			CEC Meq/100g	ESP	$CaCO_3$ %	Texture %		
						Na	K	Ca+mg				Clay	Silt	Sand
Maya 50cm	1	50	0.002	4	0.01	1.0	0.9	55.1	57	2	7	59	29	12
Maya 100cm	2	100	-	-	-	1.4	0.8	47.8	50	3	6	51	30	19
Jaref 50cm	3	50	0.002	2	0.01	0.8	0.4	18.8	20	4	6	25	3	72
Jaref 100cm	4	100	-	-	-	0.4	0.5	30.1	31	1	4	33	37	30
Dhara 50cm	5	50	0.002	3	0.01	6.5	0.4	23.1	30	22	2	31	18	51
Dhara 100cm	6	100	-	-	-	4.5	0.5	56.0	61	7	2	63	12	25
Karab 50cm	7	50	0.002	4	0.01	0.8	0.8	33.5	35	2	5	37	38	25
Karab 100cm	8	100	-	-	-	0.4	0.4	49.2	50	1	2	53	19	28

4.5 Soil

From the analysis of soil samples that were taken from the forest and which were analyzed in the soil Laboratory of the College of Agricultural Studies, University of Sudan, the study focused on carbon ratios and through the results of the analysis we found that $CaCO_3$ is present in the soil among the natural elements of soil and in different proportions according to the type of soil and the depth of soil taking as in table 5.5.

The results of the analysis concluded that the soil absorbs carbon dioxide and stores it with a group of soil elements, and we found that the carbon ratios are close in all levels of the forest at a depth of 50 cm by 0.01% of the group of soil elements in each level, while this study proved that the soil at a depth of 100 cm did not We find the percentage of carbon at each level of the forest in Table 5.5.

CHAPTER FIVE

5.1 Conclusion and Recommendation

5.2 Conclusion:

The present study was conducted to determine the quantitative change in the land use and land cover of the Siro riverine forest in Abu Hajjar locality in

The results of the study concluded that:

- The forest inventory and measurements in each plot sample, where the data were organized into excel tables, and then the density and volume of trees in the forest were calculated by applying the relevant mathematical equations to calculate the volume and density
- Following the calculation of the volume of the forest, the biomass and the carbon percentage were calculated by tabulating the inventory data and calculating the volume, from which the biomass and carbon percentage were calculated by mathematical equations utilizinging the excel program..
- Through the interviews of the locals who dwell around the forest, they confirmed that the condition of the forest in the past was better than now, which is attributed to the illegal cutting, theft, the expansion of the mango gardens and bananas, and the increase in the area of traditional agriculture around the forest.
- By analyzing the satellite image identified by 2010 to 2020, we found that there is a decrease in high tree dense by 22.88% than it was in the previous ones, and the medium tree increased by 4.61% and the bare land increased by 18.26% than it was 10 years ago.
- The study concluded that the forest is in a state of continuous deterioration and retreat, and the results proved that there is a negative change and this is a

result of the attacks on the forest resource of the local population in order to meet the daily needs such as firewood, building needs and unfair terror.

- In addition, the results of the study concluded with the production of maps of area, volume, Biomass and carbon covering the limits of the forest, which were classified into three classes, high, medium, and bare land.
- In addition, the study concluded that the soil absorbs carbon, and we found that by analyzing the soil that was collected in the forest at the levels of the forest Dahra, Karba, Maiea and Jurf and we found that all these levels absorb carbon in an approximate rate, which represented 0.01% of the group of soil elements in each level.

Finally, the study concluded through evaluating the results that it can be concluded that the land use and cover in the Siro Rriverine forest have changed significantly during the period in which the study was conducted from 2010 to 2020. In addition, the study concluded that the applications of remote sensing and geographic information systems (GIS) were very useful and helpful, in identifying changes in the study area.

