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Impact of Agricultural Mechanized Rainfed Scheme Expansion and Human Intervention on Natural Forests–Case Study: Upper Nile State, Southern Sudan

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ABSTRACT

This study was carried in northern Upper Nile State. The main objective was to study the impact of Agricultural Mechanized Rainfed Scheme Expansion on Natural Forests and human intervention affecting natural forests in the area; it was focused on vegetation cover, distribution and density. According to the differences in woody cover, which include quantity, type, density and the differences of the factors affecting them, the area was subdivided into five strata, for ease of study: First stratum includes the areas of agriculture schemes, (Goz Rom, Goz Fami and ElDola schemes); second stratum includes around the villages, (El Gagier, Renk, Shomidi, Gelhak, Palouge and Melut); third stratum comprises charcoal and gum production areas (around Gelhak); fourth stratum comprises Manpyok area in southeast Gelhak; and fifth stratum comprises Palouge and Adar Yale area. The method of simple randomized sampling of vegetation cover was specifically directed to the wood strata. A 100 x 100-m quadrate was laid at random on selected sites. Also, a questionnaire was prepared for data collection and the main target groups were foresters and those who are related to natural forests, such as charcoal makers, fuel wood cutters, nomads, gum producers, farmers, wildlife officers, and stockholders; 72 respondents were interviewed. There were expansion of mechanized rainfed schemes, traditional rainfed (shifting and monocropping), overgrazing (cutting, lobbing and bending) of *Acacia seyal*, illegal cutting of *Acacia seyal* and other species for firewood and charcoal production, overtapping in traditional ways, setting uncontrolled fires in the natural. Also, the study found that there were changes in vegetation cover and tree species. *Acacia seyal*, *Balanites aegyptiaca* and *Acacia senegal* disappeared in many areas. They have been replaced by *Acacia mellifera*, which become a dominant species in the study area. The results recommended that to mitigate the impact of these factors and utilize natural forests in a sustainable way, the integration and coordination between sectors should be achieved for better planning, implementing, and evaluating the resources.

Key words: Gelhak, Mechanized rainfed, Natural forests, Renk.

1. Introduction

Forests have an important multifunctional role for society, many people derive their income from various combination of the three form of land use, agriculture, grazing and forest exploitation, but the traditional pattern of land use have been profoundly changed by population growth. They also have a major value for nature conservation and play an important role in preserving the environment (Joseph, 1948). Before separation of South Sudan, 1500 forest trees and shrubs species, subspecies and varieties are recorded in the country. Of these, over 100 species are exotic, some of which are considered as naturalized. Acacias are the most widespread forest species that comprise more than two thirds of the forest flora. The separation of South Sudan in 2011 has major effect on the forest cover and diversity in Sudan as South Sudan is the richest in forest biodiversity. At present, 62% of the Sudan is desert and semi-desert and 88.1% is classified as drylands. During the last 110 years, the forest cover declined from about 40% to 10% and the tree cover in the humid and sub humid areas also declined from

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29.3% to 7.6% during the same period. In addition, the rate of afforestaion and reforestation in Sudan is far behind the rate of tree felling, 105000 vs 545414 ha (1,301,970 feddans, 1 feddan = 0.42 ha), (HCENR, 2014). Forest plays an important role for human well-being in many aspects and its multiple uses include non-wood forest products, recreation, soil and watershed protection, hunting, biological conservation and other goods and services. The Natural forests areas have been altered irrevocably by human intervention such as agriculture, grazing, commercial fuel wood harvesting and charcoal-making. The forests make up one of the earth's greatest reservoirs of renewable natural resources. If they are managed properly; they can provide essential products indefinitely and at the same time they can remain a home for wildlife and vital sources of water supplies.

As human population increases, the demand for forest resources will also increase. The challenge to forest managers is to provide a supply of forest resources that meet these projected demands and to increasingly implement the multiple-use concept on lands not restricted to a dominant or single use (FAO, 1993). Wood is the main source of energy used by individual in dry tropical zones as it accounts, in most cases, to over 85% of their energy sources. Population growth has thrown the ecosystems into turmoil. Burning charcoal, gathering fuel wood, rainfed agriculture expansion, over grazing, bush fires, over tapping and extraction of other forest products such as honey and bush meat from natural forest have intensified around large towns and villages, however, it is becoming increasingly difficult to acquire forest products, particularly around large towns and villages, and therefore, it has to be sought further away (Madon, 1999).

Modern rainfed agriculture of using tractors and disc harrows and sometimes mechanical harvesters is found in this semi–arid part of the clay plain. The drastic impacts of clearance of woodlands for field crop production, overexploitation of natural woodlands for charcoal and fire wood production, rangelands degradation due to increase of livestock population within the area, were the main reasons for the choice of selecting the study area. Understanding of deforestation and its impacts on plants composition, density, tree cover and its influences on micro-climate (rain, temperature, relative humidity, radiation and wind), field crop yields and woodlands productivity is essential. In the tropical forests of the world, the clearing of land for agriculture and livestock are the primary activities resulting in deforestation (Anderson, 1990).

The cutting of woods by pastoralists and cultivation are also major causes of deforestation in Sudan. Vegetation is harvested for feed, to build homes and enclosures for animals and for fuel. In the absence of the forests, the micro-climate is invariably more arid and the dry season more accelerated with a probable reduction in the total rainfall. Overgrazing occurred in Sudan for centuries, but it is assumed a wide scale and acute intensity only during the past few decades (Khairalseed, 2015). The natural forests in Northern Upper Nile state were subjected to heavy damage and these are the same factors affecting them: intensive charcoal production and gathering of fuel wood, petroleum mining and construction activities (roads, pipe line, wells etc.), agricultural rainfed schemes expansion, over grazing, fire setting, and over tapping.

Rainfed agriculture started in 1952 as slash and burn on small scales around the villages, from 1952 to 1969, Umm Dolieb agriculture scheme was established as the first mechanized rainfed schemes, it was an experimental scheme owned and administrated by the government with cooperation of local people (Ajawin, 2006).

From 1960 to 1970, private sector agriculture schemes started when more than 50400 ha (120,000 feddans) were demarcated and distributed to some pioneer farmers who administered the schemes. In 1970 Renk Mechanized Farming Corporation and El Doula Schemes was established as a branch administration of Mechanized Farming General Corporation, which was under umbrella of the rainfed agriculture administration in Sudan. Between 1960 and 1970, the productivity of agricultural rainfed crops extended into undemarcated surveyed lands. Currently there are 10 schemes in Eastern area namely, Goz Rom, Goz Rom extension, Akon, Umm Dullwis, Ataham, south Shomidi, El Dola and East Umm Dullwis. More than 1416666 ha forest lands were cleared without replanted, presently a total of 655293 ha are under cultivation, (MFC El Renk, 2007). There is no crop rotation and fertilizers applied, also there is no shelterbelt and windbreak around schemes. The area is completely clear felled particularly northward, which lead to land degradation, reduction in crop yield and declining of some trees species in the area (Adam, 2007).

The objectives of this study are to: 1) assess the impact of mechanized agricultural rainfed scheme expansion on natural forests, 2) study the cumulative effects of multiple human activities on ecosystem function, and 3) evaluate the extend and side effect of these impacts on the natives and ecosystems.

1.1 Forest in South Sudan

In South Sudan, forests and woodlands cover approximately 29% of the total land area and comprise mainly of tropical forests of mahogany and teaks in the south and acacia woodlands in the north (Omoro, 2012).

Upper Nile State have up to sixteen forest reserves totaling to 22518 ha as economic activity expands in many areas as a result of clamp in security situation, these forest resources are under threat of being inefficiently managed and exploited, **threats include;** expansion of agricultural schemes areas, most of which livelihood depend on commercial **forest** exploitation (Mohamed, 2016)**,** and **demand for construction materials, fuel wood and charcoal.** Biodiversity had decreased due to these human activities, both in terms of vegetation and wildlife in turn lead to transformation of an area from forest to terrain with little vegetation (Hamel, 2019). Degradation of soil quality was a threat also to farmers because of erosion, and possible soil compaction caused by mechanized farming.

Forestry activities are still dominated by exploitive utilization under low management intensity combined with no annual work plans. The commercial selling and domestic utilizing of forest products are now the last resort of income for many local households when agricultural and livestock income-generating opportunities are declining. The damaging forest income-generating activities include charcoal burning, firewood collection, wrongly conducted gum Arabic tapping and collection, fodder, hunting, pod collection, and collection of leaves and fruits.

Table 1 explains the number of sacks of charcoal produced and transported outside the area, 1997-2006. The charcoal production within this period was very intensive due to return of the native to the area after war. This policy played a negative role as environmental element. Furthermore, traditional charcoal burners are not aware of the impact of their activities on the natural environment; they cut trees in traditional ways, which prevent trees to regenerate or recopied. Also, there is shortage of trained staff to manage the resources sustainably. There is also a lack of means of transportation and supervision of vehicles.

Table 1. The number of sacks of charcoal (50-70 kg) produced and transported outside the area, 1997-2006.

Year	Number of charcoal/sacks
1997-1998	398,175
1998-1999	186,474
1999-2000	298,114
2000-2001	254,246
2001-2002	120,687
2002-2003	No records
2003-2004	302,600
2004-2005	725,250
2005-2006	4,235

2. Materials and Methods

2.1. Study Area

The study was conducted at Northern Upper Nile State at Southern Sudan, which covers a total area of 648051 km^2 about one quarter of Sudan's total area. It lies between latitudes 3^o 5' N and 12^o45' N and longitudes 23^o.5' and 36' E. It is a large basin, gently sloping down northwards, through which the Nile flows from Uganda (Odara et al., 2004). The Northern Upper Nile State area lies between latitude 10^o27' N and 12^o45' N and longitude 28^o 5' and 35^o E at an elevation of 380 m above the sea level. Its area is approximately 165078883 ha. It borders Blue Nile to the northeast, southern Kordofan to the west and northwest, and the White Nile state to the North. Generally, the area extends from the Joda (Wanthaw and Kuak) in the north to Melut and Kaka in the south (Garang, 1991). Northern Upper Nile State area situated in the semi-arid zone of the Sudan with two distinct seasons: rainy season (wet) May-October and dry season November-April. The area varies in temperature, relative humidity, rainfall and solar radiation due to season (dry or humid) and wind directions. Winds prevail from different directions at different times of the year. The northeast or northerly and northwest trade winds of moderate velocity prevail during winter, whereas the south and southeast winds prevail during fall.

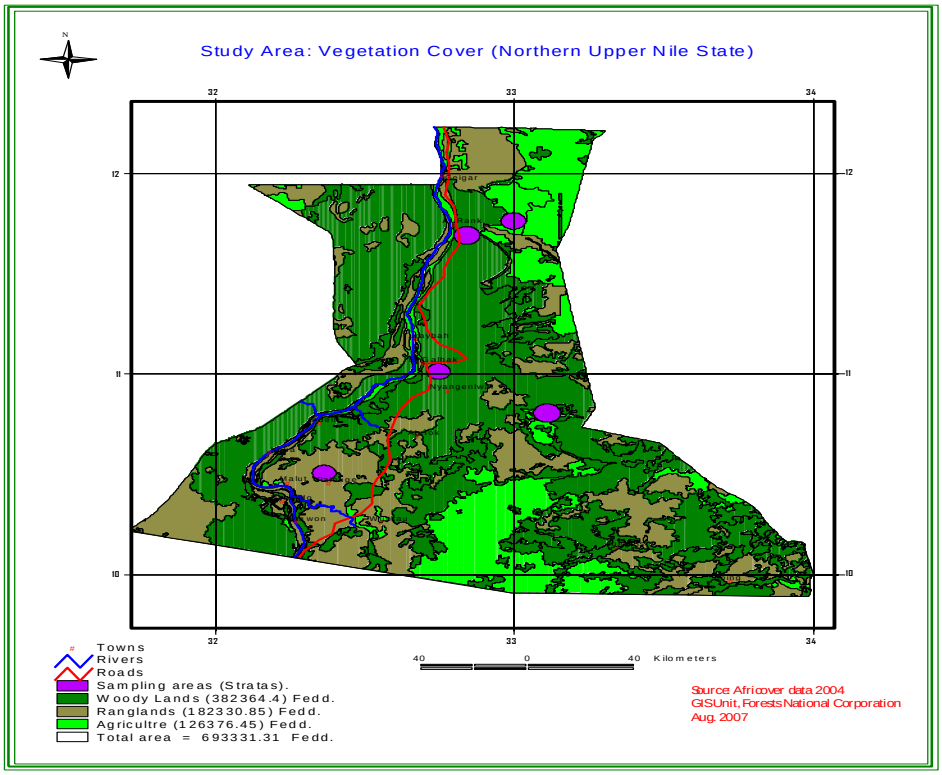

Figure 1. Vegetation cover in the study area

2.2. Methods

2.2.1. Measurements

The method of simple randomized sampling of vegetation cover was specifically directed to the wood strata. 100 x 100 m quadrates were laid at random on selected sites. The total area was divided into five strata according to vegetation cover and factors affecting the natural forests, see Figure 1. These strata are:

a. Northern area, which includes areas of mechanized agricultural rainfed schemes (North East Renk town).
b. Around villages strata.
c. Area of charcoal, fuel wood, gum tapping, grazing animals (Gelhak).
d. Undisturbed area. Manapyok.
e. Petroleum wells area (Palouge and Adar Yale).

Forty 100x100-m quadrates were used in four strata, 10 quadrates, each to present the vegetation cover in each area. Tables 1, 2, and 8 illustrate sample of data collected in the 100 x 100-m quadrates.

2.2.2. Questionnaire

A questionnaire was prepared for data collection. The main target groups were foresters and those who are related to natural forests, such as charcoal makers, fuel wood cutters, nomads, gum producers, farmers, wildlife officers and stockholders. These sectors usually use forest and rangeland for cutting trees for many purposes, such as charcoal and fuel wood, cultivation, grazing, lobbing, and bending trees for domestic animals. And the questionnaire was aim to answer the following questions.

-What is the most useful species in the area?
-What were the conditions of natural forest in the last thirty years?
-What is the condition of natural forest at the present?
-What are the causes of natural forest degradation?

A total of 72 respondents were interviewed, representing (0.15%) of the entire estimated population of Northern Upper Nile State (Renk, Gelhak) (72/49.000 x 100 = 0.15%), 72 = respondents, 49.000 = population.

The questionnaire forms were used for the impacts of some factors affecting natural forests and

socio-economic assessment amongst the professional staff from forestry, agriculture, wildlife, veterinary department, and the forest dealers. The Potential respondents were as follows:

- Natural resources managers and local administrators (44%), which include foresters, wildlife officers, agriculturists, and the local government officials.
- Forest products makers (50%), which includes charcoal burners, gum producers, fuel wood gathers and other forest products dealers.
- Farmers and nomads (6%), which includes traditional farmers. semi and mechanize farmers and nomads.

2.2.3. Interviewees

Interviews were carried out by the staff of natural resources departments of forestry, agriculture, wildlife, veterinary, and fishery.

2.2.4. Observations

Observations were obtained during field visits, which were carried out between May and June.

2.2.5. Literatures

Secondary data were obtained from archives, Internet, and report of the previous study. These secondary data were used as a source for comparing the changes in vegetation covers.

2.2.6. Data Analysis

The data were analyzed with statistical package of social sciences (SPSS) software, the analysis of data were on land vegetation cover, main factors affecting natural forest, cropped areas and their yield. The statistics obtained were used for finding extent of degradation, the statistic of normalization data, descriptive data, charts, graphs were drawn using the same statistical software. Also, frequency and percentage of variable was calculated.

3. Results and Discussions

3.1. The Impact of Rainfed Agriculture on Natural Forest

Measurements and field observations revealed that there were environmental problems in the area, because the large areas of woodlands were clear-cut for agricultural crop production and selective cutting of trees for charcoal burning, and fodder looping for domestic animals, there is no protection of reserve areas from outside aggression. Accelerated population increase in agricultural areas combined with appropriate farming systems impacted the ecosystem. The pastoral land was converted to agricultural scheme, these results agreed with (Madon.1999). Some of the native trees and wildlife species disappeared from the area, especially around the towns like Renk. The dominant species in this stratum is *Acacia mellifera* made up to 66%, associated with other species in and around water courses. *Acacia seyal*, which found in this stratum are in small sizes and wild fruits species such *Balanites aegyptiaca* disappeared in the area. In general, there was a change in vegetation cover (Table 2 and Figure 3). Therefore, agricultural scheme now are completely clear-cut and all the tree cover removed especially in the northern parts of the area. The remaining tree species are found in small patches around water courses and lowlands, which are not suitable for agriculture schemes. These species are dominated by *Acacia mellifera* (40%)(Table 2 and Figure 2).

Table 2. Number of trees and shrubs of 100x100 m Quadrate agricultural schemes areas, Doula and southern Atahm

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total	%
Acacia seyal var. seyal	1	0	2	0	0	20	8	19	23	26	97	14
Acacia senegal	0	0	0	0	0	6	3	8	5	3	25	3.6
Acacia mellifera	7	3	0	0	0	56	84	97	11	15	273	40
Acacia nilotica	1	0	0	1	0	27	17	21	0	0	67	9.7
Anogesissus leocarpus	0	0	0	0	0	0	0	0	3	10	13	1.9
Balanites aegyptiaca	0	0	0	0	0	18	23	27	17	9	94	14
Combertum glutinosm	0	0	0	0	0	0	11	7	10	9	37	5.4
Ziziphus spina-christi	0	0	0	0	0	3	11	15	0	5	34	4.9
Grewia tenax	0	0	0	4	0	11	5	4	0	0	24	3.5
Cordia sinensis	0	0	0	0	0	0	0	5	7	11	23	3.3
Tamarindos indica	0	0	0	0	0	0	0	2	0	1	3	0.4
Total	9	3	2	5	0	141	162	205	76	89	690	100

Q1-Q10=quadrate 100 x 100 m for trees and shrubs measurement

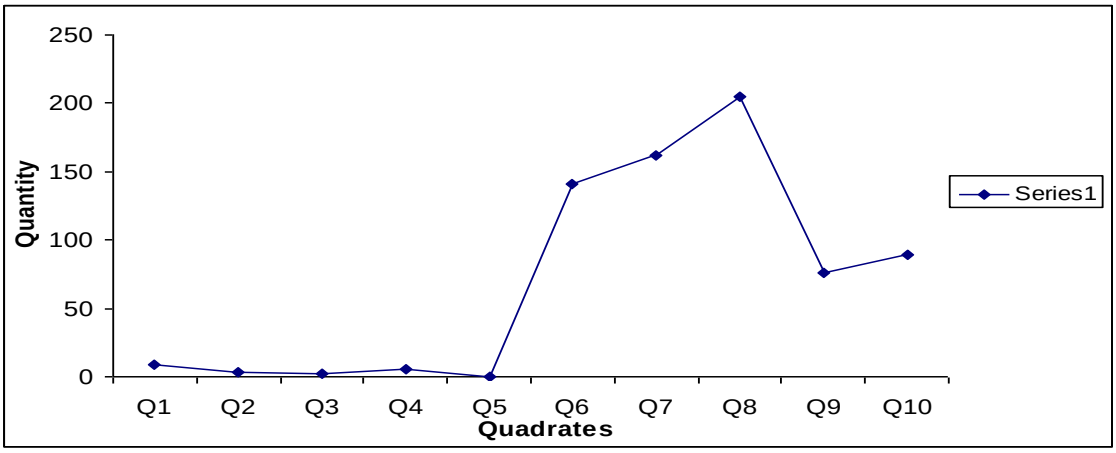

Figure 2. Amount of trees and shrubs in 10 Quadrate of Agricultural Area

The horizontal expansion of mechanized farming exhausts the soil very rapidly, particularly in the areas where tree cover were clear-cut (Adam. 2015). Such as EL Dola and Goz Rom, where the land is depleted within 3-4 years by this large scale of monocropping and shifting cultivation, so the yields of sorghum, sesame and millet decreased in degraded land (1-3 sacks instead of 6-8 sacks per feddan (0.42 ha)). This reduction in production led the farmers to move southwards. The respondents answered that the mechanized rainfed agriculture was the second cause of natural forests degradation in the area, but in the northern parts of the area mechanized rainfed agriculture was the main cause of degradation followed by illegal cutting for charcoal burning. The expansion in mechanized farming had been changed in acquiring of land. This agreed with Anderson (1990) who stated that the clearing of land for agriculture and livestock are the primary activities resulting in deforestation. The number of trees is decreasing in northern quadrate (agriculture schemes areas) and petroleum mining influenced areas, and is increasing in southern parts (utilized areas).

3.2. Impacts of Illegal Cutting on Natural Forests

Charcoal burning and firewood business have become a dominant commercial activity in the study area, because these commodities have currently fetches high prices locally and outside States, especially in the Northern States such as Khartoum and Gezeira. This led to the attraction of traditional charcoal burners from other states such as Darfur into this area for charcoal production, therefore, the figures were continuously on rise due to new settlers in the area. Charcoal burners and firewood gatherers start their activities in November immediately after rainy season and continue till beginning of the next rainy season; number of producers (burners) increased and competition became higher. Some of the charcoal burners start spending the rainy season inside the forests; they just cut trees, store them till the beginning of dry season.

Table 3. Trees and shrubs of 100 x 100 m quadrate, undisturbed area (Manopyok)

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total	%
Acacia seyal var. seyal	159	226	242	183	197	150	201	193	210	156	1917	88
Acacia Senegal	1	0	0	2	7	0	0	3	12	7	32	1
Acacia mellifera	6	3	11	9	5	11	7	4	8	3	67	3
Balanites aegyptiaca	19	6	0	8	9	20	7	25	19	8	121	6
Ziziphus spina-chriti	11	0	5	10	0	4	4	6	0	2	42	2
Total	196	235	258	212	218	185	219	231	249	176	2179	1000

Q1-Q10 =quadrate 100 x 100 m for trees and shrubs measurement

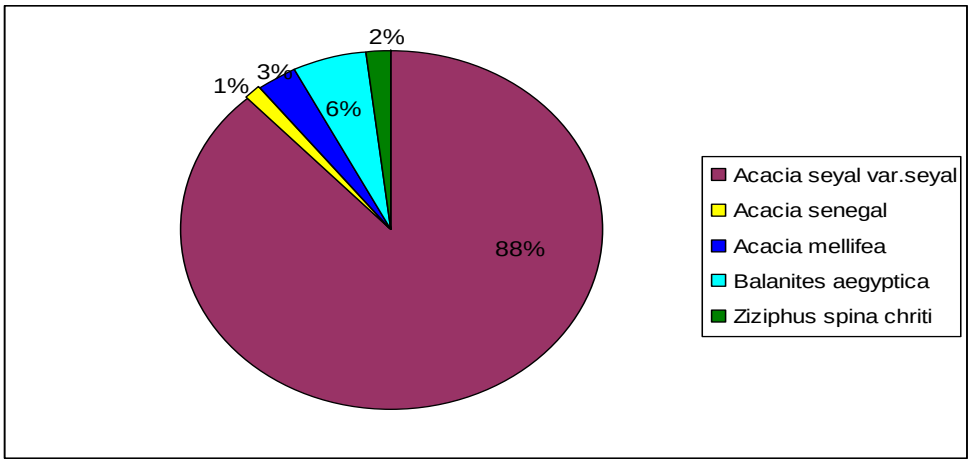

Figure 3. Trees and shrubs of 100 x 100m quadrate, undisturbed area (Manopyok)

The consumption is very high in this area because the majority of the inhabitants use charcoal as the main source of domestic energy, but most of production is exported to the northern states such as White Nile, Gazira, and Khartoum for generating income. Inhabitants practice charcoal production as source of income to improve livelihood standard. They start selecting big size of *Acacia seyal* nearby, but due to scarcity and declining of the usually used trees species for charcoal production, burners have now started to cut the important trees species such as *Balanites aegyptiaca*, *Acacia senegal* and *Anogissus leocarpus* even the remain small size in diameter of *Acacia seyal* are clear-fallen. Therefore, *Acacia seyal* and *Balanites aegyptica* declined around the settled areas, compared with the undisturbed area (Manpyok), in which *Acacia seyal* is the dominant tree species (88 %) (Table 3).

In 2004, the traditional charcoal burners were located at distances over 80 km from Renk town to southward (Onak, 2004). Now they are located in Manpyok area, which is located in about 150 km from Renk, in South Eastern Gelhak, or in the area between Karrow and Paloch. In spite of directions from authority, even local governments are neglecting the conservation of natural forests and need more revenue. Charcoal and firewood was a source of financing, which is province divided as follows: 20% for FNC, 20% for County, 20% for FNC Headquarter in Khartoum for forest conservation and 40% for the Ministry of Finance of Upper Nile State. Therefore, state governors approved the entrance of charcoal burners and continuous burning charcoal.

3.3. The Condition of Natural Forests in the Past

Concerning the condition of natural forests during the last 30 years and present, 72 persons were questioned and 94.4% of the responded that the natural forests was vigorous in the area and extremely covered with *Acacia seyal* stand associated with *Balanties aegyptic,. Acacia senegal and Anogesissus leocarpus.* But 5.6% of them answered that the natural forests were moderately vigorous (Table 4). This agreed with the study of (MFC Renk. 2007). More than 1416666 ha (3.500.000 feddans) of forest lands were cleared but not reforested, while a total of 655293 ha were under cultivation, presently

Table 4. Conditions of natural forest in the last thirty years

S/No	Condition	Frequency	Percent
1	Vigorous	68	94.4
2	Moderately vigorous	4	5.6
3	Weakly vigorous	0	0
	Total	72	100

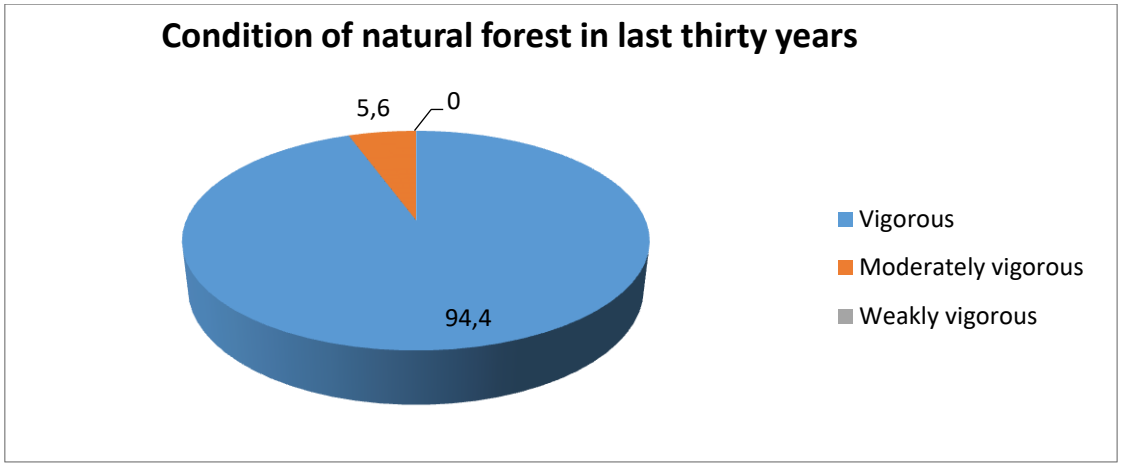

Figure 4. Condition of natural forest in last thirty years

3.4. The Present Condition of Natural Forests

Concerning the condition of natural forests at present, 72.2% of respondents answered that forest is decreasing and it dominated by *Acacia millifera*, which agreed with what was found in measurement that the percentage of *Acacia millifera* is very high. While 18% respondents answered that forests were moderate and 7% of them reported that natural forests disappeared. But 2.8% respondents responded that forests were vigorous (Table 5). This is consistent to that stated by Adam (2007).

Table 5. Condition of natural forests at the present

S/No	Condition	Frequency	Percent
1	Vigorous	2	2.8
2	Moderate	13	18.0
3	Less than before	52	72.2
4	Disappeared	5	7.0
Total		**72**	**100**

3.5. The Most Important Species in the Area

Concerning the most important tree species, which is in danger, 59.7% of the respondents answered that the *Acacia seyal* is the most important tree in the area and its major uses are charcoal making, firewood, smoking bath, fodder for livestock, building poles, gum, social and environmental benefit such as shelter and watershed protection. *Balanties aegyptiaca* and *Anogissus leocarpus* (9.7%) are used for charcoal making, building poles, and preventing soil erosion (Table 6).

Table 6. The most useful species in the area

S/No	Condition	Frequency	Percent
1	*Acacia seyal*	43	59.7
2	*Acacia senegal*	15	20.8
3	*Balanites aegyptiaca*	7	9.7
4	*Anogesissus leocarpus*	7	9.7
	Total	72	100

3.6. Causes of Forests Degradation

Concerning the causes of forest degradation, 54.2% of the respondents answered that the deterioration of natural forests in the area were caused by multi-practices of human, especially illegal cutting for charcoal making and firewood, followed by setting fires 16.7%, which destroyed seeds and young generation. But in the northern parts of the area, it is affected by rain fed scheme expansion (Table 7). This agreed with the study done by Anderson (1990) and Khairalseed (2015). The clearing of land for agriculture and livestock are the primary activities resulting in deforestation. Also, as the habitat deteriorated, most of wild animals migrated to undisturbed southward habitats, therefore, most of them disappeared in the north. Similar results were obtain by Adam (2015) and Kak (2017) and Omoro (2017).

Table 7. Causes of natural forests deterioration

S/No		Frequency	Percent
1	Agricultural Rainfed	9	12.5
2	Illegal Cutting	39	54.2
3	Over-grazing	7	9.7
4	Fire	12	16.7
5	Tapping	5	6.9
	Total	**72**	**100**

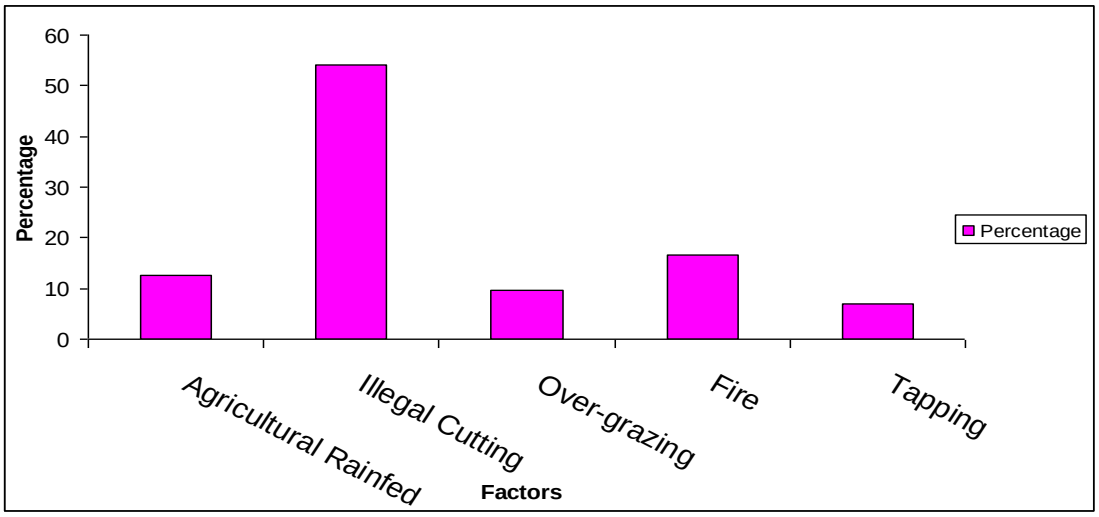

Figure 3.6 Causes of forests degradation in the study area

3.7. Field Observations and Predicted Changes and Impacts

During field visit many observations were recorded. These included that number of trees species declined in agricultural schemes area, wild fruits trees such as *Balanites aegyptiaca and Ziziphus sapin christi* disappeared and replaced by *Acacia millifera* in the area. There are no wild animals observed in area except small ones like rabbits, snakes and some birds. Extensive extraction and exportation of forest products, mainly charcoal, were observed. If the present trend of forest exploitation continues, the natural forest in this area will be degraded irreversibly in few years. The continued loss of productive tree species (*Acacia seyal, Acacia Senegal, Balanties aegyptica*) or forest resources, in general, may also lead to desertification and resources scarcity, thus leading to conflict between various groups, families, villages, payams, and counties. As resources diminish, every group can be expected to defend their rights more vigorously. In addition to the specific impact on various social groups in northern Upper Nile area, the recommendations are expected to produce a model for agroforestry business enterprises promotion and turn the area into a strategic place with regards to agroforestry activities (gum-woods, crops, animals) in different ways.

4. Conclusions

Expansion of mechanized rainfed schemes, the degradation of natural forests in the area caused by multi-practices of human, especially illegal cutting of *Acacia seyal* for charcoal making and firewood, over-tapping in traditional ways and setting uncontrolled fires in the natural forests were the main causes of deforestation in the region. Also, it was found that there were changes in vegetation cover and tree species such as that *Acacia seya, Balanites aegyptiaca* and *Acacia senegal* disappeared and replaced by *Acacia mellifera,* which became a dominant species in the study area. Following measures may be suggested to mitigate further degradation and rehabilitation of the degraded areas:

- Local people should be involved in natural resources management.
- Laws and legislations supports should be implemented to cope with illegal intervention and environmental issues.
-Government and NGOs should provide funding for technical and logistic support to forestry departments in the study area.
-Charcoal production activities should be organized, specifying the areas and quantity of production yearly and introducing improved cooking stoves that use fuel-wood
- Human pressure on natural forest in this area should be lowered through generating alternative income.
- Forest policy and forest law should be enforced to ensure 10% of all rainfed schemes and 5% of all irrigated schemes to be under tree cover in form of shelterbelts.

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