Inventory of Tree Cover in Sharg El Neel locality, Khartoum State.

By:

Afaf Ahmed Jubara Dawe

B.S.c. (Honour) forestry science, 2004

Collage of Forestry and Range Science University of Sudan

Supervisor:

Prof. Dr. Salaheldin Goda Hussein

University of Khartoum

A thesis submitted to the University of Khartoum in partial fulfillment of the requirement of the degree of Master of Science in Desertification Desertification and Desert Cultivation Studies Institute 2009
Dedication

To my mother

To my father

To that man who lighten my life:

My husband

To my sweet baby

To my dear friends

With love and respect.

Afaf
Acknowledgment

I am grateful and indebted to my supervisor professor/\textbf{Salaheldin Goda Hussein} for his help and encouragement. I acknowledge the scholarship and financial support offered to me by UNESCO Chair of Desertification, University of Khartoum. My gratitude is extended to the Forest National Corporation which nominated me for the Msc program. I would like to express my sincere gratitude to my colleague \textbf{Mohammed Osman Abbakar} for his strong support and help during the field work. Thanks also go to my fellow students and those who assisted in one way or another.

\textit{Afaf.}
Abstract

Inventory of Tree Cover in Sharg El Neel Locality, Khartoum State

This study was under-taken to evaluate the Afforestation activities in Khartoum State which has been seriously affected by desertification. East Nile Locality was selected as the study area and several parts were surveyed: Ailafoon, Elhaj Yousif, Umdawanban, Kutrang and Keriab. Sampling was done in the three chosen categories namely forest, residential and farms. In each sample, trees and/ or shrubs were identified and enumerated; ten trees were randomly selected for each of the dominant tree species for determining crown projection as a measure of tree cover. The main variables presented were: Tree species, Tree density, Crown projection and Frequency.

In the residential sites, square sample plots with an area of approximately 0.1 ha were used. Altogether 150 sample plots were laid down at the following locations: Ailafoon, Elhaj Yousif, Umdawanban, Kutrang and Keriab villages. The study showed the following species as most frequent:

*Acacia tortilis subsp tortilis*, *Accia tortilis sub-species radiana*, *Acacia ehrenbergiana*, *Azadirachta indica*, *Albizia lebbeck* and *Phoenix dactylifera*. *Acacia tortilis sub-species tortilis* were more common in forest sites, while *Azadirachta indica* was more common in the residential areas. Overall, 53 tree and shrub species were encountered. The number of species in the residential areas was far greater than in the forest areas, because they included a lot of horticulture and ornamental species. Density of trees ranged between 54 and 427 per ha in forest sites ie 189± 3 which is very low.
In forest sites, the highest species density was shown by *Acacia tortilis subsp tortilis*.

In residential areas, the highest density was shown by *Albizia lebbeck* followed by *Azadirachta indica*.

It is concluded that afforestation activities are very meager in East Nile locality. Real plantations were established in two private farms representing only 2% of the farm area. More afforestation/reforestation is needed to counter-act the deficiency in forest cover.
المستخلص
حصر الغطاء الشجري بمحلية شرق النيل/ ولاية الخرطوم

أجريت هذه الدراسة لتقييم منشأ التشجير في ولاية الخرطوم التي تأثرت بالتصحر تأثيراً بالغاز. اختبرت محلية شرق النيل للدراسة وتم المسح في مناطق عديدة: العيلفون، والحاج يوسف، وأم ضوابان، وكترانج والكرياب. أخذت العينات في ثلاث قطاعات: الغابات، المناطق السكنية، المزارع. تم إحصاء عدد الأشجار والشجيرات في كل عينة وأُختيرت عشرة أشجار من كل نوع سائداً لتعيين انتشار التاج كمقياس للتغطية الشجرية.

تم تسجيل: نوع الأشجار، الكثافة العددية، انتشار التاج والتكرارية.
?

في المواقع السكنية استخدمت مربعات عينة مربعة الشكل بمساحة 0.1 هكتار. تم إعداد 150 مربع عينة في المواقع الآتية: العيلفون، والحاج يوسف، وأم ضوابان، وكترانج والكرياب.

الأنواع الآتية كانت الأكثر تكرارية: السمر، والسياج، والشم، والنخيل، ودقن البشام والفهري.

السمر شائع أكثر في مواقع الغابات. اجمالاً، تم حصر 53 نوع من الأشجار والشجيرات. عدد الأنواع الشجرية في المواقع السكنية أكثر من مواقع الغابات لأن المواقع السكنية تتضمن أكثر من الأنواع الباستية وأشجار النزهة.

تراوحت كثافة الأشجار بين 54 و 427 في مواقع الغابات أي 189 ± 3 في المتوسط وهذا متدني جداً.

أشجار السمر كانت أعلى كثافة في مناطق الغابات. في المواقع السكنية كانت أشجار دقن البشام هي الأعلى كثافة تليها أشجار النيم.

تخلص الدراسة إلى أن أنشطة التشجير ضئيلة جداً في محلية شرق النيل.

هناك مشاجر حقيقية في مزرعتين خاصتين بنسبة 2% من مساحة المشروع.

هناك حاجة ملحة لمزيد من التشجير وإعادة التشجير لمعالجة النقص في الغطاء الغابي.
# Table of Contents

Dedication ........................................... i
Acknowledgment ..................................... ii
English abstract ................................... iii
Arabic abstract ..................................... v

**CHAPTER ONE:** Introduction ................. 1

**CHAPTER TWO:** Literature Review .......... 6
2.1 Forests in Sudan ................................ 6
2.2 Forests in Khartoum State .................... 7
2.3 Trees outside forests ......................... 9
2.4 Urban forests ................................... 9
2.5 Drought and desertification ................. 11
2.6 Forestry vs. desertification in rural development context .. 15
2.7 Afforestation concept and practices .......... 16
2.8 Afforestation in environmental policy ....... 17
2.9 Afforestation considerations .................. 18
2.10 Afforestation constraints .................... 19
2.11 Afforestation practices ..................... 21
2.12 Major afforestation projects in Sudan 22
2.13 Afforestation in Khartoum state 25
2.13.1 Community participation in afforestation 26
2.13.2 National services participation 27
2.13.3 Afforestation in farm areas 28
2.14 Forest nurseries 28
2.15 Forest management 30
2.16 Forest inventory 31

CHAPTER THREE: Materials and methods 33
3.1 Site 33
3.2 Methods 35

CHAPTER FOUR: Results and discussion 37
4.1 Tree species 37
4.2 Tree density 39
4.3 Species frequency 42
4.4 Crown area projection 44

CHAPTER FIVE: Conclusion and recommendations 45
REFERENCES 47
APPENDIXES
List of tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1: Land use in Khartoum state</td>
<td>7</td>
</tr>
<tr>
<td>Table 2: Forest reservation in Khartoum state</td>
<td>8</td>
</tr>
<tr>
<td>Table 3: Tree/shrub species encountered in the study area</td>
<td>37</td>
</tr>
<tr>
<td>Table 4: Tree density in forests</td>
<td>40</td>
</tr>
<tr>
<td>Table 5: Tree density in residential sites</td>
<td>41</td>
</tr>
</tbody>
</table>
### List of figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1: East Nile locality</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Figure 2: Species density in forest areas</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Figure 3: Species density in residential sites</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Figure 4: Species frequency in forest areas</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Figure 5: Species frequency in residential sites</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Figure 6: crown projection</td>
<td>44</td>
<td></td>
</tr>
</tbody>
</table>
Chapter One

Introduction

General:

Sudan is the largest country in Africa with a total area of approximately 2.5 million Km², and is characterized by a diversity of climate zones; the country is consequently divided into seven vegetation zones on the basis of rainfall and soil. Starting from the north to the south, these zones are: desert, semi-desert, low rainfall woodland savannah on sand, low rainfall woodland savannah on clay soil, high rainfall woodland savannah, special forests and the mountain forests (Harrison and Jakson, 1958).

Desertification and environmental change:

According to many authors including Arab Organization for Agricultural Development (AOAD, 2000) desertification is considered as the most important environmental problem facing Sudan.

Desertification affected about 13 States at varying degrees; these areas fall within arid and semi-desert zones; Khartoum state is one of the most affected areas. This study focuses on Khartoum state which has erratic rainfall and is frequently striken by drought spells (Nana-Sinkam, 1995).

Evaluation of afforestation and tree plantations:

With regard to forest and forestry, legislation was updated by the law of 1989 and establishing the National Forest Cooperation and defining its
functions. One of the most important aspects of this legislation is its emphasis on the role of forests in protecting the environment (El Houri, 1996). According to UNEP (1992) afforestation and restoration of tree cover is one of the main projects to combat desertification and mitigate the effect of drought; for this purpose Sudan has updated an action program for afforestation and tree planting.

Khartoum state had been described by the early travelers as densely forested, but through time these forests were removed by man and his herds.

Khartoum state has been experiencing a rapid degradation of tree coverage that led to deforestation and other land degradation problems; it is one of the 13 States which are suffering from the phenomenon of aridity and desertification. The State has an area of 22,122 Km² and it is bordered by the Nile state in the north, the Gazira state in the south, Gadaref in the east and North Kordofan State in the west (Figure1). The mean annual rain fall ranges between 76 and 150 mm. The total population is about 4.8 million. Most of Botana land is the type of range land because of the construction of that soil. The utilization of this soil for the different crops causes many problems such as soil deterioration and vegetation degradation that leads to desertification.
Finger 1: Sharg El Neel Locality
General trends over the last decades are relating to the expansion of the afforestation activities and awareness arising about the crucial social and environmental role of tree planting.

Economic problems which resulted from the limited budgets and resources, the misunderstanding and bad strategic planning, all these suppressed the efforts concerning to the protection of tree coverage and lead to poor implementation and inadequate information.

Poor education of local people highlighting the socio-ecological value of trees in rural and urban environments, this is one of the reasons for uncontrolled clearing of trees. A systematic evaluation of afforestation can help provide ready references for policy makers and planners to meet people’s needs. Afforestation has not been given due attention in national forest statistics. Information on the status and extend of afforestation projects is scanty and not easily accessible. Sound databases on afforestation have not been appropriately organized. One reason for this deficiency is the lack of cost-effective and practical evaluation and assessment techniques. Large-scale assessment and evaluation are of high priority for developing management strategies to help sustain tree cover and to design supportive policies that provide incentive to land holders to maintain or increase the number of trees on their land. The potential to coordinate the efforts of the different institutions for speedy evaluation of afforestation is immense. There is also a need to develop a
common methodology drawing on the strength of different approaches used.

The wide extent of Sudan, conflicts, poverty and change of policy and legislation, all these factors resulted in gaps of information and collection of data for operational uses.

**Objective of the study:**

In Sudan, there is need for detailed information and real evaluation of forests and tree resources for afforestation implementation and environmental considerations.

Accordingly, this study evaluates and assesses afforestation and tree plantation activities in East Nile locality, Khartoum state with the objective of suggesting future line of action to support development and sustainable resource management. Other objectives of this study are to produce background information for the study area and develop recommendations on the basis of the results obtained that are expected to raise the public awareness.
Chapter Two

Literature review

2.1 Forests in Sudan:

Total world forest area is estimated at 3,869,455,000 hectares representing 29.6% of the land mass (13,063,900,000 ha.) according to FAO (2005). Africa’s share is 649,866,000 ha out of 2,978,394,000 ha Land area (i.e. 21.8%). For Sudan, the estimated forest area is 61,627,000 ha out of land area of 237,600,000 ha (i.e.25.9%).

Forest plantations amounted to 186,733,000 ha world wide given an annual change of -9,391,000 ha and annual rate of change of -0.2%, the figures for Africa are 8,036,000 ha forest plantations, -5,262,000 ha annual change and -0.8% annual rate of change; for Sudan, the corresponding figures are 64,000 ha plantations, -90,000 ha annual change and -1.4% annual rate of change (Hussein, 2006).

Sudan has never had a truly national forest inventory. Forest and wood lands not constituted as forest reserves, are continuously being encroached upon by agriculture and urbanization or otherwise degraded by uncontrolled felling. The forest reservation process which started in 1923 was only able during 70 years to settle and finally gazette 1.3 million ha, equivalent to 0.5% of the total area of the country. A number
of government decrees passed in September 1993 brought the area under forest reserve to 10 million ha, equivalent to 4.0% of the total country’s area. In view of the raising official and public awareness and official enthusiasm for the sector, it is expected that more land will be explicitly allocated to forestry, range and pasture and wildlife as spelled by the CNS (Comprehensive National Strategy) in 1992-2002. The latter called for the allocation of 63 million ha for natural resources, i.e. 25% of the country’s area. That area would eventually need to be put under management plans (F.N.C. 1996).

2.2 Forests in Khartoum State:

In 1996 Forest National Corporation documented the vegetation cover in Sudan. The land use of Khartoum State is documented as following:

**Table 1: Land use in Khartoum State:**

<table>
<thead>
<tr>
<th>Type of land use</th>
<th>Area (ha)</th>
<th>Percentage of land (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated land</td>
<td>170,000</td>
<td>9.7</td>
</tr>
<tr>
<td>Pastoral land</td>
<td>270,000</td>
<td>15.4</td>
</tr>
<tr>
<td>Forests land</td>
<td>130,000</td>
<td>7.4</td>
</tr>
<tr>
<td>Residential land</td>
<td>170,000</td>
<td>9.7</td>
</tr>
<tr>
<td>Unexploited land</td>
<td>1010,000</td>
<td>57.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,750,000</td>
<td>99.9</td>
</tr>
</tbody>
</table>

Source: FAO 1996.

Table 1 shows that the forest lands occupied the smallest areas compared with other classes. The land allotted for forest is limited in a country like Sudan where Khartoum State is mainly endangered by desert encroachment in its northern, western and eastern peripheries. Although
commendable effort is done by FNC to protect and conserve forests by reservation of state forests, it is far from sufficient in terms of the magnitude of total forest land (13000 hectare). The ten years plan (1990-2000) stated that 25% of the total area of the state must be reserved as forests. But only about 3% of the state total area is reserved. This shows the slow process of establishing reserved forests in the state (Table 2).

Table 2: Forest reservation in Khartoum state:

<table>
<thead>
<tr>
<th>State of reservation</th>
<th>No. of forests</th>
<th>Area (feddans)</th>
<th>Area (%) of state total forests</th>
<th>Area(%) of state area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gazetted forest reserves</td>
<td>6</td>
<td>14,340</td>
<td>8.6</td>
<td>0.287</td>
</tr>
<tr>
<td>Forests reserved but not yet gazetted</td>
<td>6</td>
<td>10,111</td>
<td>6.9</td>
<td>0.203</td>
</tr>
<tr>
<td>Forest reserved but not surveyed</td>
<td>18</td>
<td>47,811</td>
<td>28.7</td>
<td>0.958</td>
</tr>
<tr>
<td>forests proposed for reservation</td>
<td>33</td>
<td>94,050</td>
<td>56.6</td>
<td>1.884</td>
</tr>
<tr>
<td>total</td>
<td>63</td>
<td>166,312</td>
<td>100.0</td>
<td>3.332</td>
</tr>
</tbody>
</table>


According to the Ministry of Agriculture, Irrigation and Animal wealth of Khartoum State, the total number of forests reserved and proposed for reservation amounts to 192 forests with a total area of 3017851 feddans. Of this, East Nile locality share is 75 forests with a total area of 170306 feddans.
2.3 Trees outside forests:

Among their many other characteristics, trees outside forests satisfy a wide range of household needs and form an integral part of household production, consumption and economic acquisition strategies. This non-forest system offer many direct and indirect services. Trees outside forests are found in most rural landscapes and many agro-forestry systems and agro-sylvo-pastoral landscape. Trees outside forests are part and parcel of urban, rural, private and community forests; these trees depend much on the demand from city-dwellers. Urban and pre-urban forestry include the management of single trees and clumps of trees which have either sprung up by themselves or been planted in urban areas. The term (urban forestry) embraces tree cropping, green spaces and afforested pre-urban areas. City trees have adapted to a great many constraints such as lack of space and soil, air pollution, damage by man and animals and repeated cutting.

Social forestry has advanced significantly since the 1980s mainly in response to the problem of supplying fuel wood for rural communities. It’s often associated with rural development (Shamara, 1993).

2.4 Urban forests:

The planting of trees in human settlements and as integral part of landscape architecture is not new, but only recently has their full value to
urban dwellers been recognized. Trees and green spaces play an important role in improving city living conditions.

Urban forest is defined as: Tree populations in urban settings for the purpose of improving the urban environment (FAO, 1993).

Urban forestry advocates the role of trees as a critical part of the urban infrastructure supporting appropriate tree and forest preservation, conducting research and promoting the many benefits trees provide. Urban forestry is practiced by municipal and commercial arborists, municipal and utility foresters, environmental policymakers, city planners, consultants, educators, researchers and community activists (FAO, 1993).

The urban environment presents the arboricultural challenges of limited root and canopy space, poor soil quality, deficiency or excess of water and light, heat, pollution, mechanical and chemical damage to trees, and mitigation of tree-related hazards (Lenester, 2000).

Management challenges include maintaining a tree and planting site inventory, quantifying and maximizing the benefits of trees, minimizing costs, obtaining and maintaining public support and funding, and establishing laws and policies for trees on public and on private land (ISA, 2007).

It is very clear that the urban forest must be considered as an integral part of any energy conservation plan.
Conversely, many urban foresters in developed countries use "urban greening" and "urban forestry" interchangeably. In this context, urban forestry focuses on using trees for recreational and environmental benefits. These functions include:

-Conserving energy, by providing shade and evaporative cooling through transpiration;

-Improving local and global air quality.

-Reducing wind speed and directing air flow.

-Increasing real property values.

-Providing recreational and esthetic requirements.

2.5 Drought and desertification:

The World Bank (1985) defined drought as: A markedly sub-average amount of rain fall during a year or series of years. The Sahel is thus part of the world which is most affected by prevalence of such sub-average rainfall, and therefore drought condition.

Drought and desertification are serious environmental hazards facing the world, particularly tropical Africa.

According to Graniger (1986), drought is a result of climatic changes but desertification is the result of human action. Drought could trigger rapid desertification-rates and could make its effect felt more by those living in affected areas. Drought accelerates the negative consequences of resource abuse. It is widely accepted that drought is only partly responsible for the
decrease in land productivity and that land-use method which is incompatible with the available natural resources in the Sahelian zone.

The major consequences of drought include widespread crop failures, high rate of livestock mortality and human displacement.

Desertification is a major socioeconomic problem facing the dry lands of the world. The accepted definition of desertification is: Land degradation in arid, semi-arid and dry-sub humid areas resulting from various factors including climatic variation and human activities (Lean, 1995).

DECARP (1976) highlighted the problem of desertification in Sudan and pointed to the seriousness of the situation by stating that:

“Desert encroachment is a serious problem in Sudan threatening all Nile irrigation schemes, 2.5 million feddans of pump irrigated areas, 7 million feddans of mechanized crop farming areas, 75% of the world gum Arabic production, pasture for about 10 million live stock units and vast areas of woodlands.”

The main causes of desertification are human over-exploitation of lands through over-cultivation, over-cutting of wood and over grazing. All these are conflicting and antagonistic land-use pattern (Tolba, 1984).

According to Mustafa (2007), the main causes of desertification are: adverse climatic variations, adverse human activities (over grazing, over cultivation, deforestation, and miss-management of land), and climatic changes.
The major impact of desertification is deterioration of the quality of life, consequent to the reduction of biological and economic productivity, socioeconomic deterioration, and environmental degradation.

**Impact of drought and desertification on forest cover:**

Historical events show that renewable resources (soil, plant, water, wildlife, and human-beings) were in an ecological balance; this natural balance was upset when the population increased and other new factors were involved; more food was needed, more wood was required for different uses, specially the domestic one; hence more pressure was put on land, water, vegetation cover and wildlife. The result of this disturbed natural balance was the disappearance of the vegetation cover, erosion, floods, sand dune movement etc. Other factors has accelerated the deterioration of the environment; thus increasing desertification i.e. the in-ability of people to maintain the resources. wars, invasions, and other social pressures played an important role in environmental deterioration and displacement of local communities. In Khartoum state, Internal Displacement People (IDP) are estimated as 1.8 million, which represent a very considerable proportion of the state's total population (4,997,000) (FAO, 2008), this put a great pressure on the meager forest and pasture resources. It is evident that fires, cutting, removal of trees and shrubs for different purposes, overgrazing … etc, have placed the forestry sector in a very critical situation.
The distribution of the vegetation zones in the years 1982-1999 differ from that described by Harrison and Jackson (1958); this difference is mainly due to drought and irrational land use (Hanadi and Warrag, 2005). In Sudan, Hussein (1991) made a survey on a typically dry rangeland of Acacia tortilis and Maerua crassifolia grassland in Wadi El Hawad which is inhabited by nomadic and semi-nomadic tribes to show the changes that took place over a number of years. The area is now degraded, with scattered trees of very low stocking and increasing bare ground and rocks. Aridity coupled with human misuses such as uncontrolled cutting of wood and over cultivation were the main reasons for this degradation. The need to measure degradation processes in these areas has further increased.

According to FAO (1993) deforestation is a serious problem in Sudan; the rate of deforestation is estimated as about 482 ha/ year.

Forestry lands are systematically cleared for agriculture, residential settlement, infrastructure for development projects and physical planning. According to FAO (1995), Khartoum State represents the highest rate of consumption of the forest products in the country. Yet forestry is still playing an important role, socially and economically in the arid zones. This role is mainly in providing tangible and intangible benefits such as provision of forest products particularly fuel wood and conserving the
environment, reducing erosion, protecting soil and watershed and regulating hydrological cycles and ameliorating climate.

2.6 Forestry vs. desertification in rural development context:

The case for campaigns against desertification has been largely ecological, while the case for development is primarily economic and social. Development is usually implemented according to economic, social and political criteria. There is, however an intimate relationship between desertification and development. Desertification implies that the people must change their ways to fit in with nature; development implies that the use of resources must be reorganized with the aid of newly available technologies to fit people’s expectations (FAO, 1998).

Forestry approach in the past has been ecologically biased and action has been taken with this orientation. However, it is beginning to be realized that the inhabitants of dry lands had already, through force of necessity, developed ecologically viable systems which have become modified or abandoned through external commercial pressures as well as through explosion of human and livestock populations.

The above systems applied on a small scale by family or tribal groups in the past still apply but may require modification in practice to fit in with the increased demands on the environment. Rationalization of practice is sought, not necessarily fundamental changes implying that past systems must be closely studied to analyses their benefits.
Any proposed change must be carried out with the full cooperation of the family. Tribal or community units should be involved if action is to be taken on a sufficient scale to make an impact on resolving the problems of desertification (FAO, 1989).

**The role of forestry in the national economy:**

The forestry sector contributes effectively to the Gross Domestic Production (GDP). It provides wood, fuel, feed and fodder, wildlife habitat and other secondary products such as gums, resins and medicinal values (UNSO, 1993). This contribution represent about 1-2% of GDP. A recent energy consumption study showed that the per capita consumption of fuel wood is 7 cu./ annum. 78% of the energy consumption in the country is in the form of fire wood and charcoal. Forest trees also contribute some 30% of the animal feed per annum and that share can reach 70% in extremely dry years (Ibrahim, 2007).

**2.7 Afforestation concept and practices:**

FAO (2001) defined afforestation as: ‘Establishment of forest plantations on land that, until then, was not classified as forest, while reforestation is establishing a forest in an area which carried a forest previously. Afforestation-Reforestation principles are the same all over the world aiming at increasing forest areas and regenerating existing forests for sustainability (Hussein, 2006).
2.8 Afforestation in environmental policy:
The interest of foresters in the development of arid zones has been intensified during the last two decades. In 1954, the fourth world forestry congress paid special attention to the reclamation of degraded soil and deserts, and recognized that much remained to be learned about the precise role vegetation could play in desert reclamation projects. The forestry commission for Africa gave special attention to aridity problems in the Sahel area, south of the Sahara. The CILSS/UNSO/FAO Consultation on the role of forestry in a rehabilitation programme for the Sahel, and emphasize the importance of forestry and the role of foresters in combating desertification (FAO, 2004).
The recommendations of PACD (UNEP, 1992) emphasized improving and controlling the use of plant-based fuel (wood, charcoal) and pursuing alternative sources of energy; and support for afforestation policies in developing countries including encouragement of the use of fast growing species and protecting existing forest areas.
Sudan has ratified the United Nation Framework Convention on Climate Change. This convention requires signatories to move the elimination of greenhouse gases.
Kyoto protocol (1998), recognizes that forests play an important role in the global carbon cycle through the conservation of existing carbon pools, through sequestration of carbon in new forests, through substitution of
forest products for more energy-intensive materials and through substitution of biomass fuels for fossil fuels; it also addressed the need to ensure sustainable use and development of forests and thereby requires monitoring against the initial determination of these forest resources; promotion of sustainable forest management practices, afforestation and reforestation to reduce the greenhouse gas emission.

2.9 Afforestation considerations:

Each afforestation site requires careful considerations as to species selection, Locality factors, legal aspects, labour availability, seed and/or seedling resources,

Afforestation under arid conditions generally requires the supplementary applications of water, nutrient supply, and reduction of the risk of animal damage to promote initial tree and shrub survival and growth.

Most lands of East Nile Governorate are degraded. Rehabilitation of these lands requires the successful reestablishment of vegetation cover using drought-tolerant species and strict protection against grazing and other intrusions.

Afforestation usually relies on artificial means, although natural regeneration helped in reforesting forests with minimum costs. Artificial regeneration facilitates control over afforestation programmers. For this, authenticated seeds and well raised seedling are essential. In Sudan, seeds are used mainly for *Acacia* species while seedlings are used for
Eucalyptus plantations. It is therefore important to study seeds and know nursery practices (Hussein, 2006).

2.10 Afforestation constraints:

In the implementation of field activities, a number of problems are encountered and should be considered in guiding future action. These are:

Social and human constraints:

The control of land degradation and desertification is a medium and long–term endeavor and as such, little has been done to convince dry land population that this activity is for their own interest and is more profitable to them than the over-exploitation of existing resources. This is particularly true for the forest resources and the prevailing forest laws have often prevented the involvement of rural people in the conservation and management of forest resources.

On the level of resources use, a conflict has always arisen between pastoral and agricultural activities. This conflict has prevented the integration of live stock and agro-pastoral and sylvo-pastoral activities.

Ecological constraints:

Drought has been more frequent over the last two decades and this has seriously affected the food and livestock production in many countries. Because of this phenomenon, larger areas were cropped and rehabilitation activities (reforestation, soil conservation, etc) were difficult to
implement. The most important ecological factors governing afforestation are climatological, edaphic, and hydrological factors (Kauli, 1985).

**Technical and operational constraints:**

The most important technical constraints are:

- clearing for agriculture, bush fire and over grazing;
- the low rate of afforestation and reforestation;

The lack of data turns to be a major constraint so far, and in the absence of basic and essential data, planning is not easy.

The land ownership pattern, as exists today, creates a problem in taking any program over private land. Legal procedures for the acquisition of any such land are a time consuming job. It is an established fact that protection of any area from all biotic interferences is a prerequisite for any afforestation and range improvement program (Mathur, 1983).

**Financial constraints:**

Despite an increased awareness of the fight against desertification, funding remained very low and disproportionate to the challenge posed by the problem; this has led to:

- Low extension of afforestation programs;
- Low level of infrastructure for training and research;
- In sufficient funds for maintenance activities.
2.11 Afforestation practices:

Shelter belts and windbreaks:

The value of shelter belts and wind breaks in irrigated lands, road side planting and rain-fed agricultural areas is recognized. Large scale shelter belts are valuable in all agricultural schemes in Sudan. Shelter belts were established around a number of major cities during the period 1946-1976 these have all been abandoned or converted to residential areas e.g Khartoum Green Belt.

Sand dune fixation:

Another wide spread use of trees and shrubs is for the stabilization of sand dunes; afforestation of sand dunes require some considerations in establishment of plantations. In this context a wide range of woody species are used.

Rain-fed afforestation:

Successful rain-fed afforestation using drought resistant tree species has been under taken; however, rain-fed afforestation in arid zones is not very productive.

Screen afforestation:

This is establishing trees scattered over a grazing or agricultural territory; trees are widely spaced than in forest plantations or palm groves. Screen afforestation has a favorable effect both on plant and animal yields in
tropical dry lands. Efforts may be directed to reclaiming eroded areas by establishment of screen afforestation (Hussein, 2006).

**Creation of national Parks:**

National Parks are important in assisting the conservation of genetic resources and as such provide a reservoir of species for the selection of useful drought and salt resistant varieties. Their creation is an essential component in combating desertification as they provide reference points for monitoring the advance of deserts on a regional and national scale.

**2.12 Major afforestation projects in Sudan:**

Sudan had many afforestation projects during the last four decades particularly in the desertification-prone states. Prominent among these projects, other than the major agricultural schemes, were the following:


2/ Green desert project -1977-85; wind breaks in Zaidab and Hassania area.

3/ Sudan Finland project 1979-1993: Rain-fed afforestation in the white Nile State, Blue Nile and Rahad schemes.


5/ Gum Arabic belt- Northern Kordofan 1981-1984; 1985-1989; 1990-1995 *Acacia senegal* reforestation and combating desertification through community participation; 250,000 feddans were rehabilitated covering
477 villages as an extension program, similarly with Northern Darfur State (1985-1995).

6/ Fuel wood development project 1983-87, irrigated plantation to provide forest products for rural people.

7/ Afforestation project for refugee camps 1983-87; 10,000 feddans reforested at Elshowak and Abu Rakham.


11/ 1987-1993: Afforestation- reforestation- Northern and Nile States. Protection of Alti basin agricultural scheme and villages along Atbara and Nile course from sand blow; 20 shelter belts were established totaling 104,700 meters.


14/ Forest rehabilitation project: Shendi (1988-1995) shelter belts design and establishment, sand dune fixation.


18/ Forest development project: Sudan council of churches and Sudan government 1992-1996 Afforestation project- Nile state.

19/ Sudan Irish Development project (1986-91, 1992-1996). Extension, social forestry, rehabilitation: afforestation of 5000 feddans in Gezira State, reforestation of Um Heraiza forest (22,000 feddans) and Sogadi forest (4000 feddans) in Sinnar state.


Total area afforested during the period 2002-2005 equal 93,671 feddans-7768 feddans Departmental and 24,000 feddans Social forestry and 1,903 feddans rain-fed and irrigated (Hussein 2006).

Altogether 1,224,429 feddans were afforested up to 1999 all over the Sudan (A.O.A.D, 2001); out of this total area, irrigated plantations
amounted to 50,000 feddans mainly in the major agricultural schemes such as Gezira, New Halfa and Rahad schemes. Of significance was the Khartoum Green belt on the southern fringes of the capital with a gross area of 7035 feddans. New plantations (1998-2005) totaled 93,671 feddans according to the 2005 Forest National Corporation Report (Hussein, 2006).

2.13 Afforestation in Khartoum State:

The Khartoum forest sector is responsible for protection, controlling the forest resources in the state and providing the educational, training services. Khartoum forest sector has an Extension and Afforestation Department, which has been established since 1986 in Soba. This department provides extension services to different sectors of societies (formal and informal) and provides seedlings at nominal prices (subsidized) beside periodic inspection to previously afforested areas (Extension and Afforestation Department, 1998). These efforts resulted in rehabilitation of most of the state areas including the farms and residential areas.

Governmental afforestation efforts are not sufficient and effective without people or community participation. Vast expanded countries like Sudan, which has several economic problems such as limited budget and resources for afforestation programs, needs more efforts concerning the community participation. Extension and Afforestation Department of
Khartoum forest sector has been doing great efforts in promoting and motivating community and public participation in the rehabilitation of vegetation cover in the state.

The areas which were afforested during the period 2001-2007 amounted to 7808.9 feddans in reserved forests, 198.5 feddans in community forests, 566.9 km of shelter belts, 1831 villages and 9701 schemes and institutions.

2.13.1 Community participation in afforestation:

The forestry Programs in the past few decades in response to environmental deterioration and droughts were geared towards the rehabilitation of degraded farmland, desertification control in agricultural production areas and restocking of productive forest estates. Greater emphasis was laid on the role of rural communities in reforestation, conservation and management. The international assistance and co-operation was of great help in the achievement of most of the envisaged targets with most remarkable results.

The forestry and environmental rehabilitation programs would continue in the same patterns with the prime objective of reducing the forest cover depletion trends towards positive increase in forested areas through wider involvement of the rural communities in integrated rural development programs (FAO, 2007).
The FNC provide technical assistance to local communities managing village and communal forests and to companies, organizations and individuals running private forests.

Many Non-Governmental Organizations adopted the concept of the participation and involving community in their afforestation programs (FAO, 1978). Among these NGOs the Sudanese Environmental Conservation Society (SECS), was established in 1975 as a national NGO. The overall objectives of SECS are environmental conservation and rehabilitation to achieve sustainable development, promotion of environmental awareness and law enactment in the context of community participation. In Khartoum State SECS have some programs that are concerned with afforestation aspects.

2. 13.2 National Service participation:

After signing the comprehensive peace agreement between the government of Sudan and SPLA, the efforts of national service of youth were oriented towards reconstruction, rehabilitation and development programs including afforestation practices. In Khartoum State the National Service afforestation program commenced in 2005 with a partnership of FNC. Activities carried out included seedlings distribution; tree planting on roads, houses, institutions, private and community forests and public spaces (Appendix11). In East Nile Governorate, the National service afforested some roads eg: El Gadafi street (325 seedling),
Elmaigoma street (300 seedlings) and Elsihreig street (130 seedlings) and the percent of success approached 82% (Kamalelden, 2007).

2.13.3 Afforestation in farm areas:

A wide range of production systems can be found ranging from household subsistence to large scale commercial farming. Crops grown by irrigated or rain fed in Khartoum State and intensive livestock production systems are operational within and around the city. Land currently allocated to agriculture account for 80000 ha (Dawoud et al, 2006). The policy and law of forest for 1989 advise that stipulation of setting side 10% of the land allotted in the rain fed sector and 5% in the irrigated sector for trees either to be left if they exist or in the form of shelter belts (El Houri and Murkaz, 1996). In agriculture lands the most use of trees as shelter belts.

2.14 Forest nurseries:

Both afforestation and reforestation may be carried out either by direct sowing or planting of nursery raised seedlings (El Houri et al, 1989).

A forest nursery is the place where seedlings are raised (Poloniemi, 1980).

Most afforestation in arid zones is done by planting nursery reared seedlings; only where the most favorable soil moisture conditions exist can trees be established by seeds sown directly in the field. Site selection, site preparation, seed sources, nursery practices and planting all come
within the scope of artificial regeneration. Forest nursery stock is produced to meet the demands of artificial regeneration; seedlings and transplants are raised for different planting sites and by different planting methods (Poloniemi, 1980).

**Nursery types:**

There are mainly two types of nurseries:

**Temporary nursery:**

It is planned to provide seedlings for only a few seasons and thus it requires small capital investments. It should be on the planting site near the center of the area to be planted.

**Permanent nursery:**

It is established to provide seedlings for a large area in which afforestation will be carried out over a period of many years. A large capital investment is needed to assure a steady rate of production of high quality planting stock, protection of nurseries from animals, diseases and insects (Goor and Barney, 1976).

**Seedling production and distribution:**

A National Tree Seed Centre (NTSC) was established in 1990 under the FRC with the objectives of providing seeds for the FNC afforestation and reforestation programs and resource conservation. The consumption of forest tree seeds was estimated as 135 tons per year and expected to reach 600 tons, shortly. *Acacia senegal* accounts for almost 65% of the present
seed use, followed by *Acacia nilotica*, *Acacia seyal*, and *Acacia mellifera*. The exotic species account for less than 10% of the present use (Appendix 8).

Seedling production in Khartoum State during the period 1995-2006 amounted to 4,771,201 seedlings; and distribution amounted to 2,642,666 seedlings.

### 2.15 Forest management:

All forests should be placed under management plans as soon as possible. It is recognised that data may be lacking and that because of the need to give priority to the reservation programme it may not be possible to collect all of the information required on which to base detailed prescriptions. Nevertheless short-term plans should be prepared, the essential features which should be integration of all land users and the function of the records associated with the plan to be repository for information and experience.

Four main areas related to people/forest relationships warrant special attention. The first is to assist local forest-dwelling communities to increase the range of livelihood-supporting options. The second is related to mainstreaming collaborative forest management between governments and local communities living near forests. The third is to make tree planting on farmlands more financially attractive. Agroforestry and tree planting have too often been subsistence focused. The final is to promote
production forestry for low-income urban centers or to make existing forestry activities more responsive to needs of urban areas with many poor people. The main issues relate to ensuring high productivity to compensate for high land costs near cities and identifying and strengthening institutions responsible for urban forestry (FAO, 2001).

2.16 Forest Inventory:
A forest inventory is the procedure for obtaining information on the quantity and quality of the forest resource and many of the characteristic of land area on which the trees are growing. Most forest inventories have been used for timber estimates. However, the need for information concerning recreation, water shade, wild life and non-wood values has stimulated the development of integrated or multi resource inventories (McClure et al, 1979). The emphasis placed on specific elements for measurement will differ with the purpose of an inventory (Husch, 1971).

Sampling techniques:
The size of sample plot usually varies directly with the stand under investigation. The size of the most efficient sampling unit depends on the variability and density of the stand and the cost (Spur, 1952). Plot shape such as circular, square, rectangular and diamond like are used in different countries for survey.

Temu (1990) stated that a statistical design of a forest inventory should be a relatively easy task if the population parameters and their estimates can
be clearly and unambiguously defined. The sampling design to meet inventory objectives is determined by the kind of sampling units, their size, shape, the number to be employed, the manner of selection and resultant distribution over the forest area (Stage, 1992). Systematic sampling, random sampling, strip sampling, cluster sampling, two stage sampling and sampling on successive occasions are common methods of distribution in forest sampling. Sampling is the most basic technique in choosing a representation for the population (Freeze, 1964.). Most plots shapes are circular, square, rectangular or triangular but circular plots are most commonly used. The sampling technique to be used in forest inventory varies not only with the purpose of the study but with kind of timber and forest produce and the geography as well (Spurr, 1952).
Chapter Three

Materials and Methods

3.1. Site:

The study area is situated in the eastern part of Khartoum State between 15°.33´- 16°39´N and 32°36- 34°25´ E with an area of about 79,995,933ha (Ministry of Physical planning, 2008). The total forest area is about 130,000 ha representing about 20% of the total grazing area (Appendex1).

Geological formation, topography and soils:

The dominant geological formation is the Nubian sand stone and the basement complex.

The eastern part of Khartoum State, where the study was conducted, is a flat plain with frequent undulation.

Soil types vary from Nile silt along the Nile banks to dark cracking clay plains bisected by depressions and seasonal water courses covered with pale yellowish- white coarse sand and small gravel.

Vegetation cover:

Ecologically the study area is classified as semi desert *Acacia tortilis-Maerua crassifolia* desert scrub and semi desert grassland on clay according to Harrison and Jackson (1958).
**Climate:**

The area is classified as semi desert zone with hot tropical climate. Climate is arid with an annual rainfall of 75 to 160 mm mainly falling during August and September. The average temperature ranges between 21.6°C in winter and 37.70°C in summer. Frequent dust storms blow after March.

**Demography:**

The most alarming problem in the study area is the increasing population pressure. The migration and displacement of the rural population seeking for better living conditions in urban areas resulted in increasing total population in Khartoum State. The state population, which was estimated as 800,000 in 1983, increased to 2,500,000 in 1990, 3,512,144 in 1993 (Muneer, 1996) and 4,997,000 in 2001 (FAO 2007). This means a 7.7% annual population growth rate which has resulted in a situation where about 13.7% of country population is residing in Khartoum State while it constitutes only about 1% of the Sudan total area (Muneer, 1996). In East Nile locality, the population is about 1,007,875 inhabitants, which represents 28.7% of the total population of the state.
3.2. Methods:

The study area was divided into three categories:

a/ Forests:

6 forests were selected as units to represent forest areas in the region:

Abudelaig, Um Sedaira, El Badrab, El Ferae Abu Shemal, El Samra and Wadi Soba (Appendix 1).

b/ Residential:

This division represents the residential sites both urban and rural areas; five units were selected: El Hag Yousef, Ailafoon, Kutranj, Um Dwanban and Keriab (Appendix 2).

Farms:

These usually have trees grown around it as shelters or wind breaks; four sites were visited: Dal Agricultural Scheme, Elselate south, Elwaha and Green crescent (Appendix 3).

The following variables were studied:

- Tree species.

- Tree density.

- Species frequency.

- Crown projection.

Sampling forest areas:

In each location selected, a base line was laid down using chain and compass survey (Appendix 4).
In each base line, line sampling was conducted systematically at specified distances from each other. These distances were different from one forest to another depending on the forest area and shape. Thirty sample plots were fixed at each site but the number of plots in each line differed according to the line length. Circular sample plots were laid down by tape (17.84 m radius) giving an area of 0.1 ha. In each sample plot, trees and/or shrubs were identified and enumerated.

**Sampling for residential areas:**

In residential sites the sample plots took a square shape (31.7×31.7 m) with an area approximately 0.1 ha (Appendix5).

**Farm areas:**

In farm areas trees are usually planted as shelter belts or wind brakes. Percent afforestation is around 2% in the Green crescent and Dal Agreicultural farms (Appendix6). In the other farms no plantations were established.

**Crown projection:**

Crown projections were estimated to give an indication of the extent of tree cover: Ten trees were selected subjectively for five main species. Then tape measurements were taken along two direction- maximum and minimum crown length to calculate the average crown projection.
Chapter four

Results and discussion

4.1. Tree species:

52 trees species and/ or shrubs were encountered in the study area (Table3). Out of this, seven species were found in both forests and residential sites: Acacia seyal, Acacia tortilis subsp radiana, Acacia tortilis subsp tortilis, Balanites aegyptiaca, Capparis decidua, Grewia tenax, Ziziphus spina-christi. In this group, Acacia tortilis subsp tortilis is more common in forest sites.

The number of tree species in residential areas is far greater than in forest areas because these include a lot of horticultural and ornamental species.

11 tree species were found in forest areas while 48 tree species were found in residential sites.

Acacia ehrenbergiana, Acacia mellifera and Acacia nubica are found only in forests.

Table 3: Tree/Shrub species encountered in the study area:

<table>
<thead>
<tr>
<th>Site</th>
<th>Latin name</th>
<th>Local name</th>
<th>family</th>
<th>forests</th>
<th>residential</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acacia ehrenbergiana (Hayne)</td>
<td>Salam</td>
<td>Mimosaceae</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Acacia mellifera (Vahl) Benth</td>
<td>Kitr</td>
<td>Mimosaceae</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Acacia nilotica (L.) Willd ex Del</td>
<td>Sunt</td>
<td>Mimosaceae</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>Acacia nubica Benth</td>
<td>Laoot</td>
<td>Mimosaceae</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Acacia senegal (L.) Willd</td>
<td>Hashab</td>
<td>Mimosaceae</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Acacia seyal Del</td>
<td>Taleh</td>
<td>Mimosaceae</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Acacia tortilis subsp radiana (Forsk) Hayne</td>
<td>Sayal</td>
<td>Mimosaceae</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>8</td>
<td>Acacia tortilis subsp tortilis (Forsk) Hayne</td>
<td>Samur</td>
<td>Mimosaceae</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>9</td>
<td>Adansonia digitata L.</td>
<td>Tabaldi</td>
<td>Bombaceae</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>10</td>
<td>Albizia lebbeck (L.) Benth</td>
<td>Dign Elbasha</td>
<td>Mimosaceae</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Latin name</td>
<td>Local name</td>
<td>family</td>
<td>Site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Forests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Annona senegalensis Pers</td>
<td>Gishta</td>
<td>Podocarpaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Azadirachta indica A.Juss</td>
<td>Neem</td>
<td>Meliaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Balanites aegyptiaca (L)</td>
<td>Hegilig</td>
<td>Balanitaceae</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Bauhinia rufescens Lam.</td>
<td>Kulkul</td>
<td>Caesalpiniaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 Capparis deciduas (Fosk) Edgew</td>
<td>Tundub</td>
<td>Capparidaceae</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 Cassia siamea Lam</td>
<td>Siamea</td>
<td>Caesalpiniaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 Citrus aurantifolia (Christm). Swingle</td>
<td>Lemon sweet</td>
<td>Rutaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Citrus limonia osbeck</td>
<td>Larenja</td>
<td>Rutaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Citrus limonia</td>
<td>Limon</td>
<td>Rutaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 Citrus paradisi Macfad</td>
<td>Grape fruit</td>
<td>Rutaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 Citrus sinensis (L.) Osbeck</td>
<td>Portagal</td>
<td>Rutaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22 Conocarpus erectus L.</td>
<td>Damas</td>
<td>Combretaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23 Conocarpus lantifolius Engl. and Diels</td>
<td>Damas</td>
<td>Combretaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 Cordia sinensis Lam.</td>
<td>Inderab</td>
<td>Borginaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 Delonix regia (Hock) Raf</td>
<td>Goldmor</td>
<td>Caesalpiniaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 Eucalyptus camaldulensis Dehnh</td>
<td>Ban</td>
<td>Myrtaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27 Ficus benegalensis L.</td>
<td>Labakh</td>
<td>Moraceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 Ficus benjamina L.</td>
<td>Labakh benjamina</td>
<td>Moraceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29 Ficus sycomorus L.</td>
<td>Gonmaiz</td>
<td>Moraceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Ficus religiosa L.</td>
<td>Labakh religiosa</td>
<td>Moraceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 Grewia tenax (Forssk) Fiorl</td>
<td>Gudam</td>
<td>Tiliaceae</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32 Hyphaene thbaica (L.) Mart,</td>
<td>Dom</td>
<td>palmaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33 Ixora coccinea L.</td>
<td>ixora</td>
<td>Rubiaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34 Khaya senegalensis (Des.) A. Juss</td>
<td>Mahogay</td>
<td>Meliaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 Lawsonia enermis (L.) Koehne</td>
<td>Henna</td>
<td>Lythraceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36 Leucaena leucocephala Lam</td>
<td>Leucaena</td>
<td>Mimosaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 Maerua crassifolia (Forsk) sarh</td>
<td>Capparidaceae</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38 Mangifera indica L.</td>
<td>Manga</td>
<td>Anacardiaceae</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latin name</td>
<td>Local name</td>
<td>family</td>
<td>Site</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>--------</td>
<td>------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morus alba L</td>
<td>Tot</td>
<td>Moraceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parkinsonia aculeata L.</td>
<td>Sesaban</td>
<td>Mimosaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peltophorum pterocarpum (D C) K. Heyne</td>
<td>Peltophorum</td>
<td>Mimosaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phoenix dactylifera L.</td>
<td>Nakhal</td>
<td>Palmaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pithecellobium dulce (Roxb) Benth.</td>
<td>Tamr Hindi</td>
<td>Mimosaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosopis glandulosa Torr</td>
<td>Mesquite</td>
<td>Mimosaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psidium guajava L.</td>
<td>Gauva</td>
<td>Myrtaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Punica grantum L.</td>
<td>Roman</td>
<td>Punicaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salvadora persica L.</td>
<td>Arak</td>
<td>Salvadoraceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tamarindus indica L.</td>
<td>Aradeib</td>
<td>Caesalpinaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminalia catappa L.</td>
<td>Brazilia</td>
<td>Combretaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thevetia thevetiodes (Kunsth.) Schum.</td>
<td>Thevetia</td>
<td>Apocynaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washingtonia robusta H.A.Wendl.</td>
<td>washingtonia</td>
<td>Palmaceae</td>
<td>- +</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ziziphus spina-christi (L.) Desl.</td>
<td>Sidr</td>
<td>Rhamnaceae</td>
<td>+ -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+= Present  
-= Absent

**4.2. Tree density:**

Based on our samples, density of trees and shrubs varied within a site and between two sites, although, this difference is not significant. Density ranged between 54 and 427 trees/hectare in forest sites and the average reached about 189±13 trees/ hectare (Table4) whereas the values ranged between 17 and 188 trees/ hectare in residential sites giving an average of about 81±10 trees/ hectare (Table5).
During 2005 and 2007 the total areas afforested 2950 feddans. Abu delaig, Elfaree Abu shemal, El Badrab and were afforested extensively by different species which were planted in response to the concerns about drought mitigation and environmental benefits. But most of these programmes were not successful due to mismanagement and overgrazing (Appendix 7).

Table 4: Tree density in forests:

<table>
<thead>
<tr>
<th>forests</th>
<th>Tree (N/ha)</th>
<th>Number of species</th>
<th>Afforested areas (feddans)</th>
<th>Nature of species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu delaig</td>
<td>78</td>
<td>4</td>
<td>350</td>
<td>Medium trees and shrubs</td>
</tr>
<tr>
<td>Elfaree Abu shemal</td>
<td>151</td>
<td>6</td>
<td>250</td>
<td>Big trees and shrubs/new regenerations</td>
</tr>
<tr>
<td>Um Sidaira</td>
<td>67</td>
<td>5</td>
<td>-</td>
<td>Big trees and shrubs/ scattered trees.</td>
</tr>
<tr>
<td>Alsamra</td>
<td>54</td>
<td>3</td>
<td>-</td>
<td>Big, medium trees and shrubs/converted to residential satlements.</td>
</tr>
<tr>
<td>Wadi Soba</td>
<td>427</td>
<td>3</td>
<td>-</td>
<td>Big, small trees and shrubs/ water courses</td>
</tr>
<tr>
<td>El Badrab</td>
<td>355</td>
<td>8</td>
<td>200</td>
<td>Medium/ Small trees and shrubs/ water courses</td>
</tr>
<tr>
<td>Average</td>
<td>189</td>
<td>-</td>
<td>800</td>
<td></td>
</tr>
</tbody>
</table>
Table 5: Tree density in residential sites/ha:

<table>
<thead>
<tr>
<th>Residential Units</th>
<th>Tree (N/ha)</th>
<th>Number of species</th>
<th>Species nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>El haj Yosif</td>
<td>188</td>
<td>33</td>
<td>Roadside afforestation, School afforestation</td>
</tr>
<tr>
<td>El Ailafon</td>
<td>127</td>
<td>39</td>
<td>Poor roadside afforestation</td>
</tr>
<tr>
<td>Kutrang</td>
<td>36</td>
<td>24</td>
<td>Roadside afforestation indigenous species.</td>
</tr>
<tr>
<td>Um Dawan Ban</td>
<td>35</td>
<td>23</td>
<td>Indigenous species</td>
</tr>
<tr>
<td>El Kriab</td>
<td>17</td>
<td>12</td>
<td>Poor afforestation</td>
</tr>
<tr>
<td>Average</td>
<td>81</td>
<td>_</td>
<td></td>
</tr>
</tbody>
</table>

In forest areas the highest species density (130±7 trees) was shown by *Acacia tortilis subsp tortilis* (Figure1). In residential site the highest species density (15±3 trees) was shown by *Albizia lebbeck* (Figure2).

![species density in forest areas](image-url)

Figure 2: species density in forest areas:
Figure 3: species density in residential sites:

4.3 species frequency:

The frequency of each species was recorded as it appeared in the sample units. *Acacia tortilis subspp tortilis* is the most frequent species in forests (Figure 3). It is likely to be of natural origin, while the most frequent species in residential sites is *Azadirachta indica* (Figure 4). This indicates that it was planted. These species are frequently used in afforestation programmes.

In residential sites *Azadirachta indica* has the highest frequency where as *Albizia lebbeck* has the highest density.
Figure 4: Species frequency in forest areas:

Figure 5: Species frequency in residential sites:
4.4 Crown projection:

The crown area indicates the ability of the trees to cover the ground. Crown projection area is important because of the protection it affords for the soil against erosion, production of fodder and shade. Based on dominant species in both sites crown projection ranged between 4.35 and 25.71 m² (Figure 5). Crown projection is affected by different factors like availability of water, grazing and cutting. Deciduous species are recommended for planting where the water is rare; and evergreen species are recommended where the water is available.

![Bar chart showing crown projection for different species](image)

**Figure 6: crown projection:**
Chapter Five

Conclusion and recommendations

The study revealed the following:

The total forest area in East Nile locality is 70960 ha which represents approximately 8.9% of governorate area and 54.12% of total forest area in Khartoum State.

The areas afforested in forests during the last 4 years are 2950 feddans representing 36.8% of afforestation in Khartoum forests.

The species commonly found in natural forests are *Acacia tortilis sub species tortilis*, representing 68.78% of tree density in forest areas.

The species commonly planted in residential sites is *Azadirachta indica* representing 17.28% of tree density in residential sites.

Tree species in residential sites are far greater than in forest areas.

Crown projection spread is highest for *Azadirachta indica* followed by *Albizia lebeck, Acacia tortilis ssp radiana, Acacia tortilis  ssp tortilis and Acacia ehrenbergiana*.

**Farm forests:**

Afforestation in farms (farm forestry) represents a very low percentage (2%) of the farm areas. Moreover only two farms out of five farms planted trees around or within the farm. Altogether the farm areas afforested were 78 feddans out of 4200 feddans.
Recommendations:

1- In compliance with the forest ordinances and environmental laws, forest areas should be maintained and increased progressively to the stated 25% of the states area.

2- Khartoum North Governorate should be protected with a network of shelterbelts to protect it from desertification.

3- More attention should be paid to urban forestry, farm forestry and natural forest lands in the governorate.

4- National services and Non-Governmental Organizations should be involved with the Forest National Corporation in afforestation activities.

5- Implementing the forest laws to minimize illicit tree felling.

6- Rehabilitation of degraded forest lands.

7- Strict measures should be taken to combat desertification hazards.
References


Dawoud, H.D., Kamal, E., Jens, G. and Andreas, B. 2006. The status of urban and pre-urban agriculture in Khartoum state, Sudan.


Extension and Afforestation Department 1998. Annual report, FNC.


FAO. 2008. Consultancy on the Food Security and Self-Reliance for the IGAD Partner Forum Working Group “Planning for Peace”.

http://jam.unsudan.info.


Freez, F. 1964. linear regression methods for forest research USDA.


Husch, B. 1971. Planning a forest inventory. FAO. Forestry and forest products studies.


Ministry of Agriculture, Irrigation, and Animal Welth. 2007. Annual reports.


Nana, Sinkam. S.L. 1995. Land Environmental Degradation and Desertification in Africa. FAO.


Plan of Action to Combat Desertification.

UNSO 1993. Sustainability of the Afforestation and Reforestation Project in the
Northern State, Sudan.

World Bank 1985. Desertification in the Sahelian and Sudanian Zones of West

كمال الدين محمد مبروك. 2006. تقرير عن برامج التشجير الحضري بمحلية شرق النيل.
الأدارة العامة للتخطيط العمراني والزراعة. إدارة الموارد الطبيعية.
APPENDIXES
Appendix 1: Distribution of Sample plots in forests:

<table>
<thead>
<tr>
<th>forests</th>
<th>Area( fedd)</th>
<th>No. of base line</th>
<th>No. of sample plot line</th>
<th>No. of sample plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abu deleig</td>
<td>453.73</td>
<td>1</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Wadi Soba</td>
<td>1507.51</td>
<td>1</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>El Badrab</td>
<td>430</td>
<td>1</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Um sedaira</td>
<td>3227.44</td>
<td>1</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Al samra</td>
<td>1981.27</td>
<td>1</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Elfaree Abushemal</td>
<td>2700</td>
<td>1</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>total</td>
<td>10299.95</td>
<td>6</td>
<td>41</td>
<td>180</td>
</tr>
</tbody>
</table>

Appendix 2: Distribution of sample plots in residential sites:

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of base line</th>
<th>No. of sample plot line</th>
<th>No. of sample plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elalafoon</td>
<td>1</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Elhaj Yousef</td>
<td>1</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Umdawan Ban</td>
<td>1</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Kutrang village</td>
<td>1</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td>Ceriab village</td>
<td>1</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>26</td>
<td>150</td>
</tr>
</tbody>
</table>

Appendix 3: Tree plantations in Farm areas:

<table>
<thead>
<tr>
<th>Project</th>
<th>Area (fedd)</th>
<th>Area of plantations (fedd)</th>
<th>Tree species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elselate south</td>
<td>12890</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elwaha</td>
<td>9000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Alban Koko</td>
<td>4000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Green crescent</td>
<td>3200</td>
<td>60</td>
<td><em>Eucalyptus camaldulensis</em></td>
</tr>
<tr>
<td>Dal Agricultural Scheme</td>
<td>1000</td>
<td>18</td>
<td><em>Acacia formosa</em></td>
</tr>
</tbody>
</table>
Appendix 4: Sampling forests areas:

Appendix 5: Sampling residential areas.
Appendix 6: Plantations in farm areas:

Appendix 7: Afforestation by water harvesting in Abudelaig forest:
Appendix 8: Seedling production (umdawan ban nursery).

Appendix 9: Participation of National services in afforestation programes