5.3 Recommendations

- Activating forest protection laws in order to sustain forest resources from collapse
- Protect the forest from the assaults of theft and cutting
- Return the area of the forest as it was from the date of its reservation in 1932, which was 32 stones, and today one stone is known
- Organizing the cutting cycle in the forest according to the known acacia cutting cycle of 30 years and the average today is 25 years.
- Conducting and activating the agricultural processes followed in the riverine forests, from land use reform to the cutting cycle.

- Conducting further studies of the soil in the forest to determine the properties of the soil and further knowing the extent of the possibility of introducing new types of trees.
- Participation of the local people in protecting the forest through awareness programs aiming at enhancing the sense of responsibility towards the forest as its importance to them cannot be underestimated.
- Increase the types of land use, taking into account the captured experience of other types of trees.
- Introducing new types of trees and conducting more academic research

in order to determine which one is more capable of sequestering carbon dioxide, taking into account the age of trees.

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Annexes:

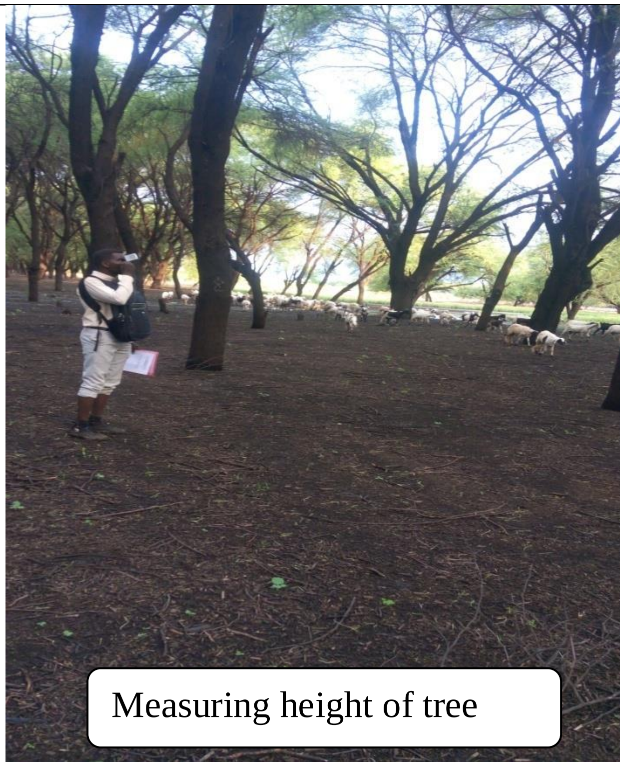
Annex A: shows the fieldwork in the study area:

Determine Sample streak/compass

Ranging rot

Taking coordinate/GPS

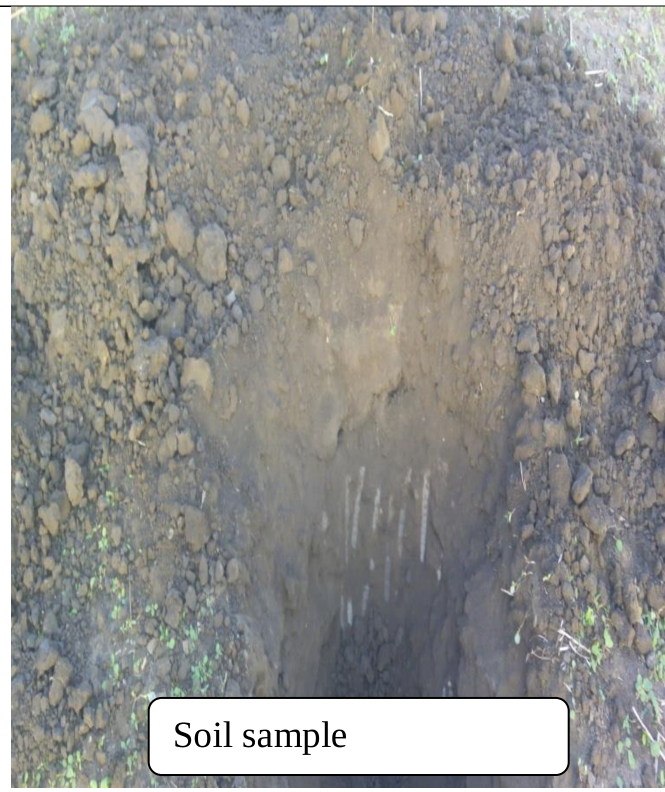
Measuring diameter



Measuring height of tree

Forest ranger and scholar

Soil digging



Soil sample

Annex B: shows illegal cutting and theft:


Oppressive cutting


Oppressive cutting

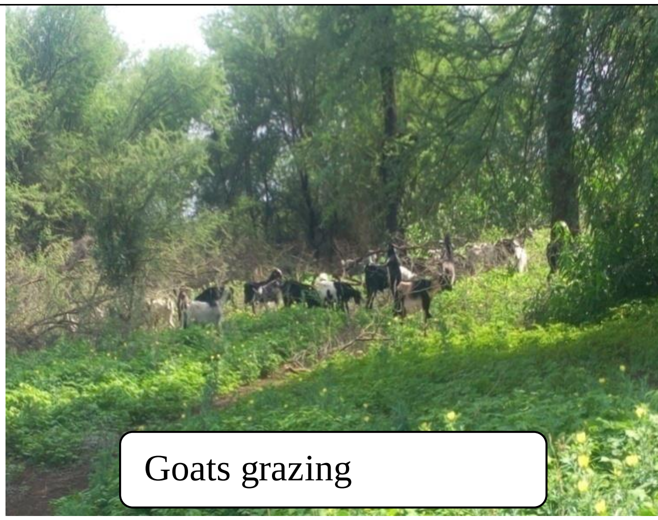

Theft firewood


Oppressive cutting

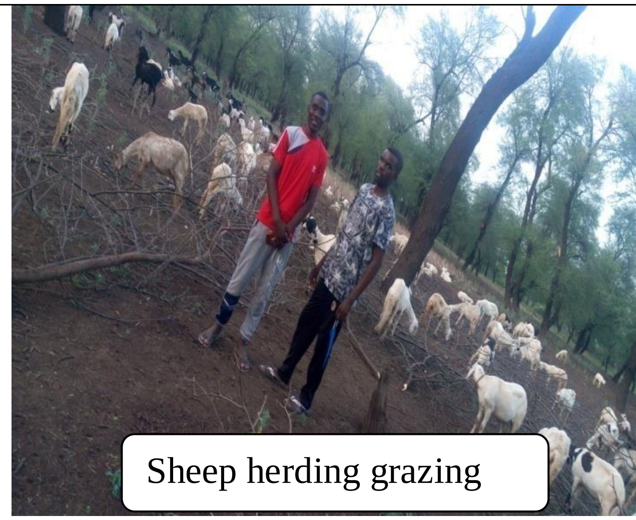

Collect firewood


Unfair cutting and firewood

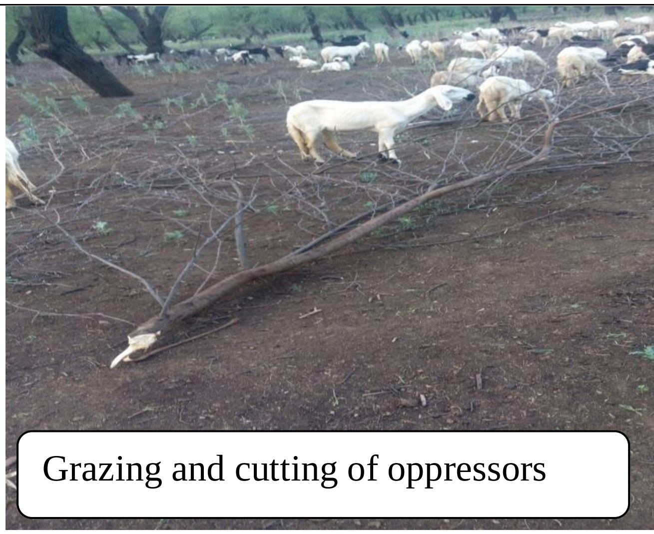
Annex C: shows overgrazing and tonjia:



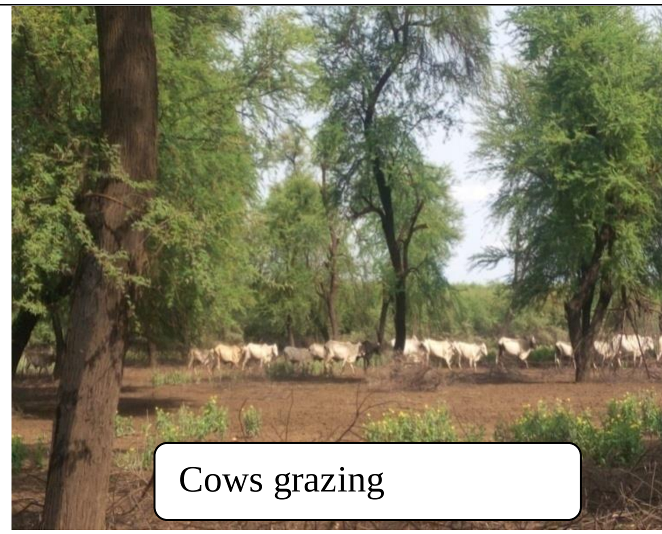
Goats grazing



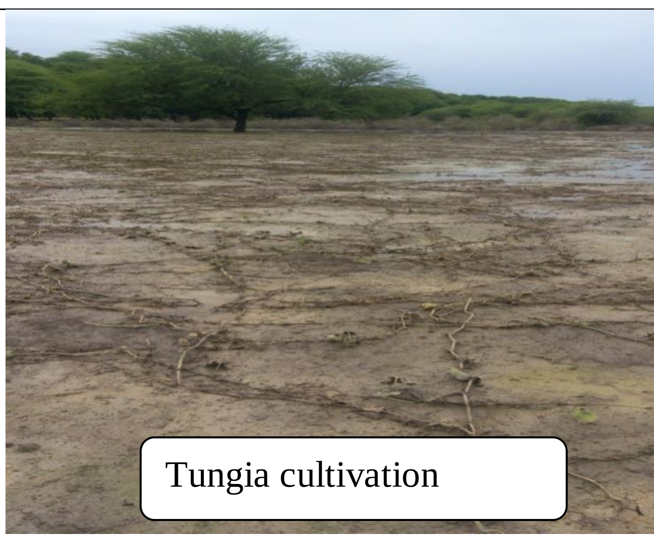
Sheep herding grazing



Grazing and cutting of oppressors



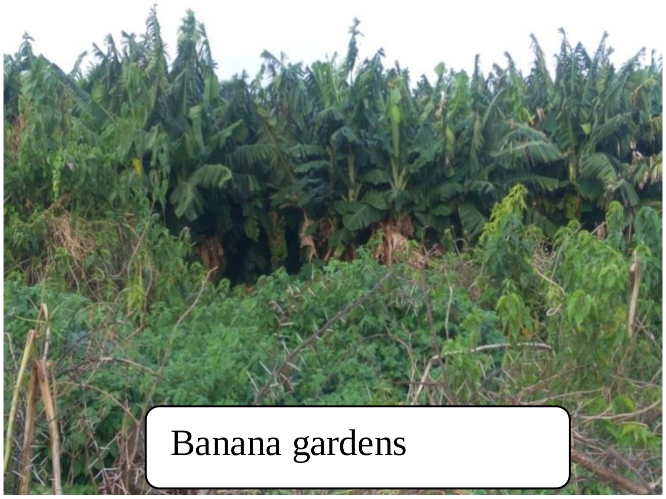
Cows grazing



Tungia cultivation

Space

Annex D: shows agricultural expansion and gardens:



Banana gardens

Agricultural expansion

Mango gardens

Agricultural expansion

Agricultural expansion

Gardens expansion

Annex E: shows the tree density in study area: