

**IMPACT OF LAND USE CHANGES ON VEGETATION  
COVER AND SUSTAINABLE LIVELIHOODS ALONG  
THE BANKS OF NILES AT KHARTOUM  
STATE, SUDAN**

**Submitted by:**

**Galal Elawad Khaled Omer**

**B.Sc. (Honours), Faculty of Forestry,**

**University of Khartoum, 2005**

**A thesis for the fulfilment of the requirements of M.Sc. degree**

**Department of Forest Conservation and Protection**

**Faculty of Forestry, University of Khartoum**

**July – 2009**

# **Dedication**

*This thesis is dedicated to*

*My Father, Mother, Brothers, Sisters*

*and Friends*

*For their encouragement and patience*

*Galal*

# Acknowledgements

First of all, all praise goes to the almighty Allah, the sustainer who has been showering His endless blessings on me throughout my life. The leaves of the tree cannot even wave without his consent.

I would like to extend my gratitude to the DAAD (Deutscher Akademischer Austausch Dienst) e.V. German Academic Exchange Service for granting me the Scholarship to complete my master's study and research and make them a success.

It is a great pleasure and privilege to convey my deepest gratefulness and immense admiration to my academic advisor and eventually my thesis supervisor, Dr. Babiker Ahmed El Hassan for his constant advice, guidance in structuring this work, and also for his invaluable inspiration, continued encouragement, and continuous supports for taking the challenge of this research idea and giving this thesis a final shape.

My sincere appreciation is also extended to Dr. El Amin Sanjak Mohamed Ali who provided me with support, advice, guidance and helpful suggestions especially in the parts related to social studies during the research work.

My special thanks to Dr. Omer Said Musa who provided a lot of information related to my research and for his guidance in preparing the research proposal.

My thanks are due to all my Friends who helped in various ways during the conduction of this research work.

My thanks are also extended to all the colleagues who participated in data collection. Elyas Ahmed Elyas, Faisal Ahmed Yassen, Eltayeb Hamid, Hythum Hashim Gebreel, Balla Elfadil Ahmed, Mustafa Kamil Fahmy, El Nour Mahmoud El Nour, and Mutasim Mohamed Said.

Finally, the faces which always shine in the deepest part in my heart are my mother, father, brothers and sister. I am lucky in having such great parents. Thanks are due to them for their endless encouragement, inspiration, and moral supports.

Here, I would like to dedicate this research work to my great lovely Mother, Father and my Brother Omer who have kindled the lighthouse in my way towards achieving success in my life.

## **ABSTRACT**

### **Impact of Land Use Changes on Vegetation Cover and Sustainable Livelihoods Along the Banks of Niles at Khartoum State, Sudan**

**M.Sc. (Forestry thesis)**

**By: Galal Elawad Khaled Omer**

**Abstract:** This research deals with the different land uses on the banks of the River Nile, Blue and White Niles in the study area. Three locations have been selected along parts of the waterfront in Khartoum State with the objective of assessing changes in land use and its impact on the vegetation cover and the sustainable livelihoods of the population. The study benefited from the techniques of aerial photographs and satellite products, which describes the current land use patterns and the former uses during approximately thirty years. The products of 1972 and 2001 were analyzed and compared with ERDAS program to determine the magnitude of changes in land use. Two types of data were used; namely, primary and secondary data. The field survey revealed the existence of four types of land use in the study area. These types were investment buildings and settlement, agricultural land (farms), forests (trees and shrubs) and red-brick factories (Kilns). The fifth category is bare lands which are left without any pattern of usage. The results showed that the area of agricultural land, industrial and residential areas have increased while the forest area and bare land have decreased as a result of the changes imposed by both the government and the local population for using land for Kilns, housing and investment buildings. These activities have led to land degradation in terms of environmental value and productivity.

An important aspect of the research results is that the impact of land use on forest cover and livelihoods of the population is very complex and dynamic. This is exemplified by the changes on the west bank of the White Nile where land adjacent to the Gerif land have changed from agricultural use to residential and investment usage, (City of business and money). Also, on the other side of the White Nile bank the Sunt forest has been affected by the creation and construction of the Ingas Bridge and Sunt city have taken some parts Sunt area and affected the lives of people in the study area. The changes in along of the banks of the Blue Nile included construction of Kilns and factories which have affected the environment. Changes in land use along the banks of the River Nile included the planned and non planned buildings and small-scale Kilns. Generally, the climate fluctuation and human illegal interference are the most important factors in this process. The study concluded that the use of land requires a clear plan for optimum land use. According to the information collected from questionnaire, various human activities are behind this change and these changes have led to the deterioration of forest cover and consequently resulted in the loss of a source of income for the local population. Some parts of the study area were converted into buildings, Kilns and residential at the expense of forests and pastures. Because of these alarming changes, decision makers should initiate efficient plans and management of the forests to reduce or stop further changes in land cover, especially in arid and semi arid areas. The study also recommends that the plan for the sound use of land need to be reviewed from time to time, to ensure rehabilitation, reduce vulnerability to desertification and halt the encroachment use by construction of facilities and buildings at the expense of environmental issues. The research arrived at other recommendations.

## ABSTRACT (ARABIC)

### تأثير تغييرات استخدام الأراضي على الغطاء النباتي واستمرارية الحياة على طول ضفاف النيل في ولاية الخرطوم، السودان

**المستخلص:** يختص هذا البحث بالاستخدامات المختلفة للأرض علي ضفتي نهر النيل، النيل الأزرق والنيل الأبيض بمنطقة الدراسة. اختيرت ثلاث مناطق من الواجهات المائية بولاية الخرطوم لدراسة وتقويم التغييرات في استخدامات الأرض وتأثيرها علي الغطاء النباتي واستمرارية حياة السكان. استفادت الدراسة من تقنيات الصور الجوية ومنتجات الأقمار الصناعية والتي تصف انماط استعمال الأرض الحالية و السابقة خلال فترة تقارب ثلاثين عاماً وحللت منتجات الاعوام 1972 و 2001 وقورنت ببرنامج ERDAS ومقارنتها لتحديد حجم التغييرات في استخدام الأرض. اعتمدت هذه الدراسة علي بيانات اولية و بيانات ثانوية. أوضحت البيانات الأولية وجود اربعة انماط لاستخدام الأراضي بمنطقة الدراسة، وهي مباني استثمارية و اراضي سكنية و اراضي زراعية (مزارع)، و غابات (اشجار وشجيرات)، و مصانع الطوب الاحمر (كمائن) والفئة الخامسة عبارة عن أراضي جرداء تركت دون أي نمط من الاستخدام . دلت النتائج علي ان مساحة الاراضي الزراعية و الصناعية و السكنية قد ازدادت بينما نقصت مساحة الغابات و الاراضي الخالية نتيجة التحول في استخدام الارض من قبل الحكومة والسكان المحليين لاستخدامها في اغراض الكائن والسكن والاستثمار، مما ادي الي تدهور الاراضي من حيث قيمتها البيئية والانتاجية. اهم نتائج البحث هي ان تأثير استخدام الاراضي علي الغابات وحياة السكان معقدة جدا وفي تغيير مستمر ، فعلي الضفة الغربية للنيل الابيض حدثت تغييرات لاستخدام الارض حيث حولت الاراضي المتاخمة للجروف من الاستخدام الزراعي الي الاستخدام السكني والاستثماري ( مدينة المال والاعمال). اما في الناحية الاخرى للنيل فنجد ان غابة السنط قد تآثرت بكثير من العوامل مثل انشاء جسر الانقاذ وتشبيد مدينة السنط الذين اخذا جزءاً من مساحتها. ويعتبر هذا نوع من انواع التحول في استخدام الارض الذي يؤثر سلباً و ايجاباً في حياة السكان بمنطقة الدراسة. ايضا تتمثل التغييرات بالنيل الأزرق في الكائن والمصانع التي اثرت علي البيئة، وتتمثل التغييرات في نهر النيل في المباني العشوائية والمخططة ومساحات صغيرة مستغلة في الكائن (اقل نسبيا من الكائن الموجودة علي النيل الأزرق). و عموماً نجد ان التقلبات المناخية وتدخلات الانسان الجائرة هي من

اهم العوامل الرئيسية لهذه العملية. خلصت الدراسة الي ان استخدام الاراضي يحتاج الي خطة واضحة للاستخدام الامثل للارض ووفقا للمعلومات التي تم جمعها من الاستبيان اتضح ان نشاطات الانسان المختلفة هي وراء ذلك التغيير وان هذه التغييرات ادت الي تدهور الغطاء الغابي وبالتالي ادت الي فقدان مصدر دخل السكان المحليين وان بعض المساحات في منطقة الدراسة تحولت الي مباني وكمانن وخطط سكنية علي حساب مساحة الغابات والمراعي. تلزم هذه التغييرات الخطيرة صانعي القرار في بدء تخطيط كفوء لادارة الغابات لتقليل أو وقف التغييرات في غطاء الأرض، خصوصاً في المناطق القاحلة وشبه القاحلة. اوصت الدراسة بوضع خطة للاستخدام السليم للارض علي ان تتم مراجعتها من فتره الي اخري وذلك لاعادة تاهيل الغابات وتقليل التعرض للتصحّر ووقف تغول استخدام الاراضي لتشييد المنشآت والمباني علي حساب المحاور البيئية. كما توصل البحث لعدد من التوصيات الاخري.

## TABLE OF CONTENTS

DEDICATION.....	I
ACKNOWLEDGEMENTS.....	II
ABSTRACT.....	IV
ABSTRACT (ARABIC).....	VI
TABLE OF CONTENTS.....	VIII
LIST OF TABLES.....	XI
LIST OF FIGURES.....	XII
ACRONYMS ABBREVIATION.....	XIII

### CHAPTER I

#### INTRODUCTION

1.1. Background.....	1
1.2. Population.....	3
1.3. Forests resources in Sudan.....	3
1.4. Statement of the problem.....	5
1.5. Justification.....	6
1.6. Objectives.....	7
1.7. Research questions.....	7
1.8. Structure of the study.....	8

### CHAPTER II

#### REVIEW OF LITERATURE

2.1. General.....	9
2.2. Land tenure.....	11
2.3. The land use and cover change (LUCC) project.....	13
2.4. Land use and land over.....	15
2.5. Land use and Land cover change.....	15
2.6. Land use and land cover classification systems .....	17
2.7. Land use and land cover change detection .....	19
2.8. Land use cover change and urbanization.....	20
2.9. Land degradation in Sudan.....	22
2.10. Impacts of deforestation.....	23
2.11. FAO framework for land evaluation.....	24
2.12. Structure of the FAO framework for land evaluation.....	26
2.13. Land use classification.....	27
2.14. Land use planning.....	29
2.15. Livelihood, land use and environment interactions.....	30
2.16. Status forest resources in Sudan.....	32
2.19. Quantifying and qualifying desertification.....	32

### **CHAPTER III STUDY AREA**

<b>3.1.</b>	<b>General.....</b>	<b>34</b>
<b>3.2.</b>	<b>Location.....</b>	<b>35</b>
<b>3.3.</b>	<b>Climate.....</b>	<b>38</b>
<b>3.4.</b>	<b>Natural vegetation.....</b>	<b>38</b>
<b>3.5.</b>	<b>The forest recourses in Khartoum State.....</b>	<b>39</b>
<b>3.6.</b>	<b>Soil.....</b>	<b>40</b>
<b>3.6.1</b>	<b>Nubian sand tone.....</b>	<b>40</b>
<b>3.6.2</b>	<b>Gezira Formation.....</b>	<b>41</b>
<b>3.7.</b>	<b>Land use system.....</b>	<b>42</b>
<b>3.8.</b>	<b>Irrigation system.....</b>	<b>43</b>
<b>3.9.</b>	<b>Problem of desertification and current status.....</b>	<b>43</b>
<b>3.10</b>	<b>Kilns around Khartoum state.....</b>	<b>44</b>

### **CHAPTER IV METHODOLOGY**

<b>4.1.</b>	<b>Introduction.....</b>	<b>45</b>
<b>4.1.1.</b>	<b>Methods and data collection.....</b>	<b>46</b>
<b>4.1.2</b>	<b>Photograph and observations.....</b>	<b>46</b>
<b>4.1.3.</b>	<b>Official record.....</b>	<b>47</b>
<b>4.2.</b>	<b>Sampling techniques.....</b>	<b>47</b>
<b>4.2.1.</b>	<b>Selection of locations.....</b>	<b>47</b>
<b>4.2.2.</b>	<b>Selection of households.....</b>	<b>48</b>
<b>4.3.</b>	<b>Construction of questionnaire.....</b>	<b>49</b>
<b>4.4.</b>	<b>Organization of the data.....</b>	<b>50</b>
<b>4.5.</b>	<b>Pre-testing.....</b>	<b>50</b>
<b>4.6.</b>	<b>Other helping data and analysis.....</b>	<b>51</b>
<b>4.7.</b>	<b>Statistical analysis.....</b>	<b>51</b>

### **CHAPTER V RESULTS AND DISCUSSIONS**

<b>5.1.</b>	<b>General introduction.....</b>	<b>51</b>
<b>5.2</b>	<b>Different activities surrounding study area.....</b>	<b>52</b>
<b>5.3.</b>	<b>The general characteristic of respondents.....</b>	<b>57</b>
<b>5.4.</b>	<b>The distribution of respondents according to Gender and Educational level .....</b>	<b>57</b>
<b>5.5.</b>	<b>The distribution of respondents according to source of income.....</b>	<b>59</b>
<b>5.6.</b>	<b>Current status of the forests.....</b>	<b>60</b>

5.7.	Dominant trees in the past and present .....	61
5.8.	The role of FNC in forest management and conservation in the study area.....	62
5.9.	Relationship between FNC and local people .....	63
5.10.	Type of forest in the study area.....	64
5.11.	Types of agriculture in the study area.....	65
5.12.	Trends of land use in the study area .....	66
5.13.	Consequences of land use changes in the study area.....	67
5.14.	The government role in land use .....	68
5.15.	Perception towards environment conservation.....	69
5.16.	The types and burning kilns .....	70
5.17.	Negative impact of human settlement .....	71
5.18.	Land use and tourism.....	72
5.19.	The purposes tree cutting.....	73
5.20.	The investor of land use in the study area.....	73
5.21.	Expansion of buildings.....	74
5.22.	Perceptions of environment conservation.....	75
5.23.	Constraints confronting land use planning.....	76
5.24.	Factors affecting land use change .....	77
5.25.	Types of rangelands .....	78
5.26.	Energy substitutes in the study area.....	79
5.27.	Suggestions to environmental conservation adoption land use systems.....	80
5.28.	Change detection and assessment.....	90
5.29.	Summary.....	83

## **CHAPTER VI**

### **CONCLUSION AND RECOMMENDATIONS**

6.1.	Conclusions.....	86
6.2.	Recommendations.....	87
	References.....	88
	Appendices.....	96

## LIST OF TABLES

<b>Table (1.1):</b>	<b>Vegetation classifications in relation to rainfall in Sudan.....</b>	<b>2</b>
<b>Table (2.1):</b>	<b>Capital assets and the sustainable livelihoods framework at the heart of the framework are the capital assets of rural communities.....</b>	<b>31</b>
<b>Table (3.1):</b>	<b>Land-use in Khartoum State.....</b>	<b>39</b>
<b>Table (3.2):</b>	<b>Land use in Sudan.....</b>	<b>42</b>
<b>Table (5.1):</b>	<b>Gender and educational level.....</b>	<b>57</b>
<b>Table (5.2):</b>	<b>Current status of the forests .....</b>	<b>61</b>
<b>Table (5.3):</b>	<b>Dominant trees in the past and present .....</b>	<b>62</b>
<b>Table (5.4):</b>	<b>The role of FNC in forest management and conservation in the Study area.....</b>	<b>63</b>
<b>Table (5.5):</b>	<b>Relationship between FNC and local people.....</b>	<b>64</b>
<b>Table (5.6):</b>	<b>Types of forest in the study area.....</b>	<b>64</b>
<b>Table (5.7):</b>	<b>Types of agriculture in the study area.....</b>	<b>65</b>
<b>Table (5.8):</b>	<b>Trends of land use in the study area.....</b>	<b>67</b>
<b>Table (5.9):</b>	<b>The government role towards land use .....</b>	<b>68</b>
<b>Table (5.10):</b>	<b>The types and burning kilns.....</b>	<b>71</b>
<b>Table (5.11):</b>	<b>Negative impact of human settlement.....</b>	<b>71</b>
<b>Table (5.12):</b>	<b>Land use and tourism.....</b>	<b>72</b>
<b>Table (5.13):</b>	<b>Expansion of buildings.....</b>	<b>75</b>
<b>Table (5.14):</b>	<b>Types of rangelands.....</b>	<b>78</b>
<b>Table (5.15):</b>	<b>Energy substitutes.....</b>	<b>79</b>

## **LIST OF FIGUERS**

<b>Fig (3.1):</b>	<b>The location of the study area.....</b>	<b>37</b>
<b>Fig (5.1):</b>	<b>Source of income of interviewed sample.....</b>	<b>59</b>
<b>Fig (5.2):</b>	<b>Consequences of land use changes in the study area.</b>	<b>68</b>
<b>Fig (5.3):</b>	<b>Perception toward environment conservation .....</b>	<b>70</b>
<b>Fig (5.4):</b>	<b>The purposes tree cutting.....</b>	<b>73</b>
<b>Fig (5.5):</b>	<b>The investors of land use in the study area .....</b>	<b>74</b>
<b>Fig (5.6):</b>	<b>Perception of environmental conservation.....</b>	<b>76</b>
<b>Fig (5.7):</b>	<b>Constraints confronting land use planning.....</b>	<b>77</b>
<b>Fig (5.8):</b>	<b>Factors affecting land use change .....</b>	<b>78</b>
<b>Fig (5.9):</b>	<b>The suggestions to environmental conservation adoption of land use systems.....</b>	<b>81</b>
<b>Fig (5.10):</b>	<b>Trends in Land Use/ Land Cover Classes 1972, and 2001.....</b>	<b>82</b>

## ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
CSIR	Council for Scientific and Industrial Research
CIESIN	Center for International Earth Science Information Network
CNS	Comprehensive National Strategy
DFID	Department For International Development
FAO	Food and Agriculture Organization
FINNIDA	Department for International Development cooperation, Finnish Ministry for Foreign Affairs
FOSA	Forestry Outlook Study for Africa
FNC	Forests National Corporation
FRA	Forest Resources Assessment
IGBP	International Geosphere-Biosphere Program
GLP	Global Land Project
GNP	Gross National Product
HCENR	Higher Council for Environment and Natural Resources
IDPs	Internally displaced persons
IHDP	International Human Dimension Program
LUCC	Land Use and Cover Change
LPG	Light Petroleum Gas
MAANR	Ministry of Agriculture, Animal wealth and Natural Resources
MAE	Millennium Ecosystem Assessment
NDDCU	National Drought and Desertification Control Unit
<u>Saqia</u>	planting and irrigation implements and system, respectively
NRD	Nile River Dispute
SNAP	Sudan National Action Programme
TDS	Total Dissolved Solids
UNEP	United Nation Environment Program
WCS	Wildlife Conservation Society
WRI	World Resources Institute

# CHAPTER I

## INTRODUCTION

### 1.1. Background

Sudan is the largest country in Africa, with an area of approximately 2.5 million square kilometers. It lies between latitudes 3°.2' N to 23°.0' N and the longitudes 21°.75' E to 38°.5' E. Sudan is characterized by diverse climatic conditions from desert (0 - 100 mm rainfall per annum) to savanna (200 - 850 mm rain fall per annum). This diversity results in different ecological regions from the desert in the north to high rainfall woodland savanna in the south. The diversity of such climatic conditions in a very large country like the Sudan constitutes major problems in natural resources development and conservation. The country is divided administratively into 25 States, and it's bounded on the east by the Red Sea and on the other sides by nine African countries (FAO, 2000). This administration is divided into 15 states which belong to the northern part of the country, while the rest is in the south. The Nile valley which runs from south to north forms the most important physical feature of the Sudan geography. The total population of the Sudan was estimated in 1993 to be 24.9 millions, of which 66% of live in the rural areas (Sudan census, 1993). The current Census of 2008 estimates the total population as 39 million persons. The forest reserves constitute approximately 12.5% of the total area of the Sudan (CNS 1992 - 2002) and the target is to increase the reserved forests area up to a minimum of 25% of the area of the country. Demands of forests products, mainly fuelwood and charcoal, was steadily increasing during the

last ten years as they are extensively used as major source of energy for more than 80% of the population (FNC, 2003).

The classification of vegetation of the Sudan based on the mean annual rainfall and soil types by (Harrison and Jackson, 1958) includes the desert, semi desert, low – rainfall savanna, high rainfall savanna, flood region and mountain vegetation. The geology of the Sudan is dominated by Basement complex formations. Other major formations are Nubian sand stone and Umm Ruwaba formations. The Sudan is divided into five ecological zones according to rainfall (Table 1.1).

Table (1.1): Vegetation classifications in relation to rain fall

Vegetation	Rainfall	Area in (ha)
Desert	0-75 mm	9020800 (36%)
Semi desert	75-300 mm	50111000 (20%)
Low rainfall savanna	300-900mm	60139000 (24%)
High rainfall savanna	900-1500mm	30070000 (12%)
Flood plains and mountain vegetation	1500-2000mm	20046000 (8%)

**Source: FOSA 2001**

The whole area of the central sector falls within the savannah region and it is characterized by short periods of rainfall for 3-4 months and longer dry periods for 8-9 months. The period from November-February is characterized by cold-dry weather and from March –June by hot dry weather, usually the rainy season starts from July and ends in October with a savanna type of distribution having its peak in August and with occasional showers in May.

## **1.2. Population**

Khartoum State is one of 25 states comprising Sudan. And it has an area of about 22000 km<sup>2</sup>, and an estimated population of about five million people (population census, 1993). Population has grown from approximately 10.26 million in 1956 to 25.6 million in 1993 and in 2002 the country's population was 30.3 million. The annual growth rate has increased from 1.9% to 2.7% and the estimated population in 2004 was 40 million giving the country an average population density of 43 persons per sq mile. The actual Census of 2008 reported the population to be more than 40 million.

Forests products and services play crucial role in the economy of Sudan and the life of its people. Wood fuel constitutes 80% of the total national energy consumption. Almost 80% of the population depends on wood fuel for energy. 70% of the people are engaged in agriculture or pastoral activities, another 21% are employed in services and only 9% have jobs in manufacturing, construction, mining and civil services.

## **1.3. Forests resources in Sudan**

In the past decades the forest resources of Sudan were subjected to severe degradation. The forest cover in 1958 constituted 35% of Sudan total area, this has declined to 25.6% in 2000 (Forest Resources Assessment, 2000). This damage was attributed to several factors such as repeated drought, uncontrolled activities of deforestation through land clearing for mechanized agriculture, over grazing, and bush burning. But Fuelwood and charcoal production is still one of the major factors causing reduction in Sudan forest area. Increased human and animal populations have also aggravated the problem (FAO, 2000). Forests products play an important

role in the economy of the Sudan and the life of its people. FOSA (2000) stated that about 40 tree species constitute fodder trees particularly during dry season. Wood fuel constitutes 80% of the total national energy consumption.

Forests are essential as local, national and global resources. At the local levels communities in and around the forests are always dependent on forests products. Despite increasing substitution by alternative materials, the demands for timber continue to rise. However, the survival of forests and wood land is fundamental to the continued functioning of the environmental system (FOSA, 2001).

Sudan natural resources cover is decreasing at an alarming rate of annual change. Lack of sound management and land use plans, population pressure, desertification, mechanized agriculture in dry Land, traditional and shifting cultivation and fire are considered as the main factors that contribute to the decrease of forests cover (FNC, 2003).

Khartoum State and the major cities that are located on the edge of the River Nile system from upstream to downstream: Juba, Damazin, Wad Madani, Khartoum, Aswan, Luxor, Cairo, and the town of Alexandria which lies near the Rozeta branch. The city of Khartoum is chosen for this study not only because it is the capital of Sudan, but also because it is located in the point of meeting for the main two Rivers Blue and White Niles. Moreover, it is heavily populated and has active development activities. Khartoum is located at the confluence of the White and Blue Niles at 370 meters above sea level (Collins, 1990).

Lebon,1965 has not merely produced a substantial justification of his 1:1,000,000 land maps of one of the largest states in Africa; but has also provided a great deal of information and a number of extremely interesting maps of Sudan, which are considered as a major contribution to our knowledge of the whole country. This has been admirably produced as a part of the world land use survey, and is taken as an elaborate monograph.

The world land use survey, on the other hand, has been conceived on a scale of 1:1M., and the map in professor lebon`s memoir has been reduced and is printed at a scale 1:6M. This map divides Sudan into land use categories, ranging in area from 145 square kilometers (Land use Settlements (Town).

Land area in Sudan is about one million miles square. Distributed between deserts in the North, various climates to tropical climate in the southern part together with a lot of water resources including streams, swamps surface and ground water. Variations in rainfall resulted in different forests and plant cover together with a good potential for food production.

#### **1.4. Statement of the problem**

Revision of laws and legislation for land settlement or planning and distribution of agricultural land and other resources are the most important factors that enhance sustainability of natural resources. One of the key factors that retain and conserve natural resources is adoption of sustainable management and improvement of the relationship between different interest groups. The lack of a clear zonation of the different land uses due to lack of relevant maps led to the wide spread of agricultural activities at the expense of other land uses. Reliance on satellite images and applications of remote sensing and geographical information systems would delineate the different sites according to its capability and suitability for certain land uses. This

technique is not exploited in the state for planning of land uses. Land uses improvement in the state necessitates revision of existing legislation and policies and consideration of the different interest groups and exploitation of their indigenous knowledge in planning of land use. Moreover, lack of specialized and qualified extension units in the state led to irrational uses of lands. This is clearly reflected in the lack of awareness towards importance of forest cover and its role in conserving the environment, particularly against erosion and desertification. The present exploitation of the natural resources in the state is practiced at the expense of forests and rangelands which are liable to depletion and dwindling.

### **1.5. Justification**

The land users in any location in the world generally use natural resources and specially natural forest land to benefit from different product (direct – indirect). These practices are meant to meet main livelihood needs and they may involve per ha deforestation activities at the expense of forests and rangelands as well as at environmental stability. Bricks-making practice is perhaps dominant in Gerif land at the banks of the Niles together with constructions activities. These trends of land use tend to reduce agricultural land and forest land. All these changes have a negative effect on the original land use map of the area. These changes need to be recognized and recorded for the creation of a balance between population requirement, development plans and, conservation of the environment.

## **1.6. Objectives of the research**

The broad objective of this research is to highlight the impact of land use changes on vegetation cover and sustainable livelihood of the population, and the more specific objectives are:

- 1- To investigate the impact of land use changes on forest cover and resilience of local communities.
- 2- To explore the role of local communities in the conservation of the environment and their relationship with the natural resources.
- 3 - To determine the main constraints and measures of risks confronting land use planning.
4. To explore the trend of land use changes in the state.
- 5- To recommend a suitable and ideal plan for proper land use.

## **1.7. Research questions**

To tackle the above mentioned objectives of the research some broad questions were formulated under the assumption that finding answers for these questions would facilitate attaining the objectives of this research.

The main questions are;

- 1- What are the patterns of land use in the study area?
- 2- What are the changes and trends of land use for the period (1972 - 2001)?
- 3- What is role of polices and legislation in the conservation of the natural resources?
- 4- What are the factors responsible for the degradation of forest cover and changes in land use in the study area?

### **1.8. Structure of the study**

The general structure of the study is being composed of six chapters. Chapter one is an introductory chapter explaining the problem statement and justifications, the main objectives and the hypotheses. Chapter two explores review of literature concerning the land use changes and population livelihood. The introduction to the study area, Location, physical features, vegetation and forest resource are highlighted in chapter three. Chapter four focuses on the methodological aspects of the study which are data collection and data analysis mostly depending on field observations. The result are presented and discussed in chapter five. The final summary and recommendations are presented in chapter six.

## **CHAPTER II**

### **REVIEW OF LITERATURE**

#### **2.1. General**

The current area under different land use categories between latitude 10°-16° N in Sudan represents the semi-arid and savanna zones that contain the major agriculture, rangelands and forest lands (HCENR, 2000). The natural resources indicate a declining trend while the wasteland and the rainfed traditional and mechanized agricultural lands show an increasing trend at the expense of forests and woodlands. Except for small land areas that are legally constituted (forest reserves, nature reserves and natural range and pasture), much of the lands are not legally legislated i.e. unregistered lands (Elsiddig, 2004) Some studies were carried out on different areas since 1925 and these have dealt with aspects of on land use pattern in Khartoum State especially on the waterfronts (Lebon, 1965 and Khaleel, 2000). Ghenaïm, 1970 stated that natural and human factors affect the types of land use in Albotana area and that climate and soil were the factors that affect and control the land use types and contribute to their distribution. The same author explored the features of natural and human factors which control and shape the pattern of land uses in Marawi and he classified land use pattern into:

1- agric-land which include fruit trees, crops, fodder, vegetables and animal production.

2- Non agric-land which includes construction land, fallow areas, public services areas and other land use.

The study concluded that:

- Marawi is an ideal area morphologically and phonographically and it has a unique site near to the Nile curve.
- Natural and human factors have a real role in land use pattern and climate is the most important natural factor affecting not only plant and crops, but also human activities because shapes the pattern of rural residence.
- Agricultural land use is the oldest and the most important human activities the area and it has been the agriculture was improved by introducing irrigation machines in the middle of last century.

Khaleel, 2000 reported that Khartoum is situated central Sudan with different means of transport, dense population, diversified cultures, trade and commerce and political leaders. This has paved the way for rapid land use changes and expansion in buildings.

Land use change is a continuous process, but learning is optional. Resources, ecosystem, biophysical environment, and land use/cover on the surface of the earth undergo changes over time. Land cover is the layer of soil and biomass, including natural vegetation, crops and manmade infrastructures that cover the land surface. Land use is the purpose for which human exploit the land cover (Fresco, 1994, cited in Verburg *et al.*, 2000). Land use change is the modification in the purpose of the land, which is not necessarily only the change in land cover but also changes in intensity and management (Verburg, 2000, cited in Soepboer, 2001). Land use and land cover change are critical issues due to their great influence in global warming, loss of biodiversity, and impact in human life. Because of their enormous impact and implications, the International Geosphere-Biosphere Program (IGBP) and the International Human Dimension

Program (IHDP) initiated a joint international program of study on Land Use /Cover Change (Geoghegan *et al.*, 2001).

Land use and land cover change is an extensive and accelerating process, and in many cases the process has negatively affected natural resources such as soil and water resources. It is driven by human actions and it often triggers changes that impact humans. Investigating the driving forces of these changes is critical for formulating effective policies and for identifying the factors that encourage or impede their implementation. The impact of land cover changes is important for society. For instance, the conversion of forested areas into other uses contributes to climate change and to a loss of biological diversity (WRI, 2000, Lepers *et al.* 2005). By altering ecosystem functions, changes in land use and land cover affect the ability of ecological systems to support human needs and such changes also determine, in part, the vulnerability of places and people to climatic, economic, or socio-political perturbations. For example, biodiversity loss due to deforestation results in a decline in ecosystem integrity and may impact hydrological processes, leading to flooding and soil erosion (Houghton 1994, Vitousek *et al.*, 1997, Millennium Ecosystem Assessment 2005).

## **2.2. Land tenure**

The type of land ownership is very important for the development of agriculture. The term land tenure is defined as the body of rights and relationships between people that have been developed to govern their behavior in the use and control of land and its resources. It includes the interest of income (Adam, 1966). In the Sudan these rights have been organized by the land settlement and registration ordinance of 1925. By this

ordinance, all unregistered land is deemed to belong to the Government but in practice the Government exercises its ownership as a trust for the people who have acquired rights over it, whether communal or individual. Land tenure in Khartoum State passed through these stages. First communal ownership by the tribe and this is still claimed. The western bank of the Nile is held by Gumuia, Hassania and Qyriat. The eastern part of the state is held by the Batahin, Hassania and Magharba tribes. Then progressed to ownership by a group or families and finally the 1925 ordinance regulated the forms of ownership and private ownership was claimed. Individual ownerships are found along the Nile on both banks where land is continuously under cultivation. These lands are either Seluka land or Saqia lands and recently pump irrigated lands. Seluka lands include all the flooded land at high Nile; namely the sloping bank which is called Jareif. Saqia land is that part irrigated by saqia or Shaduf or any lifting device and usually includes banks and small area behind the banks. In some cases seluka land is not found because most of the sloping bank and the adjoining piece in the river bed belong to the owner of the saqia land. An owner of the land behind the river can claim ownership of the banks themselves and even the islands that appear in the Nile from time to time. Behind the saqia land is the Bugur land; which is that part flooded by exceptionally high floods. Rain cultivation land also has different names such as lagid which means small depression where rain water collect and teras which is a raised earth embankment to capture run-off and Qoz land. All the three types are found in the different states of the country. This form of land ownership was suitable when the irrigation devices were primitive but with the advent of new means of irrigation such as pumps which irrigate large areas, there is a great need to allot large area for pumps.

So some privately owned lands may be expropriated when it has been required for inclusion in private pump schemes for permanent installation. The pump owner was called on to pay the cost of expropriation and the land becomes leased to him at low rent. Right owners are given preference in the opportunity to participate in the pump scheme. As a result of these, the entire area of the holding, in the province, may form a single parcel of land or be split up into two or more parcels and settled areas excluding towns and nomads; it was found that the number of holding reaches are 14.283 and it is composed of 17.632 parcels (Mohamed, 1970)

### **2.3. The land use and cover change (LUCC) project**

Much of the research on land use and cover changes has been undertaken in the framework of the Land Use and Land Cover Change (LUCC) project of the IGBP and the IHDP on Global Environmental Change (Lambin *et al.* 1999, Turner *et al.* 1995). LUCC had duration of ten years (1995-2005). Since 2005, research on land use and cover change has been organized under the framework of the new 'Global Land Project' which is located in the Department of Geography at the University of Copenhagen. LUCC defined itself as 'an interdisciplinary project/program designed to improve understanding and projections of the dynamics of land use and land cover changes as inputs to and consequences of global environmental change and as elements of sustainable development.' In order to do this, LUCC required new integrated global and regional models, informed by empirical assessments of the patterns of land cover change and by comparative case studies of land use processes, and was based on data and classification development. Furthermore, it also required major improvement in

understanding how processes of land use and land cover change vary across spatial and temporal scales. The research agenda of LUCC was composed of five major research themes: Integrated global and regional models, land cover patterns, land use processes, database and classification development and crossscalar or scalar dynamics (Turner& Ali, 1995). The LUCC program was based on an explicit statement by the global change community that:

1- Global environmental change involves far more than potential climate change or loss in biological diversity worldwide.

2- Human agency and societal structures operate synergistically in complex ways with the environment to create this change and the responses to it.

3-An improved understanding of the dynamics involved, with their implications for sustainability, requires a research strategy far wider ranging than that which has typified the history of the research community at large (Turner, 1997). Since its beginning a large number of researchers have linked their work to the LUCC program, and this study was one of many projects endorsed by LUCC. The Global Land Project builds on the research of the LUCC program. It has three main thematic areas:

1- The dynamics of land system change.

2- The consequences of land system change.

3- Integrating analysis and modelling for land sustainability. One of the main recommendations made to the GLP is to investigate the role of Remittances in relation to land use (Global Land Project 2005, Laumann, 2006).

#### **2.4. Land use and land cover**

Every parcel of land on the Earth's surface is unique in the cover it possesses. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. Land use is the manner in which human beings employ the land and its resources. Examples of land use include agriculture, urban development, grazing, logging, and mining. In contrast, land cover describes the physical state of the land surface. Land cover categories include cropland, forests, wetlands, pasture, roads, and urban areas. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover, but it has broadened in subsequent usage to include human structures such as buildings or pavement and other aspects of the natural environment, such as soil type, biodiversity, and surface and groundwater (Meyer, 1995).

#### **2.5. Land use and land cover change**

Land use affects land cover and changes in land cover affect land use. A change in either, however, is not necessarily the product of the other. Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, result in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that, cumulatively, affect global climate and biosphere (Riebsame *et al.*, 1994).

Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today is altered principally by direct human use: by agriculture and

livestock raising, forest harvesting and management, and urban and suburban construction and development. There are also incidental impacts on land cover from other human activities such as forests and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by troposphere ozone resulting from automobile exhaust (Meyer, 1995).

Contemporary global change consists of two broad types, systemic and cumulative. Systemic change operates directly on the bio-chemical flows that sustain the biosphere and, depending on its magnitude, can lead to global change, just as fossil fuel consumption increases the concentration of atmospheric carbon dioxide. Systemic change is largely associated with, but not limited to, the Industrial Age and thus has grown especially important over the more recent past (Turner & Butzer, 1992). Cumulative change has been the most common type of human induced environmental change since antiquity. Cumulative changes are geographically limited, but if repeated sufficiently, become global in magnitude. Changes in landscape, cropland, grasslands, wetlands, or human settlements are examples of cumulative change. Some cumulative changes reached continental, even global, proportions long before the 20<sup>th</sup> Century, including deforestation and the modification of grasslands (Turner & Butzer, 1992).

Changes in land cover driven by land use can be categorized into two types: modification and conversion. Modification is a change of condition within a cover type; for example, unmanaged forest modified to a forest managed by selective cutting. Significant modifications of land cover can occur within these patterns of land cover change. Conversion is a change from one cover type to another, such as deforestation to create cropland or pasture.

Conversion land cover changes such as deforestation have been the focus of many global change research agendas (Riebsame *et al.*, 1994).

The loss of rainforests throughout the tropical regions of the world as a result of deforestation for timber resources and conversion to agricultural lands has become a topic of global attention with the aid of widespread media coverage. Research specialists such as Skole & Tucker (1993), Skole et al (1994), and Kummer & Turner (1994) performed extensive studies in an attempt to bring further attention to this situation by focusing on the social implications and the environmental degradation associated with tropical deforestation in the Amazon of South America and in Southeast Asia. Yet, with all the research, awareness, and attention of the world, this potentially devastating phenomenon continues. It is an unfortunate, but fact of life that deforestation occurs on numerous expenses and at varying scales around the globe. Our society's focus on the plight of the tropical rainforests appears to have overlooked the shifting patterns of land use and land cover occurring in our own forests. Research should focus on the conversion of forest to pasture in a localized, rural setting in hopes that awareness of such occurrences may also be further publicized.

## **2.6. Land use and land cover classification systems**

A primary component of mapping land use and land cover is adopting or developing a land cover classification system. Many current land use and land cover classification systems are designed specifically for use with remotely sensed data. Many of these classification systems often resemble or incorporate other classification systems in order to maintain cohesiveness and allow for data integration. A hierarchical framework is often

implemented within a classification system. This type of framework allows the level of detail to vary for different project scopes and for the creation of land use and land cover categories that are compatible with other classification systems (Foti *et al.*, 1994). Anderson *et al* (1967) developed a hierarchical land use and land cover classification system for utilization with remote sensor data which has been adopted by the U.S. Geological Survey for 1:250,000 and 1:100,000 scale land use and land cover mapping of the United States. The Anderson classification system and/or Anderson derived land use and land cover classifications have been adopted in most contemporary land use and land cover research utilizing remotely sensed satellite data.

A hierarchical classification framework is composed of different levels of land use categories which are dependent upon the level of detail required by the project scope. Level I categories are often broad classification categories with examples such as urban, forest, agricultural land, and water classes. Level II categories offer more detail and are usually subdivisions of the level I categories. Examples of level II categories are coniferous forest, deciduous forest, and possibly mixed forest classes. Level III categories are often employed in local studies which incorporate species level land classes such as oak hickory forest or oak hickory pine forest (Anderson *et al.*, 1976).

## **2.7. Land use and land cover change detection**

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Singh, 1989). Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Change detection is useful in such diverse applications as land use change analysis, monitoring shifting cultivation, assessment of deforestation, study of changes in vegetation phenology, seasonal changes in pasture production, damage assessment, crop stress detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes (Singh, 1989).

All digital change detection are affected by spatial, spectral, temporal, and thematic constraints. The type of method implemented can profoundly affect the qualitative and quantitative estimates of the change. Even in the same environment, different approaches may yield different change maps. The selection of the appropriate method therefore takes on considerable significance. Not all detectable changes, however, are equally important to the resource manager. On the other hand, it is also probable that some changes of interest will not be captured very well or at all by any given system. An image differencing technique has been implemented in this change detection studies. According to recent research by (Coppin & Bauer, 1996) image differencing appears to perform generally better than other methods of change detection; and such monitoring techniques based on multispectral satellite data have demonstrated potential as a means to detect, identify, and map changes in forest cover. Image differencing is probably

the most widely applied change detection algorithm for a variety of geographical environments (Singh, 1989)

## **2.8. Land use cover change and urbanization**

According to one set of estimates, urban built-up areas, with average population densities of approximately 200 persons per square km., probably comprise around four percent of all land uses worldwide (Small, 2002). UN Population Division estimates suggest that the world's population will become majority urban by 2010; in contrast, the world was only 37 percent urban in 1970. Though the extent of urban areas is not that large when compared with other land uses such as agriculture or forestry, their environmental impact is significant. This is due not only to the large concentrations of population that are found in cities, but because they are centers of political, and economic influence, and are often the location of significant industrial activity (Schiller *et al.*, 2001).

Urban areas rely on vast hinterlands for food, raw materials for industry, energy, water supplies, construction materials, recreational areas and myriads of other goods and services. Uses and the expansion of these land uses into areas of natural or agricultural lands. A number of researchers are examining the impact of urban sprawl on crop-land loss (Heilig 1999, Vincent *et al.* 2002). Urbanization pathways lead to different impacts on rural landscapes in the developed and developing world. In the developed world, large-scale urban agglomerations and extended periurban settlements fragment the landscapes of such large areas that various ecosystem processes are threatened. Ecosystem fragmentation, however, in peri-urban areas may be offset by urban led demands for conservation and recreational

land uses. In a different vein, economically and powerful urban consumers tend to be disconnected from the realities of resource production and largely inattentive to the impacts of their consumption on distant locales. Urbanization in the developing world outbids all other uses for land adjacent to the city, including prime croplands. Cities attract a significant proportion of the rural population by way of permanent and circulatory migration, and the wages earned in the city are often remitted by migrants to rural homelands, in some cases transforming the use of croplands and creating “remittance landscapes.” Perhaps most importantly, this urbanization changes ways of life ultimately associated with demographic transitions, increasing expectations about consumption, and potentially a weakened understanding of production-consumption relationships noted for the well-developed world (Lambin *et al.*, 2001).

Galal El Din Eltyep, 2003 Stated the horizontal expansion of Khartoum State has been quite remarkable. The greatest expansion occurred during the last 30 years (The average annual rate of increase skyrocketed to 66.1 per cent between 1970 and 1980 while it was only 5.2 per cent between 1955 and 1970, but then dropped to 14.6 per cent during the period 1980-1998. The three towns have grown differentially, with Khartoum constituting 43 per cent of the total area of Khartoum State. Major reasons for this expansion include (in addition to those mentioned already) the high rate of population growth, abundance of flat land, availability of cheap building material (clay), the government policy of allocating a plot to every family, and natural and socio-cultural reasons (e.g. sleeping in the open air because of hot weather, separate compartments for males and females, the extended family, and high frequency of guests). People tend to acquire as large an

area as possible (when buying land or occupying it illegally). Most of the expansion is residential. The core and middle sections have been expanding outwards. Despite the formal commitment of the present rule to Islamic principles and values, the urbanization process reflects western urban morphology and functions, classification of residence on socio-economic bases, increasing roles of urban women, and constitutes a melting pot for different religious, ethnic and tribal communities.

## **2.9. Land degradation in Sudan**

Assessment of land degradation and its trends was based on the interaction of the factors of climate, soil, vegetative cover and the current human activities. Accordingly the concerned desertified states could be grouped into three categories. The states within each of the three classes share some common factors. The first class encompasses the most arid States, which are located in the northern and northeastern zones of the Sudan. It includes the Northern, the River Nile and Kassala States (SNAP, 2006).

Due to the relatively high aridity coupled with excessive agricultural land use, the land is experiencing a serious state of desertification. This stage has already been manifested in the form of bare lands around villages and water points. Riverbank erosion (Haddam) and sand dunes accumulation particularly in the western side of the Nile are all common symptoms of deterioration. The second class includes the states that are dominating the central clay plain of the Sudan, as well as the main irrigation schemes. These are the States of Gedarif, Sennar, Gezira and White Nile. This region enjoys a relatively high annual rainfall (100 – 500mm) and hence moderately desertified. The area had a fairly good vegetative cover but,

currently the land has undergone serious degradation as irrational mechanized farming, extensive woodcutting and over-grazing are over mining land resources. Northern Gezira and the western part of the White Nile are now experiencing progressive sand dune encroachment. Class three includes the western Sudan States of North Kordofan, west Kordofan, North Darfur and West Darfur (SNAP, 2006).

The soils are predominantly sandy and due to their favorable permeability and workability the soils are being extensively used for rain-fed traditional farming. These states are also the main resort for the nomadic pastoralists who flee livestock pests and diseases in the clays further south during the wet season. Consequently a multiple factors of climate, soil and irrational land use have contributed greatly to the current state of land degradation. But still the fact remains that prevention of land degradation is more cost-effective than suffering the severe consequences of desertification (SNAP, 2006)

#### **2.10. Impacts of deforestation**

Deforestation is a widely spread and complex socio- economic problem in the third world. Excessive deforestation causes generally more social cost than benefit. The burning of forest cover has been identified as one of the major sources of carbon- dioxide discharge into the atmosphere. Equally serious is the fact that deforestation leads to loss of an important source of absorbing and retaining atmospheric CO<sub>2</sub>. After fossil fuel burning, deforestation is the next largest source of global carbon emissions (Houghton *et al.*, 1983; Dixon *et al.*, 1994)

One of the most frequently recognized human causes of land degradation is deforestation. There is no doubt that deforestation is threatening or eliminating numerous forest ecosystems, species and genetically unique populations, including valuable forest genetic resources (Isager *et. al.*, 2002). Conservation of natural forests woodlands is still the main strategy and source of agricultural example, where about 200.000 ha of natural woodlands and forests are annually replaced by dry land mechanized agriculture (FNC, 2000). In addition to mechanized dry land farming fuel-wood and charcoal are the major sources of energy for the vast majority of the people of Sudan and it comes from biomass e.g. wood-fuel, charcoal and crop residues. About 9.5 million tons of oil equivalents (TOE) of biomass energy are currently annually consumed from more than 3 million ha of forests-land in Sudan (FNC, 2000).The consequence of agricultural intensification and excessive trees felling for energy purpose is a serious deforestation problem in Sudan (Hassan & Hertzler 1988).

### **2.11. FAO framework for land evaluation**

The first principle of the framework (FAO, 1976) is that evaluation is the specified land use type – a system of management relevant to local conditions in terms of the physical environment and social acceptability – so the first step is to identify and define promising land use types and establish their land requirements. For land use planning, there is also a need to know requirements for labour, capital and infrastructure – so the definition of land use types becomes a substantial, interdisciplinary task.

Knowing the land requirements, relevant information about the land is assembled and the various land suitability classes are arrived at by matching

the requirement of the land use type with qualities of each land mapping unit. The situation becomes more complicated where a land use type depends on several contrasting kinds of land, eg extensive grazing systems may require separate land areas to provide forage in the wet season and in the dry season.

Early application of the framework was qualitative and matched land use requirements with land qualities in the same way as in land capability classification. Typically, one or more diagnostic land characteristics (eg soil drainage class, slope angle) have been used as surrogates for land qualities, and limiting values for each land quality are fixed by expert judgment combined with field calibration. The principal judgment is to determine the cut-off point between suitability and unsuitability for each attribute. The next step is to determine the point at which the attribute changes from having no effect, to having a significant effect on production.

A refinement is being with a cropping calendar for the land use type and, from this, establishes critical periods of the year for different qualities, e.g. trafficability at sowing and harvest, a dry spell for ripening and so forth. The law of the minimum works remarkably well put many practitioners prefer a matching procedure that allows some compensation between different land qualities. Various procedures for rating limitations have been developed (eg *sys et al.*, 1991).

Detailed procedures for establishing land suitability are given in the series of FAO Guidelines for Land Evaluation (for rainfed agriculture, forestry 1984 and irrigated agriculture 1985, and extensive grazing 1991) and by *sys*

*et al.*, (1991&1993) the end product is reassuring families: a map of land suitability looks like a simplified soil map but, in the absence of short cuts that can be taken only by old hands, the procedures are time-consuming and, sometimes, opaque. The choice of factors may be arbitrary, the factors poorly defined and, where weightings are applied, the precision of any resulting numbers is spurious: the methods are essentially qualitative. And after all this, knowledge that a parcel of land is, say, suitability class S2 for sorghum but class S3 for cotton, is not a lot more useful to a farmer or a policy-maker than news that its land capability class is III. Various workers have attempted to develop more rigorous ways of weighting and judging land qualities and determining land suitability, eg through the use of fuzzy sets (Change and Burrough,1987;Triantafilis and McBratney,1993)

## **2.12. Structure of the FAO framework for land evaluation**

The target set by the FAO framework is a four category evaluation:

Land suitability orders. The first ordering is into SUITABLE or NOT SUITABLE for a specified land use type. Suitable means that sustained use of the kind under consideration will yield benefits which justify the inputs without risk of unacceptable damage to land resources.

Not suitable means that the kind of land use is impracticable, or would cause unacceptable degradation of land resources, or that the value of expected benefits does not justify the expected cost of needed inputs.

Land suitability classes. These reflect degrees of suitability. Experience of testing land suitability evaluations against crop performance does not support detailed subdivision. Within the suitable order, FAO recommends not more than three classes:

**Class S1** Land having no significant limitation to sustained use, or with only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.

**Class S2** Land having limitations that, in aggregate, will reduce productivity or benefits and will increase required inputs so that the advantage to be gained from the land use, though still attractive, will be less than that expected on class S1 land.

**Class S3** Land having limitations that, in aggregate, are so severe that expenditure on the land use will be only marginal justified. Within the Not suitable order, there are two classes:

**Class N1** currently not suitable. This land could be used for the purpose under consideration but the Social or economic cost is, at present, unjustified.

**Class N2** permanently not suitable. Land having limitations that appear so severe that sustained use is not possible.

Land suitability subclasses reflect the kinds of limitations, such as water, deficiency, erosion hazard, eg S2w, S3e. There are no subclasses within S1. Land suitability units. These are subdivisions of a subclass which differ in their response to management and so are significant at the farm level.

They are distinguished by Arabic numbers.eg S2e-1, S2e-2. (FAO, 1976).

### **2.13. Land use classification**

Land use is defined by Gray (1925) as that branch of land economics which comprises the study of the land resources of the nation or other geographical unit from the stand point of their economic significance with a view of determining for what and how they may be most effective. This means that the major aim of land use is to assess the land resources and see

whether their present use is economic or not. Its aim is also to conserve the land not merely to achieve maximum product per unit, but to see to what extent the particular crop used suits the conditions of the land. Also to find out facts of the present conditions and discover the conditions favoring or handicapping present production so as to be able to plan for sound future utility of the land. The aim behind this study is to find out the present land use in Khartoum State, Result may be of use in other areas of similar environment. With these aims in mind, the first objective is to find out what are the main types of land use in the state. In the Sudan the classification of land use `should be appropriate to a tropical country in an early stage of economic development in which land use types characteristic of temperate and most advanced countries have intruded only to a very limited extent. This means that the world land use inventory cannot be applied to the Sudan without modifications. The expected prevailing land use in the Sudan is those characteristic of tropical Africa, humid, semi-arid and arid. Khartoum State is in the northern half of the country where semi-arid climate prevail. Lebon, 1965 in his classification, the types which are not found in the Sudan are omitted and elaborated on types that found most such as land rotation with unimproved grazing. In mapping these categories he found difficulty in drawing boundaries between the different uses. The methods adopted by Lebon cannot be applied in such small province without some modifications. As the area is small it is necessary to map it in large maps and to achieve this air photos are used intensively supplemented by field work to identify the different crops and map the individual fields, the dominant type of land use in the province, not in terms of total area, but on its economic importance is perennially irrigated land, so it should be mapped in detail. Other uses as grazing lands and rain cultivation, though

they occupy large area but are very important. With all these in mind, the main land use categories identified in the state are:-

- a) Perennially irrigated lands; Methods of irrigation.
- b) Perennially irrigated lands; tree crops.
- c) Perennially irrigated lands; cultivation of vegetables, fodder and cereals ( Mohamed,1970)

#### **2.14. Land use planning**

Land use planning has proved to be much more difficult than gathering the supporting data. Land evaluation provides a link between the basic data and their application in land use planning; but the step from land evaluation to land use planning is a big one. Planning involves weighing land use opportunities against the problems involved, generation of a range of land use option, and making choices between the options. Not only does planning demand broader range of professional expertise than for land evaluation, but the decision made are much closer to the lives of land users and, in the final analysis, are political as much as technical.

It is only at the stage of land use planning, more specifically, the implementation of the plan that something actually gets done with land resources information. Land users have always made plans to meet their needs from the resources at their disposal. These plans have usually been informal, and limited in scale and scope, but they have been implemented. Until recently, formal land use planning everywhere has remained very much technocracy. Plans have been drawn up in the offices of the responsible agencies, remote from the areas being planned and often without any involvement by the supposed beneficiaries. Where the

responsibility to plan and the power to implement have not been in the same hands, it has always proved difficult to impose their plans. May be this is just as well. The last decades have seen two substantial responses to the shortcomings of such plans, namely decentralization and participation, both trying to bring planning closer to the people who have to implement and live with its results. Decentralization remains hamstrung by the lack of local capacity to undertake the kind of planning previously attempted centrally (Mohamed, 1970).

### **2.15. Livelihood, land use and environment interactions**

Livelihoods based on agriculture are closely linked with and dependent on the environment. But agricultural activities also powerfully shape the environment. Agriculture is, in fact, a human activity that affects the greatest proportion of the earth's surface, it is the single biggest user of fresh water (Pagiola & Holden, 2001), and is still by far the largest single source of livelihoods and income (Ohlsson, 2000). It is specifically through land use that the interaction of livelihoods and the environment is most clearly demonstrated. Land use acts as an interface between the two as it forms a unifying concept in which socio-economic and agro ecologic variables coincide (Kruseman *et al.*, 1996). However, some environmental changes are caused by natural processes and would happen without a human influence, and some changes are human induced but set in motion outside of the immediate realm and scope of the land user and his land. As the interaction usually happens in time with varying time lags of response and impact, it is not always easy to detect the underlying cause-effect relationships. Livelihoods comprise of resources or assets or capital (human, natural, social, physical and financial capital and access to use

these) that enable strategies to be employed in order to survive and attain desirable livelihood outcomes such as income, food security, well-being and sustainable use of natural resources (Carswell 1997; Carney 1998; DFID 2001). This process of transforming the resources into commodities or outcomes is influenced by a myriad of external factors such as laws, culture, policies, and institutions. In addition, livelihood dynamics are strongly influenced by personal characteristics and desires, and one's relation to others. A livelihood is considered to be sustainable if it meets three conditions: firstly, it should be adequate for the satisfaction of self-defined basic needs, secondly, it should be resilient to shocks and stresses (Chambers, 1995), and thirdly, it should not undermine the natural resource base that forms the basis of the future options (Hyden 1998; Scoones 1998).

Table (2.1): Capital assets and the sustainable livelihoods framework

At the heart of the framework are the capital assets of rural communities:

Natural capital	The natural resources stocks from which resource flows useful for livelihoods are derived(land, water, wildlife, biodiversity and environmental resources)
Social capital	The social resources(networks, membership of groups, relationships of trust, access to wider institutions of society)upon which people draw)
Human capital	The skills, knowledge and health heeded to pursue different livelihood strategies.
Physical capital	The infrastructure (transport, shelter, water, energy and communications) and the production equipment which enable people to pursue the livelihoods.
Financial capital	Moneys (whether saving, supplies of credit or regular remittances or pensions which provide them with different livelihood options.

Source: Carney (1998)

## **2.16. Status of forest resources in Sudan**

Forests are very important in satisfying basic needs of societies at all stages of development. Forest products in the form of wood fuel, charcoal, construction poles, timber, gums, Leaves, native and processed medicines are in demand at varying levels. The means by which these products are obtained has varying impacts on the role played by forests in environmental protection as well as community support. According to the FAO Global Forest Resources Assessment (FAO, 2001). The total forest cover of Sudan is estimated as 61.630.000 ha and constitutes 26 percent of the country's land area of 237,600,000 ha. The forest cover area in Sudan decreased from 71,220,000 ha in 1990 to 61,630,000 ha in 2000, a decrease of 959,000ha/year: 90% of which is for fuel and charcoal making (ADB/EC/FAO 2003: Glover 2005).

The annual reported forest cover change in the Sudan is -1.4%, and in concrete terms Sudan recorded an annual loss of 959,000 ha of forest cover from 1990 to 2000. As of 2000, Sudan had 2.1 ha of forested land per capita. In 2000, Sudan registered 60,986,000 ha natural forests and 641,000 ha of forest plantations. The volume of wood was estimated at 19 m<sup>3</sup> ha<sup>-1</sup> corresponding to wood biomass of 12 t/ha on average in 2000(FAO, 2001)

## **2.17. Quantifying and qualifying desertification**

An estimated one-third of the earth's land surface is arid or semi-arid. Some 850 million people inhabit this land area of approximately 40 to 50 million square kilometers. The incidence and threat of desertification within this area is widespread. Since the 1977 United Nations conference on desertification investigators have carried out systematic studies of the extent

of desertification. (Dregne, 1983) estimate that approximately 80 percent of productive lands in arid and semi -arid areas suffer from moderate to severe desertification. The (WRI, 1986) estimates that 88 percent of productive dry lands in the Sudano- sahelian area of Africa are desertified.

A major cause for concern in many countries is that, with present land-use practices, the natural resources are not able to support the existing population, let alone provide for population increases. The Sahelain and Sudan zones of West Africa show a current fuel-wood deficit of 50 percent and very limited potential for additional food crop and livestock production to meet population increases. The population growth rates cannot be sustained for long without deterioration in living standards unless rural productivity or non rural employment opportunities dramatically improve. Even if rural population increases by only 2 percent a year, in the year 2000 the rural population will exceed 40 million as against a total sustainable rural population (for food and livestock) of 36 million. (World Bank, 1985). The problems in that exact dimension are still unknown. However satellite based remote sensing techniques now make defining the problem with some precision possible. Without urgent remedial actions, the spread of desertification will continue to escalate; hundreds of millions of people will become environmental refugees, dependent on humanitarian relief that may ultimately be inadequate. The drought and resulting famine during 1984 and 1985 in sub - Saharan African was tragic. Before the drought the millions of people who lived in desertified areas of this region had experienced a decrease in crop and livestock yield. Consequently they were not able to store enough food to carry them through the drought. It is axiomatic that desertification leaves people poorly prepared to cope with drought.

## **CHAPTER III**

### **THE STUDY AREA**

#### **3.1. General**

This chapter deals with the description of the site condition, climate, vegetation, soil geological formations, population and land use. The study was conducted around part of the waterfronts of Khartoum State. However, the description will cover the whole state because the waterfronts are tightly linked to and affected by their neighborhood. Khartoum, the capital of Sudan, is located at the confluence of the Blue Nile and White Nile. The city has grown rapidly in recent years and today has an estimated population of about five million people including two million refugees. Khartoum is located in the semi-arid savanna belt of the Sudan, with an average annual rainfall of 100-200 mm and a long dry season from September to June. A wide range of production systems can be found ranging from household Subsistence to large-scale commercial farming (Kamal *et al.*, 2008)

Khartoum Region is densely populated and rapidly spreading on agricultural lands. These factors urged the Ministry of Agriculture of Khartoum State to look for sustainable agricultural development based on scientific basis. The most fertile soils of the recent flood plains of the Nile and its branches, the Blue Nile and the White Nile, are very limited and fully exploited for agricultural production; especially fruits, vegetables and fodder. (MAANR, 2000).

At Khartoum, the Blue Nile and the White Nile merge into the single River Nile. From downstream Khartoum, the river is called River Nile. Also, 320 km north of Khartoum, it is joined by the seasonal Atbara River that rises in the Ethiopian highland. The Blue Nile and the Atbara are subject to heavy seasonal fluctuations in flow as a result of the seasonal rains of the Ethiopian highlands. Within the section between Aswan and Khartoum, at land which is called Nubian, the River passes through formations of hard igneous rock, resulting in a series of rapids, or cataracts, which form a natural boundary to the north. The Nile receives no additional water during the rest of its 3.000 km journey through the desert before it ends up in the Mediterranean Sea. The Nile River has an annual flow in normal years of 84 billion cubic meters at Aswan, in southern Egypt. Of this, 59% from the Blue Nile (NRD, 2006) and the other 41% from White Nile and Atbara and other small tributaries. The Blue Nile contributes more than half of all Nile water throughout the year. The Nile is of great importance for the population because it is the main source of drinking water for all those who live within these countries and it is a primary source of soil formation, which is transferred from the Ethiopian mountains during the flooding season, and it is of agriculture. But factors like the rapidly growing population combined with the ecological consequences, and the increasing agricultural and industrial development, which demands more and more water, are problems facing the Nile water (Waterbury, 1979).

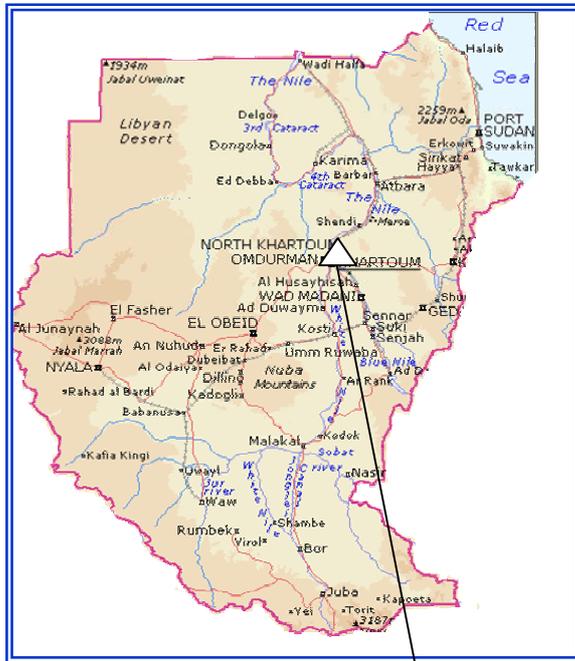
### **3.2. Location**

Khartoum State lies between Latitudes 15°:20' and 16°:20' N, and Longitudes 31°: 35' and 34°: 25' E. It almost lies in the center of Sudan at the junction of the Blue and white Nile and occupies an area of about 2611

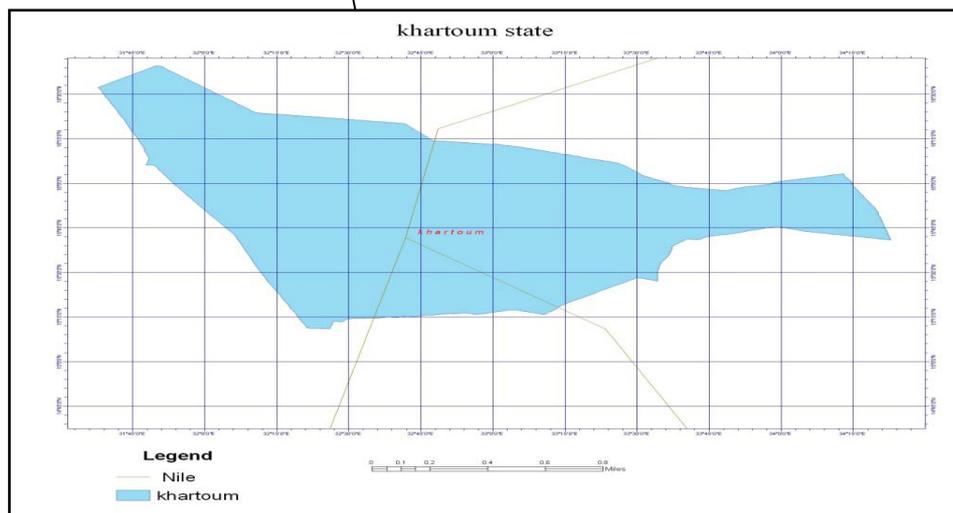
sq km. It is the smallest state in the Sudan, extending from the margins of the desert in its northern extremity to semi- wet humid regions southwards. The White Nile and Blue Nile unite at Khartoum and from the main Nile (River Nile), which flows north ward and divide the country area into two parts, one to the west and the other to the east.

Since 1984 the state has received 3 million migrants and displaced people due to famine and civil war. This uncontrolled urban growth has occurred at a time of economic hardships, inflation, rampant open and disguised unemployment, strict economic restructuring programs, and an international development assistance that has been reduced to humanitarian, life-saving aid. Seventy percent of the state population is believed to be living below the poverty line. However poverty does not appear so grim due to strong solidarity, reciprocity relationships among households and communities, and utilization of a host of coping mechanisms (El Hadi, 2006).

### The study area



Sudan



Study area

Figure (3.1): The location of the study area

### **3.3. Climate**

Temperatures, humidity and rainfall are all higher in the south. There is a large variation in annual rainfall, from less than 75 mm in the desert, 75 mm to 300 mm in the semi-desert, 300 mm to 1 500 mm in the forests and savannas and to over 1 500 mm in the mountains (FAO,2007 Forestry Division).

The prevailing climate is semi-desert to dry (Van der Kevie, 1973) it is hot, dry and rainy during summer and cold dry in winter. The average annual rainfall is 75-160mm /year and the dry season covers 8 -10 months. According to (Khartoum Metrological Station,1998), the daily average maximum temperature 37.7°C while the daily average minimum temperature 21.6°C, maximum temperature in summer exceeds 40°C, while the minimum temperature reaches 5.2°C in winter.

The daily evaporation rate according to the (Penman equation) is 7.7 mm and the highest rate takes place in April with average of 9.3mm. The daily mean of relative humidity is 38 at 8 am and 21 at 2pm, while the mean wind speed is about 9 miles/hr before autumn. The area is known for its strong wind storms (Haboub) that reaches a speed of 11 miles/hr.

### **3.4. Natural vegetation**

The whole area of Khartoum State falls in the semi- desert ecological zone. There are different kinds of indigenous trees growing wild in most of the State. That can be rehabilitated and managed properly, and their products can generate income for people in the urban area. Satellite image of Khartoum conducted recently indicated that, the vegetation cover is sparse, total differences are primarily a function of varied soils. According to

(Harrison and Jackson, 1958) the vegetation zone of Khartoum State includes; *Acacia tortilis*- *Maerua crassifolia* Desert scrub which occupies more than 90% of the State area. *Acacia tortilis* is the dominant. In the extreme North West of the State a very small portion of semi- desert grassland on sand exists. Another very small portion of the state lying on the south east named semi- desert grassland on clay. Other tree species like *Salvadora persica*, grows along seasonal courses in the semi- desert grassland and the woody species like *Acacia mellifera* show up along the drainage lines of seasonal shallow water courses. However, along the banks and sometimes in the islands of the Blue Nile, and the River Nile there are uncultivated areas along the terraces (see Appendix 3) that showed the list of the natural plants of Khartoum State.

### 3.5. The forest resources in Khartoum State

Reference to national forest inventory in 1996 provided by the Forest National Corporation (FNC), which has documented the vegetation cover in Sudan, the land use of Khartoum state is documented as follows:

Table (3.1): Land use in Khartoum state

Type of land use	Area(ha)	Percentage of land (%)
Cultivated land	170.000	9.7
Pastoral land	270.000	15.4
Forests land	130.000	7.4
Residential area	170.000	9.7
Unexploited area	1.010.000	57.7
Total	1.750.000	99.9

Sources: Forest National Corporation (FNC, 1998)

Table (3.1) shows that the percentage of forest lands 7.4%, which is recognized to be the smallest compared to other classes. The land allotted for forest is small for Khartoum State which is endangered by desert encroachment in its northern, western and eastern peripheries. Although commendable efforts were done by FNC to protect and conserve forest by reservation of state forests, the forest cover is very low when compared with the total area of the state (1.750.000hectare). The ten years plan (1990-2000) states that 25% of the state must be reserved as forests, but only about 3% of the state's total area is reserved. This mainly refers to slow process of establishing reserved forests in the state (FNC, 1998).

### **3.6. Soil**

The Basement complex covers the northern part of the state. Most of this complex is granite rocks which resist weathering. A narrow strip of the Nile is composed of recent deposits from El Faki Hashim passing through Elgaili and Wad Ramli, also it covers Abu Delig area. (Adam, 1975).

#### **3.6.1. Nubian Sand tone**

The Nubian complex covers most of the state with different forms which are liable to weathering forming the red gravel land. Due to the strong current of the Blue Nile, the Nubian sand stone become eroded forming the old and recent deposits, and as a result of that, the agricultural activities extended east of the Blue Nile. Many small khores, big wadis (Abu Hashem and El Rawakeeb) and many hilly gravels and sand dunes are found along the western parts of the White Nile (Adam, 1975).

### **3.6.2. Gezira Formation**

This formation covers the area between the Blue and White Niles.

It is formed by the pale channels of the Blue Nile forming different kinds of soils, varying in their texture from clay to sandy loam depending on its topographical position. These formations exist along the two Niles and have distinct geomorphology. Nine categories of geomorphologic units in Khartoum State were identified by (Elfadl, 2000) as follows:

- (1) Recent terraces, Gerf land and Nile Island.
- (2) Basin (Depressions of the Blue Nile (Channels and old River Nile)
- (3) Higher old terraces.
- (4) Fan plains of the old Blue Nile channels.
- (5) Mobile sand dunes
- (6).Surface red eroded plains being formed from the Nubian sand stone, rich in iron minerals.
- (7) Sloping, deteriorated and eroded plains, west of River Nile and White Nile and fan deposits.
- (8) Big and small Wadis.
- (9) Mountains and their surroundings.

The Gezira formation aquifer is unconfined so water occurs under water table conditions. However, confined or semi-confined groundwater occurs at some places due to the presence of confining bed mainly composed of clay which is to some extent permeable or leaky. The depth to the saturated zone varies from about 8 m in the areas near the Nile and increases in the south east directions of the White Nile and south west of the Blue Nile with maximum depth of about (35) m at the centre of the Gezira area. The saturated thickness of the Gezira formation varies from few meters to (40)

meters. The total dissolved solids (TDS) of this formation varies from (200) to (2500) ppm and the water in most cases is suitable for domestic and agricultural uses. The aquifer receives recharge from the Nile system and shows three directions of groundwater movement from north to south, from the Blue Nile to the southwest and from the White Nile to the southwest direction. (MAANR, 2000).

### **3.7. Land use system**

Basin irrigation depends on diversion of Nile water during flood period. Crops are then grown in winter season utilizing residual moisture stored in the soil. Water is pumped from ground aquifers at the bank of the Nile and converged to the fields by small ditches. Water is pumped from the Nile utilizing large pumping stations and it is conveyed to the fields by network of main and minor canals (Kamal *et al.*, 2008). In central Sudan the following divisions of land use can be observed (Table 3.2)

Table (3.2): Land-use in Sudan

Item	Area in (000 hectare)
Total area	250.581
Land area	237.600
Area under water	12.981
Forests and wood land	67.546
Other	170.054

(Source: FAO, 2005)

The total area of Khartoum State is about 5 million Fedden, the total cultivable land 18 m fed, Only 6 million (30%) is under cultivation, about 0.4 million faddan is occupied by infrastructures (22%).

According to land –use pattern, the agricultural lands in Khartoum State can be classified as follows: small farms (60%), cooperatives sector (25%), large schemes 15% (71000 Fedden ) Forests and rangelands cover an area of 2.3 million Fedden, and this amounts to 45% of the geographical area of the state. Forests represent 25%.

### **3.8. Irrigation system**

Khartoum State with its unique position at the confluence of the Blue and White Niles represents an ideal location for food production; this is fully oriented to satisfy urban demands:

- Crop production is practiced on 77000 ha in winter season of 2005-06.
- About 54% of this area is in the urban part of the state.
- Major crop production in the periurban area comes from large private and cooperative schemes. The biggest share of the cultivated area in season 2005-06 was allotted to fodder crops (55%), followed by vegetables (27.4%), fruits (6.4%), field crops (3.2) and spices (1.3%) (Kamal *et al.*, 2008).

### **3.9. Problems of desertification and current status in Khartoum state**

The green belt was established in 1962 within the ten years plan 1961/62. 1970/71 to cover an area of 70000 feddan of ten kilometer length and three kilometer width and kafur trees (*Eucalyptus*) were planted. The main aim of this belt, according to (Shawki and Musnad, 1964), is to protect Khartoum city from south dry wind and dust storm coming from southward.

Additionally, it is anticipated to conserve the degraded agricultural soil, provide building pole and firewood to Khartoum city beside the provision of recreational and leisure services. Forest administration made great efforts in planning, protecting and managing the plantation for satisfying the objectives of the Khartoum Green Belt.

### **3.10. Kilns around Khartoum State**

Most of clays used for brick in Khartoum state is mined by open pit methods. However no data was reported on production levels. This type of clay is known as normal clay. Brick kilns are situated along the Blue Nile flood plain on both banks. In Khartoum brick kilns are found in Greif east, Butri, Soba west and toti Island, in Omdurman brick kilns are found in Gezera Island, Wadi seidna and Elgamier. In Khartoum North, brick kilns are situated in Gereif east, Hilat koko, Halfaia, Shambat and Elkhogalab.

The total number of bricks kilns in Khartoum State is 130 (one Hundred and thirty). However, these are the official kilns that have license and pay regular rents to the Government. Those working illegally are numerous and the number may match the official one. The type of normal clay is plastic enough to mould easily. They may contain also kaolin and most misllorite. They usually contain more Alkaline, alkaline earth ferruginous minerals and less allumina and high quality kaoline. The type of clays is sometimes referred to as brick sewer pipe or tile clay. Clay and shale are used in the manufacture of structural clay products such as brick, drain tile, Portland cement, clinkers, and expanded light weight aggregates (MAANR, 2000)

## **CHAPTER IV**

### **METHODOLOGY**

#### **4.1. Introduction**

This chapter deals with the description of the scope of the research, the target group, and sample selection. The data collection instrument (questionnaire) is described with regard to its construction, validity and field testing as well as the procedures and methods employed for data analysis. The study was undertaken for the purpose of assessing the impact of land use changes on vegetation cover and population sustainable livelihoods along parts of the waterfronts of a designated area in Khartoum State. Singh, 1989 described change detection as a process which observes the differences of an object or phenomenon at different times. This means that it is a useful technique in detection of the change dynamics of land features including natural resources. Accordingly, this study developed a procedure for assessment and evaluation of land use/land cover change of Khartoum State especially in the waterfronts, which have occurred in the study area during the period 1972 - 2001. The change detection assessment was based on special statistics generated from supervised classification of spatial and temporal data using images for TM 1972, and the data of TM 2001. Furthermore pixel-by-pixel image comparison and "cross-tabulation matrix" algorithms of ERDAS IMAGING software package were used as post-classification tools to verify the change process.

In this study, two types of data were used to collect the necessary information, namely; primary and secondary data. The source of the secondary data includes FNC documents, projects documents, records of

range and pasture administration, Ministry of Agriculture and Forests, Civil engineering records, satellite images, archives, previous studies, scientific papers and annual reports. The primary data was collected through household survey (questionnaire) with the purpose of investigating the perception of the people on land and resource status. Observations were recorded during the terrestrial survey and the existing land use patterns and types of natural resources were identified.

#### **4.1.1. Methods and data collection**

The methods and data collection in this study include reconnaissance survey, questionnaire, photographing, satellite images and records reviews. Reconnaissance survey was carried out to delineate the study area and to collect some basic data that will help in preparing the questionnaire as well as in delineating the boundaries of the research sites.

#### **4.1.2. Photography and observation**

The use of private digital camera equipped with film was considered as a helpful tool to depict the current status of the land resources. They also help in serving as records for future monitoring of changes that may take place. The study combined the advantages of interviews and field observations for the purpose of securing more details and accuracy. Observations were made on the types and status of vegetation, forest cover and land use types along the designated waterfronts. Accessible areas of the forest tract between the three locations of Khartoum State were visited and the status of the vegetation cover in the main Nile, White and Blue Niles was captured by the use of Digital Camera. This was intended to provide pictorial evidence

of the degraded parts of the Forest, as well to register the various types of land use.

#### **4.1.3. Official records**

Some data was obtained from local departmental records including reports on areas, crop yield, human and livestock population, cultivated land, constructions and various human activities. This data was closely examined and arranged to help in assessing the impact of land use changes on forest cover and population livelihood.

### **4.2. Sampling techniques**

The sampling technique used in this research is simple random sampling for selection of locations and households.

#### **4.2.1. Selection of locations**

Selection of location was based on availability of land use activities in the study area. Three sites were selected to represent the study area, namely, main Nile, Blue and white Niles. Reconnaissance survey revealed that there are five types of land use, including: Constructions and building, Farming, Brick Kilns industries, Forests and Bare area, particularly on the western part of the White Nile. Taking Khartoum city as the focal point, about 5 kilometers along each of the main Nile, the White and Blue Niles were delineated as the three main sampling sites. The reconnaissance survey was conducted to cover both banks of each Nile along the specified five km. The land cover and land use activities were recorded by type, extent and current conditions. A reconnaissance survey has been conducted along narrow strips of 0.5 – 1.0 km. at both banks of each of the main Nile, the Blue and white Niles. Parameters to be measured or observed and recorded included

information related to various land use patterns including farming ,brick making, buildings, forests (tree and shrubs) and bare areas and identify vegetation cover. Random samples from each land use pattern were taken and 25 farmers were randomly selected to represent the various patterns. Twenty two random samples represented brick making, 15 samples were for buildings, Sunt forest was selected to represent forests types and four random samples to represent bare area. The sample size was adjusted according to the overall number of the different land use patterns.

Information from the random sample related to Farming included irrigation system, the current use, marketing, income levels, land ownership, and the areas in feddan. Information on areas for brick making included land administration, land ownership, areas in feddan, marketing, income levels, and dominant tree species. The information on buildings included types of buildings, design of buildings and availability of necessary services. Sunt forest has been selected to represent forests in the study area and the information included forest ownership, forest administration, types forest, protection, and negative/ positive impact on people life's and environment.

#### **4.2.2. Selection of households**

The three sites do not constitute a proper dwelling for the target group and consequently it is difficult to identify proper households. People living or just working on the sites are considered as the target group. Residence and mode of production and consumption were considered as the main criteria for defining households. These criteria are diffused in the study area, hence, people working and encountered on the site were interviewed.

The filling of questionnaire was carried out for people available in the study area, and the total number encountered was 44 persons on the banks of the Niles. The distribution was 13, 12 and 19 for main Nile, White Nile and Blue Nile respectively.

#### **4.3. Construction of the questionnaire**

The Construction of the questionnaire was made according to the standards set for proper formulation of appropriate questions. The supervisor and other experts helped in construction of the final format. The following guidelines of (Burchinal, 1989) were also given special consideration in the construction of the questionnaire:

- 1- To be certain that each question was relevant to the topic and necessary.
- 2- To ask the questions that the respondents can and are willing to answer.
- 3- To express each question as simple as possible.
- 4- To State questions in specific concrete terms.
- 5- To obtain criticism of all prepared items by a colleague or friend.
- 6- To State the items in the language that respondent's use in every day conversation.

Two types of questions were used in the questionnaire. Closed- end questions, with multiple choices or yes and no style of answer, and dichotomous questions in step- wise style, each answer leading to a specific set of follow up questions with no open, ended questions except where it is inevitable. These types of questions were used in the questionnaire in order to:

- 1- Make the least demand upon respondents.
- 2- Permit quick, efficient collection of data.
- 3- Permit easy, quick and accurate analysis of answers.

- 4- The combination of question and associated response categories sometimes help respondents to understand the questions more clearly.
- 5- They are more useful in obtaining answers to sensitive questions.
- 6- The difficulty of constructing questions at the proper level of generality.
- 7- Responses are difficult to analyze and summarize.
- 8- They may impose considerable burdens on respondents and interviewees.
- 9- They are more likely to produce irrelevant and worthless data.

#### **4.4. Organization of data**

The conceptualization step was followed by the organization of the questions. The following guidelines were considered:

- 1- To begin with simple and easy to answer questions.
- 2- To place sensitive or more complex questions late in the questionnaire.
- 3- Where it makes sense, to place the items in logical order.
- 4- To try to create an interesting mix of items within the questionnaire.

An introduction was set to the questionnaire at the top of the first page or face sheet of the questionnaire, the introduction was written in short, simple sentences in the local language used by the respondents and in words they understand. The introduction was composed of the following elements:

- 1- Identification of the person conducting the research.
- 2- Explanation of the purpose of the study and why it is important.
- 3- Assurance that answers would be protected and not made known to anyone else to assure confidentiality.

#### **4.5. Pre- testing**

The formulation of the questionnaire was followed by a pre- test step to discover and correct any flaws in it. The purpose of the pre- test is to make

sure that the questionnaire would deliver reliable and valid data for answering the problem under investigation.

#### **4.6. Other helping data and records**

Land use change analysis of Khartoum state area using aerial photographs from a landsat + ETM image for the period between 1972 and 2001 to study landscape level change over the past 30 years, and draw a comparison between the past and present conditions and status.

#### **4.7. Statistical analysis**

The statistical analysis was carried out through exploratory manipulation of the data obtained in the study area. This process was accomplished by critically examining the data through the use of simple techniques of analysis. The main tools are the construction of simple tables and selected cross tabulation which allows tentative answers to many of the questions being asked in the survey.

## **CHAPTER V**

### **RESULTS AND DISCUSSIONS**

#### **5.1. General introduction**

To determine the impact of land use changes on forest cover and population livelihoods along the waterfront in Khartoum state several visits have been conducted to the study area and information and observations were recorded for various activities. It was found that there are various activities and changes in past land use as compared to the current land uses and activities. The past mode of land use prevailed on both sides of the Blue Nile in the form of farms and Kilns. In addition to buildings, few trees and forests. As for the White Nile there is a clear change in the use of land on the West Bank and investment building of the tourism city currently exists on the east bank to indicate a clear change in land use. The Sunt forest has been affected by the White Nile Bridge and the expansion of the city. As for the Nile farms and Kilns together with a number of planned and unplanned buildings are prevailing. The three transects on the three Niles are currently dominated by modern buildings, kilns, farms, forests and scattered trees.

#### **5.2. Different activities surrounding study area**

##### **5.2.1. Farms**

The area planted each year varies from one farm to another, as well as from one crop type to another. Vegetable, fruits and fodder are the main crops that are planted in the study area. The marketing Centre for these crops in Khartoum State. Bee farms produce honey which is exported to foreign countries. Type of land ownership varies between individual, group or

government. Some land users are just lesse. (Plate 5.2.1) Showed one types of farms in the study area.



Plate (5.2.1)

### 5.2.2. Kilns brick industry

Kilns are widely spread along the waterfronts of Khartoum state especially on the banks of the Blue Nile. Kiln administration is run by the owner, lesse or partner. Ownership is either individual or partnership and the area ranges from 1 to 24 Feddans. The product is marketed at local and central markets of the State. The energy used is wood from *A. nilotica*, *A. seyal*, *A. mellifera*, *A. ehrenbergiana* and *Azadirachta indica*. (Plate 5.2.2 and 5.2.3) Show types of the Kilns.



Plate (5.2.2)



**Plate (5.2.3)**

### **5.2.3. Residential buildings**

Buildings are mainly the product of housing scheme which is run by the housing plan and these buildings are rendered by essential services such as water and electricity. However, there are unplanned houses scattered along the River banks. Heglig Company and modern enterprise projects which spread on an area of 1.600 m in length and 280 m breadth on the bank of the White Nile. Although Heglig is the main contractor, there are other Companies which are associated with these investment activities. These include: Lail Company, Fagiry Company, Monaya Company, Elaf Company, Hamdy akhwan Company and Kaf Company.

Some plantations, nurseries and recreational areas such as the famous zoological Garden have been removed or affected the building and road construction investments. These have definitely resulted in land use changes which have various effects on the environment and human livelihood. (Plate 5.2.4) and Plate 5.2.5) shows the different building in the Study area.



**Plate (5.2.4)**



**Plate (5.2.5)**

#### **5.2.4. Forests around the Nile and their impact on land use changes**

The Sunt forest is located on the eastern bank of the White Nile .the site lies within latitude  $15^{\circ} 34' N- 15^{\circ} 35' N$ , and longitude  $32^{\circ} 3'0 E -32^{\circ} 29' E$ . The forest is unique meso-habitat in the semi desert region of North Central Sudan. Unpublished report by FNC states that generally the Sunt forest is characterized by sparse natural regeneration with extensive tree less areas with shrubby and seasonal flora. The first plantation in the area of the current sunut Reserve Forest in Khartoum state was carried out in 1921.

It was gazetted eleven years after its establishment on 15 July 1932. The total area of the Sunut reserve forest is about 482 feddans. *Acacia nilotica* was selected because of its outstanding ability to tolerate flooding and water logging for long periods of time, without serious effect on growth. The forest is dominated by *A. nilotica* and limited fauna. The main objective for its establishment was to produce fuelwood for local bakeries and railway sleepers. Some interventions affected this forest and reduced its area, and these include urban planning in the form of roads, bridges and tunnels which have threaten and reduced the original reserved area. The waste dumping represents a major environmental problem in the forest. Disposal of solid waste on land causes soil pollution. Polythene bags is one of the major environmental hazards in the forest .the nasty smells that results from waste dumpings are another source of discomfort for the people. These factors affected Sunut reserve forest. Part of the Sunut area has been occupied by investment building under the name Sunt City. These activities have a negative effect on forest cover and people's life. (Plate 5.2.5) shows the site of Sunut forest.



**Plate (5.2.5)**

### 5.3. Data collected from social survey

#### 5.3.1. The General Characteristic of Respondents

The General Characteristic of Respondents are of great importance for showing the salient features of the social aspects of the study area and use the information in the analysis and assessment. These characteristics include education level, occupation, sex, source of income and the current status of the land cover and their direct or indirect influence on land use, population livelihoods and the overall environment.

#### 5.4. The distribution of respondents according to gender and educational level

The education level is an important indicator for community development. Harrison ,1987 showed that a proper forestry activity for rural development requires the existence of literate people with enough experience and knowledge. In addition, literate people are ready to accept changes in perception, attitude and adoption of new innovations related to development of their communities, if these changes were built on scientific basis. Moreover, age groups have similar importance. In this research, four age groups were encountered and they represent youth (less than 25 years) mature about (25-34years) middle age about (35-44 years) and old respondents (more than 45 years). Table (5.1) shows the distribution of the respondents in the study area with respect to gender and the education level.

**Table (5.1): Gender and education level**

Age group	N	Gender %		Educational level %		
		Male	Female	Illiterate or Khalwa	Primary or Secondary	University
<25	5.0	4.0	1.0	20.0	60.0	20.0
25-34	15	11	4.0	13.4	60.0	26.7
35-44	14	13	1.0	21.4	64.3	14.3
>45	10	10	0.0	40.0	60.0	0.00
Total	44	86.4	13.6	22.7	61.4	15.9

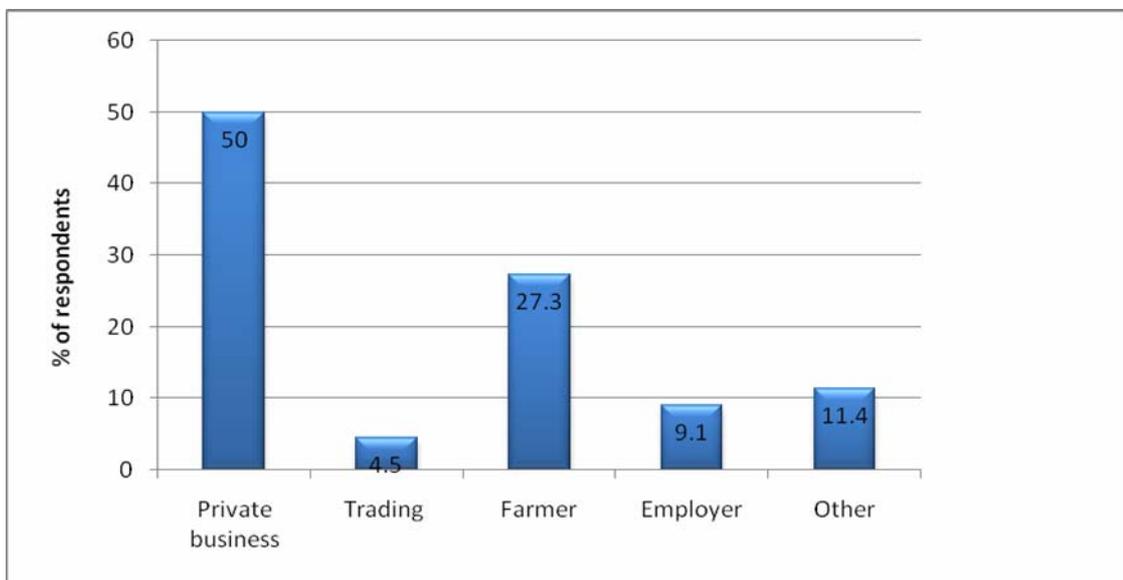
Investigation on the educational level of the target group revealed that 77.3% of the respondents are literate and 22.7% are illiterate. Illiterate are incapable of following written instruction, even when using symbols and drawings it will be of little value because illiterates are incapable or have enough potentiality to interpret drawings exactly as it is designed for (FAO,1986). Education is relatively high (36.4%). The percentage of respondents who continued formal education to high secondary level is ranked second after the primary education as asserted by 25% of the respondents. 11.4% of the respondents are of Khalwa level, illiterate is the same as the Khalwa and 15.9% received university level education.

Generally, there is a significant variation in perception between the literates and illiterates. The situation is favorable for extension program, training courses and formulation of sound legislation and policies since the literates are able to read and write and follow instructions. This situation facilitates the use of different extension methods (audiovisual, posters and other methods).

As far as gender issue is concerned, the majority of the respondents are males (86.4%) and the rest are females (13.6%). The justification of this distribution is attributed to the time during which the course of data collection took place. The team of data collection managed to collect the data in the afternoon to guarantee the availability of the head of household in farms, Kilns industries, investment buildings and other activities of land use along the waterfronts. Moreover, in Khartoum state women do not usually practice hard work in comparison to females of the rural areas.

### 5.5. The distribution of respondents according to Source of income

Source of income reflects the general well being, resilience and stability of local communities. In the rural areas of Sudan, agriculture and animal rearing are the main source of income generation. Throughout the study area sources of income are confined to two main activities, namely; private business and Farming. Fig (5.1) shows that 50% of the respondents rely on private business, 27.3% of them are farmers. In the study area there are some other minor activities that are supplementary to the above mentioned sources of income generation and these includes trading, government posts which are represented by 9.1% of the respondents. These findings reflect the preference of private business over government posts together with the fact that the overall level of education is relatively low and the posts are scarce.



**Fig (5.1): Source of income of interviewed sample**

Although agriculture in the study area irrigated agriculture from the Niles, still agriculture is the main land use pattern around the main Nile in Khartoum State and few other land use patterns like brick -making and buildings are encountered. Agriculture and kilns are the main land use patterns prevailing in the Blue Nile. These changes in land use affected livelihood and the environment particularly on forest cover of the study area. Kilns have expanded in number around the millions of people who depend on kilns as the main source of income. In the White Nile, the main land use patterns are the modern investments on the two Banks of the White Nile. These included financial city on the west bank and Sunt city in the east side of the White Nile. These reflect changes in land use from Farms to buildings. The conversion of vegetated areas into buildings has negatively affected the environment and led to a decrease in the forest area. The construction of the White Nile Bridge has also taken some land from the vegetated areas.

#### **5.6. Current status of the forests**

Respondents described the current status of the forests and mentioned the factors for the changes in land use. The status of the forest was described as either deteriorated, or constant or improving. 86.4% of the respondents asserted that the current status of the forest is degraded, while 13.6% that the status is constant or improving Table (5.2). It is evident that people over 45 years of age have unanimously stated that the status has deteriorated. However, the majority younger generations are of the same opinion.

**Table (5.2): Current status of the forests**

Age group	N	Forest current status %		Causes of degraded %		Causes of Constant or increasing %
		Degraded	Constant or improving	Human factors	Natural factors	awareness and legislation
<25	5.0	60.0	40.0	60.0	20.0	20.0
25-34	15	93.3	6.7	73.3	21.4	6.7
35-44	14	78.6	21.4	100	21.4	14.3
>45	10	100	0.00	100	50.0	0.00
Total	44	86.3	13.6	86.3	27.9	9.1

From the above table it is clear that the majority of the respondents (86.3%) believe that the forest has deteriorated. The reasons behind degradation are human interference, these included human reliance on forest, over grazing, illegal felling and/or other natural factors. Ghenaim (1970), Khaleel (2000), reported that the natural and human factors have great negative effects on the types of land use in Albotana area. Only 13.6% of the respondents described the status as constant or improving and they attributed this to the effect of awareness and legislation, 9.1% of the respondents reported that the environmental awareness, legislation, and management are behind the current forest status.

### **5.7. Dominant trees in the past and present**

*Acacia seyal* Var. *seyal* was reported to be the dominant species followed by *Ziziphus Spina chricti* and some other minor species with 23%, 18.2%, respectively. The dominant tree species currently included *Acacia nilotica*, *Azadirachta indica*, *Tamarix afilla* and some others with 30%, 39%, and 30%, respectively. Some of the current tree species in the study area showed an increase in density as reported for Neem which increased from 30 % in past to 39 % at present and other trees have decreased such as Sunt

which decreased from 46% in the past to 30% at present. This degradation was reported to be attributed to different human activities and natural causes. Changes in densities were related to reasons including illegal felling, climate change and palatability of some trees for specific kinds of animals (Table 5.3)

**Table (5.3): Dominant trees in the past and present**

Age group	N	Dominant trees in the past %		Dominant trees at present %			Reasons of dominance change %		
		Talih	Sidir	Sunt	Neem	Tarfa	Illegal felling	Grazing	Climate change
<25	5.0	20.0	0.00	40.0	20.0	20.0	40.0	20.0	80.0
25-34	15	20.0	13.3	14.3	46.7	26.7	60.0	6.7	40.0
35-44	14	35.7	28.6	50.0	28.6	35.7	92.0	0.00	50.0
>45	10	10.0	20.0	20.0	50.0	30.0	70.0	0.00	60.0
Total	44	23	18.2	30.0	39	30	70.5	4.5	52.3

From the above table, 71% of the respondents attributed change in dominance to illegal felling followed by climate change (52%), while only 4.5% of the respondents reported grazing as the reason for the change.

### **5.8. The role of FNC in forest management and conservation in the study area**

Table (5.4) shows that the respondents believe that the FNC plays a minor role in the conservation of forest and natural resources. The respondents believe that the role of FNC is represented in extension, forests protection, management (this process includes plantation forests, silvicultural treatments and paying wages for workers) and demarcation with 21%, 32% 14% and 9%, respectively.

**Table (5.4): The role of FNC in forest management and conservation in the Study area**

Age group	N	Role of FNC %			
		Extension	Protection	Management	Clear demarcation
>25	5.0	20.0	40.0	20.0	20.0
25-34	15	20.0	46.7	26.7	6.7
35-44	14	35.7	35.7	7.1	0.00
<44	10	0.00	0.00	0.00	10.0
Total	44	20.5	31.8	13.6	6.8

The justification of the minor role of FNC was reported to be due the fact that FNC has limited financial resources which is not enough to meet the needs of forests from establishment up to arrival to trees maturity. Also the Government is not giving financial support to FNC and hereby, the forests in the study area are degraded. Moreover, the FNC is under staff and the number of guards is always below the require number for proper protection

### **5.9. Relationship between FNC and local people**

Table (5.5) shows the relationship between local people and FNC in afforestation. The participation process required high coordination between institutions and the local people. In the field there are different factors that determine the relationship between the public and FNC. Table (5.5) shows aspects levies include pay dividends, nominal fees. 70% of the age group of more than 45 years asserted that there is direct relation with FNC and local people through levies. This table also shows that 4.5% of the respondents participated in afforestation programs financed by NGOs, The justification for the minor role of FNC and NGOs is due to the fact they have poor financial support for afforestation. 11.4% of the respondents mentioned

seedlings planting, 4.6% of them mentioned availability of workers and financial support (2.3%) as major limiting factors.

**Table (5.5): Relationship between FNC and local people**

Age group	N	The relation	Role of FNC %			
		levies	Through NGOs	Seedlings Planting	Availability workers	Financial support
>25	5.0	60.00	0.00	20.0	0.00	0.00
25-34	15	70.00	6.7	6.7	6.7	0.00
35-44	14	85.7	14.3	21.4%	0.00	7.1%
<45	10	70.00	0.00	10.0	0.00	0.00
Total	44	68.2	4.5	11.4	2.3	2.3

### 5.10. Types of forest in the study area

Table (5.6) shows that the two types of forest in the study area, where 61.4% of the respondent asserted that natural forest is the dominant type and 22.7% stated plantation forest is the main type, While 79.5% of the respondents mentioned clear demarcation of forest in the study area. The demarcations are very important for specific land use types for the purpose of conserving the environment and natural resources in any area.

**Table (5.6): Types of forest in the study area**

Age group	N	Types of forest %		Demarcation %	Types of demarcation		
		Natural	Plantation	Exists	Terrace	Street	Other
<25	5.0	60.0	20.0	80.0	20.0	20.0	20.0
25-34	15	60.0	13.3	73.3	20.0	33.3	40.1
35-44	14	57.1	35.7	78.6	14.3	14.3	43.9
>45	10	70.0	20.0	90.0	40.0	40.0	70.0
Total	44	61.4	22.7	79.5	29.5	27.3	34.3

From the above table a high percentage (90%) of the age group of more than 45 years mentioned that demarcation of land use exists. Moreover, 80% of the respondents of the youngest age group mentioned that the land use demarcation is clear around the main Nile, White and Blue Niles for different land use. Also the above table shows the types of land use demarcation; included terrace, streets and others which included; Farmyard, Rope, Poles and Barbed wire.

### 5.11. Types of agriculture in the study area

Allocation of land holding for farmers in the rural areas is principally administered by traditional leaders who manage to distribute lands in a way that keep justice and equalities among the members of the community. Accordingly, the size of land holding differs from one member to another according to the criteria set by the traditional leaders. Table (5.7) shows that an average of 22.7% of the respondents possess agriculture lands with an area between 0.24 - 6 Feddans, 18.2% in the range of 7- 14 Feddan, and 11.4 % of the respondents asserted land ownership can be more than 14 Feddan

**Table (5.7): Types of agriculture in the study area**

Age group	N	Agriculture area (feddan)%			Types agriculture%		Applications fertilizers and pesticides %
		0.24 -6.00	7- 14	>14.00	Rainfed	Irrigated	
<25	5.0	40.0	0.00	20.0	20.0	80.0	80.0
25- 34	15	13.3	13.3	0.00	0.00	100	93.3
35-44	14	21.4	14.3	14.3	7.1	92.9	78.6
>45	10	30.0	40.0	20.0	0.00	100	100
Total	44	22.7	18.2	11.4	4.5	94	88.6

From the above table two types of agriculture exist in the study area and a high percentage of the respondents (94%) mentioned that irrigated farms are

dominant. The other type is rainfed farms. Table (5.7) also shows that all respondents from age group more than 45 and average 88.6 percentages of the whole respondents mentioned that they applied fertilizers and pesticides to their crops.

### **5.12. Trends of land use in the study area**

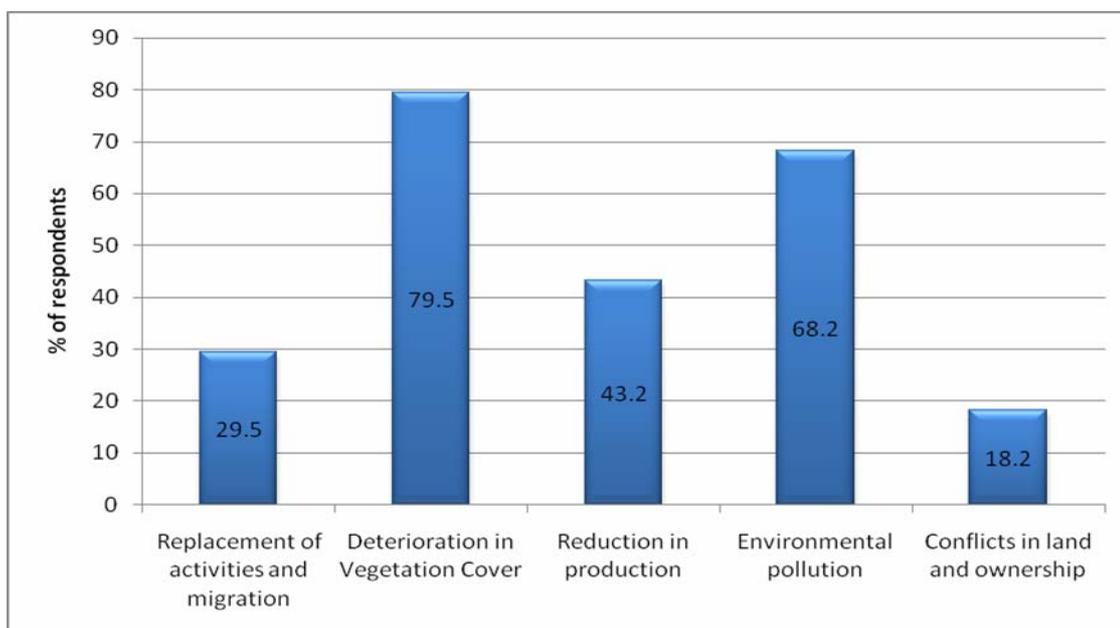
Table (5.8) shows the different types of new land use trends in the study area. The dominant types of land use change included agricultural expansion and buildings expansion. Respondents mentioned different reasons responsible for the change in land use and the effect of the change on forest cover and people life in the study area. The natural condition, the government, local people and industrial expansion were the main factors behind the new land use trends. 72.7 percentage of the respondents believed that the land use change is due to the fact that the government is assigning the land for investment buildings. This change is affecting vegetation cover and population livelihoods, especially after the increase in population. 45.5% of the respondents asserted that these changes are attributed to the fact that people practice illegal felling and convert forest lands to other uses, while 29.5 percentages of respondents mentioned that the change is due to natural condition and 18% of the respondents attributed it to industrial expansion in the study area.

**Table (5.8): Trends of land use in the study area**

Age group	N	New land use trends %		Factors behind new trends %			
		Agriculture expansion	Buildings expansion	Industrial expansion	Local people	Government activities	Natural factors
<25	5.0	40.0	60.0	40.0	40.0	80.0	40.0
25-34	15	40.0	80.0	20.0	53.3	60.0	26.7
35-44	14	35.7	92.9	7.1	57.1	64.3	35.7
>45	10	70.0	80.0	20.0	20.0	100	20.0
Total	44	45.5	81.8	18.2	45.5	72.7	29.5

### **5.13. Consequences of land use changes in the study area**

The land use changes are affecting people life, vegetation, and forest cover, and causing land degradation. The Fig (5.2) shows that 29.5% of the respondents mentioned that the land use changes led to replacement of activities and migration of local people to other area, 79.5% of the respondents asserted that it has led to deterioration in vegetation cover as a consequence to illegal felling and conversion of forest land to other uses. 43.2% of the respondents believe that this change has resulted in reduction in production, while 68.2% of the respondents mentioned environmental pollution by the bricks kilns, the relative industrial expansion and few of the respondents believe that the change in land use practice is behind the conflicts.



**Figure (5.2): Consequences of land use changes in the study area**

#### 5.14. The Government role in land use

Table (5.9) shows the clear passive and active role of government in the changes in land use. It shows that the 54.5% of the respondents asserted that the government has a passive role in changes in land use, while 13.6% mentioned that it has an active role in the changes.

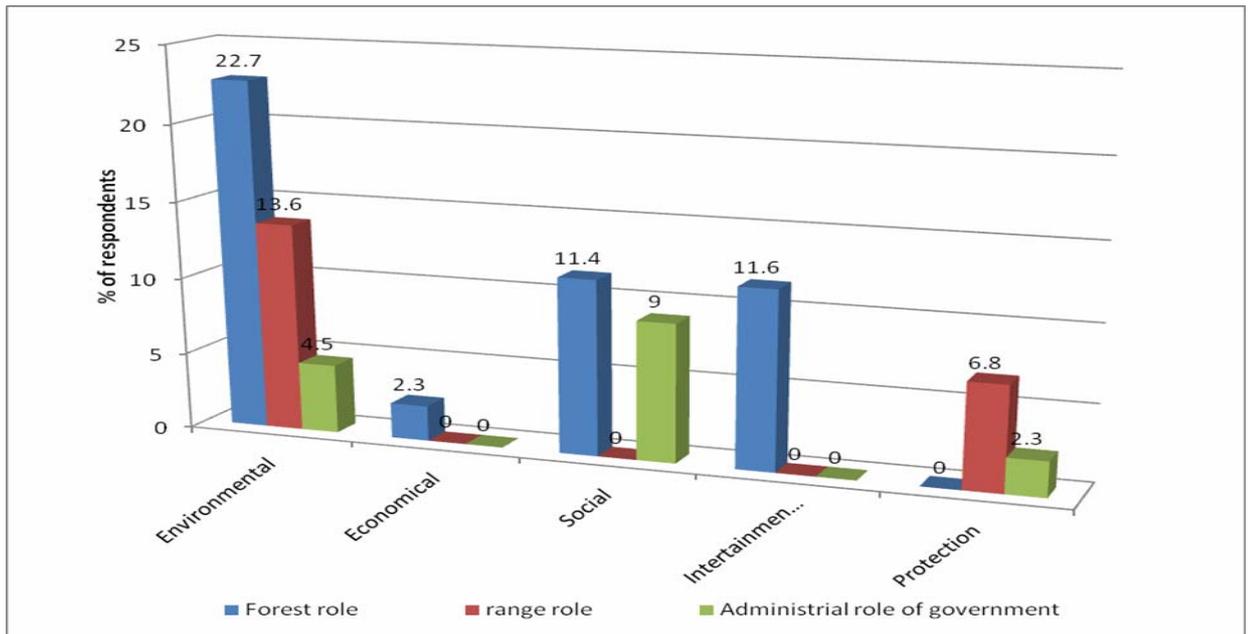
**Table (5.9): The Government role towards land use**

Age group	N	Role of government %		Passive role %			
		passive	active	Services	Provision of land for living	awareness and extension	Aspiration
<25	5	60.0	0.00	0.00	0.00	0.00	0.00
25-34	15	53.3	13.3	13.3	6.7	0.00	26.7
35-44	14	50.0	14.3	7.1	14.3	7.1	28.6
>45	10	60.0	20.0	20.0	10.0	0.00	20.0
Total	44	54.5	13.6	11.4	9.1	2.3	22.7

From above table the respondents mentioned that the positive role of government includes necessary services, provision of housing for citizen, raising awareness and provision of extension.

### **5.15. Perception towards environment conservation**

Figure (5.3) shows emphasize the role of FNC or foresters should focus on the environmental, social, economical and entertainment aspects with 22.7%, 11.4%, 2.3% and 11.6%, respectively. This role includes forests conservation, desertification control, availability of nurseries to provide seedlings for planting by citizens as gardens and parks. Economic role includes increase in plantation area and the social role includes extension and awareness campaigns. Entertainment role includes plantation of trees nearby streets and within cities and provision of access to forests for tourism. Also protection of the environment from the dust and any other polluters of the environment. Also this figure shows the administration role which includes environment role (13.6%) and protection role (6.8%) according to respondents. These roles include rangeland administration which focuses on conservation and protection of the rangeland and allocation of grazing areas to animals. The respondents mentioned that administration role of government which includes environment, social and protection roles with 4.5%, 9% and 2.3%, respectively and these roles includes forest extension, monitoring and evaluation the forest management, putting laws and legislation to protect forests, grazing and provision of funds for environmental conservation.



**Figure (5.3): Perception toward environment conservation**

### 5.16. The types and burning kilns

The brick-making is one of the factors contributing to environmental pollution through emission of smoke and also one of the causes of land use changes. Table (5.10) shows that 72% of the respondents confirmed the spread of kilns around the Niles in the study area has converted that part of the city to a rural area. The local people collect their fuel wood from natural trees available in vicinity and local markets. Reliance on forests as a source of fuel wood is significant, particularly in kilns area where it is used for burning mud bricks. 95.9% of the respondents stated that they rely on forests (reserved and unreserved) for the provision of fuel wood for burning bricks and only few of the respondents rely on Gas in kilns. This reflects the high pressure exerted on the forest cover in the study area. Forests are subjected to illegal encroachment by the local inhabitants. This is very serious in the study area which falls in the marginal land which is fragile and susceptible to further deterioration if not properly managed.

**Table (5.10): The types and burning kilns**

Age group	N	Bricks Kilns	Types of burning		Funding of gas %	
			Gas	Wood	Organizations	Companies
>25	5.0	60.0	20.0	80.0	20.0	0.00
25-34	15	60.0	0.00	100	0.00	6.7
35-44	14	85.0	7.1	92.9	0.00	7.1
<45	10	80.0	0.00	100	0.00	0.00
Total	44	72.0	4.5	95.5	2.3	4.5

**5.17. Negative impact of human settlement**

Respondents were able to identify different negative aspects of population activities responsible for the change of land use in the study area. For the respondents who believe that the changes of land use have increased or remained stable attributed their perception to awareness of the local people about the ideal land use practices. Findings of table (5.11) attributes the changes in land use to urbanization according to 70.5% of the respondents and some respondents have mentioned that the changes in land use were due to other reasons.

**Table (5.11): Negative impact of human settlement**

Age group	N	Urbanization	Types of urbanization %			Change accepted %
			Investment buildings	Housing plans	Illegal buildings	
>25	5.0	100	40.0	100	20.0	0.00
25-34	15	60.0	26.7	40.0	13.3	26.7
35-44	14	71.4	35.7	64.3	14.3	28.6
<45	10	70.0	40.0	80.0	10.0	20.0
Total	44	70.5	34.1	63.6	13.6	22.7

The above table shows the different types of urbanization, where 80% of the respondents from age group more than 45 mentioned that housing plans

are the reason and 34.1% of the respondents mentioned that investment building is the cause, while 13.6% of them asserted that the illegal buildings are behind change of land use and deterioration of vegetation cover. Only 22.7% of the respondents asserted the changes were accepted for local population

### 5.18. Land use and tourism

Table (5.12) shows that 72.7% of the respondents believes that tourism is unsuitable alternative of land use because it decreases the area besides it is not necessary and that agriculture is the main source of income for a lot of people in the study area. 27.3% of the respondents believe that converting land use to tourism is suitable for some reasons including increase of income for land owners and added aesthetical value rendered by tourism and entertainment. This reflects that tourism and recreation are not deeply routed in the culture of the people in the study area.

**Table (5.12): Land use and tourism**

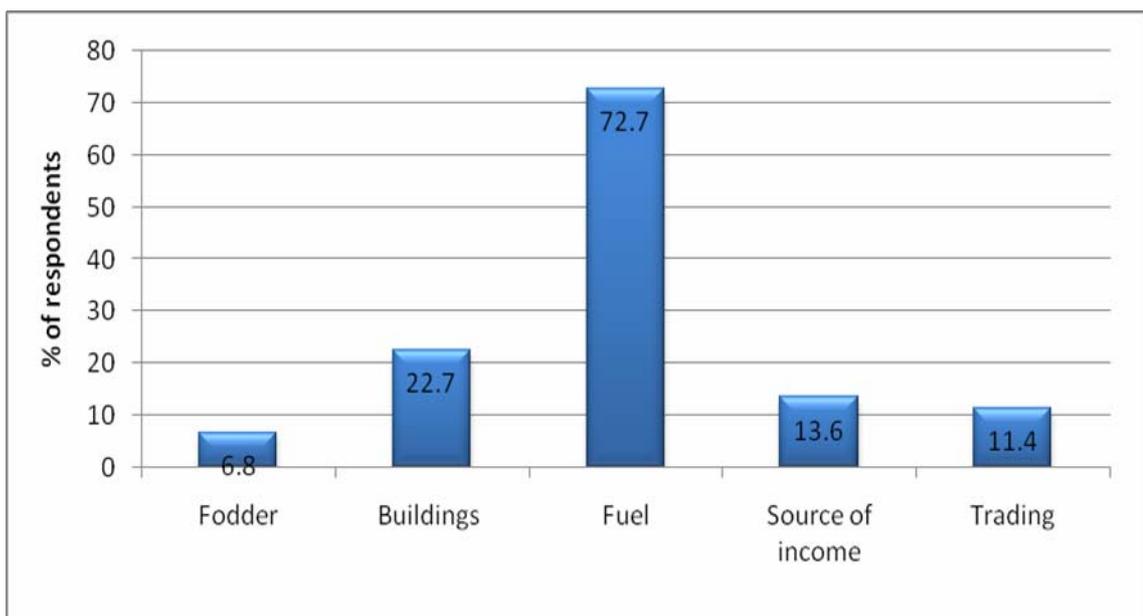
Age group	N	Consideration of tourism%		Reasons for suitable		Reason for unsuitable	
		Suitable	Unsuitable	Increased income	Aesthetical value	Decrease income	Contradict with farms
>25	5.0	60.0	40.0	40.0	20.0	0.00	0.00
25-34	15	33.3	66.7	26.7	13.3	20.0	33.3
35-44	14	7.1	92.9	7.1	0.00	21.4	50.0
<45	10	30.0	70.0	40.0	0.00	10.0	30.0
Total	44	27.3	72.7	25	6.8	15.9	34.1

This is clear from above table that the 34.1% of the respondents mentioned the change is unsuitable because it is in contradiction with farms and 15.9%

of the respondents asserted that no need to tourism because it will decrease income for workers.

### 5.19. The purposes of trees cutting

72.7% of the respondents asserted that provision of fuel wood is behind the tree cutting, while 22.7% of the respondents mentioned that buildings rely on forests products. 13.6% mentioned that they rely on it as a source of income, 6.8 % of them use the trees as fodder for their animals and 11.4% rely on forests for their trading. The attitudes reflect that land degradation and deterioration in forest cover are closely associated and they are the results of negative human interference (Fig.5.4)

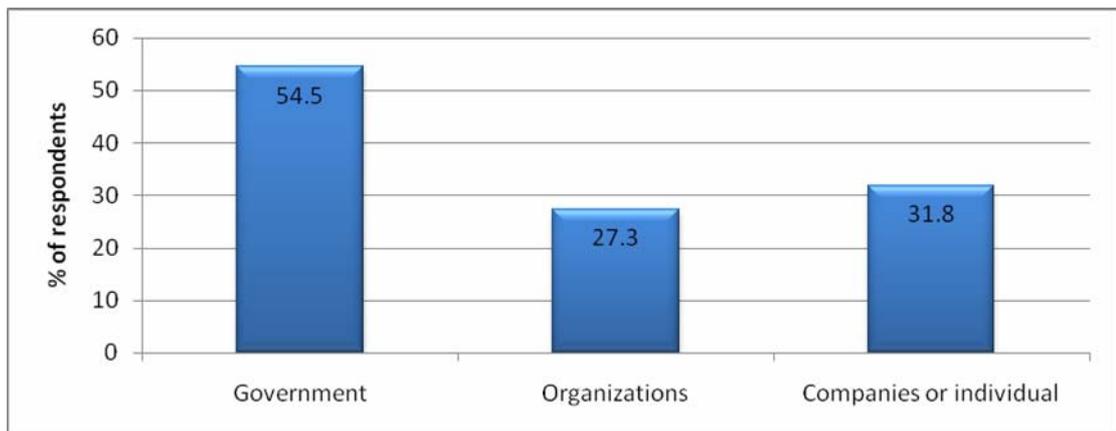


**Figure (5.4): The purposes of trees cutting**

### 5.20. The investor of land use in the study area

Figure (5.5) shows the types of investors in the study area. 54.5% of the respondents asserted that government is behind the change in land use due

to investments and modern buildings, 27.3% asserted local and foreign organizations are investors in land use for investment buildings and 31.8% mentioned that companies and individual investors were the main investors in the study area.



**Figure (5.5): The investors of land use in the study area**

### **5.21. Expansion of buildings**

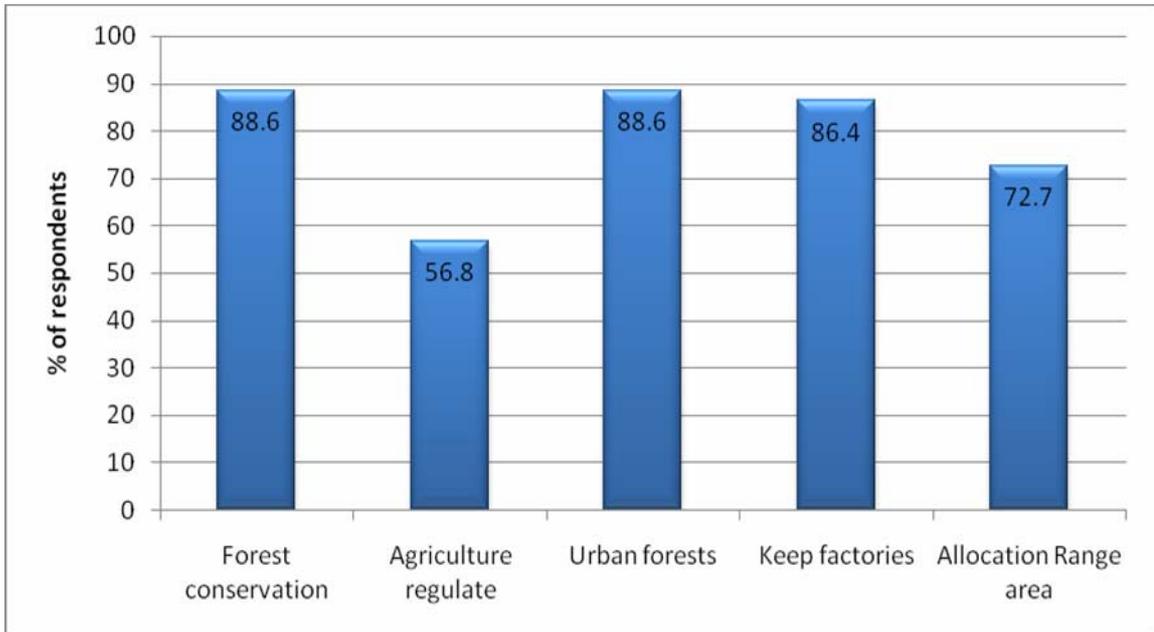
Table (5.13) shows that some of the respondents are accepting the conversion of lands to buildings and other respondents are opposing. 22% of the respondents mentioned that settlement is behind the change, 18.2% of the respondent believed that the change to buildings is suitable for population more than any other uses but buildings construction must be far from farms. The reasons for opposing the policy of building is reported by 25% of the respondents because most of the people lose source of income if land is converted to buildings, 15.9% of the respondents asserted that building construction causes deterioration in vegetation and forest cover and 11.4% of the respondents believe that it leads to decrease in income and reduction of products.

**Table (5.13): Expansion of buildings**

Age group	N	Expansion buildings	Conversion of lands to buildings %			Reasons for opposing buildings expansion %		
			Settlement	Building	Buildings far from farms	A decrease in income and product	Workers lose source income	Causes deterioration in vegetation and forest
<25	5.0	60.0	0.00	40.0	20.0	0.00	20.0	0.00
25-34	15	26.7	46.7	13.3	6.7	13.3	26.7	20.0
35-44	14	35.7	7.1	7.1	7.1	14.3	35.7	28.6
>45	10	60	20.0	30.0	10.0	10.0	10.0	0.00
total	44	40.9	22.0	18.2	9.1	11.4	25	15.9

**5.22. Perception of environmental conservation**

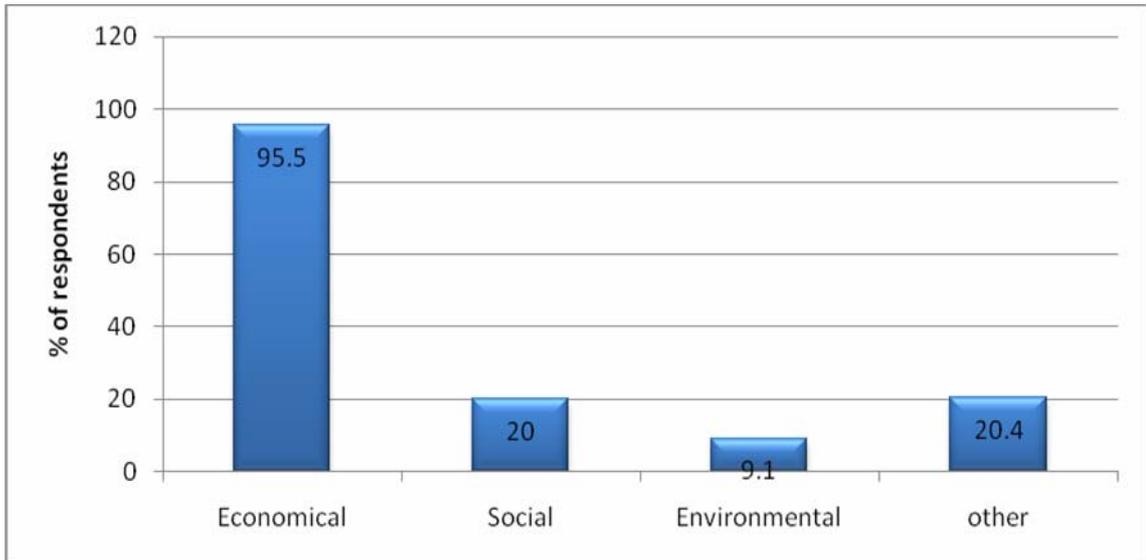
With respect to methods of environmental conservation the entire interviewed sample asserted that forest reservation is the best methods for environment conservation. 88.6% of the respondents believe in the importance of forests conservation, and 56.8% of the respondents mentioned that regulation of agriculture is one of the factors to environment conservation. 88.6% of advocate encouragement of afforestation process around towns and roads and 86.4% of the respondents mentioned the importance of keeping factories away from farms. 72.7% of the respondents mentioned the allocation of range area as a key factor for environmental conservation. Figure (5.6) shows the perception of respondents towards environmental conservation.



**Figure (5.6): perception of environmental conservation**

### **5.23. Constraints confronting land use planning**

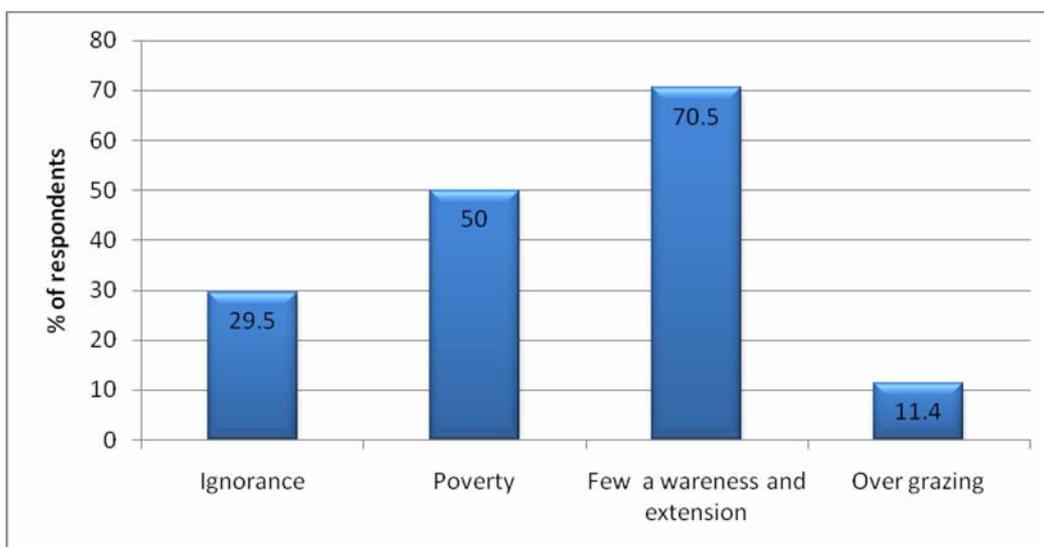
There exist some constraints confronting land use planning in the study area. These have an effect on forest area and deterioration of vegetation cover. All respondents from age group more than 45 believe that the economic aspects are the main factor confronting land use planning. 95.5% of the respondents asserted that economical constraints and financial support are necessary for planning of land use, 20% of the respondents mentioned that the constraints are socially and other constraints according to 20.4% of the respondents included administrative aspects, (3.6%) security, natural problems including water erosion, drought and desertification. Figure (5.7) shows constraints confronting land use planning.



**Figure (5.7): Constraints confronting land use planning**

#### **5.24. Factors affecting land use change**

Respondents were able to mention different factors responsible for the change of land use in the study area. For the respondents who believe that the changes in land use have increased attributed this change to low level of awareness and weak extension. Figure (5.8) shows 70.5% of the respondents asserted that low or lack of awareness and extension services are behind the land use changes, 50% of the respondents mentioned that poverty is behind the changes and 29.5% believed that change in land use reflect people’s ignorance and few of respondents stated that illegal felling and over grazing are behind the change in land use in the study area.



**Figure (5.8): Factors affecting land use change**

### 5.25. Types of rangelands

Table (5.14) shows that there are two places of grazing for animals, namely; farms and natural forest. The table also shows that 88.9 % of the respondents asserted that the best place for grazing is the farms because the grasses and fodder are available and only 6.8 % of respondents mentioned natural forest as a grazing area. The low percentage of the natural forest indicates that few forests have deteriorated as a result of human interference and natural factors.

**Table (5.14): Types of Rangelands**

Age group	N	Place of grazing %		Types of grazing %		
		Farms	Natural forests	Natural	Cultivated fodder	Grazing within Farm
<25	5.0	80.0	20.0	40.0	100	80.0
25-34	15	93.3	6.7	53.3	40.0	66.7
35-44	14	78.6	0.00	42.9	71.0	64.3
>45	10	100	10.0	30.0	60.0	40.0
Total	44	88.6	6.8	43.2	61.4	61.4

From the above table it is clear that the types of forage are divided into three types where 61.4% of the respondents mentioned cultivated fodder associated with grazing within farm with the same percentage above and 43.2% of the respondents asserted that natural grazing is one of the grazing types.

### 5.26. Energy substitutes in the study area

Table (5.15) shows that all of respondents from age groups (<25), (25-34), >45 years and 85% of the respondents from age group 35-44 years asserted existence of energy substitute, and the use of different types of stoves and the complete reliance on traditional cooking stoves. The table also shows the different types of cooking stoves used in the study area. The majority of the respondents use improved cooking stoves or butane gas as stated by 84.1, and 47.7%, respectively. This finding indicates that contrary to rural areas people around waterfronts are cognizant of the value of the improved stoves and they can afford purchasing them.

**Table (5.15): Energy substitutes**

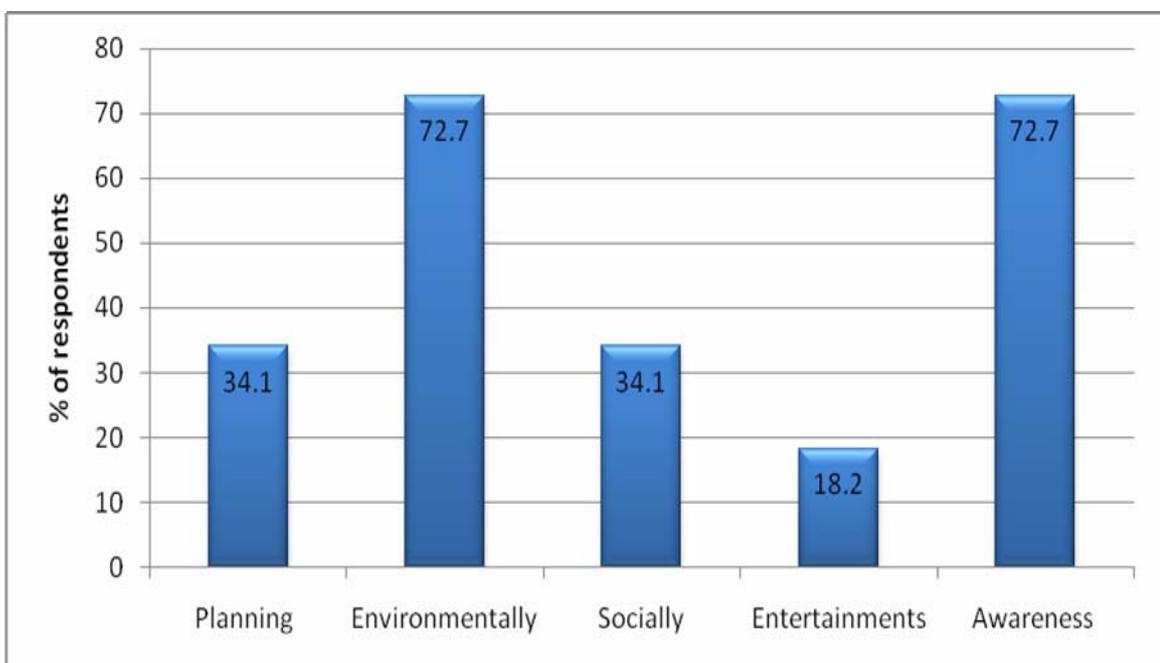
Age group	N	Energy substitute %	Types of alternative %		Extension unit %	Extension methods %		
			Improved stone stove	LPG		Individual	Groups	Posters
<25	5.0	100	100	80.0	80.0	20.0	40.0	0.00
25-34	15	100	53.3	80.0	20.0	13.3	0.00	6.7
35-44	14	85.0	28.6	85.0	28.0	28.6	0.00	0.00
>45	10	100	40.0	90.0	10.0	10.0	0.00	0.00
Total	44	95.5	47.7	84.1	27.3	18.2	4.5	2.3

It is clear from the above table that 27% of the respondents are aware of the existence of the extension unit in the study area and that the extension method includes individual, group and posters.

### **5.27. Suggestions to environmental conservation by adoption of land use systems**

The respondents mentioned some suggestions for environmental conservation. These included aspects related to environmental, ecological, planning, and social, entertainments and awareness. The specific suggestions included increasing green areas, conservation of the forests, encouragement of afforestation within farms such as adoption of certain types of agroforestry models and increasing the establishment of nurseries. Figure (5.9) also shows 38.6% of the respondents asserted that the planning aspects include designing ideal plans for different land use, keep industries and kilns far from settlement areas, regulate agricultural rotation, regulate grazing areas, design plans for expanding buildings, specific number of population in the state to reduce pressure on natural resources, keep buildings expansion far from plantation areas, ideal methods to using forest resource, ideal land use and regulate cut rotation. The same percentage of respondents reported the social and protection aspects through 34.1% for each of the suggestions which included intensive extension and awareness campaigns for local population in the study area, formulating law and legislation that regulate kilns activities because kilns are the main source of income for millions of population in the State and availability of all necessary services for population for environmental conservation. 72.7% of the respondents mentioned that awareness raising suggestion included conversion of kilns land and illegal buildings to farms and not to convert

forest and range lands to other uses, as well as launching intensive extension on all land use activities in the study area. Few percentage of respondents mentioned entertainment through the greening of towns and roads, and establishment of gardens and tourism area around the Niles. All these suggestions are advocated by the respondents as a contribution to environment conservation through a sound land use system. Fig (5.9)

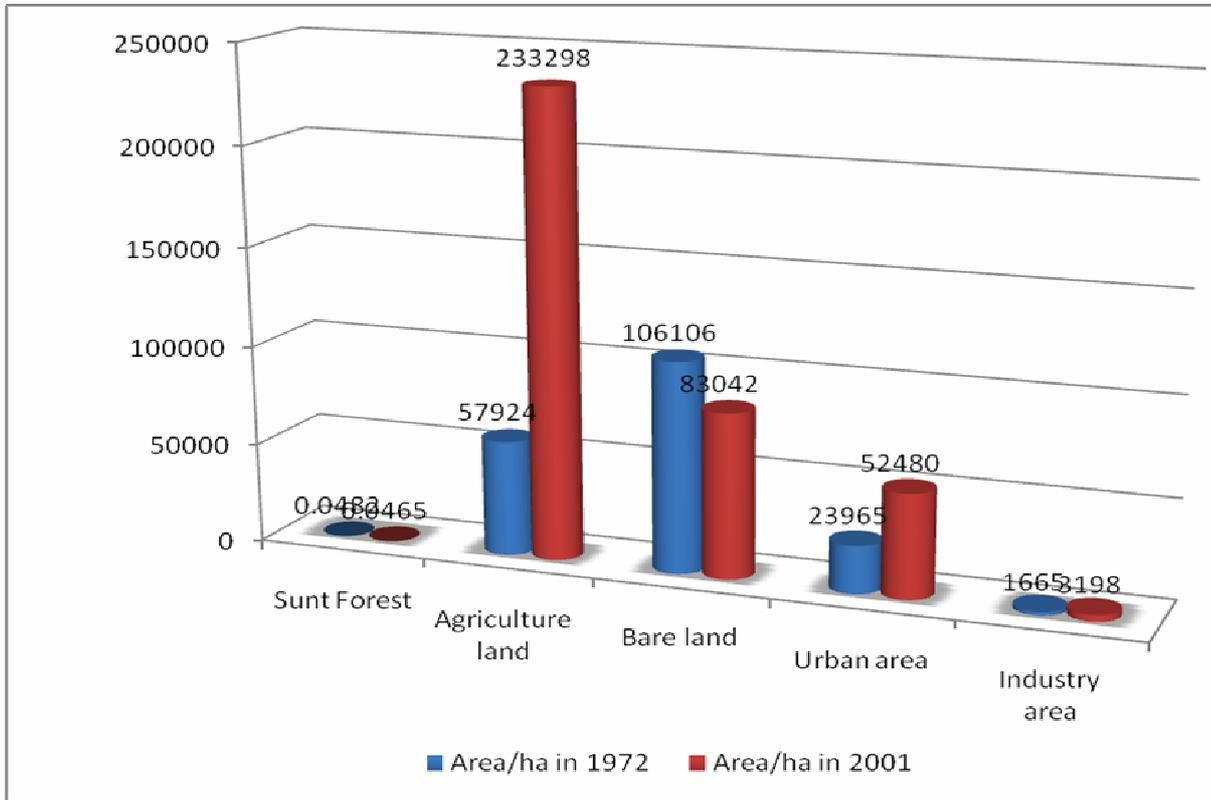


**Figure (5.9): The suggestions to environmental conservation adoption of land use system**

### **5.28. Change detection and assessment**

Land use/land cover of waterfronts has been detected from the statistical findings of the supervised classification of bi-temporal imagery (ETM 1972, TM 2001). By comparing the classification output of the two images, Fig (5.10) shows the forest and other land use categories change over the period 1972 to 2001. Taking the period (1972 to 2001) the forest cover

decreased between (1972 to 2001) this decrease start from Ingaz Bridge and extends to Tabia Street.



**Figure (5.10): Trends in Land Use/ Land Cover Classes 1972, and 2001**

It is clear that the forest cover has decreased from 482 Feddan in 1972 to 465 Feddan in 2001. Agriculture land increased from 57924 ha in 1972 to 233298 ha. This increase indicate the conversion of land from other use to expansion of agriculture as a result of increasing population and the need to satisfy needs from the agriculture. Bare land decreased from 106106 ha in 1972 to 83042 ha in 2001 and the last pattern of land use named industrial area increased from 1665 ha in 1972 to 3198 in 2001. Accordingly, the

trend of land use in the study area is agriculture and expansion buildings and few of other various land use.

The results indicate that there is a trend of increasing area of agricultural and expansion in buildings at the expense of forest and tree cover Fig (5.1).

### **5.29. Summary**

The aim of this study is to define the impact of land use changes on the environment and population livelihood along a section of the waterfronts in Khartoum State. The impact of changes on forest cover included disappearance of some tree species and shrubs, reduction forest area, environmental pollution, expansion of buildings and agriculture at expense of forest and rangelands. The impact of changes on population life included reduction of production, replacement and migration, reduced of income and some socio-economic problems. The methodology used in this study to model the impact of land use changes on vegetation cover and population were primary and secondary data, two maps of land use in the State were selected to represent the map in 1972 and 2001 to compare them and completed classified by ERDAS program to identify the land use change in the past and present. Majority of the respondents believe that the forest has deteriorated. The reasons behind degradation are human interference, these included human reliance on forest, over grazing, illegal felling and/or other natural factors. The respondents believe that the FNC plays a weak role in the conservation of forest and natural resources. The respondents believe that the role of FNC is presented in extension, protection forests, and management. The justification of a weak role of FNC is due to the fact that FNC has limited finance which is not enough to meet cost of establishment to plantation maturity. Also the government is not providing financial

support to FNC and this has resulted in forest deterioration. They are different aspects that determine the relationship between the public and FNC. The relationship aspects include levies pay dividends, nominal fees, and the employment of respondents in afforestation programs financed through NGOs. The justification of the minor role of FNC and NGOs is the fact that they have poor financial support to afforestation. Also result shows different types of new land use trends in the study area. These include increased expansion of some uses of land, especially agricultural expansion and buildings expansion. Respondents were able to mention different reasons responsible for the change in land use and the reasons affecting forest cover and people life in the study area. The natural condition, the government, local people and industrial uprise were main factors behind new land use trends. Government's policy toward settlement, house planning and investment buildings is the main cause for the land use changes. Other reasons of the changes include illegal felling, natural cause, and unplanned settlements. FNC or foresters were reported by respondents play a role in the environmental, economical, and social and entertainment aspects through forest conservation control of desertification and provision of seedlings for plantation by the public. The social role included extension and the entertainment role included tree plantation along streets, cities and allowing entering the forests for tourism and protection of the environment from the dust and any polluter. The ranges role included conservation and protection of the range land and allocation of grazing areas to animals. The research results showed existence of some constraints confronting land use planning in the study area. These have affected forest area and resulted in deterioration of vegetation and forest cover. All respondents believe that the economic aspects are the main factor confronting land use planning.

Economical constraints and financial support are necessary for planning in land use. Other constraints include administration, security, natural problems such water erosion, drought and desertification. Different suggestions to environmental conservation included environmental or ecological, planning, social, entertainments and awareness suggestions. These were presented to improve or create new green areas, conservation of forests and trees, encouragement of afforestation within farms such as types of agroforestry and increasing the nurseries. Further suggestions for improvement include formulation of ideal plan for different land use, keeping industries and kilns far from settlement area, regulation of agricultural rotation, regulation of grazing area, designing plans for expanding buildings. Moreover, expansion in buildings should be far from plantation areas, ideal methods for using forest resources, regulation of cut rotation, and intensive extension and awareness programmes for local population are necessary steps to be taken. Putting laws and legislations by government to regulate kilns is very important for environmental protection.

## **CHAPTER VI**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **6.1. Conclusion**

The study concluded that the use of land requires a clear plan to optimize the use process, according to the information collected from questionnaire it was found that various human activities are behind this change and these changes have led to the deterioration of forest cover and consequently resulted in the loss of source of income for the local population.

Some areas in the study area were converted into the buildings, Kilns and residential area at the expense of forests and pastures.

Results shows different types of new land use trends in the study area. These include increased expansion of some uses of land, especially agricultural and buildings expansion.

Existence different reasons responsible for the changes in land use and the reasons affecting vegetation cover and people life in the study area, The natural condition, the government, local people and industrial uprise were main factors behind new land use trends.

Land use / land cover change around the waterfronts has been detected from the statistical findings of the supervised classification of bi-temporal imagery (ETM 1972, TM 2001). Agriculture land has increased, as a result of converting land from other uses, bare land has decreased and industrial has expanded. The results indicate that there is a trend of increasing area of

agricultural and expansion buildings at the expense of forest and tree cover and rangelands

## **6.2. Recommendations**

The study suggested some valuable recommendations and fruitful comments which are expected to contribute to the design of appropriate and ideal land use patterns and in rehabilitate the forest cover with the objective of reducing desertification in Khartoum State.

Rapid changes in vegetation cover and land use with negative human impact activities such as urbanization and conversion of land from use to another should be addressed through taking serious measures which may include:

- \*Introduce tree planting in farms through appropriate agroforestry systems.
- \* Development, restoration and re-vegetation of degraded lands along the two banks (Blue and White Niles of Khartoum State) is highly recommended because these parts are subjected to severe agriculture activities.
- \*Put clear ideal plans, laws and legislations for land use and specify land use plans according to land suitability and capability separate for other land use.
- \*The improvements of the rangelands are an important measure for reversing the environmental degradation.
- \*Conduct more studies and research around the Niles an aspects related to appropriate crops,best land use, improved brick production, integrating animal rearing with crop production.
- \*The waterfronts of the three Niles are very outstanding recreational areas for local public and tourists. They should be properly developed to satisfy this types of uses.

## REFERENCES

- Adam, I.A. 1975.** Semi-detailed soil survey for East North Khartoum, report NO.54 soil survey administration.
- Adam, F.H. 1966** `contributions of land tenure structures to Agricultural Development in the Sudan through Incentive, knowledge and Capital, Department of rural Economy Resource Bulletin No.5, Khartoum, p.9.
- ADB** (African Development Bank) /EC (European Commission)/FAO.2003.Forestry outlook study for Africa (FOSA): Sub –regional report for North Africa .FAO, Rome.
- Anderson, et al. 1976.** A land Use and Land Cover Classification System for Use with Remote Sensing for Data. Geological Survey Professional Paper No. 964, U.S. Government Printing Office, Washington, D.C. p. 28.  
Available at [http://pubs.wri.org/pubs\\_description.cfm?PubID=3027](http://pubs.wri.org/pubs_description.cfm?PubID=3027).accessed may 2008.
- Badi, K H.A.Elhour** and **Bayoumi, A.A.1989.** The forest of Sudan-Khartoum.
- Burchinal, Lee. S. 1989.** Lecture notes and steps in conducting a survey. Presented at the 2<sup>nd</sup> annual forestry extension workshop on the methodologies and techniques in conductive forestry extension program in Sudan.
- Campbell, B.J. 1996.** Introduction to Remote Sensing, second edition. Teylor and Francis, London.
- Carney, D.1998.** Implementing the sustainable livelihoods approach. In: Carney, D (ed), Sustainable rural livelihoods: what contribution can we make? Paper presented at the Department for International Developments natural resource Adviser, conference, July, December for international Development (DFID), London. pp. 3-26
- Carswell G. 1997.** Agriculture intensification and rural sustainable livelihoods: A “think piece”. IDS working paper 64.
- Chambers R. 1995.** Poverty and livelihoods: Whose Reality Counts? University of Sussex, Institute of Development Studies. IDS, Brighton.
- Change, L and P A Burrough 1987.** Fuzzy reasoning: a new quantitative aid for land evaluation. Soil Survey and land evaluation 7:69 - 80

- CNS 1992 - 2002** Comprehensive National Strategy for the Sudan for the period 1992- 2002.
- Collins, R. 1990.** Hydropolitics and the Jonglei Canal, Clarendon press. Oxford 1990.
- Coppin, P. & Bauer, M. 1996.** Digital Change Detection in Forest Ecosystem with Remote Sensing Imagery. *Remote Sensing Reviews*. Vol. 13. p. 207-234.
- Cowbell, J. E. 1981.** Land sat features enhancement or can we separate vegetation from soil. Preceding, of 15 the international symposium on remote sensing, pp 599- 621.
- Dalal-Clyton, D B, D Dent and O Dubois 2003.** Rural Planning in Developing Countries with special focus on Supporting Natural Resource Management and Sustainability Livelihoods, London: Earthscan publications Ltd.
- DFID, 2001.** Department for International Development. Sustainable Livelihoods guidance sheets, Section 2 Department for International Development, London. [http://:www.Livelihoods.org/info/guidance\\_sheets\\_pdfs/section\\_2 .pdf](http://www.Livelihoods.org/info/guidance_sheets_pdfs/section_2.pdf)
- Dixon, R.K., Brown, S. & Houghton, R.A. 1994.** Carbon pools and fluxes of global forest ecosystems. *Science*, 263, 185–190.
- Dregne,H.I. 1983.**Desertification of Arid lands. *Advances in Desert and Arid land Technology and Development*, Vol 3. Hardwood academic Publication, New York.
- Elfadl ,M.A.2000.** Reconnaissance study on assessment of land viability for in Khartoum State.
- Elhadi, M.A. 2006.** Social and Environment Evaluation of the FINNDA Project in Khartoum area. Sudan.
- Elhori, M.A.2000.** The role of NGOs for environment protection in Sudan.
- Elsiddig, E.A. 2004.**Community Based Natural Resource Management in Sudan, In: Awimbo, J.; Barrow, E. and Karaba, M. 2004. *Community Based Natural Resource Management in the IGAD*; IUCN.
- Eltayeb, G.E. 2001.** *Human Development Paper* presented at the Civil Society Preparatory Conference for the (Rio+10) Summit Conference on Sustainable Development, 2-4 Oct 2001, Khartoum.
- Fadul,M. H.1978.** Semi detailed soil survey for Sabaluka project .Report No.95 Soil Survey Administration.
- FAO, 2007.**Forestry Division. *Country Profiles*. Food and Agriculture Organization of the United Nations. Rome. (Available at

<http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?sitetreeId=18927&langId=1&geoId=0>. Accessed March 2007.

- FAO, 2005.** Global Forest Resources Assessment 2005, Progress towards sustainable forest management. Vol. 147 of FAO Forestry Paper. Food and Agriculture Organization of the United Nations, Rome.
- FAO, 2001.** Global forest resources assessment 2000. Main report. FAO Forestry Paper No. 140. Rome.
- FAO, 2000.** The global forest resources assessment 2000 FRA2000 Main Report. FAO forestry paper p140- 479.
- FAO.1986.** Tree growing by rural people .FAO. Forestry paper No.64. forestry and food security, Rome.
- FAO, 1976.** A Framework for Land Evaluation, Soils Bulletin 32, Food and Agriculture Organization of United Nations, Rome.
- FNC, 2003.** Progress and issues related to implementation of IPF/IFF proposals for action. National Report to the Fifth Session of the United Nations Forum on Forests. Khartoum. Sudan (available at [http://www.un.org/esa/forests/pdf/national\\_reports/unff5/sudan.pdf](http://www.un.org/esa/forests/pdf/national_reports/unff5/sudan.pdf)).
- FNC, 2000.** personal communication. (FNC) Ministry of Agriculture. Khartoum. Sudan.
- FNC, 1998.** Forest National Corporation, Department of Forest Management. Annual Report (1998). Khartoum, Sudan.
- FNC, 1996.** Extension and Afforestation Department records: Green belt Administration, FNC, Soba, Khartoum.
- FOSA, July 2001.** Sudan country outlook / FNC-FAO. A.T.Vink. FAO forest management officer. Inventory of Rawashda forest reserved.
- FOSA .2000** (Forestry Outlook Study for Africa) Sudan country reports.
- Foti, T.L. and M.S. Devall. 1994.** Herbaceous plant biodiversity of stands in the Ouachita and Ozark National Forests. In: Baker, James B., ed. Proceedings of a symposium on ecosystem management research in the Ouachita Mountain: pretreatment conditions and preliminary findings. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station: 50-60.
- Fourth Population Census of Sudan 1993:** Final Tabulation, Vol. I, Central Bureau of Statistics, Khartoum, 1995.
- Fresco, L.O.1994.** Imaginable futures, a contribution to thinking about land use planning. In: Fresco LO, Stroosnijder L, Bouma J, van Kerulen H editors. The future of the

land: Mobilizing and Integrating Knowledge for Land Use Options.  
John Wiley and Sons, Chichester. p 1-8.

- Geoghegan, J., S. C. Villar, P. Klepeis, P. M. Mendoza, O. Yelena, R. R. Chowdhury, B.L. Turner II, C. Vance, 2001.** Modeling tropical deforestation in the southern Yucatan peninsula region: comparing survey and satellite data. *Agriculture, Ecosystems and Environment*. 85: pp. 25-46.
- Ghenaim, Z.A. 1970.** Study on the impact of the natural and human entity in land use in District of Albotana, Sudan (by Arabic).
- Global Land Project. 2005.** Science plan and implementation strategy. Stockholm. [www.glp.colostate.edu](http://www.glp.colostate.edu).
- Glover, E. K. 2005.** Tropical dryland rehabilitation: Case study on the participatory forest management in Gedaref, Sudan Doctoral dissertation. University of Helsinki, Tropical Forest Report No.27.183 p.
- Gray, L.C., 1925** `The field of land utilization`, Land Economics, vol.1, P.153. Department of statistics, op. cit., 1969, p .10.
- Harrison, M. N. and J.K.Jackson.1958.**Ecology Classification of the
- Harrison, P.1987.** The greening of Africa breaking through in the battle for land and food. PALADIN GRFTON BOOK Collin publishing Group, Glasgow.
- Hassan and Hretzler, 1998.** Deforestation and external costs imposed on Agriculture in Sudan .paper presented to 35th annual conference of the Australia Agricultural Economic society, Armidale New south wales 11-14 February 1991.
- HCENR, 2000.** The Sudan's National Biodiversity Strategy and Action Plan. Higher Council of Environment and Natural Resources (HCNR), Ministry of Environment and Tourism and IUCN with support from UNDP: Khartoum. 75 p.
- Heilig, G. 1999.** Can China Feed Itself? Laxenburg, Austria: IIASA
- Houghton, R.A., and D.L. Skole. 1993.** "Carbon." In *The Earth as Transformed by Human Action*, B. L. Turner II, W. C. Clark, R. W. Kates, J. F. Richards, J. T. Mathews, and W. B. Meyer (eds). New York: Cambridge University Press, pp. 393-408.
- Houghton, R.A.1994.** The worldwide extent of land-use change. *Bioscience* 44: 305-313.
- Hyden G. 1998.** Governance and sustainable livelihoods: Challenges and Opportunities. Paper for the Workshop on Sustainable livelihoods

and Sustainable Development. UNDP/University of Florida, Gainesville.

- Isager, L, Theilade, I. and Thomsen, L., 2002.** People's Participation and the Role of Government in Conservation of Forest Genetic Resources. *Danida Forest Seed Centre Guidelines & Technical Notes* No. 62
- Journal of Environmental Management (1990) An Approach to comprehensive land use planning:
- Kamal El-Siddig, Jens Gebauer, Dawoud H. Dawoud1 and Andreas Buerkert,2008** Ecological Crop Science and Agro-ecosystems Research of the Tropics and Subtropics.
- Khaleel, A.M.**2000. Land use in Jebal Awlia in Sudan. M.Sc. thesis. Nelain University, Dept. of Geography.
- Kruseman G.,Ruben R.,Kuyvenhoven A.1996.** Analytical framework for disentangling the concept of sustainable land use. *Agricultural Systems* 50:191-207.
- Lambin E.F., Geist H. and Lepers E. 2003.** Dynamics of land use and cover change in tropical regions. *Annual Review of Environment and Resources* , vol. 28, pp. 205-241.
- Lambin EF, Baulies X, Bockstael N, Fischer G, Krug T, Leemans R, Moran EF, RindfussY, Sato Y, Skole D and others.** 1999. Land-use and land-cover change (LUCC) Implementation Strategy. Stockholm and Bonn: IGBP, IHDP
- Lambin, E.F., Turner, B.L. II, Geist, 2001.** Causes of Land-Use and Land-Cover Change: Moving Beyond the Myths. *Global Environmental Change: Human and Policy Dimensions*. Vol. 11, No. 4, pp. 5-13.
- Laumann G. 2006.** "Handing over" - From LUCC to GLP. IHDP Update:25. León-Ledesma M, Piracha M. 2004. International Migration and the Role of Remittances in Eastern Europe. *International Migration* 42(4): 65-83.
- Lebon, J. H. G. 1965.** Land Use in the Sudan, Geographical Publications, Bude.
- Lepers E., E. F. Lambin, A. C. Janetos, et al., 2005.** A Synthesis of Information on Rapid Land-Cover Change for the Period 1981-2000, *Bioscience*, 55:115-124.
- Lillesand, T. M and Kiefer, R. W. 1994.** Remote Sensing and image interpretation 3<sup>rd</sup> edition, John Wiley & Sons inc., New York, USA.

- MAANR, 2000** (Ministry of Agriculture, Animal Wealth and Natural Resources) report about Land use map of Khartoum State prepared by the Administration of Soil Conservation.
- MAE (Millennium Ecosystem Assessment), 2005.** Ecosystems and human well-being: Biodiversity synthesis. Washington (D. C.): World Resources Institute. 86 p.
- Metrological Department of Khartoum State,1998.**
- Meyer, W.B. 1995.** Past and Present Land-use and Land-cover in the U.S.A. Consequences. P.24-33. M.christodoulou and G. Nakos\*Forest Research Institute, Tema Alkmanos, 115 28, Greece Receiver 28 January 1989.
- Meyer, W.B. and Turner, B.L., II. Eds. 1994.** Changes in Land Use and Land Cover: A Global Perspective. New York: Cambridge University Press.
- Mohamed, Y.A, 1970.**Land use and Rural Settlement in Khartoum province. M.Sc. thesis, University of Khartoum, Sudan.
- Nicholson, N.2002.** Environmental Degradation ( NS Lecture 11 September 2002.Nile River Dispute available at <http://www.american.edu/ted/ice/bluenile.htm#r4> visited on 20 August 2008.
- NRD, 2006.**Nile River Dispute available at <http://www.american.edu/ted/ice/bluenile.htm#r4> Accessed on 20 August 2007.
- Ohlsson, L. 2000.** Livelihood Conflicts: Linking poverty and environment as causes of conflict. Swedish International Development Cooperation Agency. Department for Natural Resources and the Environment. 19 p.
- Okigo, 1995.****Observation** mad at the consultation workshop. Abidigan, Cotedilvone.
- Pagiola S. and Holden S. 2001.** Farm household intensification decisions and the environment In: Lee D.R. and Barrett C.B. (eds.) Tradeoffs or Synergies: Agriculture Intensification, Economic Development and the Environment. CAB International.
- Riebsame W.E, Meyer W.B, Turner B.L, 1994.** Modeling land use and cover as part of global environmental change Climatic Change 28: 45-64.
- Schiller, A., A. de Sherbinin , W. Hsieh, A. Publisher. 2001.** The Vulnerability of Global Cities to Climate Hazards. Paper presented at

the Open Meeting of the Human Dimensions of Global Environmental Change Research Community, 4-5 October 2001, Rio de Janeiro.

- Scoones, I.1998.** Sustainable rural livelihoods: A framework for analysis. IDS Working Paper 72.
- Shawki,M.K. and Musnad,H.A.1964.** The Green belt South of Khartoum, forest Bulletin No.7.
- Singh, A. 1989.** Digital Change Detection Techniques Using Remotely Sensed Data. International Journal of Remote Sensing. Vol. 10, No. 6, p. 989-1003.
- Skole, D., Chomentowski, W.H., Salas, W.A. and Nobre, A.D. 1994.** 'Physical and human dimensions of deforestation in Amazonia.' Bioscience, 44: 314-22.
- Small, C., 2002.** Scientist at Lamont-Doherty Earth Observatory. Personal Communication.
- SNAP, 2006.** Sudan National Action Programme A Framework for Combating Desertification in Sudan In the context of the United Nations Convention to Combat Desertification, report by Republic of Sudan Ministry of Agriculture and Forestry, National Drought and Desertification, control (NDDCU) in Khartoum. Sudan.
- Soepboer, W., 2001.** *The conversion of Land Use and its Effects at Small regional extent CLUE-S: An application for Sibuyan Islam, the Philippines.* Laboratory of Soil Science and Geology, Environmental Science, Wageningen University <http://www.gis.wau.nl/~clue/philippines/Sibuyan.pdf>
- Sys, C, E Van Rants and J Debaveye.1991.** Land Evaluation: part I principles in Land Evaluation and Crop Production Calculations, Part II Methods in Land Evaluation, ITC University Ghent, Belgium.
- Triantafilis, J and A B McBratney.1993.** *Applications of Continuous Methods of Soil Classification and land Suitability Assessment in the Lower Namoi Valley,* Divisional Report 121, CSIRO Division of Soils, Canberra
- Turner, B. L, 1997.** Spirals, Bridges and Tunnels: Engaging Human-Environment Perspectives in Geography. *Ecumene* 4: 196-217.
- Turner, B. L. II and A. M. S. Ali. 1995.** "Induced Intensification: Agricultural Change in Bangladesh with

- Implications for Malthus and Boserup." *Proceedings, National Academy of Sciences* 93: 14984-14991.
- Turner, B. L. II and K. W. Butzer. 1992.** "The Columbian Encounter and Land-Use Change". *Environment* 43: 16-20.
- United Nations** population fund, the state of world population, 2001. Environmental change, UNFPA, New York, 2001.
- Van der Kevie, W.1973.** Climatic zones of the Sudan. Soil survey Administration. Technical Bulletin No.17  
Vegetation of the Sudan - Bull Forestry Department Khartoum N.S.No(2).
- Verburg, P.H., Y. Chen, W. Soepboer, A. Veldkamp, 2000.** GIS-based modeling of human-environment interactions for natural resource management. Applications in Asia. *In: Proceedings of the 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4): Problems, Prospects and Research Needs, Canada 2000*, 1-13. <http://gissrv.iend.wau.nl/~clue/banf/banf71/banf71.html>
- Vincent, R.K., Baquero Garcia, M. and Levine, N. S. 2002.** Landsat TM Assessment of Cropland Loss Due to Urbanization in N.W. Ohio. Presented at the Annual Meeting of the American Society for Photogrammetry and Remote Sensing (ASPRS).
- Vitousek P.M, Mooney H.A, Lubchenco J, Melillo J.M, 1997.** Human Domination of Earth's Ecosystems. *Science* 277: 494-499
- Waterbury, J. 1979.** *Hydropolitics of the Nile valley*. Syracuse University press, Syracuse, New York 13210 Water Environment Federation and the American Society of Civil Engineers, (1991). *Design of Municipal Wastewater Treatment Plants*. 2 vols. WEF Manual of Practice No. 8. Alexandria, VA: Water Environment Federation
- World Bank, 1992** .World Development Report: working paper No.84. Washington, Dc: the World Bank.
- World Bank, 1996,** *Towards environmentally sustainable Development in sub - Saharan Africa*. Dept. of agriculture and environment Division washigtonia DC.
- World Bank. 1985.** *Desertification in the Sahelian and Sudanian Zones of West Africa*. Washington, D.C.: World Bank
- WRI, 2000.** *World Resources Institute 2000-2001: People and Ecosystems: The Fraying Web of Life*. Washington, DC: World Resources Institute.  
Available at [http://pubs.wri.org/pubs\\_description.cfm?PubID=3027](http://pubs.wri.org/pubs_description.cfm?PubID=3027).accessed may 2008.

# APPENDICES I

## QUESTIONNAIRE

This questionnaire was made to collect information about the impact of land use changes on vegetation cover and sustainable livelihoods along Banks of Niles at Khartoum state. The information will be utilized for M.Sc. Degree. Please answer the questions as accurately as possible. Where actual data are not available please use your closest estimation. Your answers will be strictly confidential.

### Personal information

Sex: Male ( ) (Female ( ))

Age: > 25 ( ) 25-34 ( ) 35-44 ( ) < 45 ( )

**Level of education:** Illiterate ( ) Khalwa ( ) primary ( ) Secondary ( )

University ( )

**Source of income:** Trade ( ) farmer ( ) private business ( )

Employer ( ) other .....

### Information the research

**1 / The current status of the forest?** 1 - Declining ( ) 2 - constant ( )

3 - Increasing ( )

**2 / If the answer is constant due to?** 1 - Forest laws and legislation ( )

2 - The degree of dependence on forest weak ( ) 3 - to represent the forest Grazing ( )

4 - other ( )

**3 / If the current situation of forests in increasing what the factors that led to the increase?** 1 - Awareness ( ) 2 - Extension ( ) 3 - sequencing and ongoing management ( ) 4 - a cycle of spare ( ) 5 - other ( )

**4 / If the current status of forest Mahoney deteriorating why?**

1 - Natural conditions ( ) 2 - rights the different activity ( )

**5/ What were dominant type's trees in the past?**

1.....2.....3.....

4.....5.....6.....

**6/ What are dominant type trees currently**

1.....2.....3.....

4.....5.....6.....

**7/ What are the reasons for change of dominance?** 1 - Over cutting ( )

2 - Palatable for certain types of animals ( ) 3 - climate changes ( )

**8 / what is the role of the National Forest Corporation toward forest?**

1 - Extension ( ) 2 - cultivating ( ) 3 - Protection ( ) 4 - Management ( )

5 - Silvicultural process ( ) 6 - giving workers wages ( )

**9/What is the participation of the local population and their role in the process of afforestation?** 1 - Complete ( ) 2 - partial ( ) 3 - No participation ( )

**10 / What are the organizations that worked in the field of afforestation?**

1 - FNC ( ) 2 - NGOs ( ) 3 - LCS ( )

**11 / What is its role in the process of afforestation?**

1 - Providing seedlings ( )

2 - Provision Employment ( ) 3 - Financing support ( )

**12 / What kind of relationship between man and FNC?**

1 - Paying dividends ( ) 2 - charges ( ) 3 - a token fee ( ) 4 - free of charge other ( )

**13 / What economic activity Prevailing in the region?** 1 - Agriculture ( )

2 - Grazing ( ) 3 - Trade ( ) 4 - private business ( )

**14 / What is the place grazing?** 1 - Farms ( ) 2 - reserved forest ( )

3 - Natural forests ( )

**15 / Are there limits commas or clear land for different uses?**

1 - Have clear lines ( ) 2 - have no clear lines ( )

**16 / If it limits what is clear milestones that can rely upon**

.....  
**17 / What are the cultivated area roughly**.....

**18 / What types of agriculture?** 1 - Rainy ( ) 2 - irrigated ( ) 3 - Flood ( )

**19 / is the use of pesticides and fertilizers in agriculture?** 1 - Yes ( ) 2 No ( )

**20 / What kind of shift in land use?**

1 - Cultivation ( ) 2 - grazing ( ) 3 - Urban expansion ( ) 4 - Industrial ( )

**21 / Reasons and causes the shift in land uses?** 1 - The local population ( )

2 - Government ( ) 3 - natural conditions ( )

**22 / What are the concrete results of this change?**

1 - Migration and displacement ( ) 2 - the deterioration of vegetation and forest ( )

3 - lack of production ( ) 4 - the disappearance of species of trees prevalent ( )

5 - Environmental pollution ( ) 6 - Conflict ( )

**23/What is the role of government in the changes?** 1 - Positive ( )

2 - Negative ( ) 3 - has no role ( )

**24 / If positive what are you done**

.....  
**25/Are these changes acceptable to the local population?** 1 - Yes ( ) 2 - N ( )

**26 / verify whether the ambitions and aspirations of the population?**

1 - Yes ( ) 2 - No ( )

**27 / What is the role of relevant actors in maintaining the ecological balance**

**The role of foresters?**

.....  
**The role of household Rangelands**

.....  
**The role of Localities**

.....  
**The role of Ministries**

.....  
**28/ Is it a forest?** 1 - Natural ( ) 2 - Plantation ( )

**29/ Is there clear lines of forest, or roughly?**

1 - There are limits ( ) 2 - Roughly ( )

If the answer above b (1) How much area and its borders

- 30 / what the types of forests?** 1 - Popular ( ) 2 - individuals ( ) 3 -governmental organizations ( )
- 31 / Is there a unit extension?** Yes ( ) No ( )
- 32 / What are the extension unit?** LCS-2 ( ) FNC ( ) organizations ( )  
4 - The Ministry of Agriculture and Forestry ( ) 5 - Unions ( )
- 33 / What is the kind of guidance?** 1 - By radio ( ) 2 - TV ( ) 3 – individual  
4 -Groups ( ) 5 – posters ( )
- 34- If the role of the population is the negative what resulting of it**  
1 - The establishment of factories ( ) 2 -Kilns breaks industry ( )  
3 - Logging -4/overgrazing ( ) 5 - urbanization ( ) 6 - Establishment of bricks  
kilns ( ) 7 - other.....
- 35-What kind of a burning ambushes?** 1 - Gas ( ) 2 - wood ( )
- 36 / What if the gas funded?** 1 - Organizations ( ) 2 - companies ( )  
3 - Union workers kilns ( ) 2 - 4 - FNC ( ) 5 - individuals ( )
- 37 / what forms of urban expansion?** 1 - Buildings investment ( )  
2 - Housing plans ( ) 3 - extend horizontally ( ) 4 - housing random ( )
- 38 / Conversion in the use of the land to recreational areas**  
1 - Appropriately ( ) 2 – Unsuitable ( )  
Why? .....
- 39 - Why are logging?** 1 - Grazing ( ) 2 - Buildings ( ) 3 - fuel ( )  
4 - a source of income ( ) 5 - Trade ( )
- 40 / What do you think of turning the land into buildings**  
.....
- 41 - What is the body that invests?** 1 - Government ( ) 2 - foreign organizations ( )  
3 - local organizations ( ) 4 - Companies ( )  
5 – Individual ( )
- 42 / preserve the environmental are distributed through?**  
1 - The conservation of forests ( ) 2 - Agricultural Organization of the session ( )  
3 - Afforestation Cities and roads ( ) 4 - the dimensions of parts of plants Housing( )  
5 - the allocation of places for grazing
- 43-What are the difficulties facing the optimal use of land?**  
1 - Economic ( ) 2 – social  
( ) 3 - administrative ( ) 4 - security ( ) 5 - Natural ( )
- 44 /what is the problems facing land-use is it normal due to?** 1 - Wind erosion ( )  
2 – Water Erosion ( ) 3 - drought ( ) 4 - Desertification ( )
- 45 / If the local people are the cause of the shift is due to?** 1 - Ignorance ( )  
2 - Poverty ( ) 3 - Lack of awareness and guidance ( )
- 46 / What the types of pasture?** 1-Natural ( ) 2 - plantation ( )
- 47 / How is the organization pasture?** 1 - to allocate land for grazing ( )  
2 - To allocate part of the area for grazing ( )
- 48 / Are there alternatives to energy-forests?** 1 – Yes ( ) 2 - No ( )
- 49 / What kind of alternatives?** 1 - Improved stoves ( ) 2 - LPG ( )
- 50/What's Suggestions to preserve the environment by adopting systems of land  
uses** .....
- .....
- .....

## APPENDIX II

### List of the Natural Plants of Khartoum State

N	Botanical Name	Vernacular Name	List Form	Uses
1	<i>Abutilon pannosum</i>	(Hambok, Gergodan)	SH	B
2	<i>Faidherbia albida</i>	Haraz	T	B
3	<i>Acacia mellifera</i>	Kitir	T	B
4	<i>Acacia nubica</i>	Lao`t	T SH	B
5	<i>Acacia tortilis</i>	Seyal	T	B
6	<i>Acacia radiana</i>	Samar	T	B
7	<i>Acacia ehrenbergiana</i>	Salam	T	B
8	<i>Aerva javanica</i>	Ras Eshaieb	SH	B
9	<i>Aristida adsceniosis</i>	Gau- Hura	G	GR
10	<i>Aristida mutabilis</i>	Gau	G	GR
11	<i>Aristida funiculata</i>	Gau	G	GR
12	<i>Balanites aegyptiaca</i>	Heglig	T	B
13	<i>Boscia senegalensis</i>	Mukheit	SH	B
14	<i>Calatropis procera</i>	Ushar	SH	B
15	<i>Capparis deciduas</i>	Tundub	T/SH	B
16	<i>Cassia senna, etalica</i>	Senameka	H	M
17	<i>Cenchrus biflorus</i>	Husknit	G	GR
18	<i>Cenchrus ciliaris</i>	Huskanit	G	GR
19	<i>Colocynthus vulgaris</i>	Handal	R	GR
20	<i>Commiphora Africana</i>	Gafal	T/SH	B
21	<i>Chorchorus fascicularis</i>	Khudra	H	GR
22	<i>Chorchorus spp</i>	Khudra	H	GR
23	<i>Cymbopogon proximus</i>	Maharib	G	GR
24	<i>Cynodon dactylon</i>	Nageela	G	GR
25	<i>Cyperus rotundus</i>	Seied	GL	GR
26	<i>Dactyloctenium aegyptum</i>	Um asabi	G	GR
27	<i>Echinochloa colonum</i>	Difera	G	GR
28	<i>Fimbrislylis hispidula</i>	Um fesesiati	GL	GR
29	<i>Grewia tenax</i>	Godeim	SH	B
30	<i>Maerua crassifolia</i>	Sarieh	T/H	B
31	<i>Ocimum americanum</i>	Rihan	H	
32	<i>Panicum turgidum</i>	Tomam	G	GR
33	<i>Schoenfeldia gracilis</i>	Gobash, umferieda	G	GR
34	<i>Solanum dobium, nigrum</i>	Gobein	H	GR
35	<i>Trianthema pentandra</i>	Raba`a	H	GR
36	<i>Tribulus terrestris</i>	Dereisa	R	GR
37	<i>Ziziphus spina Christi</i>	Sider	T/SH	B
38	<i>Indigofera hoschistetri</i>	Sharaya	H	GR
39	<i>Sporobolus humifusus</i>	Aish El far	G	GR
40	<i>Sonchus oleraceus</i>	Moleita	H	GR

41	<i>Xanthium brasiliicum</i>	Ramtok	SH	
42	<i>Ricinus comunis</i>	Khewi	SH	P
43	<i>Salvadora persica</i>	Arak	T/SH	B
44	<i>Lasiurus hirsutus</i>	Garaz	G	
45	<i>Tamarix nilotica</i>	Tarfa	SH	GR
46	<i>Argemone Mexicana</i>		H	GR
47	<i>Bergia suffruticosa</i>	Mirmid	H	GR
48	<i>Euphorbia aegyptiaca</i>	Um Lebeina	H.R	GR
49	<i>Schina ischaemoides</i>	Agor	G	GR
50	<i>Euphorbia hirta</i>	Sorieb	H	GR
51	<i>Cusumis spp</i>	Ankog	R	GR
52	<i>Sesabania sasban</i>	Sorieb	H	GR
53	<i>Ischaemum afrum</i>		G	GR

(Source: MAANR, 2000)

**List form**

SH: Shrub.

T: Tree.

H: Herb.

R: Runner.

**Uses**

B: Browse (Camels, Goats)

GR: Grazing.

P: Poisonous

GL: Grass like